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Staff Meeting Bulletin  
Hospitals of the » » »  
University of Minnesota

Roentgen Diagnosis  
Acute Abdominal Conditions

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William A. O'Brien, M.D.

I.

## UNIVERSITY OF MINNESOTA MEDICAL SCHOOL

CALENDAR OF EVENTSNo. 51

December 18 to December 23

Visitors Welcome

Monday, December 18

- 9:00 - 10:00 Roentgenology-Medicine Conference; L. G. Rigler, C. J. Watson and Staff; Todd Amphitheater, U. H.
- 9:00 - 11:00 Obstetrics and Gynecology Conference; J. L. McKelvey and Staff; Interns Quarters, U. H.
- 12:30 - 1:30 Pathology Seminar; Pulmonary Hypertension, Ernest Stark, 104 I.A.

Tuesday, December 19

- 9:00 - 10:00 Roentgenology-Pediatrics Conference; L. G. Rigler, I. McQuarrie and Staff; Eustis Amphitheater, U. H.
- 11:00 - 12:00 Urology Conference; C. D. Creevy and Staff; Main 515, U. H.
- 12:30 - 1:30 Pathology Conference; Autopsies; Pathology Staff; 104 I. A.
- 4:30 - 5:30 Obstetrics and Gynecology Conference; J. L. McKelvey and Staff; Station 54, U. H.
- 4:00 - 5:00 Pediatrics Grand Rounds; I. McQuarrie and Staff; W-205 U. H.
- 4:30 - 5:30 Ophthalmology Ward Rounds; Erling Hansen and Staff; E-534, U. H.
- 5:00 - 6:00 Roentgen Diagnosis Conference; Solveig Bergh, G. Kelby, T. B. Merner, 515 U. H.
- 8:00 - Minnesota Pathological Society; The Relation of Fluorine to Dental Decay, W. D. Armstrong, 15 MeS.

Wednesday, December 20

- 9:00 - 11:00 Neuropsychiatry Seminar; J. C. McKinley and Staff; Station 60, Lounge U. H.
- 11:00 - 12:00 Pathology-Medicine-Surgery Conference; Perforated Vierticulum of Sigmoid with Massive Hemorrhage; E. T. Bell, C. J. Watson, O. H. Wangensteen and Staff; Todd Amphitheater, U. H.
- 12:30 - 1:30 Pediatrics Seminar; Lactation; Dr. Peterson, W-205 U. H.
- 12:30 - 1:30 Physiological Chemistry Literature Review; Staff; 116 M. H.
- 12:30 - 1:30 Pharmacology Seminar; Experimental Treatment of the Heart Worm of the Body; Dr. McManus; 105 M. H.

Thursday, December 21

- 9:00 - 10:00 Medicine Case Presentation; C. J. Watson and Staff; Todd Amphitheater, U. H.
- 4:00 - 5:00 Physiological Pathology of Surgical Diseases; Physiology and Surgery Staffs; Todd Amphitheater, U. H.
- 4:30 - 5:30 Ophthalmology Ward Rounds; Erling Hansen and Staff; E-534, U. H.
- 5:00 - 6:00 Roentgenology Seminar; Report on Measurements with Bone Ionization Chamber and Its Importance in Therapy; J. F. Marvin; M-515 U. H.

Friday, December 22

- 9:00 - 10:00 Medicine Grand Rounds; C. J. Watson and Staff; Todd Amphitheater, U. H.
- 10:00 - 12:00 Medicine Ward Rounds; C. J. Watson and Staff; E-214 U. H.
- 10:30 - 12:30 Otolaryngology Case Studies; L. R. Boies and Staff; Out-Patient Otolaryngology Department.
- 1:30 - 2:30 Medicine Case Presentation; C. J. Watson and Staff, Eustis Amphitheater, U. H.
- 1:00 - 2:30 Dermatology and Syphilology; Presentation of selected cases of the week; Henry E. Michelson and Staff; W-306 U. H.
- 1:30 - 3:00 Roentgenology-Neurosurgery Conference; H. O. Peterson, W. T. Peyton, and Staff; Todd Amphitheater, U. H.

Saturday, December 23

- 8:00 - 9:00 Surgery Journal Club; O. H. Wangensteen and Staff, M-515 U. H.
- 9:00 - 10:00 Pediatrics Grand Rounds; I. McQuarrie and Staff, W-205 U. H.
- 9:15 - 10:30 Surgery-Roentgenology Conference; O. H. Wangensteen, L. G. Rigler and Staff, Todd Amphitheater, U. H.
- 9:00 - 10:00 Medicine Case Presentation; C. J. Watson and Staff, M-515, U. H.
- 10:00 - 12:00 Medicine Case Presentation; C. J. Watson and Staff, M-515, U. H.

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Note: Special Calendar of Events for period December 26, 1944 to January 6, 1945 will be issued next week.

Editor.

## II. ROENTGEN DIAGNOSIS OF ACUTE ABDOMINAL CONDITIONS: A REVIEW

L. G. Rigler

### Introduction

The importance of the roentgen diagnosis in the examination of the chronic diseases of the abdomen, such as ulcer, carcinoma of the gastro-intestinal tract, or nephrolithiasis and other diseases of the urinary tract, is widely accepted and, in most larger communities at least, thoroughly in practice. Whenever possible patients suspected of having such types of abnormality are submitted to competent roentgen examination.

In the case of the more acute abdominal conditions, those which may be designated as abdominal catastrophes, often requiring emergency surgery or immediate treatment, no such unanimity of practice obtains. Even today roentgen rays are used too infrequently under these circumstances. It is notable that the first efforts at the roentgen examination in the cases of acute intestinal obstruction were made as far back as 1914 by Schwarz in Vienna and in 1917 by Case in this country. Laurell began his classical descriptions of the roentgen findings in intraperitoneal diseases in 1921. Yet there is still some hesitancy, perhaps some mental lag, in adopting the measures which were recommended as far back as that time. In large part this is due to the difficulties attending the examination of such acutely ill patients, and to a lack of appreciation on the part of the physician as to the value of such an examination.

It is notable that in this institution, where the investigations and experience of the surgical staff in regard to intestinal obstruction and other acute abdominal lesions is probably as extensive as that of any in the country, the x-ray examination is probably used more than elsewhere. The studies of our staff have demonstrated the large amount of information which can be obtained by x-ray examination, especially if it is weighed with the clinical findings. An

illustration of the failure to use this method, even under favorable conditions, is contained in the following story: A prominent surgeon in a large community reported a case of simple herniotomy in which, after some days following the surgical procedure, the patient had failed to have a bowel movement. After some time had elapsed, various measures were undertaken from day to day to induce intestinal evacuation but without success. The patient sustained his condition without very serious effects, but by the time the eleventh day had elapsed he was beginning to be distended and the situation appeared to be quite critical. Almost every method that could be thought of had already been utilized to produce a bowel movement. Finally on the eleventh day, probably ten days after it would have been done in this hospital, a simple film of the abdomen was obtained. This showed at once that there was an enormous distention of the cecum and that the situation was a most critical one which required surgical intervention immediately, as the cecum appeared to be on the verge of perforation. Cecostomy was done, and the patient recovered. The case was an unusual instance of a spastic ileus producing a marked obstruction in the hepatic flexure with enormous distention of the cecum. The important point is that not until the x-ray examination was made was the abnormality clearly determined or the emergency surgery undertaken. This is but one of many illustrations of the peculiar reluctance on the part of many clinicians to utilize this type of examination in acute abdominal situations. No doubt the tendency for the radiologist to avoid work at night and the difficulties involved in obtaining emergency technical service have militated against the fullest use of this procedure. In many institutions the emergency service for x-ray examination is poorly done because there is a tendency to push this unpleasant type of duty on to the students in technique or to the youngest technician. Actually, this is a type of x-ray technique which requires the most experienced, astute type of technician, because it is often done at the bedside under most unfavorable conditions.

It is at once obvious that adequate x-ray examinations cannot be obtained when the patient is first seen, in the home, but at the present time almost all such patients are transferred to a hospital immediately, where adequate equipment for the purpose of making such an examination is usually available.

The data which will be presented here, in general, represent a summary and review of some of our own studies on this subject, that of many of the members of the surgical staff of the University Hospital, and some review of the literature, particularly a recent paper by Levitin read at the last meeting of the Radiological Society of North America on the subject, "What Can Be Learned from the Scout Film of the Abdomen." Much of the present material was reported by the author in 1937.

#### Roentgenologic Technique

The procedure of the examination is not especially difficult, and the disturbance to the patient is not of any great moment, particularly, in proportion to the amount of information obtained. A simple anteroposterior film of the abdomen is made with the patient supine. This can be done at the bedside, although films made with the aid of a Potter-Bucky diaphragm are more desirable; in order to obtain these the patient must be brought to the x-ray department. The common procedure is to send the patient to the x-ray department directly from the admitting room on his way to the ward or to the operating room. This is somewhat saving to the patient and expedites the matter. However, in followup films, after operation, or after the patient is put under therapy, bedside films can be obtained. A roentgenogram of the chest should always be obtained at this time, as it is of vital importance to rule out a lesion of the lung, such as pneumonia. This is of particular significance in acute appendicitis, especially in children. Such films of the chest may well be made with the patient supine. A film of the abdomen with the patient upright also should be obtained if possible. If this is impossible, the patient may be placed on one side or the other and a postero-anterior

exposure made, that is, the position of lateral decubitus utilized. Preferably the patient should be on the left side with the right side up, but in certain instances this may be reversed. The lateral decubitus position is valuable as a supplementary film even if upright views are obtainable. There are other positions but those named above are the most valuable.

Wangensteen has suggested the utilization of a metallic marker such as a five-cent piece placed over the umbilicus when the scout film of the abdomen is made. This permits some localization of loops of bowel with relation to a fairly fixed point in the abdomen. In addition it may afford a means of estimating the actual diameter of the loops of bowel. In the ordinary roentgenogram the size of the bowel appears greater than is actually the case, owing to the distortion effect of the short distance used in such examinations. The real size of the coin marker being known, its enlargement can thus be determined and a rough idea of the actual size of the bowel loops can thereby be calculated.

The introduction of contrast substances in acute cases is usually to be avoided, particularly the introduction of barium by mouth. There is the danger of increasing the degree of obstruction, making it more difficult to handle if an obstruction is present. There is also the danger of extravasation of barium into the peritoneal cavity through a perforation if one should happen to be present, which militates against recovery from peritonitis. Barium sulphate given by enema is much less hazardous, and in cases wherein the diagnosis of large bowel obstruction is in doubt, the enema examination should be done. Caution must be exercised not to overdistend the colon nor to force the barium mixture above the point of obstruction. In suspected ruptures of the urinary tract, intravenous injection of diodrast, or neo-lopax, is usually considered harmless, even though some extravasation of the material may occur into the retroperitoneal tissues from a rupture of the kidney

pelvis or ureter. Likewise the introduction of gas, preferably carbon dioxide, into the bladder through a catheter is probably without danger and may prove of considerable value in demonstrating the presence of a perforated bladder. Other contrast substances may also be introduced into the bladder for this purpose, but again the danger of their extension into the peritoneal cavity should not be overlooked.

Those abnormal states considered in the category of acute abdominal conditions, which are amenable to roentgen diagnosis, are listed in Table 1. It should be noted that these include almost all of the acute lesions which may occur in the abdomen.

Table 1

1. Acute obstruction of small intestine, partial or complete
  - (a) Simple obstructions
  - (b) Strangulation obstructions
  - (c) Special types of obstruction
    1. Acute intussusception
    2. Gallstone obstruction
    3. Spastic ileus
2. Acute obstruction of colon, partial or complete
  - (a) General types
  - (b) Volvulus of sigmoid
  - (c) Spastic ileus
3. Acute appendicitis
  - (a) Without peritonitis
  - (b) With local peritonitis
4. General peritonitis
5. Intraperitoneal abscess
6. Perforation of hollow viscus
  - (a) From disease
  - (b) From trauma
7. Acute pancreatitis
8. Mesenteric thrombosis
9. Subphrenic abscess
10. Perinephric abscess
11. Rupture of liver or spleen
12. Rupture of urinary tract.

In the considerations below, only the first six of these conditions will be described. The remaining six will be reviewed in a later bulletin.

In any discussion of the value of x-ray examination in the acute abdominal states,

it cannot be emphasized too strongly that the roentgen findings must be weighed with the clinical data in arriving at a diagnosis. But the roentgen examination permits not only a more accurate diagnosis, it also gives information as to the nature of the process going on within the concealment of the abdominal wall. Wangensteen has expressed well the information desired by the clinician from the x-ray examination:

1. Information to confirm a diagnosis already tentatively made on the basis of history and physical examination.
2. Information to exclude certain diagnostic possibilities.
3. Information which may lead to the consideration of a diagnosis not previously thought of.
4. Information as to the details of pathological anatomy present.

#### Roentgenologic Signs

In the roentgen diagnosis of acute abdominal conditions certain signs are characteristic. The various findings are listed in Table 2.

Table 2

1. Visible gas in the gastrointestinal tract
2. Distension of the small intestine, generalized
3. Distention of the small intestine, localized
4. Distention of the colon
5. Distention of the gastro-intestinal tract, generalized
6. Fluid levels in the bowel
7. Obliteration of the peritoneal or visceral fat markings
8. Free fluid in the peritoneal cavity--hydroperitoneum
9. Free gas in the peritoneal cavity--pneumoperitoneum
10. Hydropneumoperitoneum
11. Localized collections of gas in the abdomen.

Table 2 (Cont.)

12. Localized collections of fluid in the abdomen
13. Localized collections of gas and fluid in the abdomen
14. Displacement of abdominal viscera
15. Displacement of the diaphragms
16. Immobilization of the diaphragms
17. Extravasation of contrast media.

These are described in general below to give some idea as to the basis for the roentgenologic diagnosis, and the application of these various signs to any particular type of condition will be discussed later.

Visible gas in the gastro-intestinal tract.--Normally gas may be roentgenologically observed in the stomach, occasionally in the first portion of the duodenum, and regularly distributed in the colon. In young children up to the age of two, always, and frequently up to the age of six, visible gas may be made out in the small bowel. After birth, gas will appear in the small bowel within a very few minutes and may appear in the rectum within an hour. In young infants gas will be seen in large quantities in the whole gastro-intestinal tract almost constantly. The appearance of gas in the intestinal tract in adults is very common under conditions which are not particularly serious and only moderately abnormal. Usually it signifies stasis, but it may be of transient nature. Thus during manipulations of various types such as cystoscopy, intravenous medication, during periods of severe stress, fright, when afflicted with lesions of the urinary tract, and during periods of serious illness, gas may accumulate in the small bowel to the point of roentgen visibility. In pneumonia, for example, it is common to find large quantities of gas in the intestinal tract. Asthmatics, during periods of severe attacks, will accumulate gas in the small bowel. Obviously as a result of enteritis or other infections of the intestinal tract, the presence of gas can also be readily made out. It should be noted that in most of these situations the bowel is not distended beyond its normal diameter. There is simply an accumulation of gas which becomes visible; a large number of coils of the

intestine are apparent but their diameter remains within normal limits.

The stomach when distended becomes readily visible, and its contours can be easily made out. The same is true of the small intestine and of the colon when gas accumulates within them to any large degree. It is important to make a distinction between the various portions of the gastro-intestinal tract. Very little difficulty is experienced in the recognition of the stomach, but the differentiation of the small from the large intestine and of the jejunum from the ileum is not always possible.

The large bowel may be identified by its characteristic distribution around the outer periphery of the abdominal cavity, by its size and by its type of segmentation. The large cecum, smaller ascending colon, still smaller transverse and descending portions, the sinuous windings of the sigmoid, and the pear-shaped rectum are often readily distinguishable without a barium enema merely by the presence of gas. The segments are broad, the haustral recesses or lateral pouches can often be seen, and the divisions are frequently incomplete; that is, there is a column of continuous gas in the center of the lumen of the colon. The duodenum and jejunum are recognized by their location and by the numerous segmentations from the valvulae connivents. It should be noted that when the bowel is distended with gas, the folds of mucous membrane appear as white lines traversing the lumen of the bowel transversely. As the upper ileum is approached the folds become much less numerous, the segments are wider. In the lower ileum the bowel is relatively patternless and when dilated shows very little of the crenelation or serration of the more proximal positions of the small intestine. As a result it may be exceedingly difficult to distinguish a dilated loop of lower ileum from the sigmoid flexure of the colon lying in the same portion of the pelvis.

Distention of the gastro-intestinal tract.--Distention of portions of the gastro-intestinal tract is a much more significant and important sign of abnormality. A markedly distended stomach, clearly seen because of its gas content,

may well be the result of high-grade pyloric obstruction, or may signify a gastrectasia, such as occurs in diabetes and occasionally as a result of operation, or from other causes.

Marked distention of the small bowel, often to three or four times its normal diameter, usually signifies intestinal obstruction. It may, however, occur as a result of paralytic ileus and even in unusual cases, as a result of obstruction of the large intestine. As stated above, the various segments of the bowel can often be recognized. Distention of the large bowel may be present at the same time, but generalized distention of the gastro-intestinal tract is almost always the result of a paralytic ileus.

Distention of the small bowel alone, when it is completely unaccompanied by a corresponding distention of the large bowel, usually is the result of mechanical obstruction. There is a distinct difference in the appearance of the loops of small bowel when affected by a mechanical obstruction than when affected by paralytic ileus. In the former the bowel has a dynamic appearance. It changes its position from time to time. The segmentations are easily apparent, and the loops tend to arrange themselves in a ladder-like fashion. In the upright position fluid can be made out within the loops of bowel, with gas arising above them; the bowel loops tend to rise into the upper portion of the abdomen. If the patient is placed in the lateral decubitus position, they will likewise tend to rise toward the upper side. Abnormal distributions of the loops of bowel, especially in the upright position, such as the presence of gas and fluid levels in the pelvis, signify the fixation of portions of the bowel, as occurs with generalized peritonitis and numerous adhesions.

Demonstration of a very localized distention of only one or two loops of bowel should always arouse the suspicion of strangulation obstruction. This is especially true if large amounts of fluid are seen in the distended coils.

Distention of the colon alone, unaccompanied by corresponding distention of

the small bowel and stomach, most commonly occurs with obstruction of the colon. Nevertheless, such distention may occur as the result of spastic ileus and occasionally even of paralytic ileus, so a sharp distinction is not always apparent from the x-ray examination alone. In the patient who has symptoms of obstruction and in whom a considerable distention of the large bowel with no distention of the small bowel is found, the diagnosis of colon obstruction can readily be made.

Fluid levels in the bowel.--When stasis occurs, either from ileus or mechanical obstruction, fluid as well as gas may accumulate in the intestine. When the films are made with the patient upright or in the lateral decubitus position, the gas rises and presents a sharp contrast to the denser fluid below, thus forming a fluid level. Such shadows are of importance, as the presence of large amounts of fluid with little gas is suggestive of closed loop obstruction. Occasionally the gas is so small in amount that the distended segments of intestine cannot be seen in the ordinary supine film but become apparent in the upright position. By this means also the position of the coils of intestine can be determined. Fixation of one or two loops in the pelvis or elsewhere can be determined by the presence of fluid levels in that situation. These may remain there regardless of the patient's position. Usually such fixation signifies strangulation or potential strangulation. Multiple fluid levels scattered about often occur with peritonitis or with numerous intraperitoneal adhesions.

In the colon likewise the demonstration of large amounts of fluid in the upright position, in the sigmoid flexure for example, may signify a closed loop obstruction such as occurs with volvulus.

Obliteration of peritoneal and visceral markings.--The layer of fat overlying the peritoneum makes it possible in many individuals to distinguish sharply between the lateral abdominal wall and the viscera within the abdomen

itself, even without the use of pneumoperitoneum. This is represented by a stripe-like area of lesser density on either side of the abdomen which can be seen in a simple supine film but better in the lateral decubitus film on the upper side. It is more apparent, obviously, in fat individuals than in lean ones, in older individuals than in young, but the shadow can usually be seen to a more or less degree in most patients. A similar stripe-like shadow of lesser density makes it possible to visualize the kidneys and the psoas muscles, again because of the contrast between the more radiable fat and the less radiable dense structure of the kidney and muscles. Obliteration of this shadow usually signifies the presence of fluid in the abdomen or of an inflammatory process in the immediate neighborhood of the shadow, causing an edema of the fat, which transforms its radiolucency to a state of radio-opacity. This is best illustrated in the case of perinephric abscess, where the shadow of the kidney and the psoas muscle are usually lost because of the secondary edema from the abscess formation. It also occurs in the case of general peritonitis, in which there is an obliteration of the peripheral peritoneal markings. Locally, such an obliteration may occur from an appendiceal abscess, for example, in which the markings on the affected side may become invisible. Occasionally instead of a complete obliteration of the fat shadow there may be a change in its contour. As a result of an accumulation of fluid in the lower quadrant alongside of it, the flank may bulge into the area of lessened density. The presence or absence of the peritoneal markings, while strongly emphasized by many writers, is not extremely important and the shadow may well be absent in normal individuals and not infrequently maintains itself even when peritonitis or an abscess is present.

Hydroperitoneum.--In many instances of acute abdominal disease, fluid, either purulent or serous, appears within the peritoneal cavity. This may be the case in long-standing intestinal obstruction, in strangulation intestinal obstruction at an early stage, in peritonitis from whatever cause, in mesenteric thrombosis,

and in cases of intraperitoneal abscess. The demonstration of such fluid can usually be made in the roentgenogram although not as accurately as in the pleural cavity. The presence of fluid becomes manifest by the separation of the loops of small bowel which it produces. Normally the gas-filled bowel can be readily made out, and between each pair of loops there is a fine white line representing the thickness of the two bowel walls which are in contact. When the segments of bowel are separated by fluid the thickness of this white stripe becomes much greater than normal, and at points where three loops of bowel are in contact, the shape of the separation becomes that of a triangle or a circle rather than of a three-pronged stellate shadow, which is normally the case. Obviously if the bowel is not distended with gas, such fluid is difficult to make out. In such an event there is simply a somewhat blurred appearance of the abdominal cavity as a whole, which is very difficult to distinguish sharply. In almost all cases, however, in which peritonitis, or abscess, or strangulation with beginning gangrene is present, enough gas is present in the bowel to permit this distinction to be made. It should be pointed out that in simple ascites a similar finding is obtained, but little difficulty need be encountered in this regard, as patients with simple ascites will not have other clinical findings which would lead one to suspect that they have peritonitis.

Pneumoperitoneum.--The presence of free gas in the peritoneal cavity is clearly abnormal, and it is an extremely important sign of many acute conditions. Pneumoperitoneum is best demonstrated by putting the patient in the upright position, whereupon the gas will find its way between the diaphragm and the subdiaphragmatic structures; the gas becomes clearly apparent in contrast with the density of the diaphragm and liver on the one side and the spleen, stomach, and other structures on the opposite side. Films made with the patient in the left lateral decubitus will also demonstrate gas effectively. It will then accumulate beneath the right lateral abdominal wall, separating it clearly

from the underlying dense shadow of the liver.

When large amounts of gas are present, the diagnosis can be made even with the patient in the supine position. In these circumstances, the outer as well as the inner margin of the stomach or bowel becomes clearly visible as a result of the accumulation of gas both around the viscus and within it. This produces a very striking and characteristic appearance, the actual thickness of the wall of the viscus being clearly apparent; the picture is quite pathognomonic of pneumoperitoneum.

It must be borne in mind that gas may appear in the peritoneal cavity in a relatively innocent fashion, for example, after an ordinary abdominal operation. Gas may remain within the abdomen for as long as three weeks after laparotomy, so that films in the upright position made for some time afterward will reveal free gas under the diaphragm. Occasionally gas can occur in the peritoneal cavity as a result of a douche with gas-forming substances, the gas extending through the Fallopian tubes directly into the peritoneal cavity. This, obviously, could occur only in women. The presence of gas-forming bacteria within the peritoneal cavity may produce gas. Aside from these considerations, the presence of free gas in the peritoneal cavity will almost invariably indicate the rupture of one of the portions of the gastrointestinal tract, or it may indicate a rupture of the bladder if there has been an artificial introduction of air into it.

Certain differential diagnostic features must be borne in mind. The hepatic flexure of the colon occasionally becomes interposed between the diaphragm and the liver, and may thus simulate the appearance of pneumoperitoneum. Careful inspection will reveal the segmentation of this gas in the characteristic fashion of the colon, and repeated examination will show it to change radically, the colon often slipping out from this position. Furthermore, there will be no gas under the left diaphragm, and in the lateral decubitus

position the gas will not shift from under the diaphragm to the lateral wall of the abdomen but remain there constantly. In the same way on the left side, a gas-distended stomach may simulate free gas under the left diaphragm; it may be necessary on certain occasions to put a tube into the stomach and aspirate its contents before a definite decision can be made. Usually gas under the left diaphragm extends somewhat laterally to the stomach, and a distinction can be made in this way. The patient can be shifted in position several times and then reexamined. If the gas is in the stomach it will change in position, thus permitting a distinction to be made.

It should be noted that a subphrenic abscess under either diaphragm will commonly accumulate gas so that a fluid level can be made out. Such gas, however, is clearly seen to be encapsulated rather than to shift about, as is the case with an ordinary pneumoperitoneum.

It has been found that pneumoperitoneum may be observed in about 80 per cent of the cases of perforation of the stomach or first portion of the duodenum. The exact reason why the other 20 per cent do not exhibit this sign is not altogether clear. In some cases it is no doubt due to the fact that adhesions exist between the diaphragm and the liver, preventing the passage of air into this space. In others it is due to the fact that the air becomes pocketed in the lesser omental cavity and cannot reach into this free space and therefore is not clearly visible. In still others little or no air leaves the stomach or duodenum, only fluid leaving and forming a valve-like mechanism around the opening so that gas cannot get out. In other cases the technique is insufficiently good to demonstrate the small quantities of air which are present.

The quantity of gas necessary to produce a visible shadow under the diaphragm is not large. In some experiments which Paine and I conducted, we were able to demonstrate as little as a 5 cc. of air giving a distinct shadow under the diaphragm. With 20 cc. there

was no doubt about the gas being present. However, these were done on the cadaver under conditions in which it was apparent that whatever air was injected intraperitoneally would come to lie up under the diaphragm.

It is notable that in perforation of the small bowel free gas is not commonly observed. In at least four cases of traumatic perforation of the small bowel I have been unable to observe any evidence of gas under the diaphragms. In two recent cases, however, free gas was observed. It is significant that in both of these cases an obstructive lesion of the small bowel, a lymphosarcoma in the one and a granuloma in the other, were present prior to the time of perforation. This had therefore produced large quantities of gas in the small bowel, and when perforation occurred a pneumoperitoneum was readily found.

In the case of the colon, when perforation occurs, the quantity of gas is so large and it comes into the peritoneal cavity under such pressure that we have been able to observe gas under the diaphragm in every case.

Hydropneumoperitoneum.--The presence of both gas and fluid in the peritoneal cavity can often be determined by films in the upright and lateral decubitus positions, a fluid level of characteristic type thus becoming visible. The gas, of course, will rise to the higher points in the abdomen while the fluid sinks to a flat level below it. The contrasting shadows of the two media make their presence easily apparent. It is only necessary to exclude localized pockets of fluid and gas, such as a subphrenic abscess or an intraperitoneal abscess, to determine that a hydropneumoperitoneum is present. The latter is not infrequently an accompaniment of rupture of a hollow viscus or peritonitis with gas-forming organisms.

Localized collections of gas in the abdomen.--The appearance of gas in abnormal areas of the abdomen clearly outside the gastro-intestinal tract but not free so that it rises up under the diaphragm is of great significance. Gas observed

in the region of the liver well above the duodenum and often outlining the biliary ducts in characteristic fashion, is an important sign as it usually means a fistula between the biliary tract and the intestinal tract. The gas may be present in the gallbladder as well as in the ducts and give the characteristic shape of the gallbladder. It must be distinguished sharply from gas in the first and second portions of the duodenum in this region or in the hepatic flexure of the colon, and also from the separation of the tissues by fat which may occur near the liver and simulate the presence of gas. Usually the distinction is quite apparent, and the demonstration of this gas indicating the presence of a fistula may have great bearing on the diagnosis of gallstone obstruction.

Gas may likewise appear in the various segments of the abdomen in bybble-like form. It is sometimes difficult to be certain if the shadows are not within the intestinal tract, and repeated examination may have to be made to determine their constancy. This is in contrast with gas in the intestinal tract, which is usually very irregular and changes its position and character from time to time. Such bybble-like shadows are often the first indication of the presence of an intraperitoneal abscess. They are commonly seen around the cecum, and likewise in the left lower quadrant, where abscesses tend to form.

Localized collections of fluid or fluid and gas.--Pockets of fluid which are encapsulated in the abdomen usually denote an abscess. This is represented by a localized area of density in almost any portion of the abdomen. It can be clearly made out because of the gas-filled bowel which often surrounds it and which is often distinctly displaced and compressed by the accumulation of fluid. Such a density may well be produced by a tumor, but usually the distinction between a tumor and an abscess is apparent from the clinical condition of the patient. Such pockets of fluid are particularly well seen in the region of the cecum, where their indentation into the gas-filled lumen of the bowel

is quite striking. They may, however, be observed in similar fashion in other portions of the abdomen.

When films are made in the upright or lateral decubitus position, the separation of a layer of gas from the fluid in such a pocket may well occur. This will indicate unequivocally that an abscess is present and often means that the abscess has been in communication with a portion of the intestinal tract. The latter does not necessarily follow, however, as some abscesses may have gas-forming organisms within them which produce the gas as well as the fluid. Localized fluid levels outside the intestinal tract, therefore, may appear, especially when the patient is shifted in various positions. These can be distinguished from subphrenic abscesses, which are localized to the diaphragms, and must be distinguished sharply from localized fluid and gas in loops of bowel. The latter can be done because in the loops of bowel the pattern of the wall is quite clear; it has a crenelated appearance due to the mucous membrane folds which are still present. In the case of an abscess, the pocket may appear well peripheral to the normal position of the bowel, and usually the outline of the wall of the mass as seen with the gas is entirely patternless. Gas may also be seen around the kidney or retrocecal in the form of stripe-like or bubble-like shadows. This often means either a perinephric or retrocecal abscess; under suitable conditions it may indicate a rupture of the retroperitoneal portion of the duodenum with escape of gas into this space.

Displacement of viscera.--The position and contour of the gas-filled gastrointestinal tract may be demonstrated with a fair degree of certainty in most acute abdominal lesions. Localized displacements of various portions of the stomach or bowel may thus be observed; these are usually due to localized abscesses or localized collections of fluid, such as blood or urine. Downward displacement of the stomach, for example, can thus be made out in cases of hematoma from rupture of the spleen. The same is true of the downward displacement of the hepatic flexure of the colon after rupture of the liver.

As stated above, localized abscesses will cause local displacement either of the small bowel, if the abscess is interintestinal, or of the cecum if it is pericecal. Under certain circumstances, where an acute abdominal condition is suspected, the demonstration of a mass rising up out of the pelvis, displacing the bowel, may suggest the possibility of a twisted cyst of the ovary or a large pelvic abscess.

Marked separation of the stomach from the colon may be a very significant sign. When the stomach is fairly well filled with gas and the colon likewise, they should normally be in fairly close apposition; the greater curvature of the stomach follows the transverse colon quite closely. Some separation may occur normally in certain individuals as a result of an unusual elongation of the gastrocolic omentum. However, a marked separation may be strongly suggestive of a hemorrhagic pancreatitis or an acute cystic enlargement of the pancreas, and this finding may well be used in the diagnosis of such acute lesions.

Displacement and immobilization of the diaphragms.--Any lesion in the peritoneal cavity which produces increased pressure will tend to cause ascent of the diaphragm. Localized lesions, such as subphrenic abscesses, may cause marked elevation of the diaphragm on one side or the other. Intraperitoneal hemorrhage or other intraperitoneal fluids will produce upward displacement of the diaphragms best observed in the supine or Trendelenberg positions. Partial or complete immobilization of the diaphragm is another manifestation of many intraperitoneal lesions, especially those of an inflammatory nature. This is particularly true of acute pancreatitis but may occur with any upper abdominal lesion. A satisfactory demonstration of immobilization of the diaphragm is best made by fluoroscopy.

Extravasation of contrast substances.--The introduction of contrast media, such as barium sulphate, into the gastrointestinal tract, may permit actual observation of the point of perforation of an ulcer or carcinoma by extravasation

of the material into the peritoneal cavity. As stated above, this procedure is definitely harmful and should not be undertaken if at all avoidable. There appears to be a distinct increase in the chances of a fatal peritonitis when barium is extravasated into the peritoneal cavity along with other material from the gastro-intestinal tract. The introduction of barium in the colon may also result in extravasation of barium into the peritoneal cavity, if a rupture of the colon has previously been present. For example, in a case of acute diverticulitis with rupture, which may simulate obstruction of the large bowel, it is conceivable that a barium enema might do some harm. Generally speaking, it is well to avoid contrast substances when the gastro-intestinal tract is under suspicion. On the contrary, in the urinary tract, intravenous urography may be undertaken in cases of suspected rupture without particular fear of harmful effects. The contrast substance may thus be traced from its normal position in the pelvis of the kidney or from the ureter into the perirenal or retroperitoneal tissues, indicating the rupture which is present. Likewise extravasation of contrast material from the bladder may be noted by the observation of the dense shadow of the medium, such as diodrast, as it extends into the peritoneal cavity or into the pericystic tissues. This can be accomplished more quickly by cystography. The introduction of air into the bladder may produce a pneumoperitoneum and may be observed with the patient in the upright position, providing the bladder has ruptured into the peritoneal space. There is supposedly some risk under such circumstances in that an air embolism may occur. As a result it may be advisable to use carbon dioxide instead of air for such a demonstration.

#### Roentgen Findings in Specific Conditions

Acute appendicitis.--The most common of the conditions under discussion is, obviously, acute appendicitis. In this disease, the negative x-ray findings are of importance. Roentgen examination of the chest should be made routinely in all

cases of suspected acute appendicitis in order to exclude lobar pneumonia; in occasional cases, particularly in children, this lesion will simulate the symptomatology and even the physical signs of acute appendicitis very closely. Roentgen examination six to twelve hours after the onset of symptoms will accurately reveal the presence of pneumonia and thereby prevent an operation, the results of which might be disastrous.

Cases have been observed in which the physical findings have apparently been characteristic of acute appendicitis while the examination of the chest was virtually negative, yet roentgenograms revealed a characteristic lobar pneumonia. It should be noted that the roentgen diagnosis of early pneumonia is not simple and that errors may occur even if x-ray examination is made. It is clear that in the majority of cases of acute appendicitis the diagnosis is clearly apparent. When there is even the slightest doubt, roentgen examination should be made.

In addition to this, examination of the abdomen as a whole should always be done because a ureteral stone should be ruled out in every case of acute appendicitis. It is not at all rare to find patients in whom a stone, passing down the ureter, produced symptoms leading to the surgical removal of the appendix without, of course, any beneficial results. Perhaps 85 or 90 per cent of stones in the ureter can be readily demonstrated by roentgen examination of the abdomen and in that way this condition can be either excluded or confirmed, thus modifying the diagnosis of acute appendicitis.

The positive findings in a case of simple acute appendicitis are relatively minor as long as no local peritonitis exists. There is, as a general rule, a moderate degree of ileus which is so common in all acute abdominal conditions. In addition, if local peritonitis has supervened, there may be an obliteration of the normal markings of the peritoneum on the right side resulting from the regional edema incidental to the inflammatory process in the appendix. The right

diaphragm is not infrequently higher than normal and somewhat splinted in position. It is important to note this fact because it often gives evidences on physical examination of suppressed breathing on the right side leading to the clinical diagnosis of pneumonia, when, in fact, the suppression of breathing is due entirely to the splinting of the diaphragm from the pathological process below it.

When acute appendicitis goes on to peritonitis or to the formation of an appendiceal abscess, more definite findings may be encountered. These will be discussed below.

Obstruction of the small intestine, simple, acute.--There is hardly a field of emergency surgery in which x-ray diagnosis can be more valuable than in that of intestinal obstruction. In recent years extensive researches by many investigators, notably in the Department of Surgery of the University of Minnesota, have indicated the important part which the roentgen examination should play in the early diagnosis of this condition. Whether we treat the condition by immediate surgery or, conservatively, by suction, the fact remains that it is extremely important to recognize the nature of the disease process at the earliest possible moment. The diagnosis from the clinical standpoint is recognized to be difficult. It should be clearly borne in mind that the diagnosis from x-ray examination alone is also inadequate, and one must combine the x-ray findings with the clinical and physical findings to arrive at a proper evaluation of the condition. Nevertheless, in some instances the x-ray findings are diagnostic in themselves; in other instances they are of the first importance in arriving at the correct diagnosis.

The presence of visible gas in the small bowel can be determined roentgenologically within four hours after the first onset of the symptoms of intestinal obstruction. Obviously it is rare to see patients at so early a period, and the amount of gas found, the number of loops involved, and the degree of distention may be insufficient to make a positive diagnosis. Further observation usually re-

veals increasing distention, a larger number of bowel segments become visible, and the characteristic ladder-like arrangement of the coils becomes apparent. The various segments of the bowel can be recognized as described above, the number depending upon the location of the obstruction. The diameter of the individual loops is greatly increased, often to four times the normal. In the upright position fluid levels can be observed, usually only in the upper portions of the abdomen. The bowel may become so distended that nothing else can be seen within the abdomen; nevertheless, the characteristic pattern can still be faintly made out. Early in the course of the condition the colon may show some gas, but the amount is small. As time goes on, if the obstruction is complete, the gas in the colon disappears unless enemata have been given.

An important fact, not generally appreciated, is that small bowel obstruction may be present with little or no symptoms and often even without physical signs. The patient will suffer an attack of colicky pain and cramps, which may apparently be relieved; not infrequently under such circumstances the physician is put off guard by the apparent disappearance of symptoms, and the diagnosis is not made. Even in this situation, in spite of the relative absence of symptoms, gas in the small bowel, with accompanying distention, will often be present in the roentgenogram and give the clue to the diagnosis.

As repeated films of the abdomen are made, changes in the appearance of the loops of bowel can be made out. The loops tend to shorten and widen from time to time depending on the degree of peristalsis. Distal to the point of obstruction, of course, there is usually no gas even in the small bowel. In mechanical obstruction the loops of small bowel are large and show rather marked angulation, giving the impression of a rather dynamic bowel.

Films made in the upright position will reveal fluid levels of varying degree, usually, however, lying well up in

the abdomen, unless numerous adhesions are present, as previously indicated. Films in the lateral decubitus position likewise permit gas-filled loops of bowel to rise to the upper side of the abdomen, and in an anteroposterior view the fluid levels can be seen here also.

Paralytic ileus.--In the paralytic or adynamic ileus, probably due to reflex inhibition, which occurs most commonly in association with peritonitis or as a postoperative complication, but may also occur with spinal cord injuries, in association with severe pulmonary lesions, and as a result of other lesions in the intestinal tract, a somewhat different picture is presented than in mechanical obstruction. It is not always easy to make the differentiation.

In typical cases the distention of the entire gastro-intestinal tract permits an easy distinction. On the other hand, there are cases of paralytic ileus in which only the small bowel is involved, no gas being present in the colon. Under these circumstances, the distinction must be made, so far as the x-ray examination is concerned, on a basis of the appearance of the bowel. In paralytic ileus the bowel loops are somewhat more shallow, less distended, the valvulae conniventes are less prominent, and the adynamic character of the process is evidenced from the general appearance of the bowel itself. The distribution of gas is much less regular, occurring in various portions of the abdomen. If peritonitis is present, the evidences of fluid in the peritoneal cavity will help make the distinction.

It should be noted at this point that after abdominal operations mechanical obstruction may occur, and in many instances in which paralytic ileus is thought to be present, the factor involved is actually a mechanical obstruction. The same is true of peritonitis, and the possibilities of a combination of the two lesions must be clearly borne in mind. Most frequently, in cases of adynamic ileus, the amount of fluid in the loops of bowel is less than in mechanical obstruction. Despite these numerous features, the differential diag-

nosis is often extremely difficult.

Strangulation obstruction.--Differentiation of a simple mechanical obstruction from a strangulation is of extreme importance, particularly with relationship to the application of therapy. While in simple mechanical obstruction the application of conservative suction therapy may be the method of choice, such a procedure in the presence of a strangulation, such as might occur from a volvulus, incarcerated hernia, or adhesions, may result in a fatality directly attributable to the neglect of proper procedures. Differentiation clinically may be made in many cases, but in a good many it is extremely difficult.

During the past few years we have observed a number of cases in which certain specific x-ray signs appear to be fairly constant and highly suggestive, if not completely diagnostic, of strangulation obstruction. Under such circumstances there appears to be an ability on the part of the bowel to pass gas into the strangulated portion, which in itself tends to distend without a corresponding distention of the loops of bowel proximal to it. As a result, a rather localized distention of two segments of bowel can be made out. In many cases the gas-filled bowel has taken on a characteristic "coffee bean" appearance, the two loops being separated by a wide band of increased density, probably representing the edematous walls of the bowel with a small amount of fluid between them. There is an unusually large accumulation of fluid within these isolated loops, and they remain relatively fixed, so that in the upright or lateral decubitus position the distended loops of bowel do not shift. In patients in whom suction has been applied, it is significant that the distended loop of bowel remains well filled with gas, being relatively unaffected, although the gas which is present elsewhere may disappear under the influence of the treatment. The demonstration, therefore, of a rather localized distention of two loops of bowel, larger quantities of fluid than usual within them,

some evidence of fluid between them, and some fixation would strongly suggest a diagnosis of strangulation obstruction.

Intussusception.--The particular type of small bowel obstruction, which occurs most commonly in children, incident to ileocecal or ileocecolic or ileo-ileal intussusception represents another type of intestinal obstruction in which an early specific diagnosis is extremely important, because of the necessity for immediate surgical procedure. In most instances the diagnosis is readily apparent from the history and physical signs. However, in patients coming from a neighborhood wherein some enterocolitis has been present, and in whom the signs are atypical, the diagnosis may remain in grave doubt, and delay in treatment may ensue. Obviously, it is not desirable to do surgery on a patient with acute enterocolitis, and as a result many cases are delayed to a point where a fatal outcome ensues. The determination of an ileocecal or ileocecolic obstruction can be made with great accuracy by the roentgen examination with a barium enema. Preliminary films will sometimes, although not always, reveal the characteristic gas accumulation in the small bowel. Barium enema examination can be then done, and a characteristic defect in the colon due to the interposed bowel is made out. The defect is of typical appearance because of the mucous membrane of the bowel, which, being inverted, lies in contact with the barium in the colon which has been filled. This gives a shadow, resembling multiple rings, of lesser density, partly filled with gas and partly surrounded with barium. The intussusciens may be encountered as low as the sigmoid colon and anywhere along the course of the large bowel up to the ileocecal valve. During the course of the enema examination, some obturator reduction of the intussusception may occur, but we do not make any strenuous efforts to produce a cure by this means. The demonstration of the passage of barium through the ileocecal valve into the ileum is excellent evidence that the intussusception has been reduced, but the possibility of a compound intussusception, that is, with an ileo-ileal intussusception in

addition to an ileocecal cannot be excluded by this means. As a diagnostic procedure, however, barium enema examination does no harm and should be done whenever there is any doubt whatever about the diagnosis.

Gallstone obstruction.--In any obturator obstruction of the small bowel, immediate surgery is indicated because of the possibility that a gallstone or other foreign body will erode the intestine and produce a fatal peritonitis if not immediately relieved. Gallstone obstruction occurs, generally speaking, as a result of the passage of a stone, either from the common ducts or from the gallbladder into the duodenum. The stone itself finds its way through the intestinal tract until it reaches a point of smaller lumen than it can pass, or until, because of the roughness of the stone, a spastic contracture of the bowel occurs, producing an obstructive spasm, which in turn eventuates in a true obstruction. The diagnosis of gallstone obstruction may well be suspected from a careful analysis of the clinical findings. However, in the majority of cases, until the x-ray signs were described, the diagnosis was missed, because gallstone obstruction tends to be intermittent and very atypical in many of its findings. As a result, the x-ray examination is of first importance.

In such cases there is evidence, as described above, of mechanical obstruction of the small bowel. The obstruction is often not complete, so that gas will be found in the colon. If, in addition to this, local accumulations of gas over the liver or in the region of the gallbladder and ducts are found, the diagnosis can be advanced with considerable certainty. In some cases the stone shadow itself can readily be made out; if a shadow similar to that of a gallstone is seen lying some distance away from its normal situation and if symptoms and signs of intestinal obstruction are also present, the diagnosis may well be suspected. In a series which Borman and I have reported both from our own experience and from a study of the literature, it appears that approximately 2 to 5 per cent of all cases

of intestinal obstruction are due to gallstones. It should also be noted that the mortality in cases of gallstone obstruction, prior to 1930, was reported as being as high as 90 per cent, largely due to delay in diagnosis.

The mechanism whereby gallstones pass into the intestinal tract was clearly observed in a case observed at autopsy reported by Borman, Noble, and myself. Large stones in the common duct or in the gallbladder may gradually erode through the wall of the structure into the neighboring bowel. The bowel is often adherent to such a gallbladder or common duct, so that erosion occurs without peritonitis or other incident. In one case, a massive stone eroded through the common duct, while the ampulla of Vater itself remained firmly closed. It is possible, however, for stones to pass through the ampulla itself and into the intestinal tract, yet eventually produce obstruction. Under such circumstances, the sphincteric activity of the ampulla is destroyed and a fistulous tract is established through the common duct itself. Otherwise a new tract between the biliary structures and the intestinal tract is established, and the possibility of regurgitation of intestinal contents becomes apparent. The pressure within the duodenum being greater than in the biliary tract, there is a tendency for gas and, when barium is given, for barium, to regurgitate and thus demonstrate the fistulous communication on roentgen examination. This is seen not too rarely even without gallstone obstruction being present. The stones which pass in such situations are often small enough to be evacuated with the fecal contents. Cholecystocolic fistulae also occur, but these do not produce obstruction.

It should be observed at this point that other types of obturator obstructions of the intestine may occur, but they are relatively rare. I have seen one such case in which the bones of the feet of a chicken became impacted in the small bowel and produced a complete obstruction. Other types of bezoars may occur and produce obstruction likewise.

In a series of fourteen cases of

proved gallstone obstruction, which Borman, Noble, and I reviewed, we found that the diagnosis might have been made, although it was not made in each case, in thirteen cases because of the combination of evidences of intestinal obstruction, demonstration of an opaque gallstone far removed from the region of the gallbladder, and most importantly the evidence of gas in the biliary duct, indicating the presence of an internal biliary fistula. It is conceivable that a gallstone may pass and that the fistula itself may spontaneously close. The gallstone may lie in the intestine for rather long periods of time, eventually producing obstruction. We have seen one case recently in which the internal biliary fistula was closed surgically by Doctor Wangenstein, but a gallstone remained in the intestinal tract; weeks later it produced a complete intestinal obstruction. In such situations the gas will not be seen in the region of the liver, and the findings cannot be distinguished from those of any simple small bowel obstruction.

#### Roentgen examination in the suction treatment of small bowel obstruction.--

When conservative measures such as suction are undertaken in any type of small bowel obstruction, the observation of the effects of the treatment, the passage of the tube, the position of the tube, all are dependent largely upon repeated x-ray examination. Often these must be done at the bedside, but reasonably satisfactory results can be obtained even in this way. Observation of a tube which has failed to pass or a tube which has passed into the small bowel but which does not result in a reduction in the degree of gas distention of the bowel, are all of great significance so far as estimating the effects of this type of therapy. It should be noted particularly that localized loops of small bowel which remain distended after the introduction of suction, especially if there is a reduction in the distention of other loops of bowel, should always arouse the possibility of a strangulation obstruction being present. The observation of cases of small bowel obstruction in which suction is used will reveal that as the therapeutic procedure begins to

have a beneficial effect, gas will begin to appear in fair quantities in the colon. This is of the first importance in estimating the improvement in the situation and giving confidence in proceeding further with it.

Acute obstruction of the colon.--Acute obstructions of the colon are not infrequent and most commonly are due to carcinoma which has been neglected. The surgical problem in these cases is not that of dealing with the carcinoma but rather to relieve the obstruction, particularly to prevent rupture of the cecum. The latter is probably the most common fatal complication of acute obstruction of the colon. Under such circumstances a barium enema examination, which under more ordinary conditions, is a highly effective aid in diagnosing carcinoma of the colon, may not be as useful. It is often extremely difficult for the patient, under the conditions of acute distention, to retain the barium, and marked caution must be exercised in adding the additional pressure of the enema to a colon which is already enormously distended with gas. Nevertheless in some cases, it may be advisable to do so, and if sufficient care is exercised, as pointed out above, to prevent barium from reaching above the point of obstruction and to avoid excessive pressure, no harm will result. A combination of the evidence obtained in this way with that obtained through the careful examination of simple films of the abdomen, will usually reveal that it is the colon and not the small intestine which is primarily involved. Some distention of the small bowel may also be present, but this is a secondary effect.

Characteristically, in a scout film of the abdomen the colon can be made out, as pointed out above, by reason of its typical haustral recesses. Depending upon the point of obstruction, the distention of the colon will be of more or greater extent, and usually the gas column can be followed right up to the point of obstruction. In many cases the tumefaction of the obstructive process can be observed. In many cases of acute obstruction of the colon, the obstruction is not complete, and as a result some gas will be seen distal to the point of occlusion. The

colon proximal to the closure will be dilated up to the ileocecal valve, the cecum itself usually being much more distended than the remaining portions of the colon.

In a fairly large percentage of cases, as recently pointed out by Dennis, a perceptible accumulation of gas can be made out in the small bowel, even though the obstruction is in the colon. This is particularly true when the obstruction is rather proximal, such as in the ascending colon or cecum. The amounts of gas seen under such circumstances, however, are of insufficient grade to give much difficulty in differentiation, as the small bowel is not especially distended. In about 30 per cent of the cases, however, actual distention of the small bowel was found, but to a lesser degree than that of the colon. Under such circumstances, the differentiation, by means of the x-ray findings alone, from a paralytic ileus becomes exceedingly difficult. In a smaller percentage of cases, approximately 8 per cent, the distention of the small bowel was of greater degree even than the colon. In several instances which I have observed the ileocecal valve was completely deficient, and the intestinal tract became one complete unit. In such situations the symptoms and signs and the roentgen findings may all simulate small bowel obstruction. The presence of fairly large quantities of gas in the colon may indicate that the diagnosis is not that of a small bowel obstruction, and further studies may thus be stimulated. In some such cases the administration of barium by enema may clarify the situation. In one case we gave barium by mouth, and despite the great dilation of the small bowel we failed to find a point of obstruction, the barium passing right on into the cecum. Later a carcinoma of the ascending colon was demonstrated. It should be observed, therefore, that the presence of gas in the small bowel or the demonstration of small bowel distention does not exclude obstruction of the colon.

In volvulus of the sigmoid, the x-ray findings may be of particular importance.

This is a type of colonic obstruction in which immediate intervention is necessary. We have observed cases of acute obstruction occurring from volvulus of the sigmoid in patients who had previously been observed on a number of occasions and who had exhibited extremely elongated, redundant sigmoids. This redundant bowel had become twisted, with acute obstruction resulting. In such cases the roentgenogram is likely to show a very marked distention of the sigmoid far out of proportion to the distention of the remainder of the colon. The sigmoid may ride over to the right side, coming to lie up under the liver, or in some cases it extends well up under the left diaphragm as a result of the extreme elongation and distention. Films made in the lateral decubitus or upright position will show an unusual accumulation of fluid within the sigmoid loop itself, and this combination is strongly suggestive of volvulus. In addition, careful study may reveal two points of obstruction in the gas column, which likewise is suggestive of volvulus. In such cases also, barium enema examination is strongly indicated, and the characteristic twisting of the mucous membrane pattern of the bowel can readily be observed; it is pathognomonic of the condition.

In all cases of acute obstruction of the colon which are not treated immediately, repeated roentgen examinations should be made so that the size of the cecum may be closely observed. A marked increase in the size of the cecum is always indicative of the possibility of perforation; this is almost always a fatal complication of acute obstruction of the colon. If opportunity is afforded to examine the patient from time to time, this observation may be of great value.

General peritonitis.--In general peritonitis from any cause, the most common finding is the presence of adynamic ileus. The findings have been described above. As stated above, it should be borne in mind, however, that in many cases of general peritonitis an actual mechanical obstruction from adhesions occurs, and care should be exercised not to overlook it because of the presence of a generalized ileus. In the upright position, in

patients with peritonitis, fluid levels can be made out, and not infrequently loops of bowel will be found well down in the pelvis and partially fixed, owing to the diffuse adhesions which may be present. Usually there is gas distention of the colon as well as of the small bowel. Obliteration of the peritoneal markings on both sides is commonly present, although not necessarily so, and the presence of these markings does not exclude a peritonitis. Elevation of both diaphragms is fairly common, and there may be some degree of immobilization, but not to the same extent as would be found in a subphrenic abscess, for example.

Evidence of fluid within the peritoneal cavity may readily be obtained in cases of general peritonitis. Usually the amount of fluid is not great and is best manifested by the separation of the loops of bowel, as described above. In cases where an abscess is already forming, the fluid may accumulate locally in larger quantities and in that way indicate the tendency toward the formation of an abscess, although a distinctly encapsulated pocket is not clearly made out.

While the presence of fluid and the obliteration of peritoneal markings occur from ascites also, it is obviously not a very difficult problem in differentiation, since most patients with peritonitis have severe, acute symptoms. The distinction between postoperative ileus with a moderate postoperative fever, and an actual peritonitis is infinitely more trying, and it is in this situation that the x-ray examination may be of very great value.

Intra-abdominal abscess.--Abscesses within the abdominal cavity may well be divided into three groups, subphrenic, interintestinal, and pelvic abscesses. For purposes of this discussion, subphrenic abscess will not be considered, as it represents a subject almost in itself. The interintestinal and pelvic abscesses occurring commonly from acute appendicitis with rupture, as a secondary phenomenon from ruptures of the intestinal tract, from pelvic inflammatory disease,

after operation, or as sequels of any type of general peritonitis, are of great importance. The roentgen examination is very helpful in their delineation. Patients with ruptured appendix, for example, in whom conservative therapy is used, can be observed in this fashion and the development of the abscess itself as a localized pocket of fluid, can be clearly delineated. I have observed cases in which a pericecal abscess and, as time went on, an interintestinal abscess in the left upper quadrant both developed following a perforated appendix in which intervention was not immediately undertaken. In such cases as have had a general peritonitis for some period of time and, owing to the condition of the patient, it is thought unwise to interfere, repeated examination at the bedside is of very great value in determining the eventuation of the condition. Likewise, after operation, the development of an abscess either from accidental perforation of the bowel or from other causes can be followed in this way.

An abscess either in the pelvis or in the interintestinal area manifests itself essentially as a local area of density displacing the loops of gas-filled bowel about it. A generalized ileus is usually present accompanying it. In some instances the loops of bowel can be clearly made out adherent to the abscess itself and sometimes even overlying it.

A distinction must be made from an ordinary intra-abdominal tumor, and here again the clinical findings usually suffice; furthermore in an ordinary tumor the generalized bowel distention, commonly accompanying an abscess, is not present.

The development of gas within the abscess may occur as a result of a communication with the gastro-intestinal tract or from gas-forming organisms. This may give a very characteristic picture in that the density of the pocket of fluid is greatly diminished in the supine position, and if upright or lateral decubitus films are made the gas can be separated out.

As pointed out above, the observation of small bubble-like shadows of gas in a local portion of the abdomen should always

raise the suspicion of an abscess. Such shadows may be the first evidences of abscess formation.

#### Perforation of a hollow viscus.--

Roentgen examinations in cases suspected of a perforated hollow viscus have been employed for a good many years and are very informative in their delineation. As in some of the other conditions discussed here, a perforated ulcer of the stomach or duodenum is often quite obvious from the clinical standpoint. In some instances, however, doubt is certainly present, and under these circumstances, x-ray examination, particularly in the upright or lateral decubitus position is of great value. The demonstration of free gas, as stated above, may be made in approximately 80 per cent of the patients who have had a perforation of the stomach or of the first portion of the duodenum. In cases of perforation of a carcinoma of the stomach the same is true. In the case of perforation of the colon, almost 100 per cent of the cases will exhibit gas which is readily observable. As stated above, the evidences of a spontaneous pneumoperitoneum may also be obtained with the patient in the supine position alone. Perforation of the small bowel has a much smaller percentage of accuracy in this regard, probably due to the lack of accumulation of free gas within the small bowel; not much gas escapes unless an obstruction has been previously present.

In a rare case or two, a traumatic perforation of the retroperitoneal portion of the duodenum might cause the gas to extend retroperitoneally. In that event the gas will not be free and will therefore not appear under the diaphragms but will be seen around the kidney or psoas muscle or in the pericecal region; the clue to the nature of the perforation may thus be obtained.

When peritonitis from a perforation has been present for some period of time or when there has been much extrusion of fluid from the perforated viscus into the peritoneal cavity, both gas and fluid may be observed, if the patient is put into the upright or lateral decubitus

position. The findings described under hydropneumo-peritoneum are then obtained. In rare cases of gas-forming peritonitis a similar finding may occur.

### Summary

Roentgen examination is of the first importance in the conduct of almost all of the acute abdominal emergency conditions. The information obtained from such examination, when combined with the history, the clinical and laboratory findings, will lead to a more rapid and more exact diagnosis of the nature of the disease process.

Roentgenograms of the abdomen without contract media should be made in the supine position and, where possible, in the upright and lateral decubitus positions as well. A simple roentgeno-

gram of the chest, in the supine position, should also be obtained.

The various roentgen signs of abnormality are described and the importance of a careful analysis of the roentgen shadows is indicated. The application of the roentgen findings is detailed as regards the following conditions:

1. Acute appendicitis
2. Acute small bowel obstruction, simple
3. Acute intussusception
4. Gallstone obstruction
5. Strangulation obstruction
6. Acute obstruction of the colon
7. Volvulus of the sigmoid
8. General peritonitis
9. Intraperitoneal abscess
10. Perforation of a hollow viscus.

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## III.

LEO G. RIGLER -- An Appreciation

Over 100 friends of Leo G. Rigler gathered at a special dinner in Minneapolis, December 9, to wish him well. The occasion was the fall meeting of the Minnesota Radiological Society, and the guest speaker was Fred J. Hodges, Professor of Roentgenology, University of Michigan, Ann Arbor. Walter J. Ude, representing the Minnesota Radiologic Society and friends of the honored guest, gave nearly \$10,000 to the University of Minnesota to establish the Leo G. Rigler Lectureship in Radiology. This was accepted by Dean H. S. Diehl. Speakers were Robert G. Allison, George E. Fahr, E. T. Bell and others. For some time the radiologists have wanted to express to Dr. Rigler their appreciation for his untiring efforts in their behalf. When his friends in other branches of medicine heard of this proposal, they too wanted to help. The sum accumulated so rapidly that it quickly reached the desired amount.

Leo George Rigler was born October 6, 1896 in Minneapolis. He attended the University of Minnesota, from which he received his M.D. degree in 1920. Following an internship in St. Louis City Hospital, St. Louis, Missouri, and practice in North Dakota, he was named teaching fellow in Internal Medicine, University of Minnesota (1921-22). The following year he was appointed Roentgenologist at Minneapolis General Hospital largely as the result of his interest in the Roentgen diagnostic aspects of Medicine. He was named Associate Professor of Radiology in 1927, and Professor in 1929. In 1935 he became chief in the department and has served in that capacity to date. In 1930 the State Board of Institutions made him a consultant. In 1941 the Minneapolis General Hospital named him chief of the Department of Roentgenology. Prior to accepting the departmental appointment, Dr. Rigler completed his studies in Europe spending most of his time with Professor Forssell in Sweden. Here he also learned to speak Swedish.

He is a member of Alpha Omega Alpha, Sigma Xi, American Medical Association, Hennepin County Medical Society, Minnesota State Medical Association, Minneapolis Academy of Medicine, Minnesota Academy of Medicine, American Roentgen Ray Society, Radiological Society of North America, Minnesota Radiologic Society, American College of Radiology (fellow), American Association of Thoracic Surgery and the American Association for the Advancement of Science. Civic activities include Council of Social Agencies, Jewish Family Service Association, Minneapolis Federation for Jewish Service, Foreign Policy Association and State Selective Service Association. He is married (Matil Sprung, 1920), and has three children, Stanley, Nancy and Ruth. Dr. Rigler is the author of Outline of Roentgen Diagnosis (Lippincott), Second Edition, 1943, and many scientific reports.

As long as any of us can remember Leo Rigler has been doing things for other people. The list is long and impressive. He has arranged and organized departmental conferences with most of the other departments in the hospital, as well as with the pre-clinical branches. He is always ready and willing to speak at medical gatherings and to teach special courses at the Center for Continuation Study. His contributions to graduate training include not only service to members of his own department but service to practically every other clinical department. He has been instrumental in putting life and vigor into the Minnesota Radiological Society and he has been active in the councils of national associations. In recent years he has made a large contribution to War-Time Graduate Medical Meetings through his visits to all the hospitals in our area. It is at clinical pathological conferences that he is at his best, standing in front of the group, calling

attention to what he sees and giving his conclusions just ahead of the pathologist with his postmortem report. He has been associated with roentgenology during its greatest period of development, and he has made a significant contribution to this specialty.

It is just and fitting that this honor should come to him. The only regret is that everyone who likes Leo and appreciates what he has done could not participate in the offering. The University of Minnesota has been a better place because of his contributions and all of us look forward to profitable years of association with him.

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We wish you all the choicest greetings of the season. Hospital Party for staff and employees -- Tuesday, December 19, 3:30 to 5:30 P.M., Nurses Lounge. Everyone Welcome. Next Staff Meeting will be January 5, 1945.