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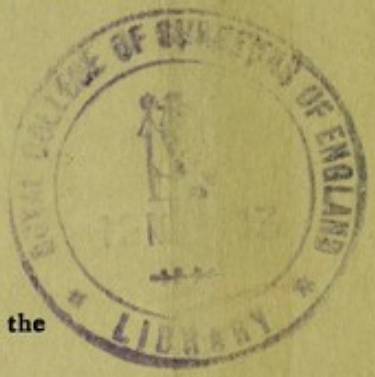
Serial Radiography of the Stomach and Duodenum

DESCRIBING

1. THE COMPLEX MOTOR PHENOMENA OF VARIOUS TYPES OF UNOBSTRUCTED GASTRIC PERISTALSIS
2. RADIOGRAPHIC STUDY OF THE PYLORUS AND DUODENUM WITH AND WITHOUT ARTIFICIAL DILATATION OF THE DUODENUM
3. THE DIAGNOSIS OF CARCINOMA AND HOUR-GLASS STOMACH, GALL-BLADDER INFECTION, AND GASTRIC OR DUODENAL ULCER WITH THE CARDINAL POINTS OF DIFFERENTIATION



BY

LEWIS GREGORY COLE, M.D.

Clinical Professor of Radiology, New York Polyclinic, and Radiologist to the Cornell University Medical College

The enclosed reprint, "SERIAL RADIOGRAPHY OF THE STOMACH AND DUODENUM", describes and illustrates gastro-duodenal lesions which may be diagnosed by serial radiography. Reference to this reprint will aid the practitioner to interpret reports on radiographic findings of gastro-duodenal examinations.

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THE COMPLEX MOTOR PHENOMENA OF VARIOUS TYPES OF UNOBSTRUCTED GASTRIC PERISTALSIS.

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Reprinted from "Archives of the Roentgen Ray," December, 1911.

THE COMPLEX MOTOR PHENOMENA OF VARIOUS TYPES OF UNOBSTRUCTED GASTRIC PERISTALSIS.

By Lewis Gregory Cole, M.D.,
Clinical Professor of Radiology, New York Polyclinic; Radiologist to Cornell University Medical College.

Early in the spring of 1910, through the invitation of Dr. William G. Lyle, I had the pleasure of seeing the Roentgeno-cinematographic films which had been made by Rosenthal projected on the screen. These films were later reproduced to illustrate an article by Kaestle, Rieder and Rosenthal, entitled "Bio-Roentgenography of the Internal Organs," published in the Archives of the Roentgen Ray, June, 1910. An immense amount of credit is due to these men for accomplishing a feat which a few years ago seemed visionary to the most ardent radiologist.

In the first paragraph of this article the authors justly called attention to the fact that a true cinematographic reproduction of the movements of an organ is made up of a series of radiograms taken of successive phases of a single cycle, and that when the successive phases are made up of different cycles no logical claim should be made to the term "Roentgeno-cinematography." Later in their article they stated that the twelve radiograms were made during a single respiratory phase of twenty-two seconds, which, they say, is the normal duration of a single peristaltic contraction.

The term "single peristaltic contraction of the stomach" is so ambiguous that it may be well to consider its meaning. I believe it should be applied to the formation and progression of a peristaltic contraction from its origin to its termination at the pylorus; and it seems to me that a better term would be "individual peristaltic contraction." We should be careful not to confuse this with the formation and duration of an individual antrum, or the terminal wave; this, as will be shown later, is a *true gastric cycle.*

While the duration of a gastric cycle, as above described, varies within wide limits, the average duration is not over two or three seconds. Authority for this statement is based on repeated fluoroscopic examinations and double exposures on a single plate, making two exposures of one-tenth of a second, each about one-fourth of a second apart. These plates show that the peristaltic contraction travels along the greater curvature about one-fourth of an inch in one-fourth of a second, or at the rate of an inch per second. Therefore the duration of a *single gastric cycle,* as described above, does not exceed two or three seconds; and the time it takes any *individual contraction* to pass from the fundus to the pylorus usually does not exceed ten seconds, and this is divided into as many gastric cycles as there are peristaltic contractions. I shall lay no claim to the term "Roentgeno-cinematography" until I have succeeded in obtaining at least four radiograms per second. This will be ten or twelve to a gastric cycle, and about forty radiograms in ten seconds would be required to show a contraction from its origin near the

fundus to its termination at the pylorus. Eighty-eight radiograms instead of thirteen would be required if a period of twenty-two seconds were utilised in making them.

After seeing the wonderful set of radiograms made by Rosenthal projected on the screen, I realised the scope of this method of diagnosis, and went to work immediately to produce it. No information whatever was then available concerning his apparatus or technique. I therefore designed two types of plate and film-changing devices. One of these was somewhat similar to that later described by Kaestle, Rieder and Rosenthal; the other, which was exhibited at the American Roentgen Ray Society meeting in September, 1910, is described with full technique in the Transactions of that Society.

The technique in brief is as follows:

With the patient in a fasting condition, 2 ounces of bismuth subcarbonate suspended in 8 ounces of thick buttermilk is administered, and the stomach studied fluoroscopically with the patient both in the erect and prone postures. A series of twenty to twenty-four radiograms is then made with the patient erect and prone, the preponderance of these being made with the patient in the posture which showed the best distribution of the bismuth. When plates are made with the patient in the prone posture, it is important that the weight of the body should be sustained on pillows placed under the hips and chest. The construction of my table, described in the Transactions of the American Roentgen Ray Society, 1908, enables one to see on a fluoroscopic screen what is being registered on the plate at the instant of exposure; this also enables one to centre the plate so that one of small dimensions—8 × 10 inches—is of sufficient size to include the average stomach. An exposure of about one-tenth to one-fifth of a second is made, passing 40 to 50 milliampères through the tube.

Mindful of the chaos which has existed in the minds of physicians in general, and radiologists in particular, since Rieder gave his first bismuth meal, and proved that the majority of stomachs do not lie in the abdomen, in the old textbook fashion, I hesitate at the mere mention of normal peristaltic contraction. The description of normal peristalsis was avoided by Kaestle, Rieder and Rosenthal, who refer in their article to the peristaltic contraction of a normal stomach. This is a perfectly fair statement, because the girl whom they radiographed undoubtedly had a normal stomach. But in view of the variation in size, shape, and position, of the stomachs that functionate in a normal manner, so far as can be determined by all other methods of examination combined, the peristaltic contractions of these stomachs may be assumed to vary with in even wider limits with the quantity and quality of the food and the mental condition of the patient.

Avoiding the terms "normal" or "abnormal," I shall refer to peristaltic contractions as "unobstructed" or "obstructed," and this paper will be limited to various types of unobstructed peristaltic contractions.

In the light of recent investigation, we must adopt Kaestle, Rieder and Rosenthal's suggestion, and drop the terms "antrum" and "preantrum." It

seems to the author that a satisfactory way to classify the different types of peristalsis is as follows:

1. One-cycle type—described by Holzknecht as normal.
2. One-and-a-half-cycle type—claimed by Holzknecht as belonging to the preceding type, and by Kaestle, Rieder and Rosenthal as belonging to the following type.
3. Two-cycle type—described by Kaestle, Rieder and Rosenthal as normal.
4. Three- and four-cycle types—observed most frequently by the author, and considered by him as more common than all the other types combined. Of these two types, the four-cycle type is the more common.
5. A group representing an active peristalsis where more than four cycles are required for the progression of a contraction. A similar condition has been described by a recent French author as the "choreic type."

The one-cycle type of gastric peristalsis described by Holzknecht, in the following citation from the *Münchener Medizinische Wochenschrift*, and quoted by Kaestle, Rieder and Rosenthal in the ARCHIVES OF THE ROENTGEN RAY of June, 1910, is so rare that I have not succeeded in obtaining a full set of radiograms limited to the pure one-wave type; therefore only a single radiogram illustrating this type of peristalsis is shown.

"The motor phenomena of digestion, as seen in Roentgenoscopy, are as follows: While there is no active movement to be seen in the cardiac portion of the stomach, the lower portion of the greater curvature exhibits deep contractions. These depressions travel toward the pylorus, gradually getting deeper during their passage, till they get their maximum depth at the sphincter pylori, a point three or four fingers' breadth above the pylorus. The maximal point of depression is characterised by the length of time it remains in a state of tonic contraction, and by the fact that the contractions here are the most energetic of any part of the stomach wall.

"Opposite to this deep constriction of the greater curvature appears a similar depression of the lesser curvature, of almost equal depth. There is no movement of the lesser curvature visible in the upper part of its contour. Eventually the depression of the smaller and that of the greater curvature meet, so that on the screen there is seen a clear line between the shadow of the contents of the corpus and of the antrum. Soon afterwards the shadow of the antrum disappears, its contents being emptied into the duodenum by a process of concentric contraction.

"The constriction three or four fingers' breadths above the pylorus, mentioned above, has the effect of a sphincter antri which periodically cuts off the antrum pylori from the body of the stomach. The circular constriction at this point is comparable in breadth and extent with the pylorus itself. The button-like reduction of the antrum is brought about by a process of concentric contraction. It is doubtful, however, whether there is a simultaneous peristaltic movement of the circular contraction towards the pylorus, or whether the circular depression remains stationary, and the evacuation is brought about by a contraction of the longitudinal fibres alone."

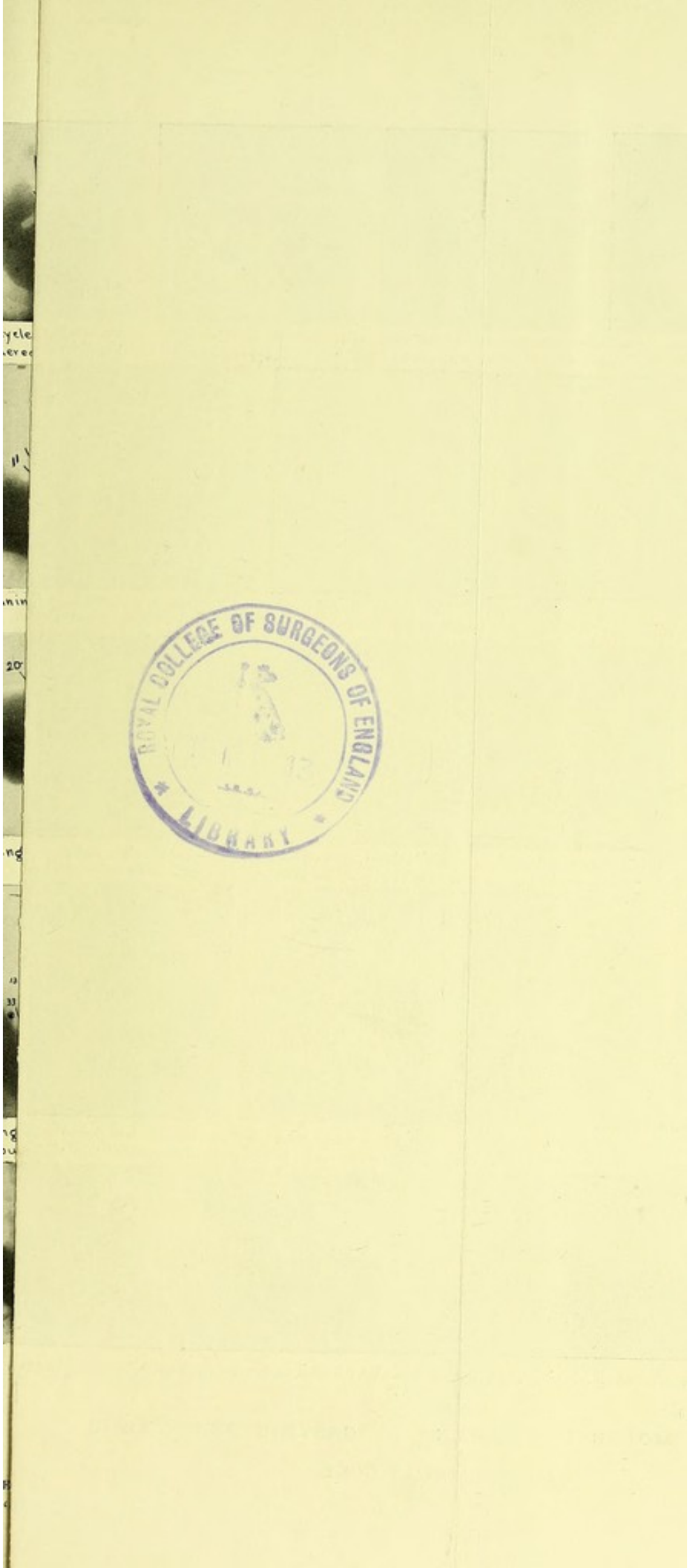
The first print on the first row of Plate CCCLXXV. illustrates the one-cycle type, where one contraction begins about three or four fingers from the pylorus, and disappears before there is any indication of the succeeding contraction. This is a one-cycle type of gastric peristalsis, because the contraction progresses from its origin to its termination during the period that the stomach passes through a series of shapes and assumes the same shape again.

The remaining prints on the first row illustrate the one-and-a-half-cycle type, which is much more frequent. In these radiograms there is one well-marked peristaltic contraction near the pylorus, such as is described by Holzknecht, and a second smaller contraction on the lesser curvature without a corresponding contraction on the greater curvature. Studying the case fluoroscopically, one would observe only the one well-marked contraction, and consider that it corresponded with the motor phenomena described by Holzknecht. Studying the case radiographically, one would detect the smaller second wave on the lesser curvature, and consider that it represented a slight modification of the type of motor phenomena described by Kaestle, Rieder and Rosenthal. This case explains some of the confusion that has existed regarding the gastric motor phenomena, and where this is intermediate between that described by Holzknecht and that described by Kaestle, Rieder and Rosenthal, it would seem that the term "intermediate" would alleviate some of this confusion.

The second row of radiograms demonstrate the two-cycle type of peristalsis, described by Kaestle, Rieder and Rosenthal as follows :

"Our investigation shows that during digestion there is no such division of the stomach into two distinct parts (described by Holzknecht), and that a strongly differentiated antrum pylori in the old acceptation of the term does not exist. As our tracings show, the formation of the new antrum does not commence at the spot where the final emptying of its contents occurs, and is therefore not a mere relaxation of the contracted walls. If we adhere to the idea of an antrum pylori, then it is necessary to speak of two such antra existing side by side and at the same moment. We must speak of an old and a new antrum, as we have done, for clearness of expression, in the foregoing pages. As the old antrum disappears, a new antrum is developed from the wall of the body of the stomach. This new antrum passes pylorus-wards, and ultimately exactly takes the place of the old antrum, whilst another new antrum begins to form. Moreover, if we wish to adhere to the term, our idea of the antrum pylori must be modified. In our opinion there is no true antrum pylori, any more than there is a sphincter pylori, in the sense of the older observers; what we see in the regio pylorica is an increase in the energy of the gastric peristalsis, and an increase in the height and depth of the wave summits and depressions."

These ten radiograms represent different phases of peristaltic cycles ; a contraction begins at the point indicated by the arrow marked (1), and in each succeeding radiograph it has progressed pyloric-ward until it reaches the point marked (10) in the last radiogram on the second row. This represents one



complete cycle, the stomach assuming practically the same shape as in the first radiogram; then referring back to the first radiogram on this row, the contraction continues at the point marked (11), and progresses pyloric-ward until it reaches the pylorus in the tenth radiogram of the row. Therefore in this type of peristalsis it requires two complete gastric cycles for a peristaltic contraction to progress from its origin to its termination at the pylorus; one would consequently refer to this as a two-cycle type of gastric peristalsis.

The third and fourth rows of radiograms illustrate respectively the three- and four-cycle types of gastric peristalsis—observed by the author to be more frequent than either of the other types, and the latter more frequent than the former. In both of these rows the peristaltic contraction at its origin is indicated by arrow No. 1, and in each succeeding radiogram it is shown to have progressed pyloric-ward. In the third row it required three complete cycles for the contraction to progress from its origin to its termination, and therefore this should be considered as the three-cycle type of gastric peristalsis. The fourth row shows a stomach requiring four cycles for the progression of the peristaltic contraction, and therefore is of a four-cycle type. It will be noted that the contraction begins high up near the fundus, and not in the lower portion, as described by Holzknecht, and that its depth does not increase except relatively, the actual height from the trough to the crest being as great in the upper as in the lower portions of the stomach.

These two rows illustrate very graphically the *systole* and *diastole* of the stomach. The first seven radiograms in each row demonstrate various stages of systole, and the last three various stages of diastole. When the sixth or seventh radiogram, showing the stomach in complete systole, is compared with the tenth radiogram, which shows it in complete diastole, this phenomenon is so evident that it is beyond question. When one does find a stomach of the one-cycle type, the combination of the systole and diastole, and the progression of the contraction pyloric-wards, correspond very closely with the motor phenomena described by Holzknecht, but the author has so rarely found this type that he cannot possibly consider it as a typical manifestation of the gastric phenomena.

A systole and a diastole occur during each gastric cycle. The systole and diastole, and indeed the whole gastric cycle, is governed, but not completely controlled, either directly through the vagus by the same nervous impulses which govern the respiratory function, or indirectly by respiration itself. This may explain many obscure symptoms, such as the pain which frequently occurs when one exercises vigorously immediately after eating, and it may serve as a basis for therapeutics in stimulating a sluggish, lazy stomach.

The fifth row of radiograms show an unusually active gastric peristalsis; six or seven peristaltic contractions are present at the same instant, and it would require six or seven gastric cycles for an individual contraction to pass from its origin near the fundus to its termination at the pylorus. This the author believes is as unusual as the one-cycle type of gastric peristalsis.

Résumé

This article, which is the first of a series of four, describes only various types of unobstructed gastric peristalsis. The author does not claim that the extremes of these types are strictly within the limits of a normal motor phenomenon. They do, however, represent various types of gastric peristalsis in stomachs that show no radiographic evidence of a pathological lesion in or around the stomach or duodenum, and are therefore called "unobstructed," in contradistinction to those in which the peristaltic contraction or wave is obstructed by early carcinoma, ulcers, or adhesions from gall-bladder infection.

The series of radiograms illustrating this article demonstrate the following facts: 1. That the *gastric motor phenomenon is complex* rather than simplex, as evidenced by a *systole* and *diastole* of the stomach in addition to the peristaltic contractions passing pyloric-ward.

2. That the stomach goes through a series of motions best described as a *gastric cycle*.

3. That peristaltic contractions progress pyloric-ward, requiring as many cycles as there are contractions visible. A "single" or "individual" peristaltic contraction should not be confused with a gastric cycle.

4. That three or four peristaltic contractions in the stomach at the same time are more frequent than one or two.

5. That when food is in contact with the cardiac end of the stomach, contractions begin near the fundus, and frequently are as deep in this region as near the pylorus.

6. They show why considerable confusion has arisen from previous contributions along this line, which were apparently contradictory.

In closing, the author desires to give an immense amount of credit to Kaestle, Rieder and Rosenthal for their wonderful work along this line, and he does not claim that these radiograms are true Roentgeno-cinematographs, as he can only claim this when he succeeds in making twelve radiograms in three seconds, or eighty-eight in twenty-two seconds. But an immense amount of valuable information can be gleaned by careful study from such a series of instantaneous radiograms.

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A RADIOGRAPHIC STUDY OF THE PYLORUS AND DUODENUM, WITH AND WITHOUT ARTIFICIAL DILATATION OF THE DUODENUM.

By Lewis Gregory Cole, M.D.,
Radiologist to Cornell University Medical College.

In this article, which is the second of a series on the radiographic diagnosis of gastric and duodenal lesions, I shall attempt to show variations in the duodenum, pylorus, and pyloric sphincter, where there is no radiological evidence of organic disease.

The first article in this series described different types of unobstructed gastric peristalsis, and the systole and diastole of the stomach, and it will be difficult to understand the motor phenomena of the pylorus and duodenum without understanding the motor phenomena of the remaining portion of the stomach previously described.

The peristaltic waves of the small intestine are so rapid and small that it is difficult to study them either fluoroscopically or radiographically. We can, however, radiographically distinguish the ileum by the coagulated appearance of the bismuth contents, and the jejunum by the flocculent appearance (Plate CCCLXXXIV., Fig. 1). This appearance is constant in normal cases, but may be modified in pathological conditions and in cases of intestinal motor inefficiency.

The second and third portions of the duodenum are usually readily identified by their shape and position (Figs. 2 and 3), unless the intestinal peristalsis is so active as to have a tendency to suck the food away from the pyloric sphincter more rapidly than it is allowed to pass through. In such cases I have pursued a method of artificial dilatation of the duodenum, which will be described later on.

The first portion of the duodenum deserves special attention. Anatomically and physiologically it has always been considered a part of the small intestine. Since writing this paper I have learned that Mayo has suggested, both on account of its embryology and its acidity, that the first portion of the duodenum should be considered a part of the stomach. Radiographically it should undoubtedly be considered as a part of the stomach. It is dilated into a cap which surmounts the pylorus, and corresponds in size and shape with the pyloric end of the stomach. It has absolutely no resemblance to the small intestine. Its motor phenomena correspond with the gastric cycle, and have no resemblance to the small, rapid, peristaltic contractions of the remaining portions of the duodenum. The acidity of the contents of this duodenal cap may account for prevalence of ulcers, over 90 per cent. occurring in this

portion of the duodenum. Considering its embryology, its acid contents, its motor phenomena, its surgical importance, and the very important part that its radiological appearance plays in the diagnosis of gastric and duodenal lesions, it should be dignified by a separate name. Its appearance and position, sitting like a cap on the pylorus, immediately suggest its name. Hence, for convenience of description, I shall call the first or ascending portion of the duodenum the "cap." This cap varies in size, shape, and position, but a normal cap can usually be differentiated from a pathological one. It varies in different patients. Figs. 4, 5, and 6, represent different types of the cap. It varies with the posture of the patient under examination. With the patient in the prone posture, but without pressure on the abdomen, as described in the first article, there is no tension on the first portion of the duodenum; the cap is symmetrical, its lines are clear cut and well defined, as shown in Fig. 7. But with the same patient in the erect posture the distended stomach drags on the cap, and there is usually an attenuated appearance of the cap, as shown in Fig. 8. Frequently, where the cap is not completely filled, the level of the chyme is discernible (Fig. 9). Occasionally above the chyme an accumulation of gas may be seen, similar to that usually seen in the stomach (Magenblase). The cap varies during each gastric cycle. Sometimes it sets up on the head of the pylorus in a perfectly proper manner (Fig. 10), separated from it by about $\frac{3}{16}$ inch; at other times it drops down over the head of the pylorus, like the "peach-basket" lady's hat (Fig. 11). During the stage of diastole the stomach contents drop away from the cap, and it then has the appearance of having been "blown off," as in Fig. 12. The cap also varies with the activity of the intestinal peristalsis. If the peristalsis of the second and third portions of the duodenum is so active as to withdraw the food as fast as it passes through the pyloric sphincter, the duodenal cap may not be dilated to its full size.

There may be an angulation of the cap at the pyloric sphincter. The cap may be displaced to the left, or, what is more likely, the pyloric end of the stomach is drawn to the right, while the cap is held in its normal position by the gastrohepatic ligaments. This condition is illustrated in Fig. 13. In Fig. 14 there is an irregularity on the greater curvature near the pylorus, which may indicate the attachment of adhesions to the pyloric end of the stomach, drawing it to the right.

In other cases the angulation may be due to adhesions binding the pyloric end of the stomach to the lower surface of the liver. This does not allow space for the cap to surmount the head of the pylorus, and it is displaced backward and to the right, as illustrated in Fig. 15.

In all of these cases there was more or less evidence of obstruction; but in none of these, except possibly in the last, was there any evidences of adhesions contracting the lumen either of the pylorus or duodenum.

The clear space between the cap just described and the bismuth contents of the pyloric end of the stomach during the systole indicates accurately the pyloric sphincter. The breadth of this clear space varies slightly with the

muscular development of the patient, but it is one of the most constant factors in gastro-intestinal radiography. It should be $\frac{3}{16}$ inch, varying from $\frac{1}{8}$ to $\frac{1}{4}$ inch; both outlines should be clear cut and well defined during the gastric systole, as illustrated in Figs. 16, 17, and 18. The lumen of the pyloric sphincter should be in the centre of the sphincter, and about $\frac{1}{8}$ inch in diameter. The variation of the radiographic appearance of the pyloric sphincter during different phases of the gastric cycle is due in part to the pressure of the food against the pyloric sphincter, as shown in Figs. 19 and 20.

There is some question whether the pyloric sphincter takes part in the motor phenomena of the stomach, contracting and relaxing during each cycle, or whether it remains contracted, the food being forced through it by the peristaltic action of the stomach. Personally I consider the pyloric sphincter as a "butler," guarding the entrance to the intestine, and allowing only the food that he recognises as properly prepared to be served to the intestine, and closing the door during diastole to prevent it from passing back into the stomach. I believe that the relative strength of the pyloric sphincter (the butler) to the peristaltic contraction of the stomach (the cook) is one of the most important factors in functional derangements of the digestive tract. If the pyloric sphincter is too strong, the stomach may be overdistended with food, and yet the small intestine may be starved. On the other hand, if the pyloric sphincter is weak and the peristaltic contractions are too strong, improperly prepared food will be served to the intestine.

During the stage of systole, with the patient in the erect posture, the food is pressed up against the surface of the pyloric sphincter, and we have a clear-cut, well-defined outline of the sphincter, as is shown in Fig. 21; but during the stage of diastole the food drops away from the pyloric sphincter, and there is a wide space between the bismuth contents of the cap and that of the pyloric end of the stomach, as is shown in Fig. 22.

In the interpretation of the radiographic plate, great care should be taken not to interpret this space as evidence of obstruction of, or adhesions to, the pylorus.

The relation of the pylorus to the umbilicus varies with the size, position, and type, of stomach. The position of the umbilicus itself also varies with the build and obesity of the patient and the flabbiness of the abdominal wall. The relation of the pylorus to the body of the stomach is much more important, and varies with the type of the stomach, as is shown in Figs. 23, 24, 25. The most important point, however, is the relation of the level of the chyme to the pylorus when the patient is in the erect posture. If the upper level of the chyme is 3 or 4 inches below the pyloric sphincter, and the peristalsis is inefficient, as indicated in Fig. 26, how is the chyme going to get out of the pylorus, even if the latter is wide open? Fig. 27 is of the same patient in the prone posture, with the abdomen flat on the plate. These two plates illustrate the relative value of the two different postures in determining the shape and contour of the stomach, particularly when the stomach is dilated and atonic.

Artificial Dilatation of the Duodenum.—When the chyme is drawn away from the pyloric sphincter by unusually active intestinal peristalsis, it is difficult to detect the second and third portions of the duodenum. In such cases I have adopted the following method, which was described in my article, "The X-Ray Diagnosis of Pyloric and Duodenal Lesions," read before the American Association of Obstetricians and Gynæcologists at Louisville, Kentucky, September 29, 1911. A second paper, on "Artificial Dilatation of the Duodenum for Radiographic Examination," was published in the *American Quarterly of Roentgenology.*

The lumen of the entire duodenum and upper portion of the jejunum can be examined by the following procedure: The patient swallows an "Einhorn pyloric dilator." This is a small metallic ball and rubber bag attached to a fine rubber tube, the rubber bag collapsing round the tube just behind the ball. The whole apparatus is as easily swallowed as the old-fashioned pill. This dilator may be administered with the food the day before, or given three or four hours before the examination, the patient assuming a position which will allow it to pass into the duodenum and jejunum.

The small rubber bag, which is surrounded by a silk bag about the size of the lumen of the duodenum, is then inflated with air, and acts as an intestinal obstruction. A meal of bismuth and buttermilk is then given by the mouth, and passes readily into the duodenum, the temporary obstruction preventing the bismuth from passing on through the jejunum. The duodenum is dilated by the bismuth and buttermilk, and a radiograph shows perfectly the contour of the dilated duodenum.

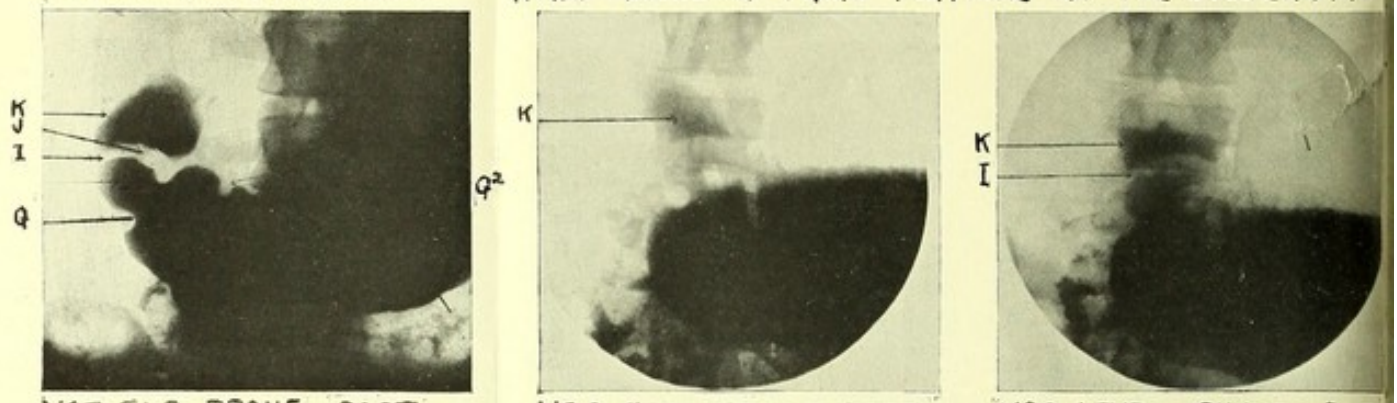
I am indebted to Dr. Max Einhorn for the case illustrated in Figs. 28, 29, 30. The dilator was passed into the stomach by Dr. Einhorn about fourteen hours before the examination. Forty plates were made, with an interval of about five minutes between each exposure, some before and some after the administration of the bismuth.

The first plate made after the bismuth was administered showed the stomach and cap distinctly, but the second and third portions of the duodenum were not visible. Then the second portion began to fill, as shown in Fig. 28, the tube and bag being in the jejunum. Later the third portion filled, and Fig. 29 shows the entire duodenum artificially dilated. In both Figs. 28 and 29 the bag is not so completely inflated as it should be, but in Fig. 30 one readily sees the bag properly inflated.

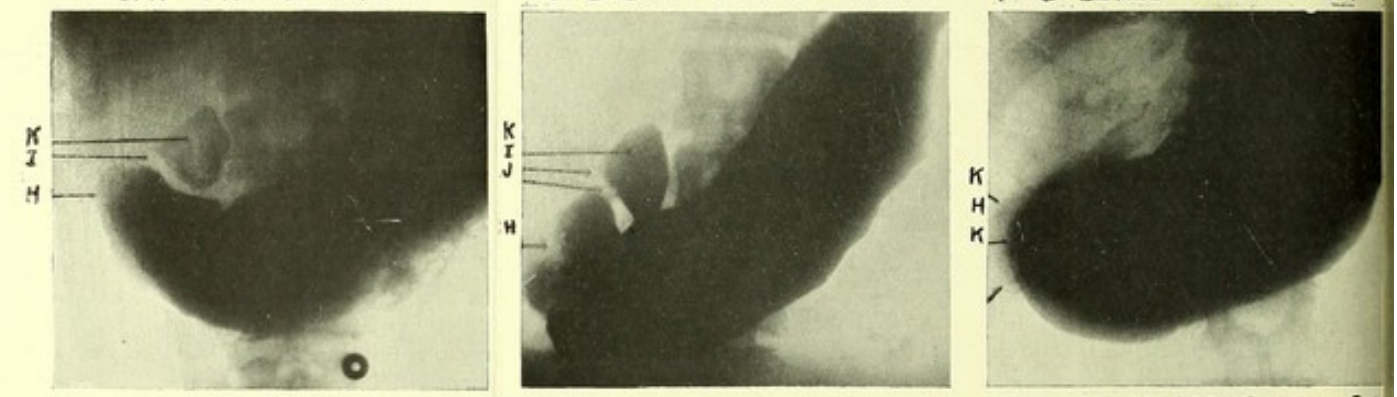
This case is interesting as showing how far the dilator may pass into the small intestine, and yet be withdrawn without causing any unusual sensations. The dilatation of the duodenum would have been more complete if the tube had passed only into the first portion of the jejunum, and the inflation of the bag had been as thorough as in Fig. 30.

The following modification of Einhorn's dilator will, I believe, be of great value: The tube is surrounded by a second tube slightly larger than the first. This outside tube terminates just behind the rubber bag, and through it the bismuth and buttermilk may be injected and aspirated directly into or from

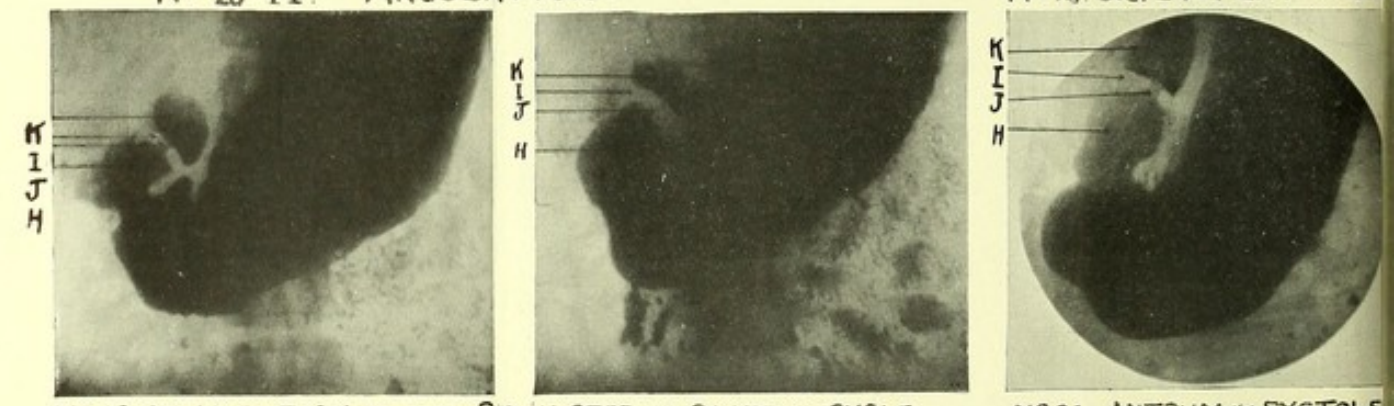
Nº 1. ILEUM AND JEJUNUM. Nº 2-3 SECOND AND THIRD PORTIONS OF THE DUODENUM.



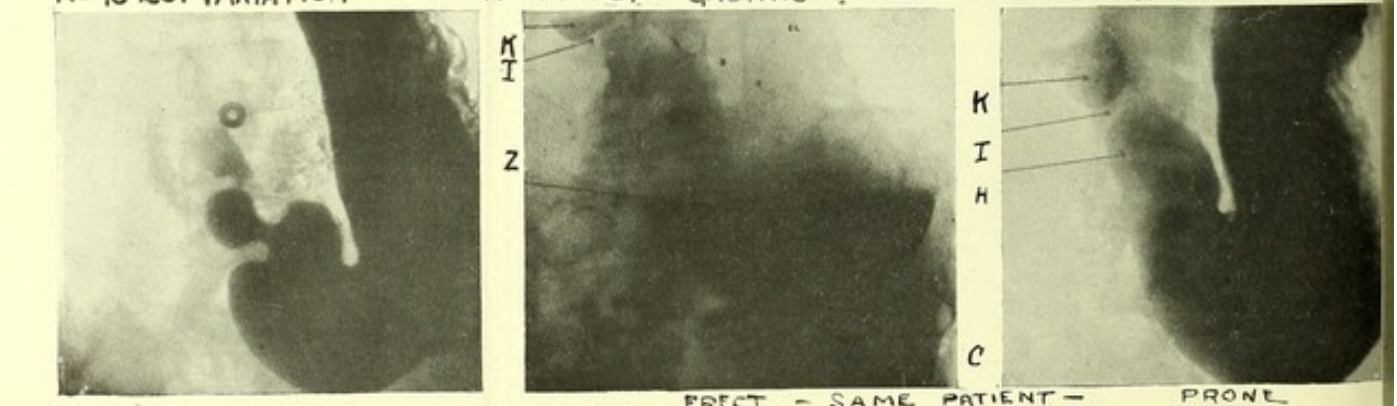
Nº 7. CAP. PRONE. POST. Nº 8. CAP. ERECT POST. Nº 9. LEVEL OF CHYME IN CAP.



Nº 13-14. ANGULATION. Nº 15. DISPLACEMENT OF CA



Nº 19-20. VARIATION OF THE SPHINCTER IN GASTRIC CYCLE. Nº 21. ANTRUM IN SYSTOLE



Nº 25. FISH-HOOK STOMACH ERECT - SAME PATIENT - PRONE

Nº 26-27. INEFFICIENT PERISTALSIS OF PYLORUS.

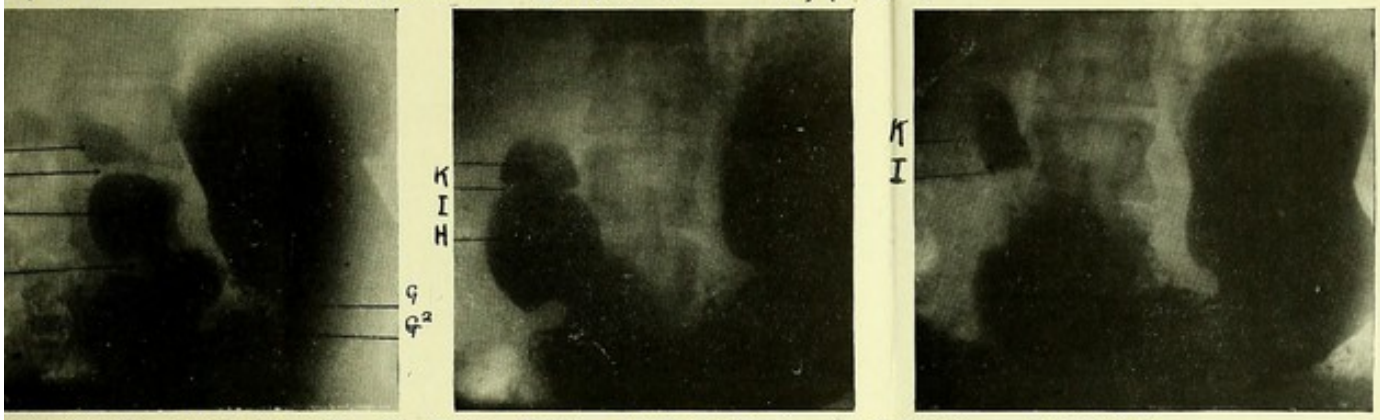
RADIOGRAPHIC STUDY OF

By DR. LE

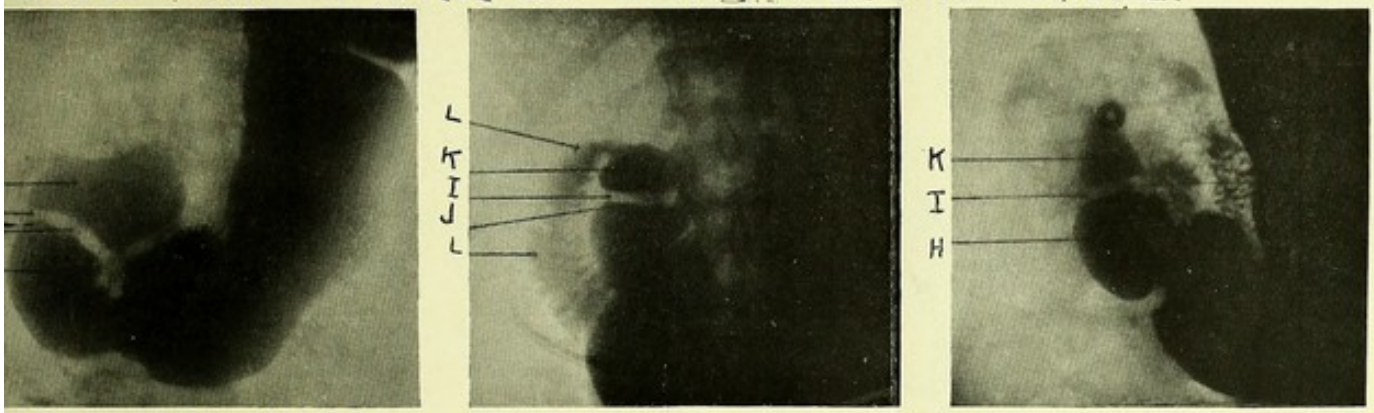
PLATE CCCLXXXIV.

("*Archives of the Roentgen Ray.*"—*Copyright.*)

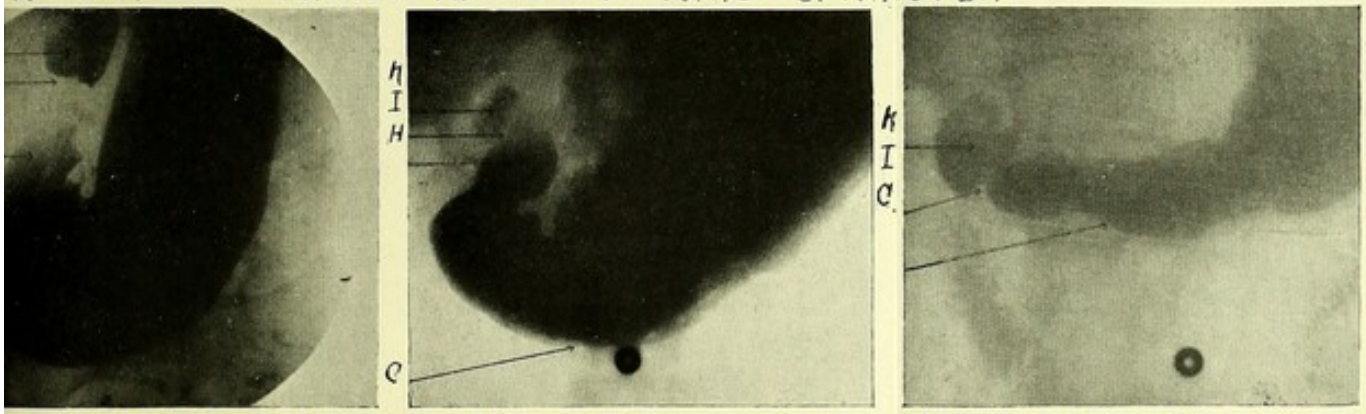
4-5-6 VARIOUS SHAPED "CAPS".



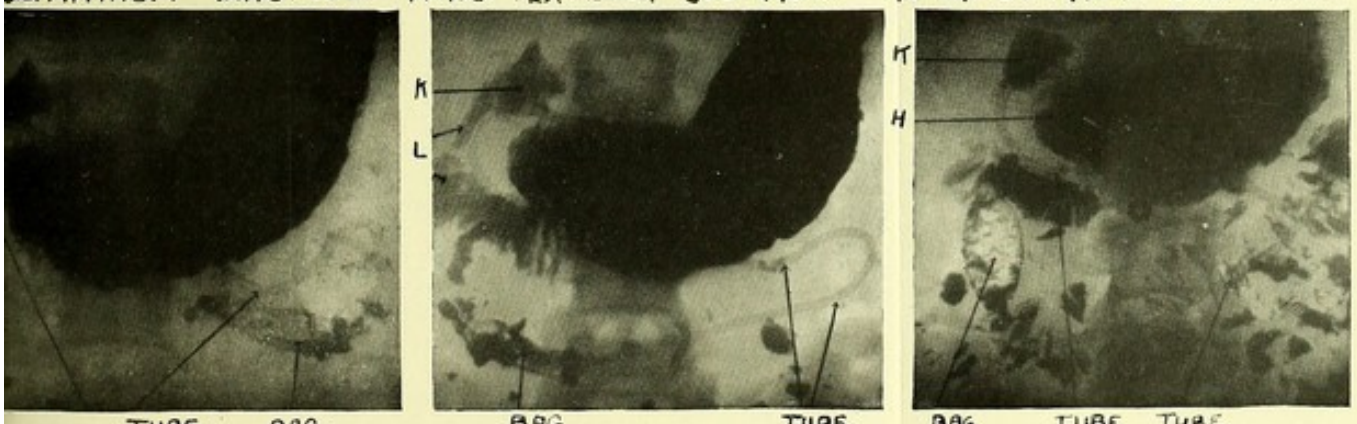
10-11-12 VARIATIONS IN THE CAP DURING A GASTRIC CYCLE.



Nº 16-17-18. VARIATIONS OF PYLORIC SPHINCTER.



22. ANTRUM IN DIASTOLE. Nº23. TEXT-BOOK STOMACH. Nº24. COW-HORN STOMACH.



28-29 30. ARTIFICIAL DILATATION OF THE DUODENUM.

RUS AND DUODENUM.

Y COLE.

the duodenum. In this way the exact amount of the distension of the duodenum may be diagnosed.

Radiographic examination, besides showing adhesions from duodenal and gastric ulcers and gall-bladder infection, also enables us to examine the head of the pancreas, which can be more perfectly outlined by the duodenum, as suggested by Dr. Crane. In some cases I have been able to clearly demonstrate the shadow of bismuth in the canal of Wirsung.

Reprinted from "Archives of the Roentgen Ray," October, 1912.

SERIAL RADIOGRAPHY IN THE DIFFERENTIAL DIAGNOSIS OF CARCINOMA OF THE STOMACH, GALL-BLADDER INFECTION, AND GASTRIC OR DUODENAL ULCER.

By Lewis Gregory Cole, M.D.,
Clinical Professor of Radiology, New York Polyclinic; Radiologist to the Cornell University Medical College.

The demand for a more definite method of diagnosis of gastro-duodenal lesions is evidenced by the great efforts which are being made to accomplish this end by chemical and instrumental methods of examination. Any report on the recent work done in this field should be prefaced by a tribute to such men as Rieder, Holzknecht, Schönberg, Groedel, Cannon, Hemmeter, and Hulst, who have done such valuable pioneer work in the radiographic diagnosis of this region. Many, and perhaps all, of the observations here recorded may have been published in foreign languages, but the chief object of this communication is to state as concretely as possible the value and scope of serial radiography in gastro-duodenal lesions.

In my original communication on this subject, presented at the 1910 meeting of the American Roentgen Ray Association, no claim was made to true Roentgen-cinematography as described by Kaestle, Rieder, and Rosenthal; but attention was called to the following facts:

1. The plate requires to be changed much more rapidly than thirteen in twenty-two seconds, in order to show the progression of a single contraction from its origin to its termination.

2. The real value of these attempts to make Roentgen-cinematographs lies in the number and instantaneousness of the individual exposures, rather than in the fact that the successive plates show various phases of the same cycle, which is doubtful.

3. From a practical standpoint, numerous instantaneous radiographs of various phases of different cycles are of more diagnostic value than various phases of the same cycle, although perhaps not so scientific.

The construction of the plate-changing table, described in the Transactions of the American Roentgen-Ray Society, 1908, allows the changing of eighteen to twenty-five plates in five minutes. These radiographs show various phases of different cycles. Two exposures on a single plate, one-quarter of a second apart, indicate the speed and progress of a single contraction, and form the key to the assemblage of the plates. The radiograms are assembled in their proper sequence and then studied. In this and future communications such procedure will be referred to as "serial radiography," in order to distinguish it from Roentgen-cinematography, in which, at least, eighteen radiograms must be made in three seconds. Even this number projected on a screen would exaggerate the speed of the peristaltic contraction progressing pylorus-wards. Twenty-four or more instantaneous radiograms may be assembled, reduced to cinematographic size, and projected upon a

screen, giving a very graphic and fairly accurate representation of the gastric cycle. This, however, does not have the diagnostic value of the original radiograms assembled and studied individually and collectively.

The relative value of fluoroscopy and the study of single radiographs in gastro-duodenal diagnosis is an open question, and undoubtedly each method has its value. But with the technique used for this examination we have the advantage of both methods. At any time before, during, and after the examination, one can study the stomach fluoroscopically, and during each exposure one sees grossly what is registered in detail on the plate. There is detail in the radiographs which even the most ardent supporter of fluoroscopy does not claim to see on the screen. This detail is essential for the differential diagnosis of gastro-duodenal lesions. Moreover, we have a permanent record of various cycle phases which may be studied at will, compared with other cases, or with subsequent radiographs of the same case.

Either serial or Roentgen-cinematography must be employed before one is warranted in expressing any opinion regarding the condition of the wall of the stomach or duodenum, except in extreme non-operable cases of carcinoma. There is no justification for a diagnosis on which surgical procedure is to be based, unless two series of fourteen to twenty-four radiographs have been made, the second confirming the first in every essential detail. A series of radiographs of one or two cases would more clearly illustrate the value of serial radiography, but by selecting one characteristic radiograph out of several sets we can better show the scope and accuracy of this method of diagnosis.

The type, size, and position of the stomach may be determined by two or three radiographs with the patient in various postures, so that these conditions are not strictly within the scope of this article. Suffice it to say that, for the purposes of filing and indexing, six types are recognised :

1. Textbook.
2. Fishhook.
3. Cowhorn.
4. Drain-trap.
5. Saddle-shaped.
6. Deformed.

These refer to the position of the stomach with the patient prone, but with the weight of the body resting on the thigh and chest.

The gastric and duodenal lesions that may be recognised by this method are as follows :

1. Carcinoma (Plate CCCXCVI., Figs. 1 to 6, inclusive).
2. Hour-glass constriction (Fig. 7).
   (*a*) False hour-glass constriction—spasmodic contraction—(Figs. 8, 19, 20).
3. Adhesions (Figs. 9, 11, 14, 17, 18).
   (*a*) From gastric ulcer (Fig. 10).
   (*b*) Duodenal ulcer (Fig. 12).
   (*c*) Gall-bladder infection, with no calculi shown (Fig. 15).
   (*d*) Gall-stones (Fig. 16).
4. Tumour pressing on the stomach from without (Figs. 19, 20).

5. Prognathian or " undershot" dilatation of the pars pylorica from pyloric obstruction (Fig. 21).

6. Atonic dilatation of the stomach (Fig. 22).

7. Atrophic contraction of the stomach (Fig. 23).

The radiographic indications of carcinoma are very characteristic in advanced cases; and even in early cases some of these findings are sufficiently definite to justify one in stating with a reasonable degree of certainty that the process is malignant. The lumen of the stomach is encroached upon by a nodular growth in the wall of the viscus, with islands or projections into the normal tissue, giving the appearance of finger-prints (Figs. 2 and 5). The line of invasion may have a worm-eaten appearance with overhanging edges (Fig. 4), or the growth may progress in the form of a cone (Fig. 1), terminating at its apex in a small constricted lumen (Figs. 1 and 3), which may be reduced to $\frac{1}{8}$ inch in diameter (Figs. 1, 3, 4), and filled with bismuth, or entirely obliterated (Fig. 6). The area of constriction is devoid of peristaltic contractions or rugæ, and is constant in size, shape, and position. The cone (Fig. 1) may be filled and emptied during each gastric cycle by the peristalsis of the normal portion.

If the growth is annular, small, and freely movable, the surrounding tissue is usually not involved (Fig. 4). Such a case offers an exceptionally good opportunity for surgical procedure.

An extensive carcinoma may occur without dilatation. If the growth is limited to one wall, and the lumen is not sufficiently diminished to cause obstruction, there may be no dilatation, and the stomach is emptied in the normal time. Even in advanced cases of annular growth, involving the entire pars pylorica or body of the stomach, dilatation may not be extreme (Figs. 1 and 6), because the peristaltic contractions of the fundus are relatively small compared with the lumen of this portion, and therefore lack propulsive force. If, however, the growth surrounds the pylorus and diminishes its lumen, dilatation and stasis of the food occurs early (Figs. 3 and 21).

The following rather full description of an hour-glass contraction is justified by the danger of mistaking an unusually deep peristaltic contraction for this condition, and by the importance of differentiating between such a constriction and carcinomata. The constriction of the hour-glass stomach (Fig. 7) is usually narrow, having the appearance of a ring with clear-cut edges. It resembles a peristaltic contraction, except that it does not progress pylorus-wards nor relax during diastole. The upper segment is large in proportion to the lower one, which corresponds in size and shape to a normal empty stomach. The amount of chyme that collects in the lower segment depends upon the relative size of the constricting ring, compared with the pyloric sphincter and the activity of its peristaltic contractions. A deep peristaltic or spasmodic contraction (Figs. 8, 19, 20) may so closely resemble an hour-glass stomach, that one is not justified in making a diagnosis of such a condition unless two complete series of fourteen to twenty-four radiograms are made, preferably on subsequent days. In several cases much discredit

has been cast on radiography because a diagnosis has been based on only three or four radiograms, and a deep peristaltic contraction has been mistaken for an hour-glass stomach. In a series of radiograms the real peristaltic contractions relax with each diastole, and as they progress pylorusward they move up to the constricting ring, which remains stationary.

The existence of adhesions, involving the pylorus and duodenum, which forms the heart of this communication, has been recognised. But in many cases previous methods of diagnosis have not been sufficiently accurate to justify surgical procedure except in extreme cases, and their symptoms have been attributed to chronic appendicitis, mobile cæcum, kinks in the ileum, renal calculus, etc. Not that these latter conditions do not exist, but where on operation a normal or perhaps constricted appendix is found, and in spite of its removal the symptoms continue unabated, and where the symptoms are attributed solely to the right hypochondrium, why look to a distant region for the source of reflex symptoms when a sufficient lesion is present at the site of the symptoms ?

The radiographic indications of adhesions are—

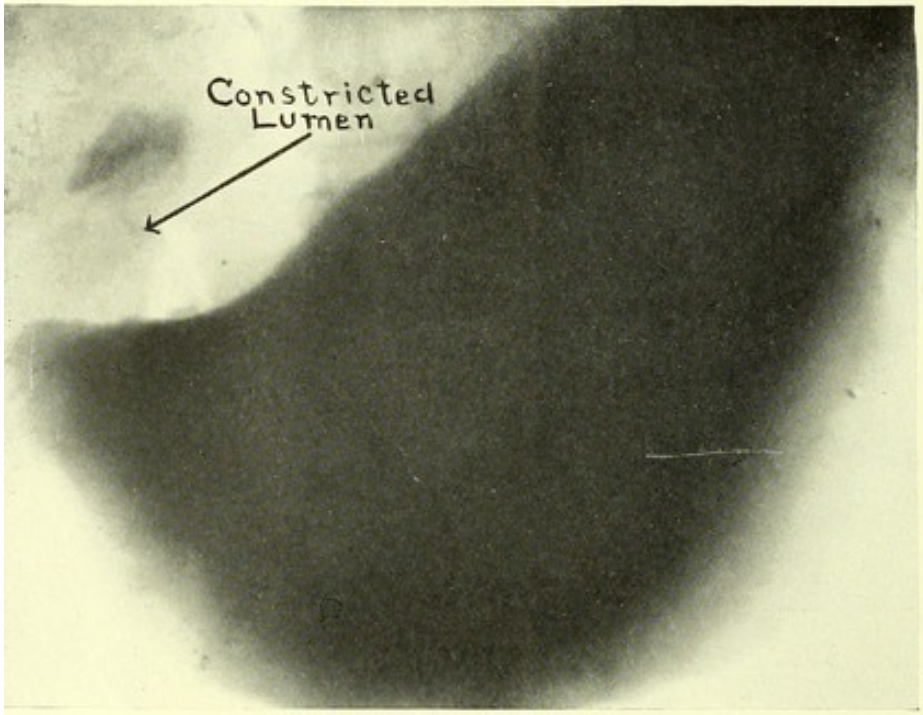
1. The lumen varies in diameter, but does not dilate to its normal size.
2. The rugæ show unusually distinctly, have a crinkled appearance, and run obliquely or transversely.
3. The peristaltic contractions are clear-cut in the normal portion, but cease or are distorted when they reach the adhesions.
4. The cap is constricted, asymmetrical, displaced, or absent.
5. The duodenum is angular or contracted.

Extensive adhesions (Fig. 9), involving all of the pars pylorica, may resemble an hour-glass stomach, or extensive, non-operable carcinoma. This condition can, however, readily be differentiated from the latter, and usually from the former. The adhesions, even though very extensive, do not constrict the lumen of the stomach sufficiently to prevent the chyme from passing freely through it, and dilatation of the fundus is not likely to result.

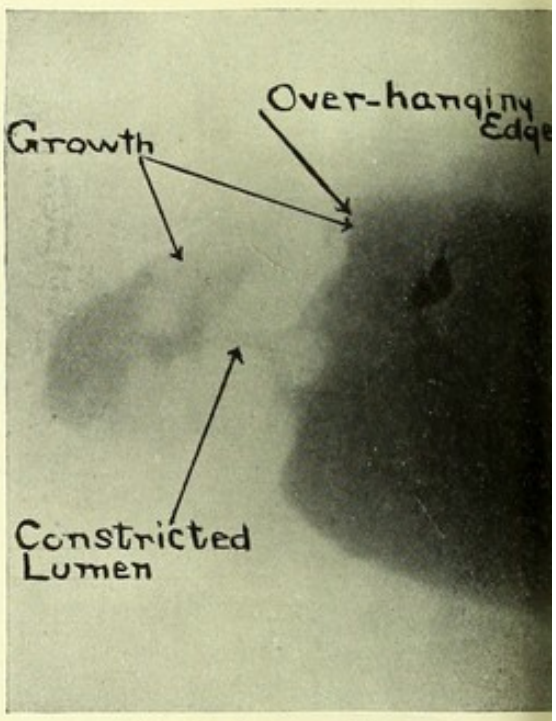
The point where the adhesions begin, which corresponds with the line of invasion in carcinoma, is more clearly defined than one would expect, and has either a clear-cut outline, resembling the constriction ring of an hour-glass stomach, or a serrated appearance, caused by the numerous deep rugæ, where the stomach " tails out " (Fig. 10). The lumen of the affected area is somewhat contracted, approximately corresponding in size to the normal empty stomach. It varies slightly in size as the chyme is propelled into it by the peristalsis of the normal part of the stomach, and changes in size and shape during each gastric cycle. But in none of the radiographs of the series is its dilatation in proportion to that of the uninvolved part of the stomach, neither does it move as much as would a normal stomach of similar type. The peristaltic contractions in the uninvolved portion are normal (Fig. 9), but at the line of invasion they cease abruptly. There is evidence of attempts at peristaltic contractions in the affected portion, but its inability to expand as the chyme is forced into it by the peristalsis of the normal part of the

No. 1.—Extensive Carcinoma.

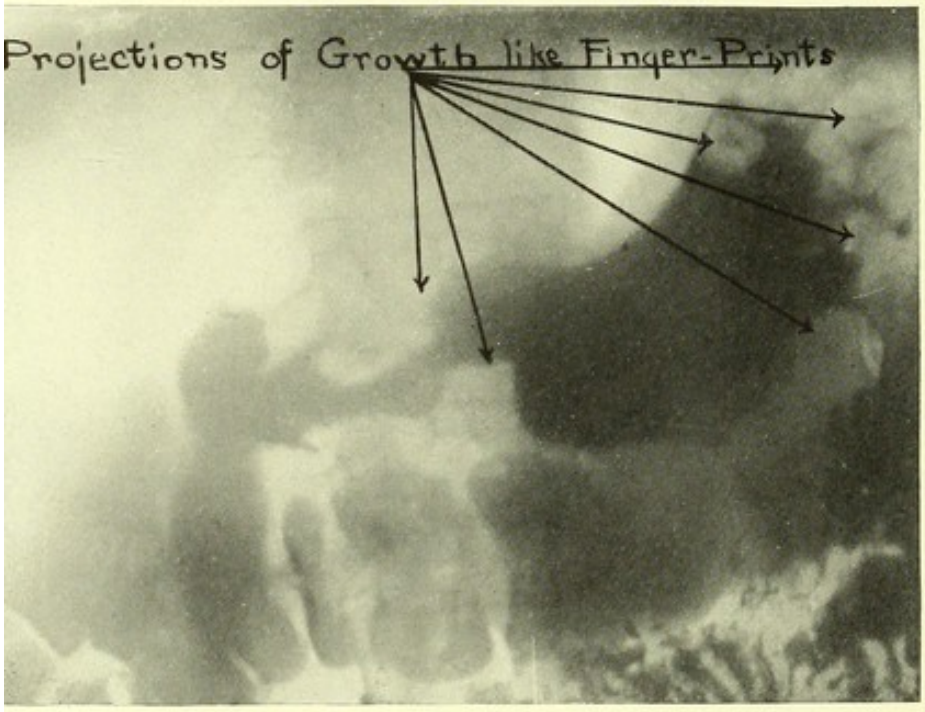
No. 2.—Nodular Carcinoma.



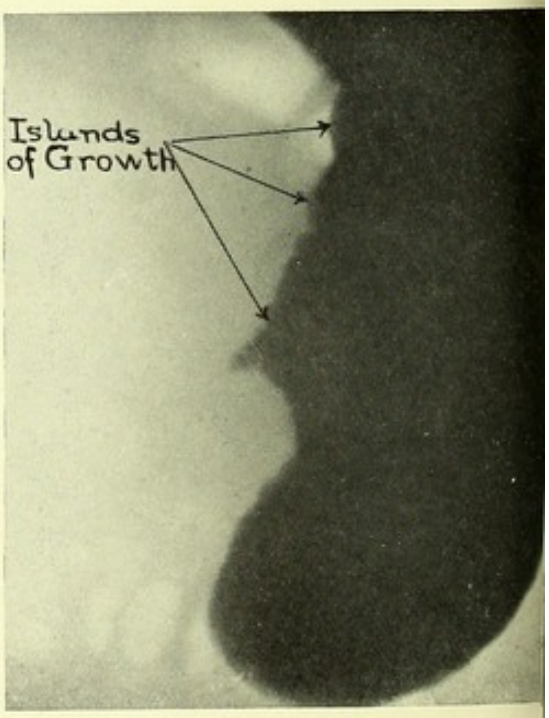
No. 3.—Annular Carcinoma.



No. 4.—Annular Growth.



No. 5.—Extensive Nodular Carcinoma.



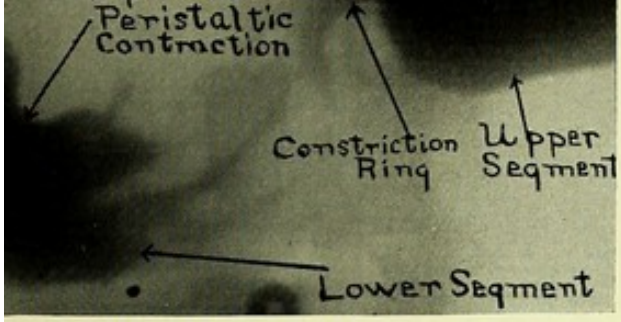
No. 6.—Extensive Carcinoma.

TO ILLUSTRATE DR. LEWIS GREGORY CO

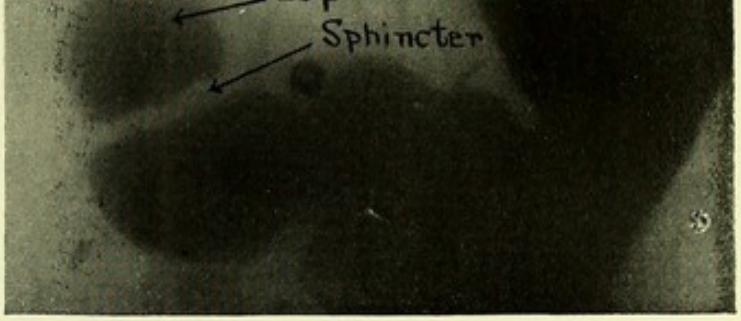
Plate CCCXCVI.

("*Archives of the Roentgen Ray.*"—*Copyright.*)

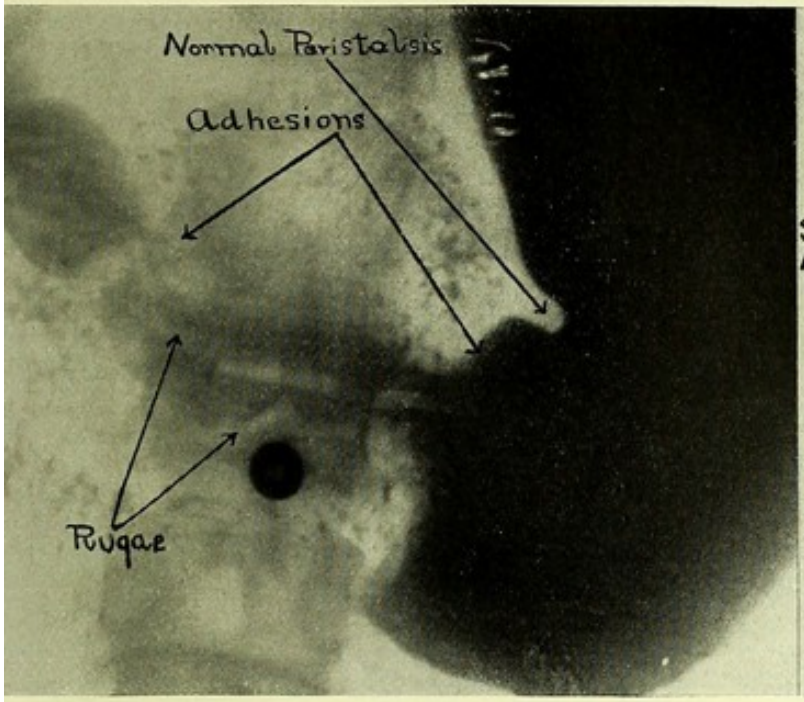
but at the line of invasion they cease abruptly. There is evidence of attempts at peristaltic contractions in the affected portion, but its inability to expand as the chyme is forced into it by the peristalsis of the normal part of the



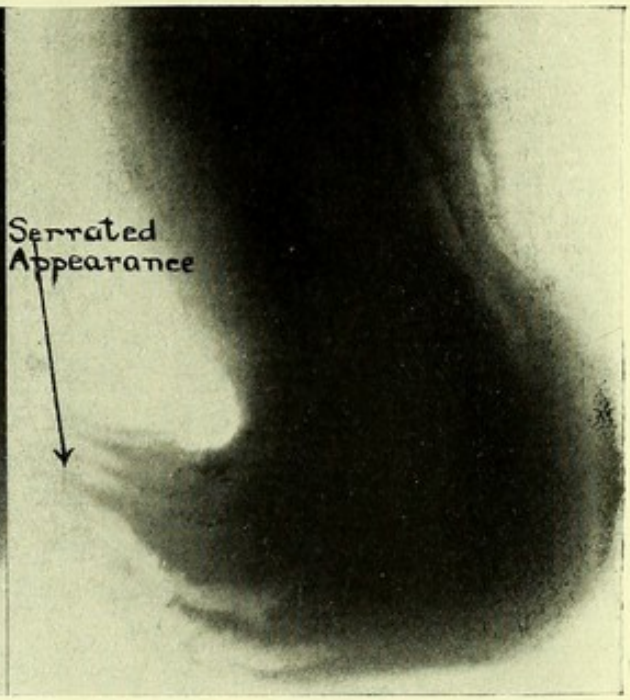
—Non-Malignant Hour-Glass Constriction.



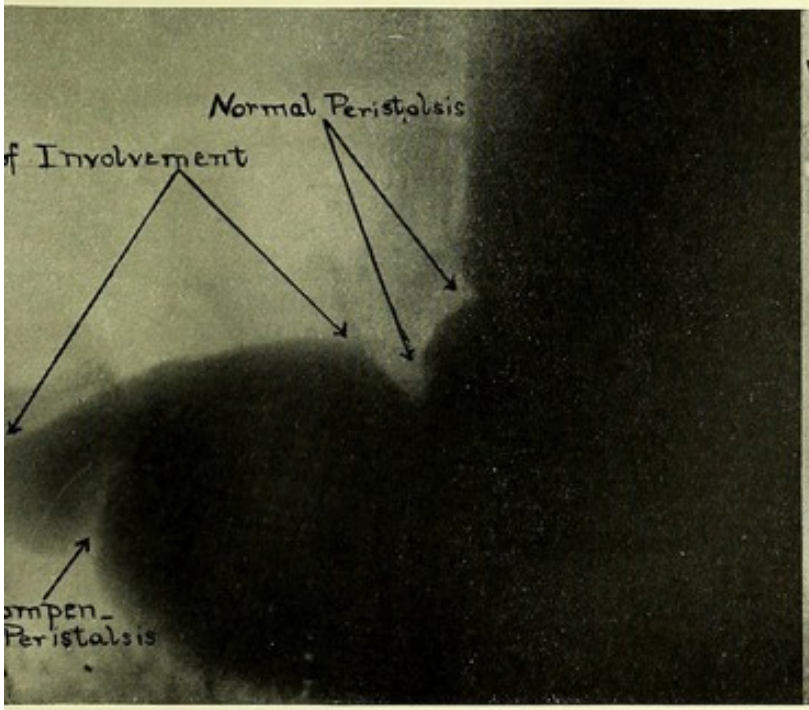
No. 8.—Spasmodic Contraction resembling Hour-Glass Constriction.



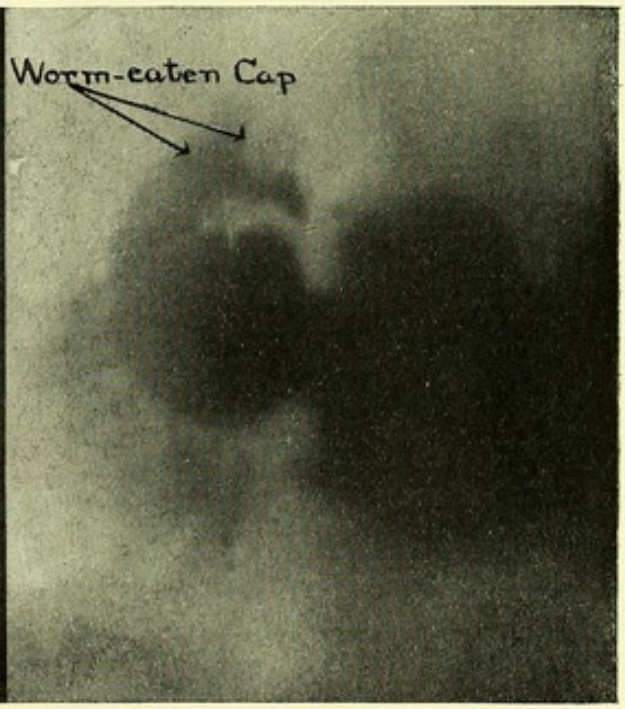
No. 9.—Extensive Adhesions.



No. 10.—Adhesions from Gastric Ulcer.



—Adhesions binding Stomach to Under Surface of Liver.



No. 12.—Duodenal Ulcer.

ON "SERIAL RADIOGRAPHY," ETC.

dhesions may occur without any dilatation of the stomach (Fig. 14); if the dhesions are limited to the gastric surface of the sphincter, the contour of he cap may be perfectly normal.

stomach gives a very characteristic distorted appearance to the constricted area. The rugæ of the affected part show unusually distinctly, generally one or two of them being much deeper than the others. Frequently they run obliquely, or even transversely, instead of longitudinally. Peristalsis causes them to vary somewhat in size and shape, but they are as constant and characteristic as finger-prints, and, like them, could be used for identification.

Adhesions limited to one wall of the stomach may involve the body, the pars pylorica, the pyloric sphincter, or the cap. Such an involvement does not encroach upon the lumen as does a carcinoma, although the lumen fails to expand in proportion to the normal part of the stomach. The contour of the affected area will frequently suggest to which viscus the stomach is attached, whether the liver, gall-bladder, or colon.

If the adhesions bind the lesser curvature to the under-surface of the liver (Fig. 11), the peristaltic contraction on this side is normal until it reaches the point of adhesions. Here it stops suddenly, and the contour of the lesser curvature corresponds to the under-surface of the liver. This should be constant in all the radiographs of a series. The contraction on the greater curvature becomes deeper in this region, thus compensating for the absence of movement on the lesser curvature.

If the adhesions are limited to the right side of the pars pylorica, thus drawing it to the right and attaching it to the gall-bladder (Fig. 13), the irregularity is usually, but not always, discernible. The peristaltic contraction is somewhat interfered with, but not entirely obliterated, as when the stomach is attached to the liver. The greater curvature is drawn into a straighter line than normally. The cap is held near the median line by the gastro-hepatic ligament, causing an acute angle at the sphincter. The lumen of the sphincter in these cases runs horizontally instead of perpendicularly. Most of these cases are associated with very definite neurotic symptoms.

If the adhesions involve both the right side of the pars pylorica and the lesser curvature, the pylorus may be bound to the gall-bladder and under-surface of the liver, displacing the cap posteriorly, externally, or internally, or contracting it so that it is unrecognisable (Fig. 15).

If the adhesions are entirely limited to the pylorus, the sphincter is irregular on the gastric, or duodenal, or on both surfaces (Figs. 17 and 18). The lumen is not clear-cut, or it is much wider than $\frac{3}{16}$ inch, which is the normal size of the pyloric sphincter. This increased thickness may be unilateral (Fig. 14), giving the appearance of a wedge, or bilateral, resembling an annular constriction (Fig. 18). The rugæ in the terminal portion of the pylorus show unusually distinctly (Figs. 17 and 18).

Dilatation of the stomach is more frequent when the adhesions are limited to the sphincter than when they are more general. Moderate or even dense adhesions may occur without any dilatation of the stomach (Fig. 14); if the adhesions are limited to the gastric surface of the sphincter, the contour of the cap may be perfectly normal.

The manner in which the cap lies between the gall-bladder on the right and the common duct on the left, and the fact that slight adhesions prevent its normal dilatation, must always be borne in mind. When the adhesions involve the cap only, it is asymmetrical, contracted, ragged, or absent (Fig. 15). Frequently a small indentation is observed either on the right or left side of the cap. This may be caused either by pressure from the second portion of the duodenum, where it descends from the top of the cap, or by the common bile-duct, which is in close proximity on the left. This indentation might readily be mistaken for an ulcer of the duodenum (Fig. 16).

Radiographs made from four to six hours after the ingestion of bismuth and buttermilk frequently show a deposit of bismuth in the cap after the stomach, the remaining portion of the duodenum and the jejunum, are completely evacuated (Fig. 24). This retention is most often observed in cases where the appearance of the cap in the plates taken immediately after the bismuth meal is not normal. I believe that it is this retention in the cap which has frequently been considered an accumulation of bismuth on the surfaces of an ulcer. In some such instances an ulcer of the stomach or duodenum may exist, and absence of peristalsis in the cap, due to adhesions, will cause the accumulation.

The differential diagnosis of carcinomata from extensive adhesions or hour-glass stomach is very important. In advanced cases this may be made with great accuracy, and many non-operable cases may thus be saved the shock of an unnecessary exploratory operation. In early cases the radiologist can differentiate between malignant and non-malignant lesions with about the same degree of certainty as can the surgeon at an exploratory operation without a microscopical examination of the specimen. A permanent contraction which is not properly located nor yet sufficiently deep to be dignified by the term "hour-glass contraction" may be the seat of an old ulcer. It is impossible to say this is not malignant, but, considering the present surgical tendencies, the chance of its developing into a real hour-glass constriction is remote. All radiographic evidences of adhesions should be considered of benign origin, unless there are present some with the characteristic evidences of carcinoma. The following are the characteristics of carcinoma, hour-glass contraction, and adhesions respectively:

Carcinoma.

1. The lumen of the constricted area is constant in size, shape, and position.
2. The growth is relatively wide.
3. The rugæ are absent.
4. The peristaltic contractions are absent.
5. The line of invasion is characterised by nodular indentations similar to finger-prints.

Hour-glass Constriction.

1. The lumen of the constricted area is constant in size and shape, but not necessarily in position.
2. The area of constriction is relatively narrow, or ring-like.
3. Peristalsis is present in either or both segments, and the ring very closely resembles a peristaltic contraction.
4. The line of involvement is smooth, and shows no evidence of nodular indentations.

Adhesions.

1. The lumen varies in diameter, but never completely expands or contracts.
2. The area of involvement may be extensive or localised.
3. The rugæ show unusually distinctly, generally running transversely or obliquely.
4. The peristaltic contractions in the involved area are wider than normal.
5. The line of invasion may be sharp or serrated, and shows no nodular indentations.

Adhesions are caused by gastric or duodenal ulcer, or gall-bladder infection, with or without calculi, in a large percentage of cases, and therefore they generally indicate that one of these conditions is present or has existed. From the location and character of the adhesions one can sometimes tell which of these conditions has caused them.

A small localised constriction in the body of the stomach, or pars pylorica, having the appearance of an embryonic hour-glass contraction, associated with a distortion of the rugæ, suggests an ulcer, old or new.

Extensive adhesions, involving the right side of the pars pylorica, drawing that portion of the stomach to the right, and straightening out the greater curvature, the cap being of normal dimensions but angulated, and the sphincter being normal, suggests gall-bladder infection, with or without calculi (Fig. 13).

If the cap is contracted and worm-eaten, but not drawn to the right, and the duodenal surface of the sphincter is irregular, duodenal ulcer should be considered.

As a rule, however, it is much wiser to state the character, location, and extent of the adhesions, and leave the surgeon or pathologist to determine the cause. The important question is, Do the adhesions themselves, or the conditions which caused them, justify surgical procedure? This must, of course, be decided by the surgeon and attending physician, after a careful study of the radiograms with the radiologist. If a gastro-enterostomy is decided upon, the distance of the pylorus from the most dependent portion of the stomach may be easily determined with the patient in the erect posture, and the anastomosis made at this point.

If there is any radiological evidence of malignancy, as previously described, surgical interference is indicated, regardless of whether the symptoms are at present severe enough to justify this procedure; but if there is no evidence of malignancy, the cases group themselves radiographically into three classes:

1. *Surgical.*—Adhesions, with or without dilatation of the stomach, accompanied by symptoms of ulcer or gall-bladder infection, sufficiently severe to indicate surgical procedure.

2. *Medical.*—A definite lesion without sufficient symptoms to justify surgical procedure. Such a case should be watched.

3. Definite radiographic findings, with obscure but prolonged symptoms referable to the right hypochondrium.

The third class includes the border-line cases, which should be studied carefully by the attending physician or surgeon in consultation with the radiologist; and, if necessary, several sets of radiographs should be made to watch the progress of the adhesions. Figs. 17 and 18, with the history, illustrate such a case.

A tumour posterior to the stomach or an enlargement of the pancreas may be differentiated from a growth in the stomach itself. If the tumour is posterior to the stomach and presses on it when the patient is in the prone posture, the bismuth is displaced from the body of the stomach during

expiration (Fig. 19), and the rugæ on the anterior wall show distinctly, but have a normal appearance. During inspiration the tumour is raised off the stomach (Fig. 20), which then assumes a normal contour, and the peristaltic waves progress without interruption. In thin subjects, where a thick cassette is placed under the patient, giving local pressure on the abdomen, the normal stomach may be compressed by the vertebral column or the pancreas, causing a similar phenomenon ; careful technique is therefore essential to prevent errors. A comparison of the above description with that of carcinoma shows that one of these conditions is not easily mistaken for the other.

Dilatation of the stomach may be readily recognised by other methods of examination, but it is of two types—one from pyloric obstruction, and the other from atony. It is important to differentiate between these conditions, because surgery is indicated in one case and contra-indicated in the other.

Pyloric obstruction causes unusually active peristalsis, generally of the three or four cycle type, which forces the chyme against the greater curvature at the pars pylorica, dilating this portion and forcing it to the right, giving it the prognathian " undershot " appearance of a bull-dog's jaw (Fig. 21). Such local dilatation indicates lack of compensation of this portion of the stomach, and calls for surgical procedure, regardless of the cause of the obstruction.

The atonic type of dilated stomach is enlarged uniformly (Fig. 22), the greater curvature sometimes sagging down into the pelvis, with or without a prolapse of the pylorus. The peristalsis is absent or feeble, and usually of the one or one and one-half cycle type. The narrow contractions, equal on the greater and lesser curvatures near the pylorus, show a pliability of the gastric wall. The sphincter is clear-cut and smooth on both surfaces, and relaxed in proportion to the atony of the stomach. Its lumen is slightly enlarged, but centrally located. The chyme passes out of such a stomach readily, although it may not completely evacuate itself if the patient remains in the erect posture. In such cases surgical procedure is not indicated.

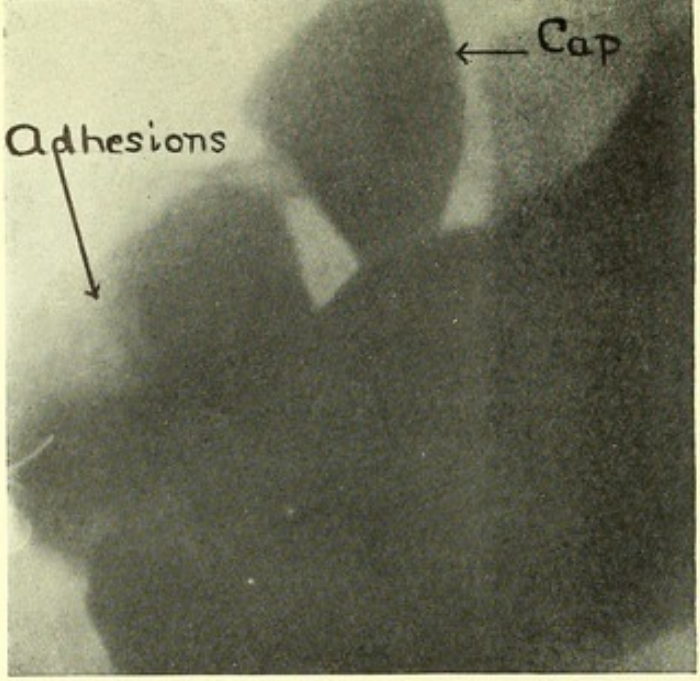
The atrophic contracted stomach is high (Fig. 23), the greater curvature being 3 or 4 inches above the umbilicus. The pylorus is usually attached in the right hypochondrium, and the greater curvature forms almost a straight line from the fundus to the pylorus. The cap is usually absent, contracted, or displaced. The peristalsis may be absent. When present it is feeble, and the contractions are very wide and shallow, showing a lack of pliability of the gastric wall. This condition is most frequently found in cases having an alcoholic history, or those showing a tendency to sclerotic changes in other organs, and is generally associated with some adhesions holding the pylorus to the region of the gall-bladder.

SHORT HISTORIES OF THE CASES ILLUSTRATED

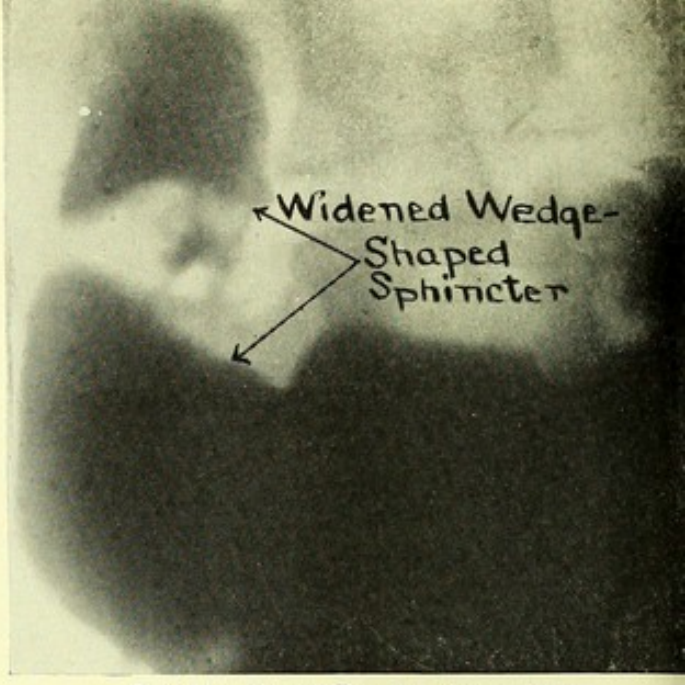
(Plates CCCXCVI. and CCCXCVII.)

Fig. 1—*Extensive Carcinoma.*—The clinical history and physical signs indicate carcinoma. This condition was verified by surgical procedure.

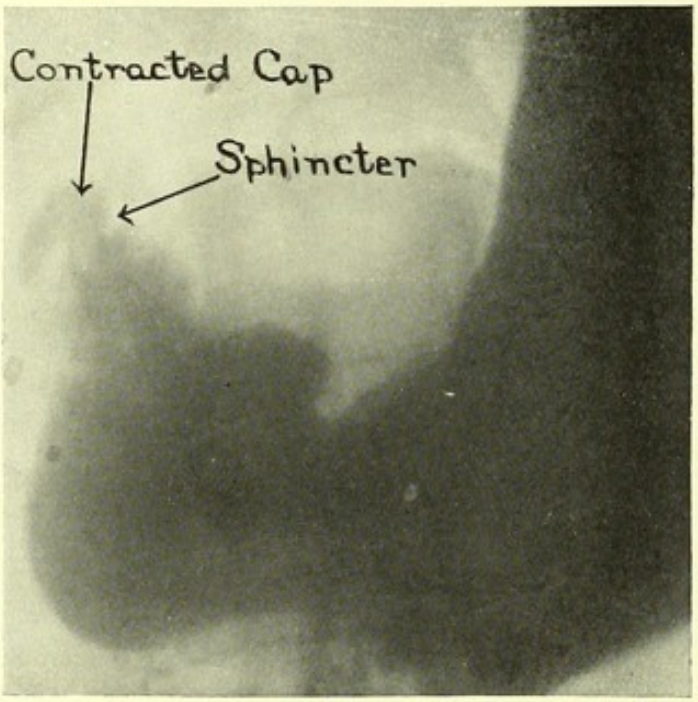
Fig. 2—*Nodular Carcinoma.*—The clinical symptoms were not definite. Considering the age



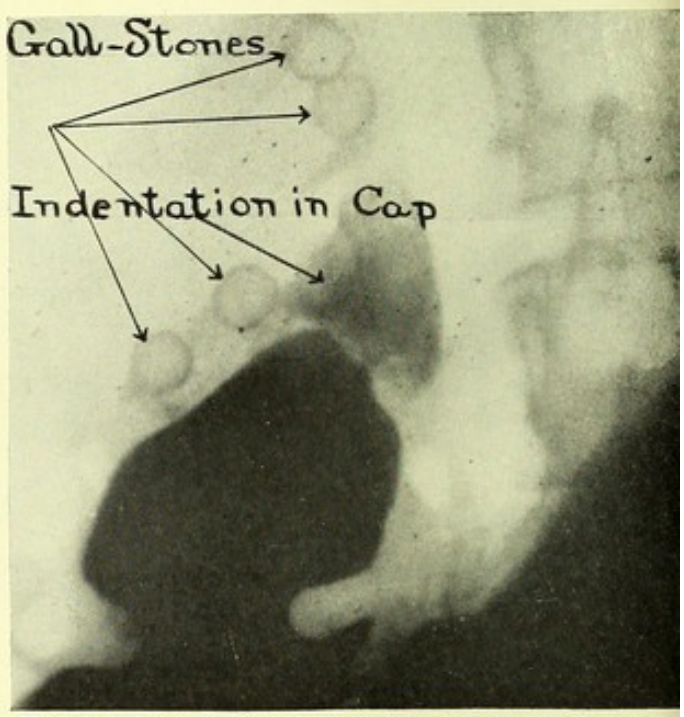
No. 13.—Adhesions and Angulation of Cap.



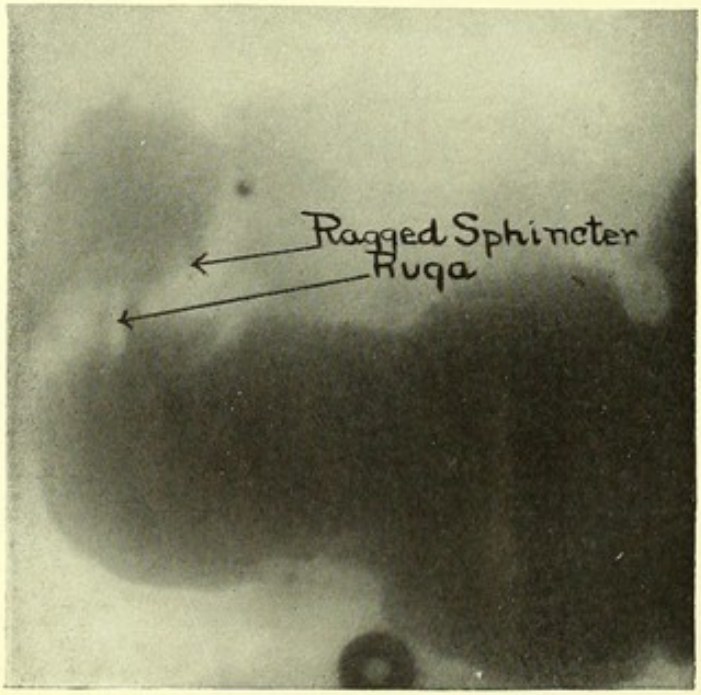
No. 14.—Dense Pyloric Adhesions.



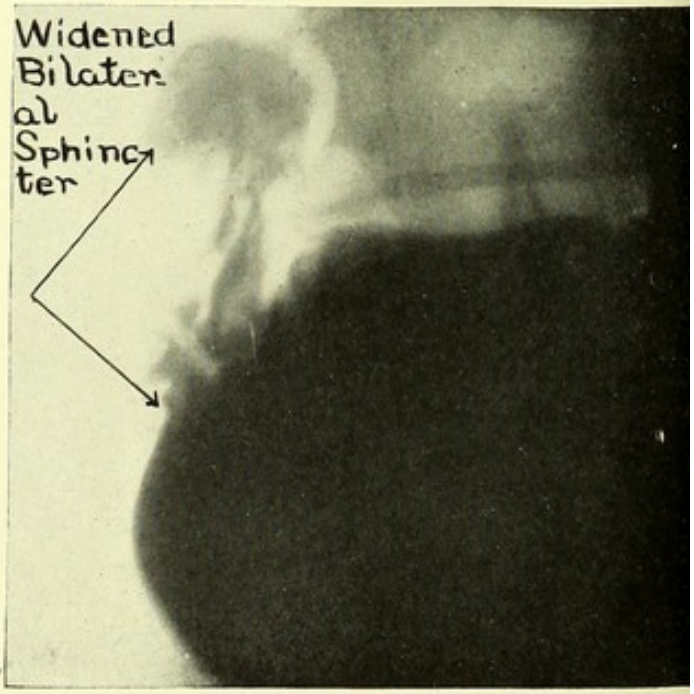
No. 15.—Gall-Bladder Infection (Contracted Cap).



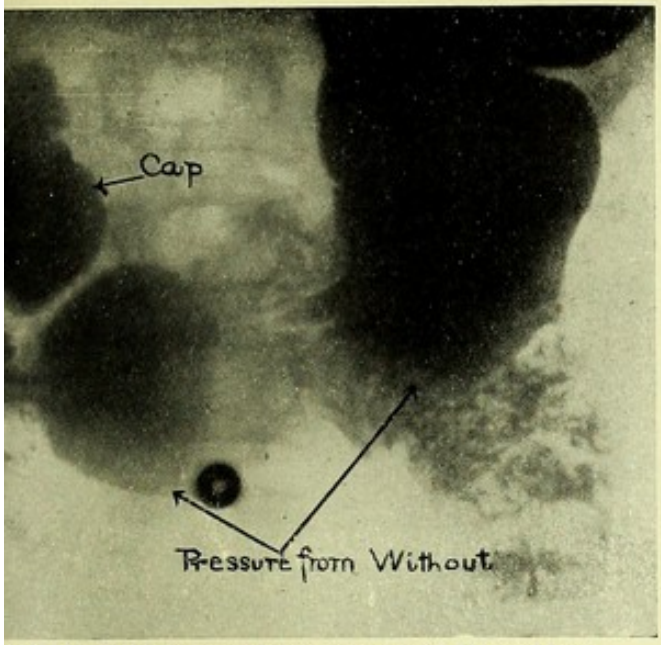
No. 16.—Gall-Stones and Indentation in Cap from Pressure by Second Portion of Duodenum.



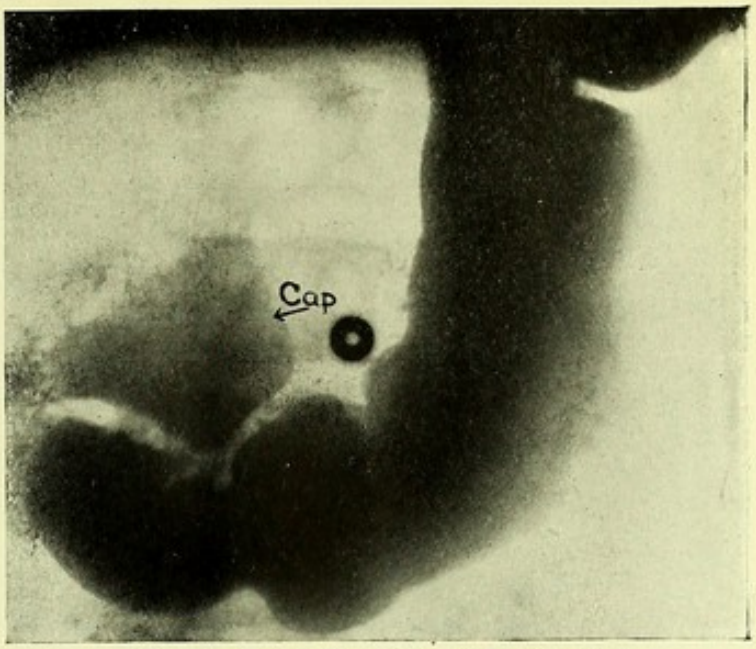
No. 17.—Progressive Adhesions, First Examination.



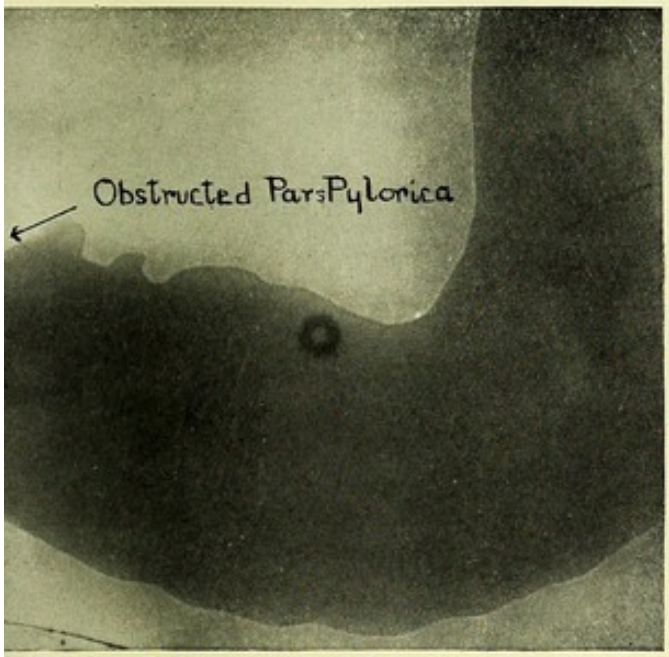
No. 18.—Progressive Adhesions, Second Examination.



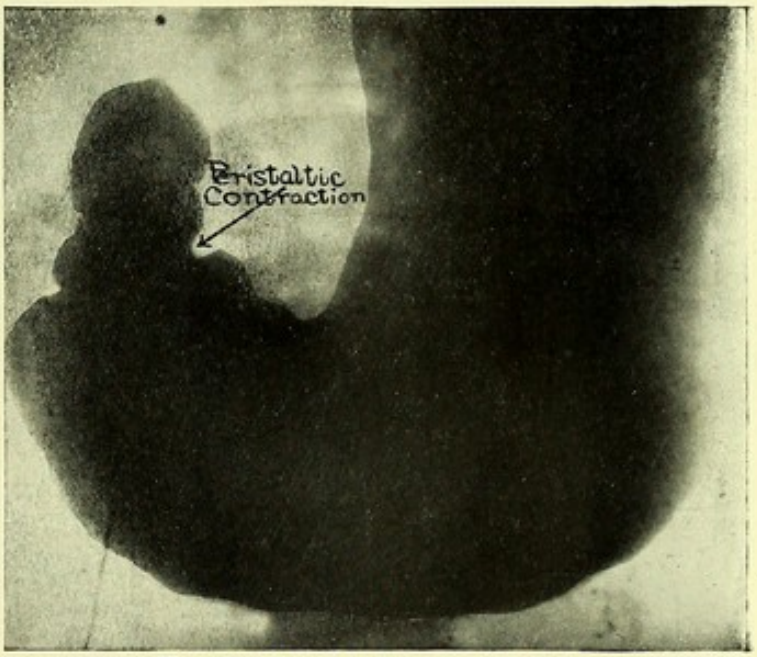
19.—Pressure from Without during Expiration.



No. 20.—Same Case during Inspiration.

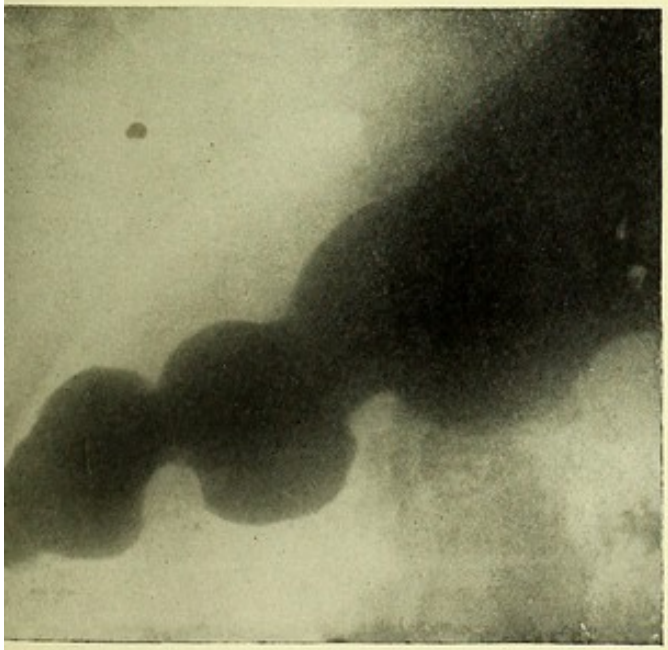


No. 21.—Dilatation from Obstruction.

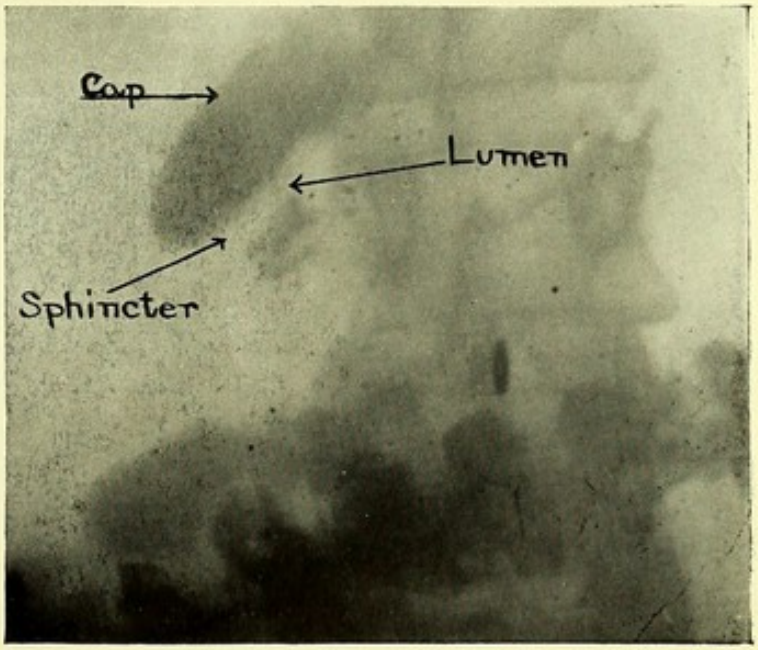


No. 22.—Dilatation from Atony.

(These two plates accentuated for reproduction.)



23.—Contracted Stomach with Thickened Walls.



No. 24 —Cap filled after Stomach and Duodenum are completely evacuated.

and condition of the patient, surgical procedure was not resorted to, and under medical treatment the symptoms subsided for about six months. The patient then began to fail; there was a loss of flesh and strength, and definite gastric symptoms appeared. Ten months later, or sixteen months after the diagnosis of carcinoma had been made on the X-ray findings, the patient died with aggravated gastric symptoms. No autopsy was performed.

FIG. 3—*Annular Carcinoma.*—The patient was under observation in hospital for one month. Owing to the fact that chemical analysis of the gastric contents did not indicate carcinoma, the case was considered non-malignant. Surgical procedure, however, showed a small annular carcinoma at the pylorus.

FIG. 4—*Annular Growth.*—The patient was a middle-aged woman, whose symptoms were not characteristic of carcinoma or even of pyloric obstruction. No tumour was palpable. The diagnosis was based largely on the radiographic findings. The surgical findings were a small annular growth, "about the size of an English walnut," without glandular involvement. As the physical condition of the patient at the time of the operation did not justify pylorectomy, no pathological specimen was obtained. Gastro-enterostomy was performed, and the patient is still living eighteen months after the operation, but is losing strength and weight.

FIG. 5—*Extensive Nodular Carcinoma.*—The symptoms were limited to the colon. The only gastric symptom was belching. The radiographic diagnosis was carcinoma of the stomach without pyloric involvement, and non-malignant adhesions of the transverse colon. An operation revealed an extensive non-operable carcinoma of the posterior wall of the stomach, with large nodules in the pars pylorica, but with no involvement of the pylorus or cap, and adhesions of the transverse colon independent of the growth in the stomach. The symptoms were entirely alleviated by relieving the colonic obstruction.

FIG. 6—*Extensive Carcinoma.*—The symptoms were those of pyloric obstruction. A tumour was palpable. The radiographs showed an extensive growth involving the pars pylorica and lesser curvature all the way to the fundus, indicating that the case was non-operable, except for relief of the obstruction. The patient died about two months later without surgical procedure or autopsy.

FIG. 7—*Non-malignant Hour-Glass Constriction.*—The history of this case dated back twenty years. There was extensive emaciation and loss of strength, with symptoms of pyloric obstruction. A radiographic diagnosis of hour-glass stomach (non-malignant) was made. The surgical findings were a narrow constricting ring in the body of the stomach, with no evidence of malignancy. Gastro-enterostomy was performed, and resulted in complete relief of the symptoms.

FIG. 8—*Spasmodic Contraction resembling Hour-Glass Constriction.*—The first series of radiographs of this case showed a constriction of the greater curvature, but none of the lesser curvature. Although most of the radiographs of the second series also showed this constriction, in a few of them it was absent. A diagnosis of spasmodic constriction, resembling an hour-glass constriction, was made. No operation was performed.

FIG. 9—*Extensive Adhesions.*—There was a definite and prolonged history of gall-bladder infection. The radiographic diagnosis was extensive adhesions, involving the pars pylorica, without evidence of pyloric obstruction. Surgical procedure has not yet been resorted to.

FIG. 10—*Adhesions from Gastric Ulcer.*—The history was one of gastric ulcer. The radiographic diagnosis was "a lesion of the pylorus calling for surgical procedure." Operation was temporarily delayed at the patient's request, and an ulcer of the stomach ruptured, necessitating an emergency operation, which was successful.

FIG. 11—*Adhesions binding the Stomach to the Under-Surface of the Liver.*—This case had been operated on for gall-stones, but none were found, and the symptoms were not relieved. The radiographic diagnosis was adhesions binding the lesser curvature to the under-surface of the liver. Surgical procedure was not recommended.

FIG. 12—*Duodenal Ulcer.*—The clinical history was one of pain, tenderness, and soreness in the right hypochondrium for the past fifteen years. The radiographic findings were interference with the peristalsis at the pyloric end of the stomach, although the chyme passed freely from the stomach, and a moderate abnormality of the cap and sphincter. These irregularities were not, however, sufficient to justify surgical procedure independent of the clinical history. The surgical

findings were an ulcer of the duodenum. This case is typical of a definite group of cases where there are characteristic radiographic indications of adhesions without pyloric obstruction, and where the radiographic findings must be corroborated by a definite clinical history.

FIG. 13—*Adhesions and Angulation of Cap.*—This skiagram is characteristic of some ten cases with very similar histories. There was pain referable to the right hyperchondrium without much tenderness, and the predominating symptoms were neurotic, the patient exhibiting extreme symptoms of hysteria.

FIG. 14—*Dense Pyloric Adhesions.*—There were definite symptoms referable to the right hypochondrium, and loss of flesh. No tumour was palpable. A radiographic diagnosis was made of a lesion involving the pylorus and lesser curvature, although it was not possible to state definitely whether this lesion was simple adhesions or a new growth. Surgical procedure was recommended. The operation showed a dense band of adhesions involving the pylorus, holding it down so tightly that observation was difficult. These were severed, and there was no evidence of malignancy. The symptoms were relieved, and the patient gained twenty pounds. A subsequent set of radiographs showed a normal sphincter, and the patient has now remained well for two years.

FIG. 15—*Gall-Bladder Infection* (*Contracted Cap*).—This case had a typical history of renal calculus, but the X-ray examination of the kidney was negative. The radiographic diagnosis was adhesions of the cap, either from gall-bladder infection or ulcer. The operation was based on the radiographic findings instead of the clinical history, and gall-bladder infection was found with biliary calculi, which were not visible in the radiograph.

FIG. 16—*Gall-Stones and Indentation in Cap from Pressure by Duodenum.*—The clinical history was one of duodenal ulcer. The radiographic findings were gall-stones without adhesions. The operation confirmed their existence, and revealed also a carcinoma of the appendix.

FIGS. 17 AND 18—*Progressive Adhesions.*—The history was pain and tenderness in the right hypochondrium, following an operation for gall-stones, in which no calculi were found. The radiographs showed slight adhesions.

Fig. 18 is a skiagram of the same case, taken a year later. The symptoms had greatly increased. These two series of radiographs show the progression of adhesions in one year, corresponding with the increasing symptoms.

FIGS. 19 AND 20—*Pressure from Without.*—There was a history of hysterectomy, with probable malignancy. An indefinite tumour was palpable on deep pressure. The radiographic diagnosis was a tumour posterior to and pressing on the stomach. The two skiagrams show the appearance during expiration and inspiration respectively. There has been no surgical procedure to date.

FIG. 21—*Dilatation from Obstruction.*—The history of this case was that of pyloric obstruction. The radiographic findings were pyloric obstruction, with dilatation of the pars pylorica, giving a prognathian or "undershot" appearance. The surgical findings were carcinoma of the pylorus.

FIG. 22—*Dilatation from Atony.*—There was a history of gastric symptoms, with dilatation of the stomach. The radiographs showed a uniformly enlarged stomach, with feeble peristalsis and no evidence of pyloric obstruction. The cap and sphincter were normal. No surgical procedure was contemplated. In both this and the preceding plate the outlines were so faint that it has been found necessary to accentuate them for reproduction.

FIG. 23—*Contracted Stomach with Thickened Walls.*—The history was one of prolonged alcoholism.

FIG. 24—*Cap filled after Stomach and Duodenum are completely evacuated.*—The precise history of this case is not available, but the skiagram shows well the condition which, with pain in the right hyperchondrium, is symptomatic of gall-bladder infection, or possibly of an ulcer.