ORIGIN AND COURSE OF INFECTION IN SUBPHRENIC ABSCESS

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There has been considerable discussion as to the avenue by which infection reaches the diaphragm. Although there are many sources from which infection may extend to the diaphragm to produce abscess, such as appendicitis, perforated peptic ulcer, cholecystitis, ruptured diverticulitis, furunculosis, and other septic foci in the body, the most common site of origin is either an appendiceal abscess or a perforated peptic ulcer. In 890 observations, Piquand[1] found 251 cases of gastric origin, 191 appendiceal, 131 hepatic, fifty intestinal, forty splenic, twenty-seven pancreatic, twenty-six renal, seventeen genital, and thirty-two originating in the thorax. These figures agree with statistics compiled by Barnard,[2] Lockwood,[3] and Fifield and Love,[4] who name peptic ulcer, biliary disease and appendicitis as the principal sources of infection.

From a study of our own twelve cases of subphrenic abscess and from opinions expressed by contemporary authors, we are led to believe that the most common channel of infection is by way of the lymphatics. In studying their function as conveyors of infection it is difficult to determine the exact anatomical relationships involved. To secure a clear picture of lymphatic distribution it is essential to review the methods by which the lymphatic system was outlined by three investigators during the previous century.

First was the method of Mascagni,[5] which was published near the close of the Eighteenth century. It consisted of the injection of a colored solution of gelatin into the arteries. The solution after filling the blood-vessels passed through their walls, permeated the surrounding tissues, and was taken up by the lymphatics. Dilated by this liquid, which soon coagulated, the lymphatic vessels were made to stand out quite clearly. Then they were injected with mercury and traced throughout the course of their small branches. This method was incomplete, however, because it did not show the lymphatic trunks nor the entire network of capillaries. Thus at the end of the Eighteenth century we knew how the lymphatics united in their course and how they terminated, but not their origin. Mascagni left this great problem for his successors to solve.

The second method of showing the lymphatics appeared in 1830. It was introduced by Fohmann and Panizza.[6] After injecting mercury under the skin, mucous membrane, or serosa, they dissected up these layers and found the anastomosis of the first radicles of the lymphatic system. But this brilliant network did not include the lymphatic trunks. Viewed with the naked eye they appeared excellent, but under the microscope they lost all importance because they seemed to indicate that lymphatic trunks did not exist.

The German method was applied to the absorbent epithelium of the vessels. By the use of silver nitrate, von Recklinghausen,[7] in 1865, outlined this layer of cells and made it possible to examine the vessels under the microscope. This method offered great hopes, particularly in demonstrating the star-shaped cells indicating the origin of the lymphatic capillaries. But this silver stain often gave a result that was variable and a picture

difficult to interpret. It possessed distinct advantages and was used about twelve years, but it was still an intermediate step.

Sappey's[8] researches in 1874 differed entirely from those which had preceded. In order to bring the vessels into plain view, he did not direct his attention to the wall of the vessels but to their contents. He used the lymph itself as a means of investigation. He believed that if he could color the contained lymph, it would offer the best agent for determining the source from which it came. After lengthy and laborious study, he found a suitable color which imparted a dark tint and appeared almost black. Presently the flow of lymph through a network of transparent threads produced a deep tint in separating perfectly on the background of the preparation. Thus to the observer the conditions presented were similar to those of the capillaries when naturally or artificially injected. In this manner Sappey obtained the greatest degree of enlargement of the vessels and revealed the lymphatic trunks.

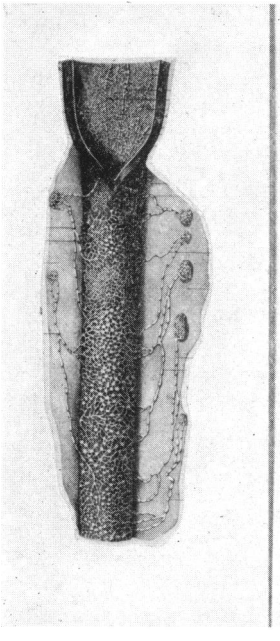

FIG. 1.

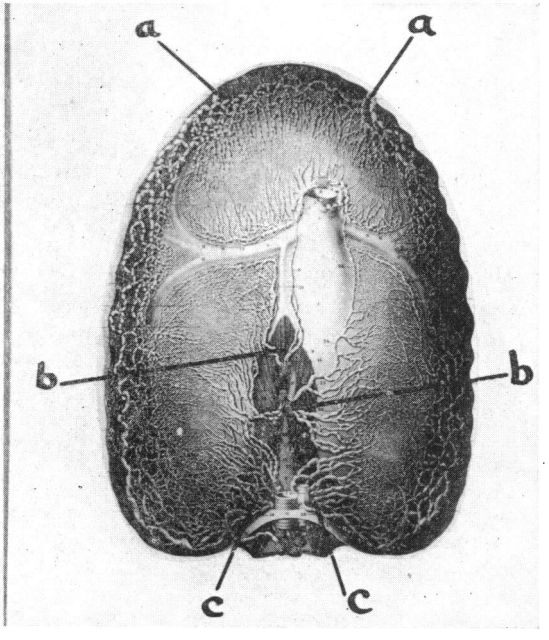

FIG. 2.

Following these collective researches, MacCallum,[9] of Johns Hopkins, in 1903, may be considered to have contributed more than any of his predecessors to our knowledge of the complicated process by which granular materials are absorbed by the diaphragm through the peritoneum under normal and pathological conditions. He chose the diaphragm as the most important absorbing area of the peritoneum and studied in detail the anatomy of the tissues which separate the lumen of the lymphatic channels from the cavity of the peritoneum. On the pleural surface of the diaphragm the lymphatics anastomose abundantly and form a network over the whole surface. On the peritoneal side the lymphatics are arranged differently. In their arching course they lie in spaces between the connective-tissue fibres and are separated from the peritoneal cavity by an extraordinarily thin layer of tissue. These thin areas form the most favorable site for the entrance of materials from the peritoneum. These sac-like channels appear as small, diamond-shaped clear areas and are plainly seen in the accompanying illustration of the œsophagus. (Fig. 1.) When granular material is injected into the peritoneal cavity,

we find that these blind sacs or *lacunæ* in the diaphragm become injected with the granular substance, and from them we can trace the material into the anastomosing trunks of the pleural network, then into the efferent trunks, and on into the mediastinal lymph-glands.

MacCallum studied this tissue further by employing thin paraffin sections fixed in Zenker's fluid. The lymphatics were injected with an 0.5 per cent. solution of silver nitrate followed by agar which when cooled kept the channels widely distended. In this way the smoothly stretched lining could be studied. It was discovered that the endothelial lining of the lymphatics was complete with no perforations, and that the peritoneal

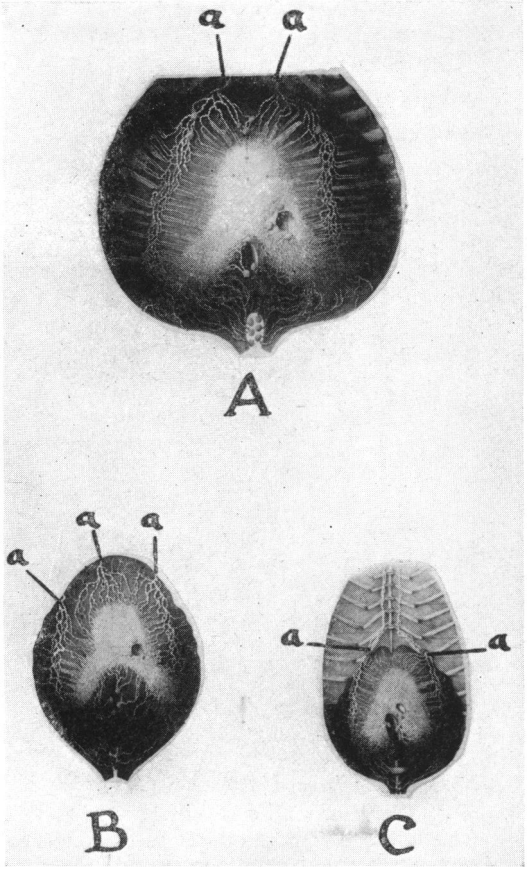

FIG. 3.

epithelium like the lymphatic endothelium was a complete membrane. The nature of the tissue between the peritoneal epithelium and the endothelium of the lymphatics was next studied. This basement membrane was demonstrated by Bizzozero,[10] Vincenzi,[11] and Muscatello,[12] who macerated the tissue in Müller's fluid and alcohol and found that it could then be readily torn away in small strips. MacCallum found no communication between this basement membrane and the lymphatic *lacunæ*. These *lacunæ* were the absorbing terminals of the diaphragmatic lymphatics, had a complete lining endothelium, and were separated from the peritoneal cavity by loosely woven connective tissue and the peritoneal epithelium.

MacCallum was forced to conclude that absorption of granular material was brought about by phagocytosis. He demonstrated this by injecting a suspension of carmine into the peritoneum of a rabbit. After a few hours, examination of the diaphragm showed the *lacunæ* sprinkled over with leucocytes which swarmed over the surface of the *lacunæ* and could be seen in large numbers making their way with the load of pigment through the roof of the *lacunæ*. Finally, the endothelial cells in the lymphatics became swollen with pigment.

CHART

ANALYSIS OF CASES		
Total Number Cases		12
I	Sex	(a) Males 8 (b) Females 4
II	Age	(a) Oldest 72 (b) Youngest 20 (c) Average 44.5
III	Symptoms	(a) Septic temperature 12
		(b) Definite leucocytosis 11
		(c) Local pain and tenderness 12
		(d) Evidence of fluid in chest 3
		(e) Referred pain to shoulder 3
		(f) Fecal expectoration 4
IV	Cause	A. Following initial operation, for– 8
		(a) Acute suppurative appendicitis 4
		(b) Perforated duodenal ulcer 2
		(c) Acute cholecystitis 1
		(d) Carcinoma of oesophagus 1
		B. Abscess present on entry; origin undetermined 4
V	Type of Drainage	(a) Thoracic 5
		(b) Abdominal 5
		(c) Abscess undrained 2
VI	Result	(a) Died 9
		(b) Recovered 3
VII	Operative mortality	70%
	Total mortality	75%

Although MacCallum observed that individual cells could be separated by respiratory movements and fine granules forced between them, he found no support for the statement that there exists open communication between the peritoneum and the lymphatics and proved that the peritoneum is not a part of the lymphatic system. Each of these structures is lined with cells which retain their specificity throughout and nowhere merge into one another.

These investigations by MacCallum have not been disproved so far as we know.

The diaphragm of the horse, as injected by Sappey, owing to its enormous development, provides a good illustration of the origin of the lymphatic network covering the muscle fibers and accompanying them to the lymphatic trunks into which they drain. (See Fig. 2.) These comprise two anterior groups, *a a*, five trunks which lie centrally and give off branches that com-

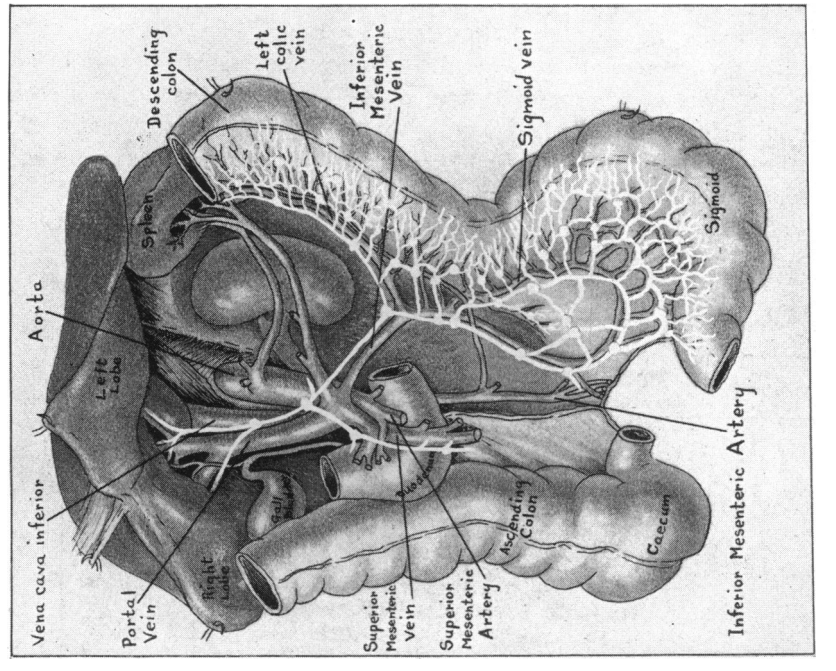
Vena cava inferior
Aorta
Portal Vein
Left Lobe
Right Lobe
Spleen
Descending colon
Left colic vein
Inferior Mesenteric Vein
Sigmoid vein
Sigmoid
Superior Mesenteric Vein
Superior Mesenteric Artery
Ascending Colon
Caecum
Inferior Mesenteric Artery

FIG. 5.

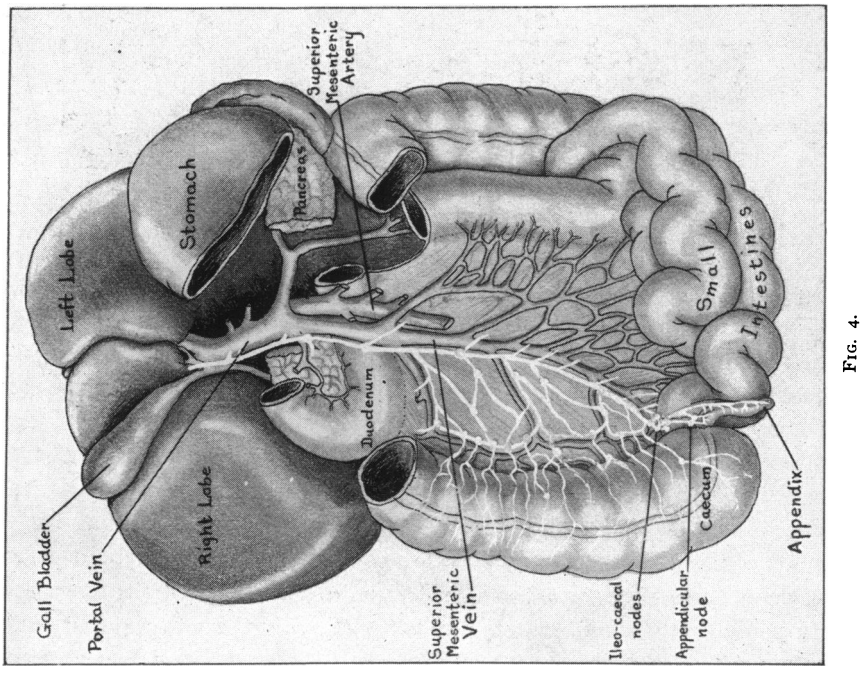
Gall Bladder
Portal Vein
Left Lobe
Right Lobe
Stomach
Pancreas
Duodenum
Superior Mesenteric Artery
Superior Mesenteric Vein
Ileo-caecal nodes
Appendicular node
Caecum
Small Intestines
Appendix

FIG. 4.

municate with glands located around the vena cava, *b b*, and five or six aortic trunks which lie posteriorly on either side, *c c*.

The next figure (Fig. 3) illustrates the lymphatic system in the diaphragm of a man, *A*, a dog, *B*, and a rabbit, *C*. In the rabbit the lymphatic system is as highly developed as in the dog. In both the arrangement is similar even in the anterior portions. In man, however, the two anterior groups *a a*, continue in closer relation with the mammary veins. In addition, one or two independent vessels are found between the two groups of main trunks which empty into the same vessels. In observing the myriads

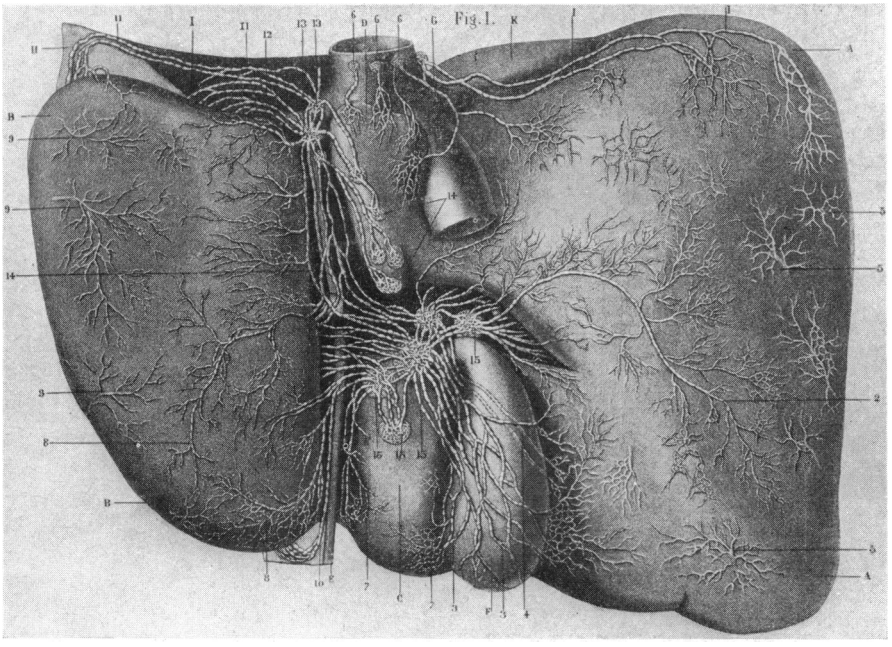

FIG. 6.

of small vessels contiguous and superimposed, one is surprised to find so many vessels in so thin a membrane.

The chart on page 849 contains a list of twelve cases of subphrenic abscess recorded at the Truesdale Hospital. In seven of the twelve cases the focus of infection was within the peritoneal cavity, in one case within the thorax, and in four undetermined, though in each the history was suggestive of an intestinal lesion. Four of the intraperitoneal cases followed operation for appendiceal abscess.

Since the majority of these cases developed as a sequela of appendicitis, we have studied the lymphatics in their course from the appendix to their distribution in the region about the diaphragm. The bacillus-laden lymph passes from the appendiceal abscess to the appendicular nodes which communicate with the ileocecal nodes. The stream then empties into the

lymphatic trunk following the superior mesenteric vein (Fig. 4) which in turn empties into the portal vein.

Likewise a focus of infection at any point in the descending colon would gain access to the lymph channels accompanying the inferior mesenteric vein (Fig. 5), which finds its way into the superior mesenteric vein before emptying into the portal vein. Thus the lymphatics draining the entire colon

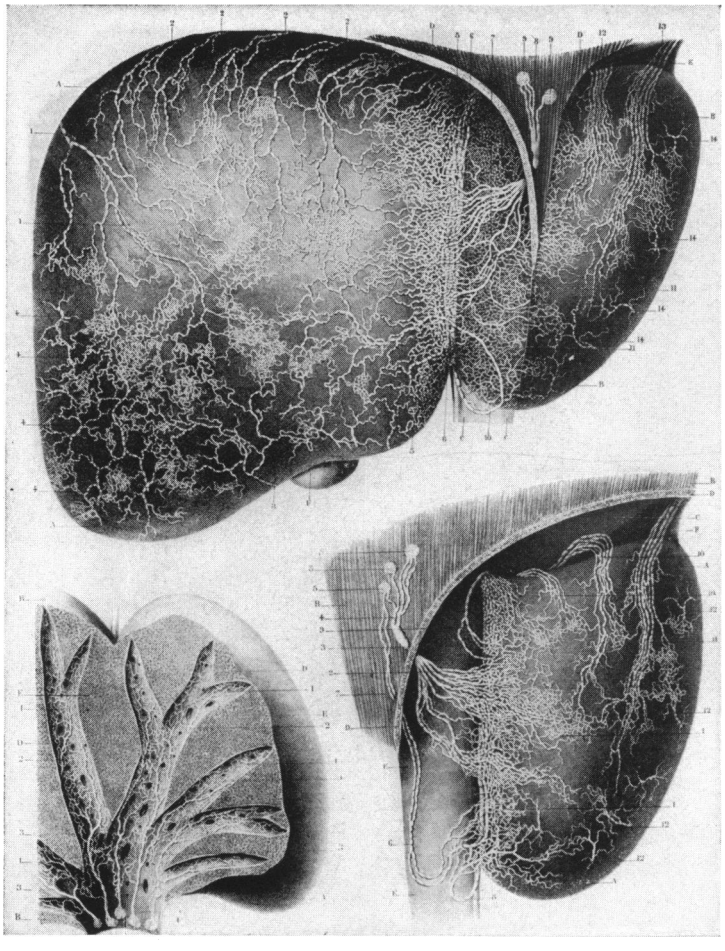

FIG. 7. (Sappey)

reach the liver in juxtaposition with the mesenteric veins. This course of the lymphatics offers an explanation for the frequency of extension of malignant disease from the colon to the liver.

When the lymphatic vessels reach the liver they pursue a most intricate course. Their distribution is seen in detail in the next two illustrations.

On the inferior surface of the liver (Fig. 6) there are six principal trunks. Those which arise mainly from the right lobe of the liver (*A*)

terminate in nodes surrounding the vena cava (1, 1, 6, 6, 6). Trunks 2, 3, 4, and 7 empty into nodes 15 resting on the neck of the gall-bladder. Deeper branches 5, 9, disappear in the liver to follow branches of the portal vein. Trunk 8 is the principal trunk of the left lobe (*B*). Trunks 10, 11, 12, and 13 come from the superior surface of the liver and terminate in nodes in the posterior part of the longitudinal fissure. Still other lymphatic trunks connect with the terminal part of the œsophagus, 14.

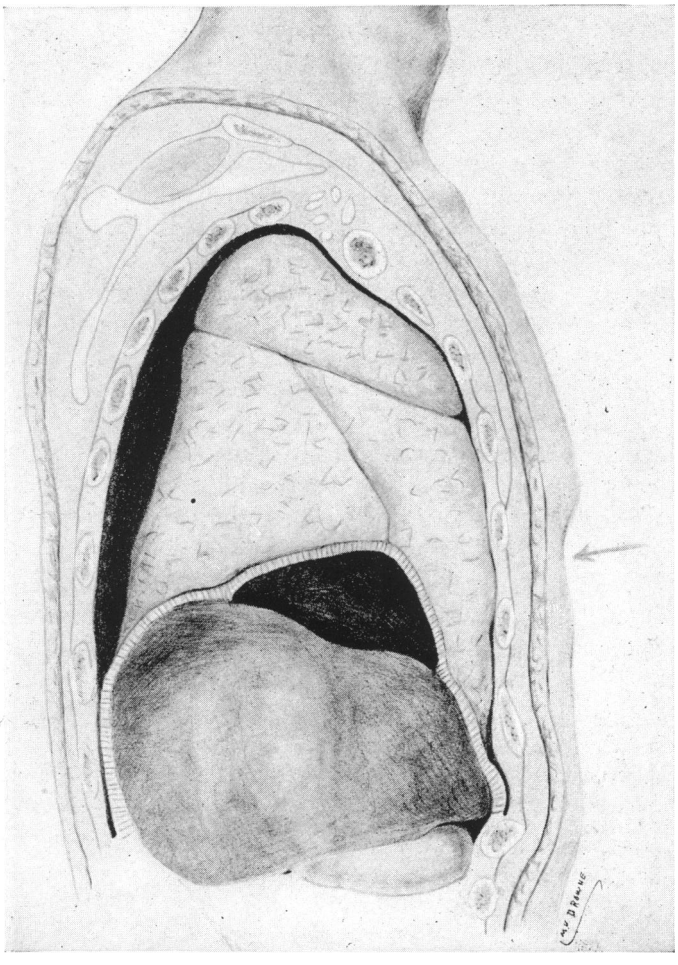

FIG. 8.

A more diffuse distribution of the lymphatics is noted on the superior surface of the liver. (Fig. 7.) The collecting stems are more conspicuous on the right lobe (*A*) than on the left (*B*). They pass forward and downward, 1, 2, as they curve around the anterior border of the liver and join stems from the gall-bladder, which pass into the hepatic nodes in the transverse fissure. In the anterior view (A, B, C in Fig. 7) the dense net-

work of lymphatic vessels is seen along the line of attachment of the falciform ligament. In Fig. B, side view, some lymphatic trunks are seen passing backward along the vena cava and through the diaphragm; others pass between the layers of the falciform ligament toward the under surface of the diaphragm. Figure C shows a cross-section through the liver. The lymphatic vessels are seen accompanying branches of the portal vein.

The lymphatic vessels which pass through the diaphragm finally terminate in the lower nodes of the inferior deep cervical group. Thus a direct route is provided for the metastasis of the supraclavicular nodes frequently induced by abdominal carcinomata; and since these stems also communicate with the lymphatics of the pleural surface of the diaphragm, which are closely associated with the thoracic vessels, opportunity is afforded for the development of pleuritis as a result of a subdiaphragmatic abscess.

After coursing through the liver the lymphatic vessels continue their route and finally reach the diaphragm with their infected lymph. Localizing above the liver, the infection develops into an abscess. Fig. 8 shows a subphrenic abscess with the superimposed right lung adherent to it. By blunt dissection the lung was separated from the diaphragm, revealing the site of rupture of the abscess where it communicated with the lung, a frequent channel of evacuation. The lung was peeled back to make the abscess accessible for drainage.

Summary.—The lymphatics are the common carriers of infection from the peritoneal cavity to the liver and diaphragm.

The diaphragm is richly supplied with lymphatics and on its peritoneal aspect is found an elaborate network of lymph-vessels which promotes rapid absorption.

The channels through which infection reaches the liver and diaphragm from the ileocecal region and the descending colon are quite clearly demonstrable.

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[10] Bizzozero: Mentioned in MacCallum: *op. cit.*

[11] Vincenzi: *Ibid.*

[12] Muscatello: *Ibid.*