EXPERIMENTAL OBSERVATIONS ON THE LOCALIZATION OF THE PAIN SENSE IN THE PARIETAL AND DIAPHRAGMATIC PERITONEUM

JOSEPH A. CAPPS, M.D., AND GEORGE H. COLEMAN, M.D.
CHICAGO

Pain is, perhaps, the most important evidence on which we base our interpretation and diagnosis of abdominal disease. So whatever contribution may be made to the better understanding of abdominal pain, its origin, nature, and localization, is of direct interest to the clinician.

Our present knowledge of sensation in the abdomen and its viscera is due largely to the careful and ingenius observations during laparotomies of Lennander [1] and Sir James Mackenzie.[2] These observers are agreed that the hollow viscera and omentum give no sensation response to heat or cold, to cutting or clamping.

Lennander found that the parietal peritoneum was sensative to irritation, especially when inflammation was present. This pain sense he explained by the rich supply of cerebrospinal nerves to the parietal peritoneum and its subserosa, in contrast to the sympathetic nerve supply of the insensitive viscera. From these premises he contended that all visceral pain was the result of inflammation and traction on the parietal peritoneum. Ross,[3] however, has furnished convincing proof of a true visceral pain (splanchnic) induced by tension of the hollow organs, and in addition to this the somatic pain originating in a sensitization of the posterior spinal roots and a radiation of painful sensations along the course of the corresponding spinal nerves to the skin and deeper tissue layers.

The peritoneal membrane lining the abdominal wall has received less attention from experimenters than the viscera, while the peritoneum covering the under surface of the diaphragm, because of its inaccessibility has remained almost "terra incognita" to the surgical explorers who have been interested in charting areas of sensation by direct experimental methods. All animal experiments on pain are open to serious criticism of results obtained and, in any event, are far less trustworthy than experiments on human beings.

The parietal peritoneum in the immediate vicinity of laparotomy incisions made under cocain anesthesia has been tested for pain with

1. Lennander, K. G.: Mitt. a. d. Grenzgeb. d. Med. u. Chir. **21**:125, 1910.
2. Mackenzie, J.: Symptoms and Their Interpretation, London, 1909.
3. Ross, J.: Brain **10**:350, 1888.

somewhat conflicting conclusions. For example, Lennander finds pain sense in the parietal peritoneum and the neighboring serosa. Mackenzie, working under similar conditions, believes that the parietal peritoneum is without sensation, but that the pain sense is acute in the subserosa lying just outside the peritoneum. This view is also supported by Hertzler.[4]

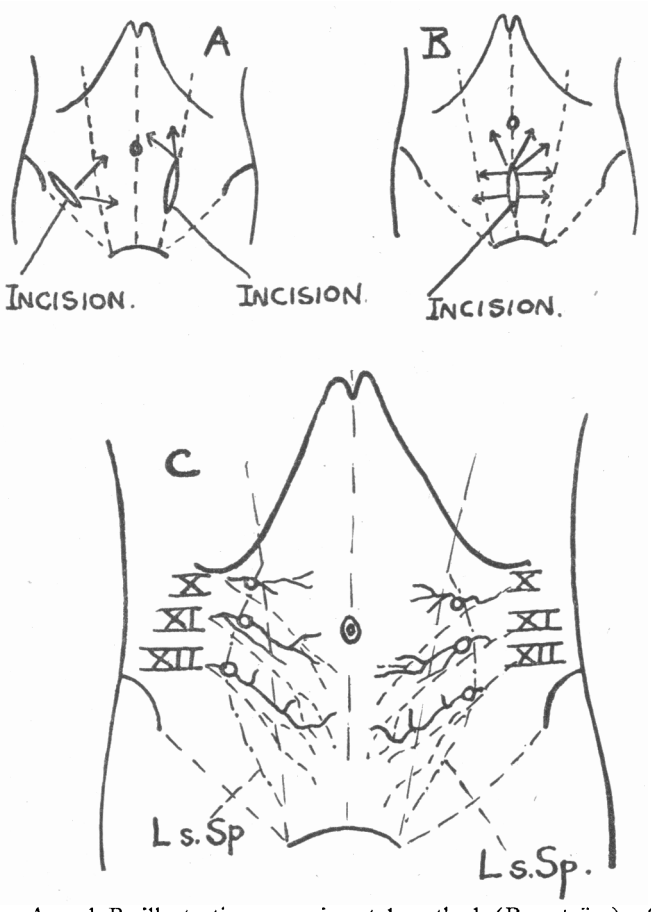

Fig. 1.—A and B, illustrating experimental method (Ramström); C, showing distribution of dorsal nerves to abdominal wall (broken line) and to peritoneum (solid line), (Ramström).

Subsequently, Ramström,[5] the celebrated anatomist, carried out a series of experiments in this region in cooperation with Lennander. Ramström had already demonstrated the presence of the Vater-Pacini bodies in the anterior portion of the parietal peritoneum and proposed

4. Hertzler, A. E.: The Peritoneum **1**:24, 1919.
5. Ramström: Mitt. a. d. Grenzgeb. d. Med. u. Chir. **13**:314, 1908.

to test this membrane for "pressure sense," which was supposed to be the specialized function of these nerve structures. The method of the procedure is illustrated in Figure 1. After the incision was made through the abdominal wall under cocain, the neighboring peritoneal covering of the wall was tested for sensation by inserting a rubber glove covered finger and by a flat spatula, with varying degrees of pressure. He also used hot and cold instruments. He found that light pressure produced no sensation; strong pressure set up a cramplike pain; cutting the parietal peritoneum caused a stitchlike pain. There was no response whatever to temperature changes. Ramström concludes that the parietal peritoneum has no pressure sense ("Drucksinn") and that the Vater-Pacini bodies, therefore, are not specialized structures for this sensation. Also, the sense of heat and cold is lacking. Finally, the parietal peritoneum is richly endowed with pain sense.

The chief purpose of our experiments was to determine the localization of pain from stimulation of the parietal and diaphragmatic peritoneum.

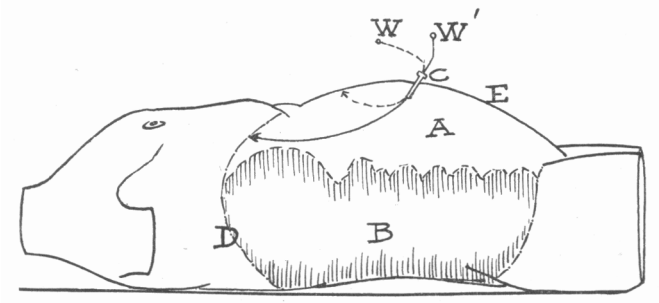

Fig. 2.—Schematic drawing to illustrate method of procedure. A. Air in abdominal cavity. B. Abdominal viscera depressed by the air. C. Cannula or trocar through abdominal wall (E), into abdominal cavity. Trocar freely movable in all directions. D. Diaphragm. W and W'. Wires used in testing.

PERSONAL OBSERVATIONS

Our experiments were carried out by a method previously employed by one of us in the study of sensation in the pleural cavity. After partially anesthetizing the skin with ethyl chlorid, a trocar is inserted through the abdominal wall until the end moves about freely. The point is withdrawn and through the cannula is passed a long silver wire, one end beaded and smooth, the other end relatively sharp. Each end is slightly curved in order that it may more easily be brought in contact with the abdominal wall. In our earlier experiments patients with ascites were chosen because the fluid distended the wall and facilitated exploration. Recently, however, we have employed the method of injecting air, which has proven harmless in the hands of the roentgenologists. As will be seen in Figure 2 the air forces the hollow viscera to the bottom of the cavity, leaving a large domelike

area free for testing. The air also fills the subphrenic spaces and permits the passage of the wire to the under surface of the diaphragm, a region not accessible in ascites.

PROTOCOLS

EXPERIMENT 1 (Fig. 3).—Observations were made during drainage of ascites in a case of cirrhosis of the liver. The wire end came in contact with the viscera without causing sensation. Several points on the parietal peritoneum were touched from 3 to 5 inches lateral and above the cannula with enough pressure to locate the tip by the observer's touch. The patient complained of "pain like a needle puncture" and with eyes closed localized the spot by touching the skin with the end of his finger. The patient's localization was usually a little below the actual point of irritation, but always within a radius of one-half inch. Pressure toward the flanks against the parietal wall caused a more diffuse pain.

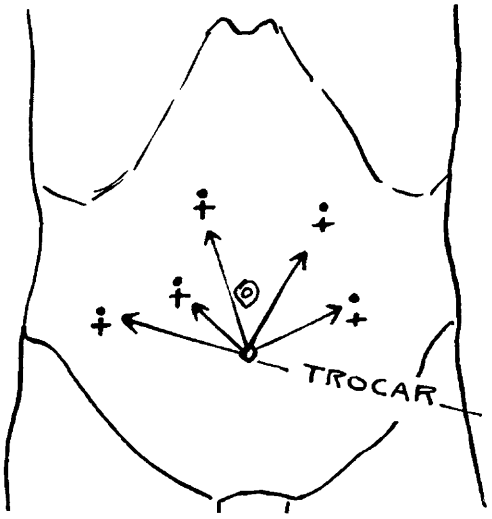

Fig. 3.—Experiment 1. Showing areas of parietal peritoneum stimulated by a wire passing through cannula. · = actual point stimulated; + = localization of pain by patient; arrows show direction of wire.

EXPERIMENT 2 (Fig. 4).—Patient with ascites. Wire passed along parietal wall in direction of arrows. Beaded wire end caused no feeling unless tip was pressed with considerable force. Rough end caused pain at points indicated of sharp character and localized by patient in close proximity to the point of contact.

EXPERIMENT 3 (Fig. 5).—Case of ascites. Beaded end of wire entangled in viscera caused cramplike pain on movement, but none by superficial contact. Rough end of wire followed the parietal wall freely for some distance on both sides and above the navel. Contact with slight pressure or gentle movement over the parietal peritoneum produced sharp pain which the patient localized with remarkable precision close to the actual site of stimulation.

EXPERIMENT 4 (Fig. 6).—Ascites from cirrhosis of liver. Conditions favorable to free exploration with wire. Localization by patient always within three-quarters inch of point stimulated.

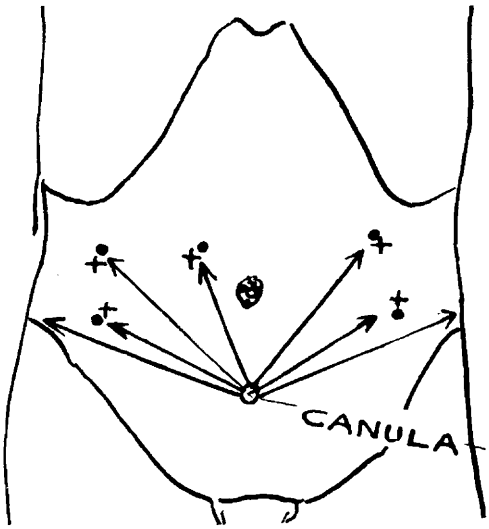

Fig. 4.—Experiment 2.

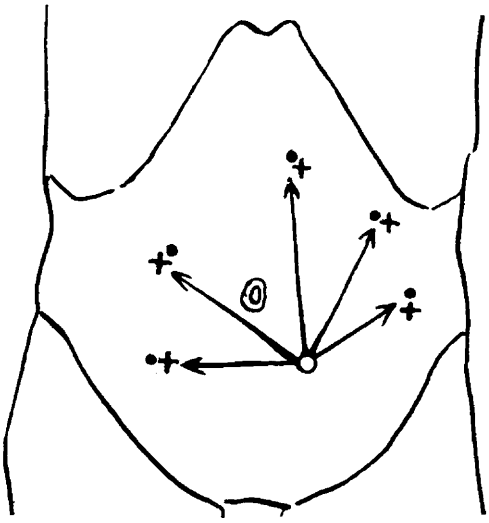

Fig. 5.—Experiment 3.

EXPERIMENT 5 (Fig. 7).—Patient had early tuberculous peritonitis. No fluid obtained by puncture. Filtered air slowly forced into the cavity until 3,000 c.c. had entered. The abdominal wall was thin and tympanitic over all of the anterior aspect and well down in the flanks. To prevent escape of the air, a strip of adhesive tape was stretched over the opening of the cannula and the wire passed through the tape into the cannula and abdominal cavity. The silver wire was passed with ease along the inner abdominal wall in the direction of the arrows, the point being readily detected by the palpating finger and even with the eye. Slight pressure with the beaded point produced no sensation. Similar pressure with the rough point caused a sharp pain like a stitch. Gentle lateral motion of the point produced a similar and more severe pain. The localization of the pain by the patient was always within a radius of one-half inch from the point irritated.

EXPERIMENT 6 (Fig. 8).—Patient was a thin subject with no pathologic condition of the abdomen except a scar from a laparotomy performed two years ago for removal of pus tubes. About 4,000 c.c. of air was introduced. The results of irritating the parietal peritoneum with the wire were similar to

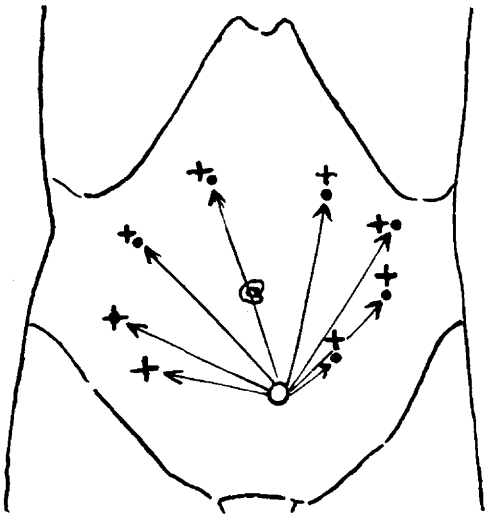

Fig. 6.—Experiment 4.

those obtained in previous experiments. When the wire came in contact with the adhesions beneath the scar and enough pressure exerted to produce displacement or stretching, the patient complained of a dragging painful sensation in the region of the scar tissue.

EXPERIMENT 7 (Fig. 9).—Patient had a very thin fat layer over the abdomen and no abdominal disease. After puncture, more than 4,000 c.c. of air was introduced, with resulting tympany over the whole abdomen and even over the liver and spleen. The wire tip could be followed readily by the eye as it passed along the inner wall. The localization of pain was made with the same accuracy over the upper parietal peritoneum as in previous experiments. The wire could be seen passing upward to the left costal border until it disappeared beneath the ribs. About 2 or 3 inches above this point within the mammary line the beaded point came in contact with the diaphragm (central portion). Moderate pressure caused a sharply localized pain at a point situated over the middle third of the trapezius ridge. When the rough tip of the wire was brought in contact with this region even slight pressure or a lateral motion set up pain of great intensity over the spot in the neck. This spot

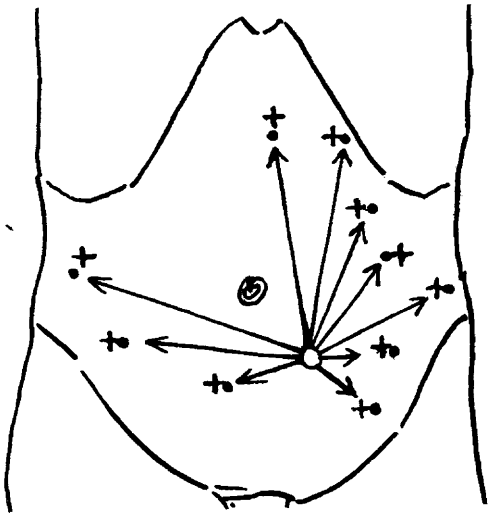

Fig. 7.—Experiment 5.

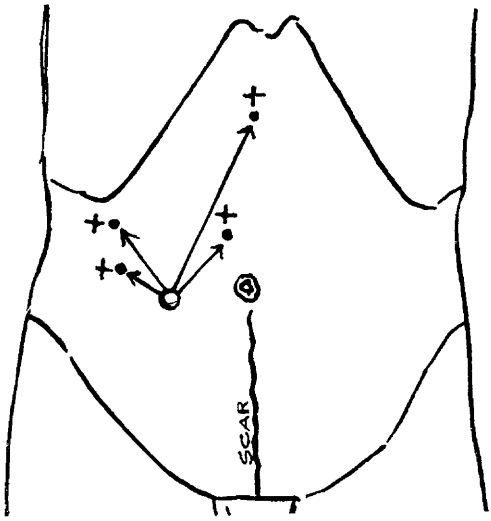

Fig. 8.—Experiment 6.

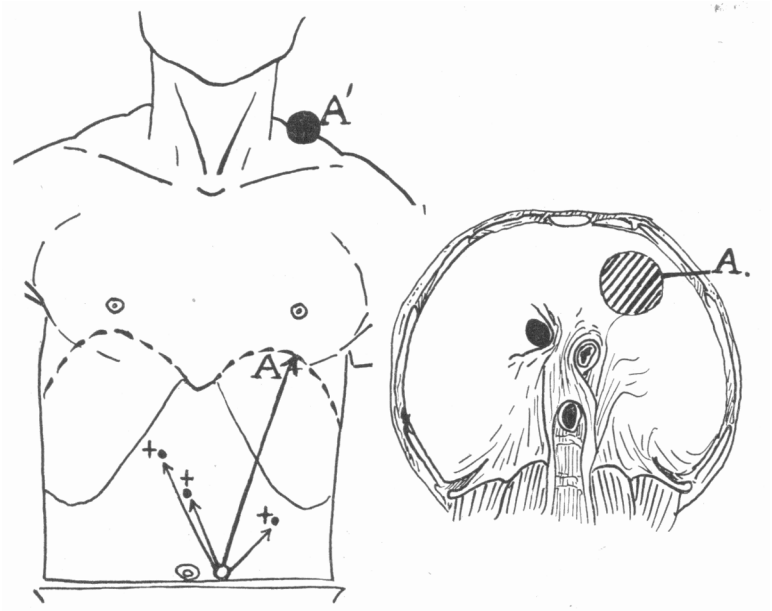

Fig. 9.—Experiment 7. Upper figure showing stimulation of parietal peritoneum and of the under surface of the diaphragm (A) with resulting referred pain in neck (A'). Lower figure showing under surface of diaphragm, and region (A) stimulated.

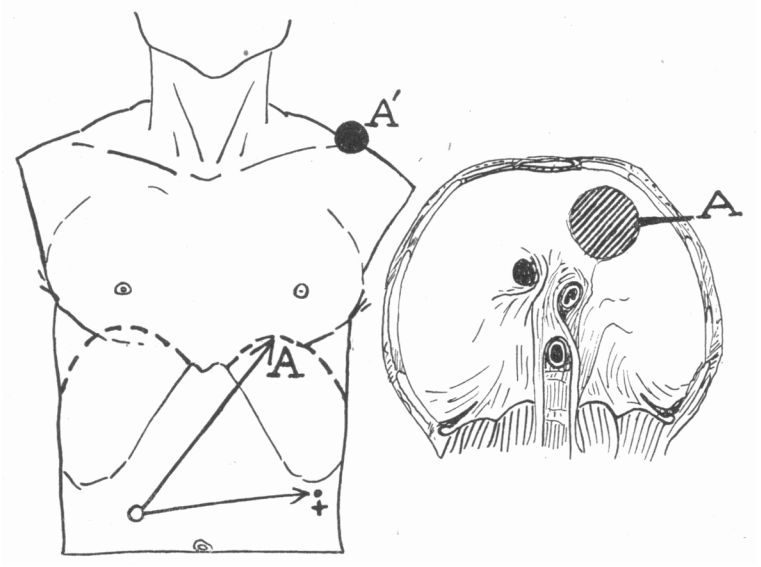

Fig. 10. — Experiment 8. For explanation of symbols see caption under Figure 9.

of referred pain did not change its location with shifting of the wire point over an area of the diaphragm 2 or 3 inches in diameter. As the wire was drawn down below the costal border on to the abdominal wall the pain in the neck ceased and the patient localized the pain over the portion of the abdomen corresponding to the point of wire.

EXPERIMENT 8 (Fig. 10).—The patient was thin, with no abdominal symptoms. More than 5,000 c.c. of air was injected, creating tympany over anterior aspect of abdomen and high up under the thorax. The rough end of the wire was passed along the inner wall to the costal border, then upward 3 or 4 inches until it came in contact with the dome of the diaphragm. On the slightest pressure the patient complained of sharp pain definitely localized at the outer edge of the trapezius ridge. This point was tender to pressure over the skin. Withdrawal of the wire was followed by slow cessation of the pain, eight or ten seconds passing before its complete disappearance. Later contact of the wire with the parietal peritoneum an inch below the costal border produced pain close to the stimulated point.

EXPERIMENT 9 (Figs. 11 and 12).—This patient entered the hospital with a marked pneumoperitoneum, probably due to perforation of a gastric ulcer. As shown in Figure 11 there was a large collection of gas separating the

Figure 11

liver and spleen from the diaphragm. As the patient had no fever and was not very ill the following experiment was carried out in the erect position before the fluoroscopic screen. A trocar was inserted under the costal border upward into the air cavity over the liver. After the removal of the trocar the wire was run through the cannula and the escaping gas controlled by a rubber film. The beaded wire end could now be brought in contact at will with the greater part of the under surface of the diaphragm and be followed by the eye while the patient was asked to register sensation and its location. A light touch of the beaded end or gentle stroking motion produced no sensation anywhere. Firmer pressure produced pain (Fig. 12). Over the peripheral margin, narrow anteriorly and broad posteriorly, the pain was diffuse and referred to the right costal border, the patient indicating the area with his hand placed transversely over the lower ribs and over the right hypochondrium. On removal of the wire this pain slowly disappeared. Over the central portion of the diaphragm firm pressure elicited a sharp pain over the outer third of the trapezius ridge. The patient indicated the spot with the tip of his finger and described the sensation as "the wire sticking into my neck." The patient complained if the observer pressed his finger on the skin at the spot

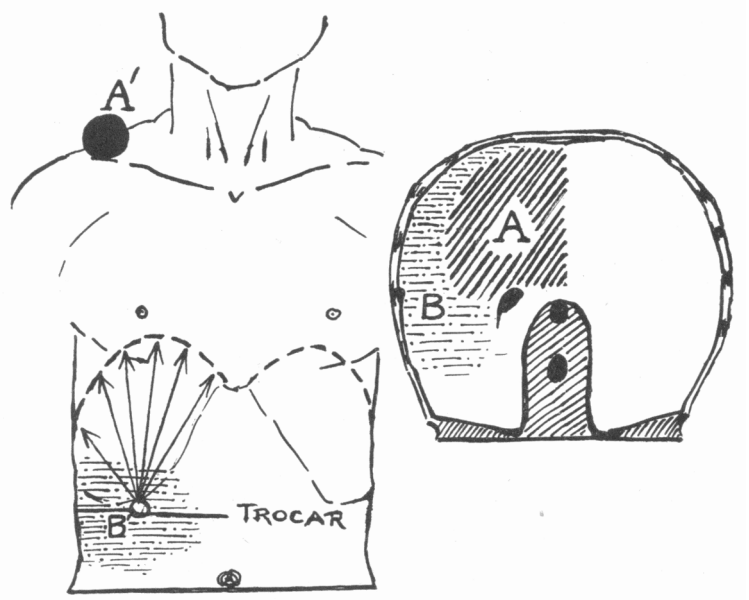

Fig. 12.—Experiment 9. Schematic drawing of Figure 11. Upper figure indicates points of stimulation of diaphragm with wire (patient standing before fluoroscopic screen). Lower figure (schematic representation of lower surface of diaphragm) showing approximate region (A), the stimulation of which caused localized pain at (A'); also approximate region (B), stimulation of which caused diffuse pain in region (B').

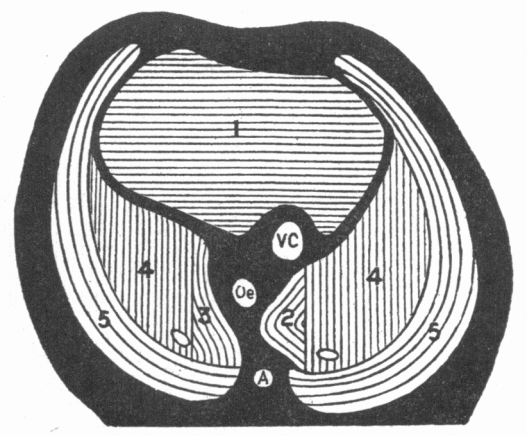

Fig. 13.—Diagram of the primitive diaphragm to show the several parts from which it is built up. (After Broman.) (Quain's Embryology, p. 243, Fig. 298.) 1, pericardial part derived from septum transversum; 2 and 3, parts derived from the mesentery; 4, 4, parts derived from pleuro-peritoneal membranes: between these dorsally and the mesenteric portions are the nearly closed pleuro-peritoneal openings; 5, 5, parts derived from the body-walls; 1, 2, 3, 4, 4, cover the cranial aspect (upper surface) of the liver.

indicated. This pain also continued with decreasing intensity for several seconds after the pressure was removed. When the roughened wire point was used, the pain produced was much more severe, although the localization was the same as with the beaded point. After the above observations were completed the gas was allowed to escape and the patient went on to complete recovery.

The penetration of the phrenic nerve fibers into the peritoneal (as well as the pleural) covering of the diaphragm was demonstrated by Ramström, although their course could not be followed with accuracy.

The diagram of Quain [6] (Fig. 13) shows that in the embryo a part of the diaphragm is a derivative of cervical myotomes which are displaced backwards as the diaphragm descends to its permanent level. These myotomes carry down in their descent portions of the third, fourth and fifth cervical nerves, fusing into the phrenic nerve and originally containing both motor and sensory fibers. We may reason that the motor fibers continue their function in activating the diaphragm muscle, while the sensory nerves through disuse cease to register localized sensations in the diaphragm. Under strong stimulation, however, these afferent fibers of the phrenic nerve retain their ability to carry impulses to the cervical cord and thereby give rise to referred pain in the neck.

The pain elicited from stimulation of the outer surfaces of the diaphragm is explained by the known distribution of the lower six intercostal nerves to the diaphragm. Afferent impulses through these nerves to the cord find expression in pain referred to the abdominal wall and lower thorax which receive their sensory supply from the corresponding cord levels.

The pain elicited in these experiments, in our judgment, arises from stimuli both in the peritoneum and the subserous tissues. The pain caused by pressure of the smooth point Mackenzie would attribute to stretching the nerves in the subserosa and the pain from the sharp point to tearing of the delicate peritoneal covering and penetration into the sensitive subserosa. It is easier, however, to assume that both structures are sensitive since both have the same supply of cerebrospinal nerves. It is well to emphasize that the pain from the parietal peritoneum is always direct and not referred in contrast to that of the diaphragm.

SUMMARY

1. The parietal peritoneum, and its underlying serosa, so far as explored, namely, all the anterior median areas and the lateral areas as far as the anterior superior spines, are sensitive to pain from strong pressure of a smooth point or light pressure or lateral movement of a rough point of wire.

6. Quain: Anatomy **1**:243, 1906.

2. The pain elicited by stimulation of the parietal paretoneum is localized with considerable accuracy by the patient, the error being less than one inch.

3. Our observations confirm the conclusions of Ramström and Lennander that the parietal peritoneum is devoid of pressure sense.

4. The peritoneum covering the diaphragm is devoid of pressure sense as applied by light contact or stroking of a beaded wire point. But to strong pressure with a beaded point or light contact with a rough point it is acutely responsive to the sense of pain.

5. The localization of pain from stimulation of the diaphragmatic peritoneum is never in the diaphragm itself. It is always referred to some distant part. Stimulation of the outer margin causes diffuse pain over the lower costal region and subcostal abdominal wall. Stimulation of the central portion produces pain over a sharply limited point somewhere along the trapezius ridge. These impulses are doubtless carried by afferent fibers of the phrenic nerve to the cervical cord and thence referred to the neck by the sensitized cutaneous nerves of the fourth cervical segment. This pain has not been observed along the course of the phrenic nerve itself.