An Address ON SURGICAL ASPECTS OF SUBPHRENIC ABSCESS.

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(Continued from page 377.)

THE GENERAL ETIOLOGY OF SUBPHRENIC ABSCESSES.
THE following organs occupy the fossae which abut upon the under surface of the diaphragm: The stomach and duodenum, liver and bile passages, pancreas and spleen, and the upper end of the kidneys. In the event of perforation or suppuration occurring in these organs the infection will spread directly to the peritoneal or cellular space in which the organ lies.

On the other hand, the infection may originate in the lower part of the abdominal cavity, such as in the small intestine, the appendix, or the pelvic viscera. The infective process then spreads along those peritoneal or cellular fossae which at their upper end communicate with the spaces which abut upon the diaphragm (see Fig. 8). I have analysed the causes of 76 consecutive cases of subphrenic abscess which have occurred at the London Hospital in eight years, and have arranged them in order of their frequency:

Gastric ulcer	21 cases.
Appendicitis	12 "
Suppurating hydatid	8 "
Tropical abscess of liver	6 "
Duodenal ulcer	5 "
Parturition	3 "
Pyemia	3 "
Splenic infarct	3 "
Thoracic	3 "
Cancer of stomach	2 "
Acute peritonitis of transverse process of lumbar vertebrae	2 "
Operations, resections	2 "
Suppurative cholangitis	1 case.
Pylephlebitis	1 "
Cancer of pancreas	1 "
Typhoid	1 "
Pyosalpinx	1 "
Ruptured gut	1 "
Gall stones, cholangitis	1 "
Congenital cystic kidney	1 "
No cause found	2 "

NOTE.—There is a little overlapping in this table.

It will be seen that perforating gastric and duodenal ulcers are responsible for about one-third of all cases. Appendicitis is responsible for one-sixth, and hydatid and tropical abscesses of the liver for another sixth. Between them, whilst the remaining third of the cases is distributed among many causes, each of which is individually rare.

The Routes of Infection and Localization of Subphrenic Abscesses due to Gastric Ulcer.

Twenty-one cases of subphrenic abscess out of 76 were due to gastric ulcer, and these contain examples of the localization of pus in all the six subphrenic spaces but one.

1. In 16 cases the perforation was on the anterior wall of the stomach, and near the lesser curve. The septic matter escaped direct into the left anterior intraperitoneal space, and the abscess was localized there.

2. In one case the margin of the left lobe of the liver formed such firm adhesions to the anterior surface of the stomach, that the infection was directed to the right into the subhepatic pouch.

3. The right anterior intraperitoneal space was involved in 4 cases. One of these was a further extension from the subhepatic pouch of the case described under (2). In the other 3 cases perforation occurred near the pylorus, and the septic matter and gas passed direct into this fossa. The liver became separated from the diaphragm, and dropped upwards and backwards, so that the whole of the space was filled with gas and pus, which presented in the right hypochondriac region.

4. In 2 cases a posterior perforating gastric ulcer infected the lesser sac of the peritoneum.

5. In 1 case the cavity of the lesser sac was obliterated by adhesions. The ulcer then invaded and infected the left extraperitoneal cellular space, where a large abscess formed. Mr. Mayo Robson¹ has recorded a similar case.

6. Finally, a perforating gastric ulcer may produce pylephlebitis, and the branching abscesses in the liver may infect the right extraperitoneal cellular space, or the right anterior intraperitoneal fossa.

In cancer of the stomach the infection follows a similar course, and localizes in like situations.

The Routes of Infection and Localization of Subphrenic Abscesses due to Appendicitis.

Of the 12 cases of subphrenic abscesses due to appendicitis, in the series of 76 cases, the pus was localized as follows:

Right anterior intraperitoneal fossa	10 cases.
Right posterior intraperitoneal fossa	6 "
Left anterior intraperitoneal fossa	1 case.
Right extraperitoneal fossa	1 "

Two fossae were involved in 6 cases.

Appendicitis may infect the subphrenic fossae in four ways:

1. As a part of an acute general peritonitis, but these cases are not included here because they are clinically so different from the localized abscesses which are the subject of this paper.

2. By a more or less slow and direct extension up the lumbar peritoneal fossae, from the pelvis.

3. Through the medium of the portal vein, as a part of pylephlebitis.

4. By lymphatic extension (a) up the right retroperitoneal cellular tissue, or (b) up the lymphatics around the deep epigastric artery to the falciform ligament.

In the majority of cases the appendix lies external to the caecum and ascending colon, and reaches a variable distance up the right lumbar fossa, towards the liver margin: (1) When it becomes inflamed the infection passes into the subhepatic fossa (6 cases), and (2) in practically all these cases, and in some others in addition, the sepsis also extends between the liver and the diaphragm into the right anterior intraperitoneal space (10 cases). (3) It is stated that pus may pass from the subhepatic fossa through the foramen of Winslow, to the lesser sac of the peritoneum, but no such case has occurred at the London Hospital. (4) A localized pelvic appendix abscess may escape up either loin. When it does so on the left side it spreads up either the internal or external lumbar fossa to the left anterior intraperitoneal fossa. One such case occurred in my series, and the details of this extension are more fully described under the heading of that fossa (see Figs. 8 and 9).

5. A retrocaecal or retrocolonic appendix may infect the right retroperitoneal cellular tissues, either as a diffuse cellulitis or as a lymphangitis. In either case the infection may spread to the extraperitoneal cellular space between the layers of the coronary ligament or to the lesser omentum and its glands.

6. In one of my cases in which cellulitis of the abdominal wall followed an appendicitis, an abscess formed in the epigastrium, between the layers of the falciform ligament. Apparently extension had taken place along the lymphatics around the deep and superior epigastric arteries.

7. Pylephlebitis is not uncommon in appendicitis, and when this occurs the abscesses in the liver frequently infect the right extraperitoneal space and the right anterior intraperitoneal fossa. I have seen both these spaces infected in this manner, where the appendicitis was due to a pin in the appendix.

It will be seen that all the subphrenic spaces and fossae may be infected by appendicitis, except the left extraperitoneal cellular space.

The Routes of Infection and Localization of Subphrenic Abscesses due to Liver Disease.

Of the series of 76 cases of subphrenic abscess at the London Hospital 18 were due to liver diseases. Under this heading are grouped suppurating hydatids, tropical abscesses, pylephlebitis, cholangitis, and liver abscesses due to some other cause.

The subphrenic abscesses which resulted were localized as follows:

Right anterior intraperitoneal ...	7 cases.
Right posterior intraperitoneal...	1 case.
Left anterior intraperitoneal ...	1 "
Left posterior intraperitoneal ...	0 "
Right extraperitoneal ...	15 cases.
Left extraperitoneal ...	0 case.

As a liver abscess enlarges, it tends to thin out the liver substance over it and come to the surface. In the majority of cases this occurs between the layers of the coronary ligament, which are pushed aside until the diaphragm forms a considerable part of the upper boundary of the abscess. (See Fig. 1.)

The cellular tissue of the right extraperitoneal space may, however, be infected from quite a small abscess in the liver, especially when this is due to pylophlebitis or suppurative cholangitis, and in these cases the subphrenic abscess and the hepatic abscess are separate. A hepatic abscess may reach the surface of the liver where it is covered by peritoneum, and it may then either actually rupture or infect the corresponding peritoneal fossa by transudation of micro-organisms. In this way any of the intraperitoneal fossae may be infected, but a reference to the above list will show that this is only common in the case of the right anterior intraperitoneal space.

The Routes of Infection and Localization of Subphrenic Abscesses due to Gall Stones.

Only one such case is included in my series of 76 subphrenic abscesses. In this case suppurative cholecystitis led to abscesses in the glands of the small omentum, and from these the lesser sac was infected and suppurative cholangitis was produced. The suppurative cholangitis led to a right extraperitoneal subphrenic abscess and to a right anterior intraperitoneal subphrenic abscess. Another case has recently come under my notice, in which a stone impacted in the diverticulum of Vater led to distension and rupture of an ulcer on the right side of the neck of the gall bladder. The septic bile poured into the subhepatic pouch and was shut off below, but the infection spread round the edge of the liver into the right anterior intraperitoneal fossa, which was also occupied by an abscess. It is also said that a gall stone impacted in the lower third of the common bile duct may infect the retroperitoneal cellular tissues by actual perforation or transudation of micro-organisms, and by this route reach the right extraperitoneal space.

The Routes of Infection and Localization of Subphrenic Abscesses due to Duodenal Ulcers.

This series of 76 cases of subphrenic abscess contains 5 due to duodenal ulcer, and these were localized as follows:

Right anterior intraperitoneal ...	1 case.
Right posterior intraperitoneal ...	2 cases.
Left anterior intraperitoneal ...	1 case.
Left posterior intraperitoneal ...	0 "
Right extraperitoneal ...	2 cases.
Left extraperitoneal ...	0 case.

The most important distinction is into anterior and posterior perforating ulcers. An anterior perforating duodenal ulcer nearly always directly infects the subhepatic pouch in which it lies, but it is easy for the infection to reach the right anterior intraperitoneal fossa round one of the margins of the liver. A duodenal ulcer is, however, as a rule, so close to the pylorus that it is practically in the middle line, and consequently the pus may pass to the left of the falciform ligament and enter the left anterior subphrenic space.

When the ulcer is posterior it may infect the retroperitoneal cellular space. This occurred in 2 cases of my series.

The Route of Infection and Localization of Subphrenic Abscesses due to Thoracic Causes.

Only three such cases occurred in my series. It is a very remarkable fact that whilst nearly all subphrenic infections pass readily through the diaphragm to the pleurae, lungs, or pericardium, it is a very rare circumstance for the contrary to occur. The causes of this are: (1) that the intrathoracic pressure is negative, whilst the intra-abdominal is positive; and (2) because the lymphatic flow through the diaphragm is always ascending; and (3) probably the lymphatics of the diaphragm are valved upwards.

In one of the three cases referred to above, an acute lobar pneumonia of the right base was followed by a

pneumonic abscess in the right anterior and posterior intraperitoneal fossae. This was presumably a lymphatic infection.

In another a localized empyema at the left base burrowed into the left extraperitoneal cellular space, passing below the external arcuate ligament. In the third case a bronchiectasis of the right base in a child perforated the diaphragm into the liver. The liver abscess so formed ruptured into the subhepatic fossa, and further infected the left anterior intraperitoneal space.

THE SYMPTOMS OF SUBPHRENIC ABSCESSES.

The diagnosis of a subphrenic abscess is not really a difficult matter when the physical examination is conducted in an orderly and complete manner. To achieve this it is well to divide the examination under several headings.

I. The history of (a) diseases which may produce a subphrenic abscess, and (b) the character of the onset.

II. The general signs and symptoms which indicate that suppuration is going on somewhere in the body.

III. Abdominal signs and symptoms.

IV. Thoracic signs.

V. Under the heading of local signs will be considered the direct evidence of the abscess itself.

I. The History in Subphrenic Abscesses.

Of the Cause.—Of 21 cases of subphrenic abscess due to gastric ulcer a previous history of dyspepsia was obtained in 17. The patients complained of pain after food, relieved by vomiting, and in several instances of haematemesis.

In the duodenal cases the pain had been in the right hypochondrium and had occurred some two hours after meals, and some stated that the pain was relieved by taking further food, and in several melaena was noted. Of the 12 cases due to appendicitis, a history of previous attacks was obtained in only two, no doubt because appendix abscesses nearly always occur in the first attack. The cases due to tropical abscess of the liver gave a history of foreign residence without exception, and in nearly every instance stated that they had suffered from dysentery, malaria, or enteric fever. It is interesting to note, however, that three patients who had resided in the tropics suffered from subphrenic abscess from other causes than liver abscess; namely, cancer of the pancreas, acute periostitis of the left transverse process of the second lumbar vertebra, and pyaemia after a confinement. A history of jaundice was recorded in 10 of 15 cases due to hepatic abscesses of various kinds, and this symptom did not occur in any other case. One patient who developed a left subphrenic abscess in a blood clot which formed after a resection of the transverse colon for a new growth, gave a previous history of haemophilia. Three patients dated their trouble from a septic confinement, and two from an attack of enteric fever.

The duration of the symptoms when the case came under observation was noted in 48 of 76 patients. This period varied from one day to sixteen months, and averaged eight weeks, but nearly all the cases due to perforative peritonitis were admitted ten to fourteen days after the onset.

The Nature of the Onset of Subphrenic Abscesses.

Of 76 cases of subphrenic suppuration, in 40 the onset was sudden, and in 36 more or less insidious. The chief importance of this distinction is that the great majority of intraperitoneal subphrenic abscesses begin by an acute perforation into the peritoneum, whilst, on the other hand, extraperitoneal collections of pus below the diaphragm result from a spreading cellulitis, and are therefore slower in their beginnings. Twelve cases of subphrenic abscess due to appendicitis were all acute in onset. Of 23 cases due to gastric ulcers and cancer, 15 were acute in onset, and 8 were insidious. The only two cases in the whole series due to cancer of the stomach were insidious in their onset. The other 6 cases were due to chronic gastric ulcers which formed adhesions before they perforated the wall of the stomach. Of the 5 cases of subphrenic abscesses due to duodenal ulcer, 3 were anterior in position and acute in onset; 2 cases were posterior, and insidious at the beginning, and in both these cases melaena was present. Of 8 suppurating hydatids of the liver, 6 were slow in onset; 1 was suddenly infected, and 1 ruptured into the peritoneum, so that the onset of symptoms was instantaneous. Of 7 hepatic

abscesses, 6 were subacute in onset, and in only one was the commencement described as sudden. The one subphrenic abscess due to cancer of the pancreas began acutely. When a subphrenic abscess is secondary to septicaemia or pyaemia, the origin is subacute, and the same remark appears to apply to those cases which are secondary to splenic abscesses.

Pain is nearly always the first symptom of the onset of a subphrenic abscess. It was noted in 56 of 76 cases, and was referred in every case to the situation where the abscess afterwards formed. In cases due to perforative peritonitis it was sudden, severe, and stabbing, whilst in extraperitoneal cases it was gradual in onset and aching in character. In 4 gastric cases the pain suddenly supervened after a full meal.

Vomiting is the next symptom in point of frequency and time, and occurred in 29 of 76 cases. It is almost entirely restricted to those subphrenic abscesses which originate in a perforative peritonitis, and especially to gastric and duodenal cases.

Nausea, hic-cough, and collapse were described in a few histories of the onset of subphrenic abscesses. In 8 of 76 cases it was stated that the acute onset was followed by a period of obstinate constipation, no doubt due to the peritonitis, but as will be pointed out later, as the abscess becomes well localized septic diarrhoea nearly always appears.

Haematemesis and melaena bear a dual relation to subphrenic abscesses. In the majority of cases they are due to haemorrhage from a gastric or duodenal ulcer, which subsequently perforates, and are a part of the previous history, but in a few cases they arise from a chronic and insidious subphrenic abscess which has ruptured into the stomach and has then become acute in its progress. In the latter case they are described under the onset.

II. The General Signs and Symptoms of Suppuration.

In nearly all cases of subphrenic abscess an examination of the general symptoms has made it clear that a collection of pus was present in some part of the body, and when the rest of the body, including the pelvis and thorax, had been excluded, it was probable that the abscess was beneath the diaphragm. These septic symptoms were as follows: The patient's tongue was dirty and often dry and cracked. His face was pale, anaemic, and muddy, an appearance which I have elsewhere described as the *purulent complexion*. The majority of cases were covered in a profuse sweat, which soaked the pillow, and were

weak, listless, short of breath, and had no appetite for their food. Some suffered from a great thirst. They were thin and emaciated, and had lost from 1 to 2 st. in weight since the onset of their illness. This wasting is a very constant sign. The majority suffered from a profuse septic diarrhoea, but not a few continued constipated.

Pyrexia was always present. As a rule it was low (100° to 101°), sustained, and rocked night and morning. In several cases, however, it frequently reached normal, and was never above 100° F. These cases were well localized, or had ruptured into the stomach or intestine. On the other hand, in the diffuse and acute stages temperatures as high as 104° to 105° F. were often recorded.

The pulse rate per minute varied according to the degree of

localization of the abscess. In many cases it was no faster than 70 to 80, and as a rule was about 100, but in acute cases it often reached 130 or 140 per minute.

Rigors occurred in 10 of 76 cases, and of these 6 died, so that this is a very fatal symptom. In 5 pyaemia was present, but 2 of these were very chronic cases, and recovered. In 2 a perigastric abscess freely communicated with the stomach. One was due to suppurative cholangitis, and 1 to acute periostitis of the transverse process of the second lumbar vertebra.

Parotitis was present in 1 gastric case, which did not live.

Petechiae and other cutaneous signs of pyaemia were present in 2 cases, of which 1 succumbed, but the other recovered.

Albuminuria was present in 1 case and *delirium* and *coma* in another.

Leucocytosis was noted in all the cases examined. In 2 cases it was as low as 11,000 per c.mm. In 2 cases a differential count was made, and in one of these the polymorphonuclear cells numbered 71.5 per cent. and in the other 87 per cent.; in the others it is simply stated they were in great excess.

Leucocytosis appears to be a most valuable sign, and it is to be regretted that it was not sought for more frequently in this series.

Eosinophilia was noted in 2 of 3 cases of subphrenic abscess due to hydatids of the liver in which it was looked for.

III. The Abdominal Signs and Symptoms of Subphrenic Abscesses.

An abdominal swelling was described in no less than 50 of 76 cases of subphrenic abscesses. In 33 of these the

Fig. 10.—From a specimen in the London Hospital Museum, prepared by Dr. Cecil Wall. A left anterior subphrenic abscess, L.A.S., communicating with the stomach S through a perforation P.S. The cavity of the abscess is laid open by an incision turning up a flap of the diaphragm D. It is limited to the right by the falciform ligament F.L. Another perforation, P.B., connects the abscess through the diaphragm with a bronchus. P, Pericardium. L, Liver. A, Aorta.

swelling was due to the abscess and the peritoneal adhesions round it. In the remaining 17 cases the swelling was the liver, but in 14 of these a hepatic abscess was present. In the remaining 3 cases, in one the edge of the liver only was felt, in another a Reidel's lobe was present, and in the third case the pus was in the right extraperitoneal cellular space. When the pus was located between the liver and diaphragm within the peritoneum, the liver was not pushed down in a single instance, because it was adherent to the diaphragm along its lower margin, as has already been explained under "Pathology."

The abdominal swelling formed by a subphrenic abscess does not descend on respiration, because it is adherent. The part of the swelling formed by peritoneal adhesions is rigid, tender, and dull on percussion. The part formed by pus in contact with the abdominal wall is scarcely tender, bulges and fluctuates, and is dull on percussion. Where gas is present in the abscess a tympanitic area is formed, as a rule, high up in the epigastrium, and over the liver dullness, amphoric and coin sounds can be obtained, and the tympanitic area travels round the chest as the patient is rolled over.

In only 2 of 76 cases was the liver dullness recorded to be lost, although this is usually considered a very constant sign of perforation. The special shape and signs of abdominal swellings in the different anatomical varieties of subphrenic abscess are recorded under that heading.

The veins of the abdominal wall were listed in one case, and in another a peritoneal rub was heard and felt over the lower margin of a subphrenic abscess. Ascites was also present in one case,

Fig. 11 shows the diagnostic triangle of a left anterior intraperitoneal subphrenic abscess. F, Falciform ligament convex to the right. A, Broad band of adhesions, tender and rigid, stretching from umbilicus to costal margin. CM, Costal margin. P, Bulging lower part of area of triangle, dull, and not very tender, occupied by pus. C, Circular area over liver dullness, tympanitic, amphoric, and coin sounds travelling to the left as the patient is rolled over. This is due to gas in the abscess, and is seldom absent in this situation. L, Liver.

whilst pus was discharged from the rectum in a like number.

IV. The Thoracic Signs and Symptoms of Subphrenic Abscesses.

Thoracic signs were present in 56 of 76 cases of subphrenic abscess, and were only stated to be absent in 3 cases. In 41 cases the signs were present at only one base, but in 15 cases they were described at both. In 2 gastric cases the abscess was on one side and the basal signs on the other. The conditions indicated by these signs were those of compression, and inflammation of the base of the lung and pleura, namely:

- (a) Displacement of the lung upwards, and obliteration of the lower pleural angle.
- (b) Dry pleurisy.
- (c) Pleural effusion.
- (d) Compression of the lung.
- (e) Consolidation of the lung.
- (f) More or less bronchitis at the base.

The most frequent association of signs at the base was dullness (30 cases), with diminution or absence of breath sounds (22 cases), vocal resonance (12 cases), and tactile vocal fremitus (16 cases).

Pleuritic friction sounds were only recorded in 7 cases.

Dullness on percussion was also associated with tubular breath sounds (9 cases), and increased vocal resonance (5 cases).

Râles, rhonchi, and crepitations were recorded in 3 cases.

In 9 cases tympanitic, amphoric, and coin sounds were discovered at the base of the thorax, usually over the liver dullness, and were proved to be due to gas below the diaphragm. In 6 of these the resonance shifted with position.

The gurgling of gas and fluid was heard in one case, and a very sudden spread of dullness up the thorax was noted in another, and was proved at the operation to be due to a clear pleural effusion. The thorax was recorded to have moved less on respiration on the affected side in 12 cases.

Pericarditis was noted in only one case.

The position of the heart apex beat was noted in 9 cases.

It was displaced upwards, but was very little if at all moved laterally in 7 cases.

In 2 cases in which pleural effusions complicated the subphrenic abscess, the apex beat was considerably displaced to the other side.

Pain on deep inspiration and coughing was noted in 5 cases.

A severe cough was recorded in 17 cases. In 8 of these pus was expectorated, and in 2 cases blood; whilst 1 patient expectorated pus and flatus, with collapse and profound mental anxiety.

In 5 cases it is definitely stated that thoracic symptoms were present without expectoration.

Dyspnoea was present in 7 cases, and varied from 32 to 48 breaths a minute. The average was 37.

The alae nasi were seen in active movement in several cases.

V. The Local Signs of Subphrenic Abscess.

These local signs were found over the abscess and encroaching upon the thorax and abdomen or both:

The abscess caused a visible bulging of the thorax or a definite swelling in the abdomen in no fewer than 46 of 76 cases. These swellings were located as follows:

Beneath the lower ribs, 11; in the right hypochondrium, 12; in the left hypochondrium, 15; in the epigastrium, 3; in the left loin, 3; in the right loin, 1; in the left abdomen, on a level with the umbilicus, 1.

In several cases the circumference of the thorax at the level of the ensiform cartilage was shown by the tape measure to be from 1 to 3 in. greater on the side of the abscess.

Deep tenderness was elicited in 25 cases on palpating deeply over the swelling. In 4, between the ribs; in 10, in the right hypochondrium; and in 11 in the left hypochondrium.

The x rays demonstrated the abscess as a dark shadow in the only case in which it was used.

Oedema was recorded over the abscess in 4 cases, and the veins were noted to be enlarged in 2.

The signs which indicated that the swelling contained gas, pus, or was formed of peritoneal adhesions have been already described under the heading of "Abdominal Signs." The most conclusive and certain sign, however, is needling; but this matter must be discussed at length.

THE EXPLORATORY NEEDLE IN SUBPHRENIC ABSCESS.

The most careful examination often fails to make it certain whether a subphrenic abscess is present or not. If pus is then found below the diaphragm with the exploring needle, the case at once becomes clear, and the abscess can at once be opened. On the other hand, many authorities (Dr. Acland) are opposed to the use of the exploring needle because it is not free from the risk of infecting the pleura, and because when the result of a puncture is negative, doubt and delay are only increased. This impeachment is confirmed by the experience of the

Fig. 12.—A subphrenic abscess occupying the small sac of the peritoneum. The lower part of the cavity is obliterated by adhesions. Above, the cavity extends up in a narrow pouch between the Spiegelian lobe and the crus of the diaphragm. P, Pancreas in posterior wall. S, Stomach in front with lesser omentum. C, Transverse colon below with its mesocolon.

hollow needle at the London Hospital. Of 76 cases the aspirating needle was employed in 18, and in 11 of these the pus was not found. In 1 of these further measures were delayed for twelve days, and in another for five days, and in the others for various periods. In 1 case nothing was found on puncture with the needle at the right base, but the patient collapsed and died three hours later, and it was then found that a pint and a half of turbid offensive pus had passed through the puncture from the right subphrenic space into the pleura; and the lung was collapsed.

It is therefore clear that a promiscuous search for pus with an ineffective syringe is dangerous and deceptive.

On the other hand, the proper use of a good aspirating needle upon the operating table, and under a full anaesthetic, is the most certain means of diagnosis we possess, and it has never failed or deceived in my own experience. The only safe rule in thoracic operations is to follow the needle, and it is useless to make a large opening and admit air to the pleura where the needle can demonstrate that no pus is present.

It may seem too elementary a matter to discuss the character of an efficient aspirating needle, but no other instrument is so often badly made and out of repair. The needle should be of large calibre so that thick pus and

the base of the other lung, which was also dull, and the patient did not survive.

When the signs and symptoms indicate the presence and location of pus below the diaphragm, the patient should be prepared for operation and fully anaesthetized, and only then should the needling be carried out. With the patient in the semi-prone position, I begin by passing the needle deeply into the tenth intercostal space in the scapular line, and then, if no pus is found, into the ninth, eighth, seventh, and sixth spaces in turn. I then search the spaces in the mid-axillary line, from below up. Several signs indicate that the needle has passed through the diaphragm. There is often the sensation of a second obstacle through which the needle is thrust. A deep puncture of, say 3 in., in the lower intercostal spaces is certain to pass through the diaphragm. When the end of the needle is through the diaphragm and the latter is not paralysed by the inflammation, the barrel of the syringe moves up and down with respiration (Furbringer's sign). This is practically a very constant sign, although when the diaphragm is paralysed the movement may be absent or even reversed (Devic and Challer). Finally, the character of the blood drawn into the syringe is an indication of where the point of the needle is. Blood from the liver is dark venous, and is often obtained in quantity from the hepatic sinuses. On the other hand, blood from the lung is foaming and scarlet, and is not obtained in large quantity unless a big vessel is entered, when haemoptysis follows; but this is a very rare occurrence, and is practically never a serious matter.

The needle should be passed in to its full depth of about 3 in., and then slowly withdrawn whilst suction is

Fig. 13.—The signs of a right extraperitoneal subphrenic abscess, RES, pointing in the epigastrium below the ensiform process, E, and having separated the layers of the falciform ligament, FL, so that the abscess may be opened extraperitoneally. Note that the liver is well pushed down in this case, and freely movable. Compare Fig. 4.

Fig. 14.—(From Kelly's *Appendicitis*.) Showing "Fowler's position" to prevent purulent serum gravitating into the subphrenic spaces in cases of diffuse peritonitis. The arrows indicate how in the sitting-up posture fluid flows into the pelvic pouch, from which it can be drawn off by a tube passed through a suprapubic puncture.

lymph may be drawn through it. It must be at least 3 in. long, so that deep collections of pus may be reached, and well tempered, so that it may not break in the patient. I have removed two broken needles from the thoracic wall under these circumstances. The syringe must not leak either round the piston or where the needle is attached to it. The best way of testing this is to draw a little water into the syringe, and then plunge the end of the needle into a bar of soap, and draw the piston out to the full extent. It is easy then to see if the air enters at these points, and on releasing the piston it should fly back to the surface of the water, and no bubble of air should have appeared. If this precaution is not taken, and the syringe becomes filled with gas during its use, the operator cannot be certain that the gas entered from the point of the needle. Finally, the needle must be made of such material that it may be boiled for aseptic reasons. M. s. rs. Krohne and Sesemann have made a very good needle which meets all these requirements.

During its use the syringe should be washed free of blood between the punctures in sterile water, and carbolic and other antiseptic lotions should be avoided because they render clear serum and blood turbid, and simulate purulent fluids very closely. When air has filled the syringe whilst the thorax is being explored the needle should be withdrawn in order to expel the air, and the syringe should never be unscrewed from the hollow needle whilst it is *in situ*, otherwise air may enter the pleura and the lung collapse. In one lamentable case of empyema with which I was acquainted this accident happened to a medical man whilst he was puncturing

maintained. Timidity may lead the operator to only enter the pleura, from which he may obtain nothing, or only clear serum. Thus in the 11 cases at the London Hospital in which pus was present below the diaphragm, and the hollow needle failed to find it, in 5 nothing was withdrawn, and in 4 clear serum was obtained, and in 2 blood-stained serum.

When pus is found, and the needle is known to be below the diaphragm, the diagnosis of subphrenic or hepatic abscess is certain. When different fluids are withdrawn at different depths, or at separate punctures, the diagnosis is also highly probable. Thus clear serum and pus may be associated, or foul gas and clear serum, or even foul pus and sweet pus.

Needling should never be abandoned until it is certain that no pus is present; and it may be added that although the method is so free from risk when practised through the thoracic wall, as recommended above, it is never safe to puncture abdominal swellings across the peritoneum and through the abdominal wall, because they afterwards leak into the peritoneum. Thus a tuberculous pyonephrosis which was punctured in the loin, led to acute general peritonitis. When pus has been found, the rib below should be resected, and after the diaphragm has been sewn to the intercostal muscles, I usually make another puncture before incising it.

THE OPERATIONS FOR OPENING SUBPHRENIC ABSCESSES.

The methods employed to drain subphrenic abscesses may be arranged as follows, and I have added the number

of cases treated by each method among the 73 operations performed on 64 cases at the London Hospital (1900-1907):

		Operations.	Deaths.
A.—THORACIC.			
Posterior transpleural (Scapular line)	Right	11	3
	Left	3	1
Subpleural... ..	Right	0	0
	Left	1	0
Anterior transpleural (Nipple line)	Right	0	0
	Left	1	1
Subpleural... ..	Right	2	1
	Left	1	0
Lateral transpleural (Axillary)	Right	1	1
	Left	0	0
Subpleural... ..	Right	3	2
	Left	0	0
B.—ABDOMINAL.			
Median	—	5	1
Hypochondriac or epigastric ..	Right	17	9
	Left	17	5
Loin	Right	6	2
	Left	5	1

Speaking in a general manner, posterior methods of drainage are more favourable than anterior. In the above series 26 posterior operations were performed, with 7 deaths (27 per cent.); 43 anterior operations, with 17 deaths (39.5 per cent.); and 4 lateral, with 3 deaths (75 per cent.).

I have performed 24 operations on 21 patients for subphrenic abscesses; 15 of these were posterior, with 2 deaths—13.3 per cent.; 9 were anterior, with 2 deaths—22.2 per cent. The posterior routes should always be adopted when it is possible.

The Posterior Transpleural Thoracic Operation.

As far as possible this operation is carried out in the line of the angle of the scapula, with the patient semi-prone. The exploring needle is inserted through the intercostal spaces, in turn from below up, beginning at the tenth space. When pus is found 3 in. of the rib below is resected, whilst an assistant presses up the liver on the right side to obliterate the pleural cavity, should it be open. The diaphragm is then firmly fixed to the intercostal muscles with three or four interrupted catgut sutures inserted by a sharply curved needle in a handle. Pus is then once more found with the exploring needle before the diaphragm is incised, and a finger passed into the abscess cavity. This finger should hook the diaphragm well up against the thoracic wall whilst the pus escapes, and before it is withdrawn the diaphragm and intercostal muscles should be sewn together by a continuous catgut suture. This should be done whether adhesions are present or not, for as the abscess emptied and the diaphragm descended, the adhesions gave way in 5 cases in my series, and pneumothorax resulted, in 2 cases at the operation, and in 3 cases after a day or two. Silk should not be employed for these sutures, because in one case a sinus persisted for two and a half years, but closed as soon as a stout silk suture was discharged. As large a drainage tube as is convenient should be employed, and irrigation, suction, and position may be employed to clear the cavity after a day or two.

No rib higher than the seventh should be resected, for great difficulty will then be found in bringing the diaphragm up to the thoracic wall. The exploring finger in a right anterior intraperitoneal subphrenic abscess can often feel the upper surface of the liver deeply cupped below, whilst above the diaphragm is thrown into great folds which contract in a futile manner at each inspiration.

The Posterior Subpleural Thoracic Operation.

When the tenth or eleventh ribs have been resected in the line of the angle of the scapula, it is stated by Elsberg that the reflection of the pleura may be recognized and pushed up before the diaphragm is incised. This method is, however, needless if the above precautions are taken

to prevent air and pus from entering the pleura (see also Figs. 15 and 16).

The Anterior Subpleural Thoracic Operation.

Landau has pointed out that in the mammary line about 2 in. intervenes between the costal margin and the reflection of the pleura. If the costal cartilages are resected over this space an incision may be made through the diaphragm, below the pleura, and above the peritoneal adhesions shutting in the abscess. This method is especially adapted to left anterior perigastric abscesses. It may also be used at other positions on the costal margin, but the space is narrower there (Figs. 15 and 16). The series of 78 cases at the London Hospital contained 8 such operations with 5 deaths (62.5 per cent.), and in several of these the pleura was opened none the less; the operation is moreover anterior, and drains badly.

The Median Abdominal Operation.

This route is usually adopted when a strictly median swelling is pointing in the epigastrium, and when the exploring needle has shown that the pus cannot be reached from behind. When the swelling is due to a right extra-peritoneal, or hepatic abscess, tracking forward between the layers of the falciform ligament, it is possible to open the abscess without wounding the peritoneum if the incision is strictly median (see Fig. 13), and the opening is deepened at the upper end immediately below the ensiform process. I have operated on two such cases successfully. An abscess occupying the small sac of the peritoneum may project forwards between the liver and the stomach. The general peritoneal cavity is then opened, and the bulging small omentum is sewn to the parietal peritoneum before it is incised, and a large drainage tube is inserted. I have drained one such case, and at the autopsy, three weeks later, the cavity was found empty and nearly closed. Death was due to suppurative cholangitis and pyaemia.

Right and Left Hypochondriac and Epigastric Operations.

These operations are adapted to the drainage of those right and left anterior intraperitoneal abscesses which present in the epigastrium, and give rise to the triangular swelling which is described under the headings of these special forms of subphrenic abscess. Even when an anterior swelling is present I prefer the posterior transpleural route if the exploring needle finds pus behind.

When it has been decided to open the abscess from in front, a vertical incision is made well within the triangle. It must not encroach at all on the band of adhesions below, lest the pus or gastric juice should be admitted to the general peritoneal cavity. The incision is therefore deepened at its upper end, and I prefer to incise the peritoneum in the angle between the costal margin and the ensiform process.

The Loin Operation for Subphrenic Abscess.

The right loin operation is adapted to the drainage of the early and diffuse infections of the subhepatic pouch and the right anterior intraperitoneal fossa when the liver is not firmly adherent to the diaphragm. At all stages it is the method to be selected for the drainage of the subhepatic pouch. On the left side it is employed alone for the diffuse stage of peritonitis. In some cases, where a very large left anterior intraperitoneal subphrenic abscess has been opened in the left epigastrium and projects sufficiently below the ribs, it may be counter-opened in the left loin.

The incision is an oblique one downwards and forwards, far back, and high up in the loin. When the peritoneum is opened, should no adhesions be present, the general peritoneal cavity is packed off with gauze below and in front. The index finger then feels for the margin of the liver on the right side, and is passed transversely below it into the subhepatic pouch, into which a drainage tube can then be introduced. Should the signs indicate the presence of pus in the right anterior intraperitoneal subphrenic space and in all doubtful cases, the finger is then insinuated between the liver margin and the diaphragm separating the adhesions. A drainage tube is then introduced up the side of the finger and pushed up under the dome of the diaphragm as far as it will go—a distance often of 6 in. or 7 in. Should a lumbar abscess be present, a tube may be passed down the loin. In one case I opened and drained a large perinephritic and retrohepatic

abscess from the posterior angle of this wound in addition to intraperitoneal abscesses in front. The procedure is very similar upon the left side, but here the exploring finger feels for the tail of the spleen, and the tube is pushed up into the left anterior intraperitoneal fossa. When the abscess is retroperitoneal and left, it usually projects in the loin, and an incision is made over its most prominent part and a tube passed up under the diaphragm as before.

The Methods of Irrigation Suction and Position in Dependent Cavities.

When it has been found necessary to open a subphrenic abscess from the front the cavity is usually dependent, so that gravity does not ensure complete drainage. The methods which should then be adopted are as follows:—The largest size of drainage tube ($\frac{3}{4}$ in.) should be passed to the very bottom of the cavity to act as a well for the pus. A long strip of gauze may be passed down the inside of this to soak up the fluid by capillary action into the dressings. Twice a day the cavity should be washed clean

Fig. 15.—From Kelly. Shows the reflexion of the pleura, R.P., in a lateral thoracic subpleural operation. The writer does not favour the lateral operation, nor in his experience is the subpleural space so liberal as is indicated here in the ninth intercostal space.

with sterile water, or very weak carbolic (1 in 100), through an elastic catheter passed down the inside of the drainage tube to the bottom of the cavity. The cavity should then be sucked dry by the same catheter applied to a syringe. At intervals during the day the patient should sit up and lie semiprone on the opposite side to the abscess cavity, so that the contents may gravitate along the tube. With these precautions the temperature will remain normal, the abscess will rapidly close, and very little tendency will be shown by the abscess to pocket and track, although a constant watch should be kept on neighbouring cavities and fossae.

THE MORTALITY OF SUBPHRENIC ABSCESSES.

Of the 78 consecutive cases which make up this series, 40 lived and 36 died, a mortality of 47.4 per cent.; 12 cases were not operated upon, and none of these survived, a mortality of 100 per cent.; 64 cases were operated upon (by 73 operations) of the series of 76 consecutive cases, and of these 24 died, making a mortality of 37.5 per cent. These operations were divided up as follows: 26 posterior operations with 7 deaths, 27 per cent.; 43 anterior operations with 17 deaths, 39.5 per cent.; and 4 lateral operations with 3 deaths, 75 per cent.

Posterior operations are therefore more favourable. Of my own series of 21 consecutive cases submitted to 24 operations, 4 died, 19 per cent.; 15 of these operations were

posterior, with 2 deaths, 13.3 per cent.; and 9 were anterior, with 2 deaths, 22.2 per cent.

I have analysed the cause of death in 36 cases, and have found that it was unavoidable in 12 cases, and might have been avoided in 24 cases. The 12 unavoidable causes of death were 5 multiple abscesses of liver, 2 cancers, 2 lung complications, 2 hourglass stomachs, and 1 general peritonitis. It has been truly said that "wise men learn by others' experience," and it will therefore not be time wasted to consider in detail the 24 deaths which may be classed as avoidable. In 12 cases the condition was not diagnosed and no operation was performed. For the most part these cases died in the medical wards. In 8 cases an anterior incision was made into the abscess, which was inefficiently drained. Other loculi of pus were left undrained in several cases. By a fuller knowledge of the subphrenic spaces, and further incisions, these cases might have been saved. In 2 cases the transpleural method was adopted during the acute and diffuse stage, when the loin incision was indicated. The pus was not efficiently drained, and in one case the lung collapsed. In one case

Fig. 16.—(From Kelly's *Appendicitis*) "The lateral subpleural thoracic operation." RAIA is a right anterior intraperitoneal abscess, which, having localized below the diaphragm, has extended down as low as the tenth space. The pleura, P.O., is obliterated below, and the lung, L, is pushed up. The reflexion of the pleura, R.P., is seen below. The ninth or tenth rib has been resected, and the exploring needle is being inserted below the pleura. Below the adhesions, A, of the liver to the diaphragm are seen shutting off the abscess. These adhesions might in a recent case be separated by a finger passed upwards through an oblique loin incision, but after ten days the liver would probably be torn. This figure illustrates the advantages of waiting a reasonable time for a subphrenic abscess to develop.

a puncture by a needle failed to find pus, but admitted more than a pint of pus and gas to the pleura. In one case an epigastric incision was prolonged downwards beyond the line of adhesions, so that when the abscess which communicated with the stomach was opened in the upper part of the incision, it gravitated into the general peritoneal cavity in the lower angle of the wound.

In short, half the avoidable deaths may be attributed to the fact that the condition was not diagnosed at all. The other half to the absence of exact and detailed knowledge of the localization and character of subphrenic abscesses on the part of the surgeons when they were planning and executing their operations.

With a perfect opportunity, knowledge, and technique these 76 cases might have been treated with an ideal mortality of no more than 16 per cent.

The diagrams illustrating this paper were drawn by Dr. Stanley Beale, to whom my best thanks are due for their skill and lucidity. [Appendix on page 436.]

REFERENCE.

1 *Diseases of the Stomach*, 1904, p. 320.

APPENDIX.
Anatomical Varieties.

	No. of Cases.	Simple.	Compound.
A.—INTRAPERITONEAL.			
I. Right:			
(a) Anterior	27	11	16
(b) Posterior	10	0	10
II. Left:			
(a) Anterior	30	26	4
(b) Posterior	3	1	2
B.—EXTRAPERITONEAL.			
I. Right	19	13	6
II. Left	4	4	0
Not classified	2	—	—

Simple = One cavity only involved.
Compound = Two or more cavities involved.

Anatomical Varieties according to Causes.

Anatomical Variety.	Gastric Ulcer.	Appendicitis.	Hepatic Abscesses.	Duodenal Ulcer.
Intraperitoneal right anterior.	4	10	7	1
Intraperitoneal right posterior	1	6	1	2
Intraperitoneal left anterior ...	16	1	1	1
Intraperitoneal left posterior...	2	0	0	0
Extraperitoneal right.....	0	1	15	2
Extraperitoneal left	1	0	0	0

Etiology.

	Cases.
Gastric ulcer	21
Gastric cancer	2
Appendicitis	12
Liver: Suppurating hydatid ...	8
" Tropical abscess	6
" Abscess	1
Pylephlebitis	1
Suppurative cholangitis	1
Duodenal ulcer (anterior)	3
Duodenal ulcer (posterior)	2
Splenic abscess	3
Pyæmia	3
Parturition	3
Thoracic pneumonia	1
Thoracic bronchiectasis	1
Thoracic empyema	1
Periostitis of vertebrae	2
Operations resections... ..	2
Pancreas cancer	1
Kidney cystic	1
Intestine ruptured	1
Typhoid	1
Gall stones	1
Pyosalpinx	1
No cause found	2

Age of 75 Cases of Subphrenic Abscess arranged in Decades.

Age	0-10	10-20	20-30	30-40	40-50	50-60	60-70
Cases	6	5	29	15	13	6	1

Sex of 76 Cases of Subphrenic Abscess.

	Cases.	Per Cent.
Male	43	56.6
Female	33	43.4
Total	76	100

The Spontaneous Rupture of 23 Cases of 76 Subphrenic Abscesses.

Into—	Cases.
A bronchus	4
The pleura, right	2
" left	3
The general peritoneum	1
The stomach	8
The intestine	1
The colon	2
The skin (a) umbilicus	1
(b) right hypochondrium	1
	23

Micro-organisms found in Pus of Subphrenic Abscesses.

Number examined	Cases.
Sterile	12
<i>B. coli communis</i>	3
<i>Staphylococcus aureus</i>	3
<i>Streptococcus</i>	2
<i>Pneumococcus</i>	1
<i>B. pyocyaneus</i>	1
<i>B. typhosus</i>	1

Onset in 76 Cases of Subphrenic Abscesses.

Acute	40 cases = 62.6 per cent.
Subacute	
Chronic	36 " = 47.4 "

Gastric ulcer (21 cases):	
Acute	15
Subacute	6
Chronic	
Gastric cancer (2 cases):	
Acute	0
Subacute	2
Chronic	
Appendicitis (12 cases):	
Acute	12
Subacute	0
Chronic	
Hydatid of liver (8 cases):	
Acute	6
Subacute	
Chronic	
Hepatic abscesses (7 cases):	
Acute	1
Subacute	6
Chronic	
Duodenal ulcer (5 cases)	
Anterior (= Acute)	2
Posterior (= Subacute)	
Splenic abscess (3 cases):	
Subacute	3

The Significance of Rigors in Subphrenic Abscesses.

Number recorded	Cases.
Died	10
Pyæmias (2 chronic ones lived)... ..	6
Communicated with stomach	2
Suppurative cholangitis	1
Acute periostitis	1

The Use of the Aspirating Needle in Eighteen Cases of Subphrenic Abscesses. Some Several Times.

	Cases.
Failed to diagnose	11
Pus	7
Foul pus	2
Anchovy pus	1
Pus and serum	1
Clear serum	4
Blood-stained serum	2
Gas	2

Mortality of 76 Cases of Subphrenic Abscess.

	Deaths.	Per cent.
76 cases	36	47.4
12 cases no operation	12	100.0
64 cases operated on	24	37.0
21 cases operated on by author	4	19.0

ANALYSIS OF 36 DEATHS.

A, Unavoidable.—12 deaths = 16 per cent. (about).

Multiple abscesses of liver	5 cases
Cancers	2 "
Hourglass stomach	2 "
Lung complications	2 "
General peritonitis	1 case

B, Avoidable (probably).—24 deaths.

Not operated on	12 cases
Anterior operation: other pouches left	8 "
Transpleural operation in diffuse stage	2 "
General peritoneum opened by anterior incision	1 case
Inefficient needling	1 "

The Ideal Mortality of Subphrenic Abscess = about 16 per cent.