THE ANATOMY OF THE MAJOR DUODENAL PAPILLA OF MAN, WITH SPECIAL REFERENCE TO ITS MUSCULATURE[1]

By VINCENT J. DARDINSKI, M.D.[2]
Fellow in Pathology, The Mayo Foundation, Rochester, Minnesota

THE major duodenal papilla is that portion of the duodenum through which, in the majority of instances, the common bile duct and the main pancreatic duct, or duct of Wirsung, empty their respective secretions into the intestine. Under normal conditions it is situated on the medial aspect of the descending portion of the duodenum, approximately 7·5 cm. from the pyloric valve of the stomach. It is not to be confused with the minor duodenal papilla through which the accessory pancreatic duct, or duct of Santorini, sometimes empties into the duodenum. The latter is found in the same portion of the duodenum as the former, but it is usually 2–3 cm. nearer to the pyloric valve and is much smaller.

The appreciation of the importance of the major duodenal papilla and the part it may play in regulating the flow of bile dates back to Glisson (5) in 1681. He was the first to suspect a sphincter muscle in this region but gave no proof of its presence.

In 1685 Govert Bidloo (2) first noted the major papilla as being a common outlet for both the bile and pancreatic ducts. In 1879 Gage (3), an American zoologist, gave the first anatomic description of this region in the cat. In his work he stated: "The terminal portion of the common duct in the cat, as it passes obliquely through the intestinal muscular layers, is surrounded by a narrow layer of smooth muscle fibres. A similar layer is found around the terminal part of the pancreatic duct. These fibres are sphincter fibres and appear to be intimately connected with the fibres of the intestinal musculature, making it difficult to separate one from the other." He added further, "there is another sphincter common to both ducts formed by the intestinal musculature".

Oddi and Marcacci (14), while studying the effects of cholecystectomy on animals in 1887, noticed dilatation of all the extrahepatic ducts, especially the cystic duct. They were of the opinion that this was a compensation for the absence of a gall bladder. From this observation Oddi concluded that in order to produce this effect a sphincter must be present at the termination of the common duct. He thereupon set out to prove this by investigating the region in various animals, such as the dog, rabbit, ox, hog, cat, and horse. In all of

[1] Thesis submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfilment of the requirements for the degree of Master of Science in Pathology.

[2] Now Associate Professor of Pathology, Georgetown University, School of Medicine, Washington, D.C.

these animals he found a similar disposition of muscle fibres in the region where the common duct penetrates the intestinal musculature, and he stated that these fibres constituted the sphincter of the common duct. He also described a similar muscular disposition around the terminal portion of the pancreatic duct and a common sphincter for both ducts formed by the intestinal musculature. The individual sphincter muscles of the ducts, he stated, are independent of the intestinal muscle.

Hendrickson (7), in 1898, described the musculature of the extra-hepatic biliary system of the dog, rabbit, and man. He concluded that in all of these a sphincter muscle was present. Helly (6), Letulle and Nattan-Larrier (10), Matzuno (13), Job (8), Mann (11, 12) and his collaborators (4, 9), and others have contributed to this subject, and the conclusions reached by them are confirmatory of the work done by the foregoing investigators, that is, that an independent sphincter muscle is present at the intramural portion of the common duct. In 1922, Auster and Crohn (1) stated definitely that they found no structure in this region that they could call a sphincter or any structure that resembled other sphincters in the body.

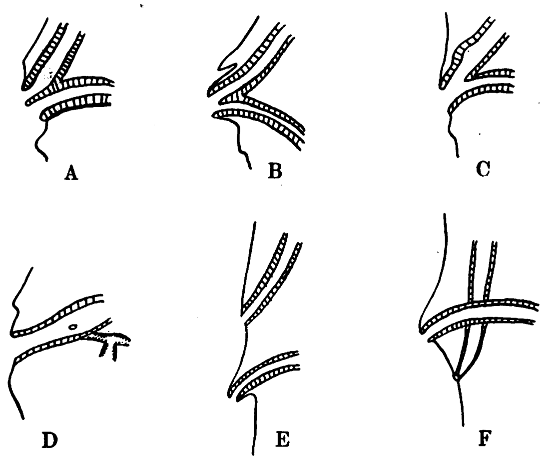
A complete anatomic and histologic study of this region was made on twenty-one specimens obtained at necropsy by Letulle and Nattan-Larrier. Most of their conclusions, however, were based on microscopic study of sections.

Because of the complicated picture presented by a histologic section of this region and the infrequency of a complete study of the papilla and its relation to the surrounding intestinal muscle, it was deemed advisable to carry on a more complete investigation.

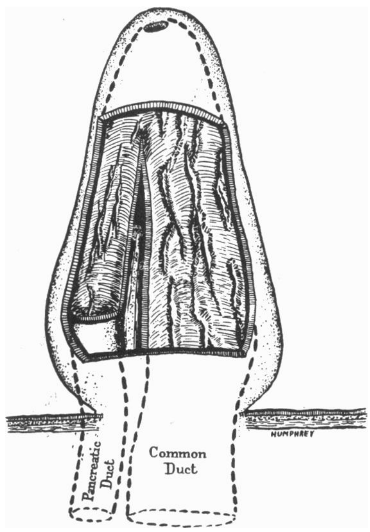
The work that I wish to present is the result of my study at necropsy of duodenal papillae and associated ducts in 100 cases. Microscopic dissection was made of thirty different specimens after treatment for several days in Marcacci's macerating fluid, which consists of equal parts of concentrated nitric acid, glycerine, and water. Macroscopic examination was made to determine the point of termination of the common and pancreatic ducts and the frequency of true ampullar dilatation within the papilla.

The results obtained with regard to the presence of an ampulla and the point of termination of the ducts are as follows: In fifty-one cases both ducts emptied separately into the tip of the papilla. In twelve cases both ducts united in the papilla 1 mm. from its outlet, in five cases 2 mm. from its outlet, in twelve 3 mm. from its outlet, in ten 4 mm. from its outlet, in four 5 mm. from its outlet, and in four 1 cm. from its outlet. In one case both ducts emptied separately into the intestine, and in one case the pancreatic duct passed through the major papilla, and the common duct passed through a slit-like opening in the wall of the intestine 1 cm. below the tip of the papilla (text-fig. 1).

True ampullar dilatation within the papilla is present in those cases in which the two ducts unite 5 mm. or more from the outlet. In the remainder both ducts are separated by a thin membrane, formed by the adjacent walls of the pancreatic and the common ducts, which extends from the base of the papilla to the point where they unite. In fifty-one cases or 51 per cent., however, this membranous partition extended from the base of the papilla to the



Text-fig. 1. Points of termination of common bile and pancreatic ducts in 100 cases at necropsy were as follows: as in A in fifty-one cases, as in B and C in forty-three cases, as in D in four cases, as in E in one case, and as in F in one case.



Text-fig. 2. The course of the common and pancreatic ducts within the papilla. A window has been cut out to show the membranous partition separating the two ducts. As can be seen, this membrane is formed by the adjacent walls of the two ducts and extends toward the tip of the papilla where the two ducts unite to form the ampulla.

outlet, so that the two ducts did not unite and no ampulla was formed (text-figs. 1 and 2).

The mucosa within the ampulla has been mentioned by Matzuno, Helly, Opie, Letulle and Nattan-Larrier, and Mann (11) as being thrown into numerous longitudinal folds, but none of these has given any description of it. Mann and Letulle and Nattan-Larrier refer to the folds as valves, and mention the fact that these valves are often seen projecting through the outlet of the papilla.

By studying Plate I, fig. 1, the following observations can readily be made: There is an abrupt change of the inner structure of the terminal portion of the common duct, which for purposes of description is divided into the extraduodenal and intraduodenal portions. The dividing line between these portions can readily be seen and corresponds to the point at which the intestinal muscle surrounds the duct, or the intramural portion. The extraduodenal portion is fairly smooth and contains numerous large pits which are the outlets of sacculi found in the wall of the common duct. The intraduodenal portion is composed of numerous folds that course longitudinally; these folds vary from 2 to 4 mm. in length and from 2 to 3 mm. in width. On closer study it can be seen that the tip or end of one fold fuses with the tip or the side of another fold, forming by this union a pocket or cavity that in the majority of instances roughly corresponds to a triangle with its base directed toward the extraduodenal portion of the common duct. The triangular appearance, however, is not always apparent, for many appear elliptical in shape and others only as a slit-like opening. The size or depth of the pocket formed is not constant and each one is different from the next in some respect. It can be seen that these pockets are found around the entire inner surface of the papilla, and, as one passes toward the tip, the pockets are seen to become smaller and more shallow. In the final 1–2 mm. of the papilla these longitudinal folds do not fuse but hang free, their tips sometimes extending through the outlet of the papilla.

The intrapapillary portion of the pancreatic duct contains similar folds, but they are smaller in size and are not as prominent as those in the intrapapillary portion of the common duct and they do not arrange themselves to form such pockets as have already been described.

Such a complicated arrangement is not abnormal nor the result of inflammatory adhesions because it is present in various aged foetuses and persists throughout life. The youngest foetus that I have studied was five and a half months old.

The important point to be mentioned here is that the greatest point of constriction of the common duct is always present in the intramural area and always corresponds to the region where the intestinal muscle surrounds it. It does not correspond to the independent muscle fibres which will be described later.

The external surface of the papilla, with its relation to the surrounding intestinal musculature, together with the relation of the terminal portions of the common and pancreatic ducts, can best be described from actual dissection using a dissecting microscope, because what was found by actual dissection was later confirmed by study of serial sections.

The best results from actual dissection were obtained by placing fresh unembalmed or unpreserved specimens in Marcacci's macerating fluid for from 48 to 72 hours. At the end of this time dissections were made under water using fine instruments, such as those used in surgery of the eye.

The mucosa and submucosa of the duodenum covering the external surface of the papilla are removed without difficulty, and, if one is careful, it will be observed that the blood supply to the papilla is obtained from four main blood vessels (text-fig. 3*a*). Two of these blood vessels are situated on either side of the base, just at the point of penetration of the papilla through the intestinal musculature, and two are found on either side, at the tip of the papilla. These vessels are small and give off numerous branches. Some of the branches come off the main vessel immediately after it penetrates the intestinal musculature; others arise at irregular points from the main vessel as it passes along the side of the papilla. All four main vessels, however, continue along the side of the papilla, and their numerous branches supply the papilla and the surrounding intestinal musculature.

The nerve supply of the papilla can also be seen at this stage, for at the point where the four vessels penetrate the intestinal muscle there can be seen white, glistening fibres that more or less follow the course of the blood vessels and give off numerous branches. Many of these can be traced to the papilla where, in their course, at the point of branching, the fibres appear to be definitely swollen. These swellings of the nerve fibres correspond to the ganglia that Oddi (15) described in 1894.

The removal of the blood vessels, nerves, and submucosa leaves the muscle bundles of the inner, circular intestinal muscle stained light yellow. The papilla is now seen lying in a trough formed by the inner layer of intestinal muscle, and it is attached to the latter by connective tissue (text-fig. 3*b*). At the base of the papilla are the circular intestinal muscle bundles, some of which take a curved course as they pass over it (text-fig. 3*c*).

With the specimen held in place the papilla can be pulled forward. When this is done a few, narrow, flat, ribbon-like bands of muscle fibres will be seen which appear to be independent of the intestinal muscle at the base of the papilla. These fibres are only four or five in number, and are very loosely arranged (text-fig. 3*d*). Turning the papilla to one side, some of these fibres are seen running forward to become attached to the circular muscle of the intestine (text-fig. 3*d* and *e*). The remainder run obliquely forward and downward around the side of the papilla to the under surface where their ends either become invisible in the dense connective tissue or they interdigitate with the opposite end of the same or other fibres (text-fig. 3*b*).

This group of fibres at the base of the papilla, best seen in text-fig. 3*d* and *e*, are the only fibres that would correspond to Oddi's description of the sphincter muscle of the common duct.

If the circular muscle of the intestine is now removed from the base of the papilla, a groove is readily seen encircling the common duct just posterior to the narrow layer of fibres, which was described above (text-fig. 3*e*). This groove is formed by the circular muscle of the intestine and corresponds to the most constricted portion of the duct on the inside. Now also can be seen the longitudinal muscle of the intestine, whose fibres are small and loosely arranged around the common duct (text-fig. 3*d*). Some of these fibres are found running forward on the under surface of the papilla and becóme lost in the dense connective tissue (text-fig. 3*b*). Others swing laterally away from their normal course and blend with the circular muscle of the intestine (text-fig. 3*d*).

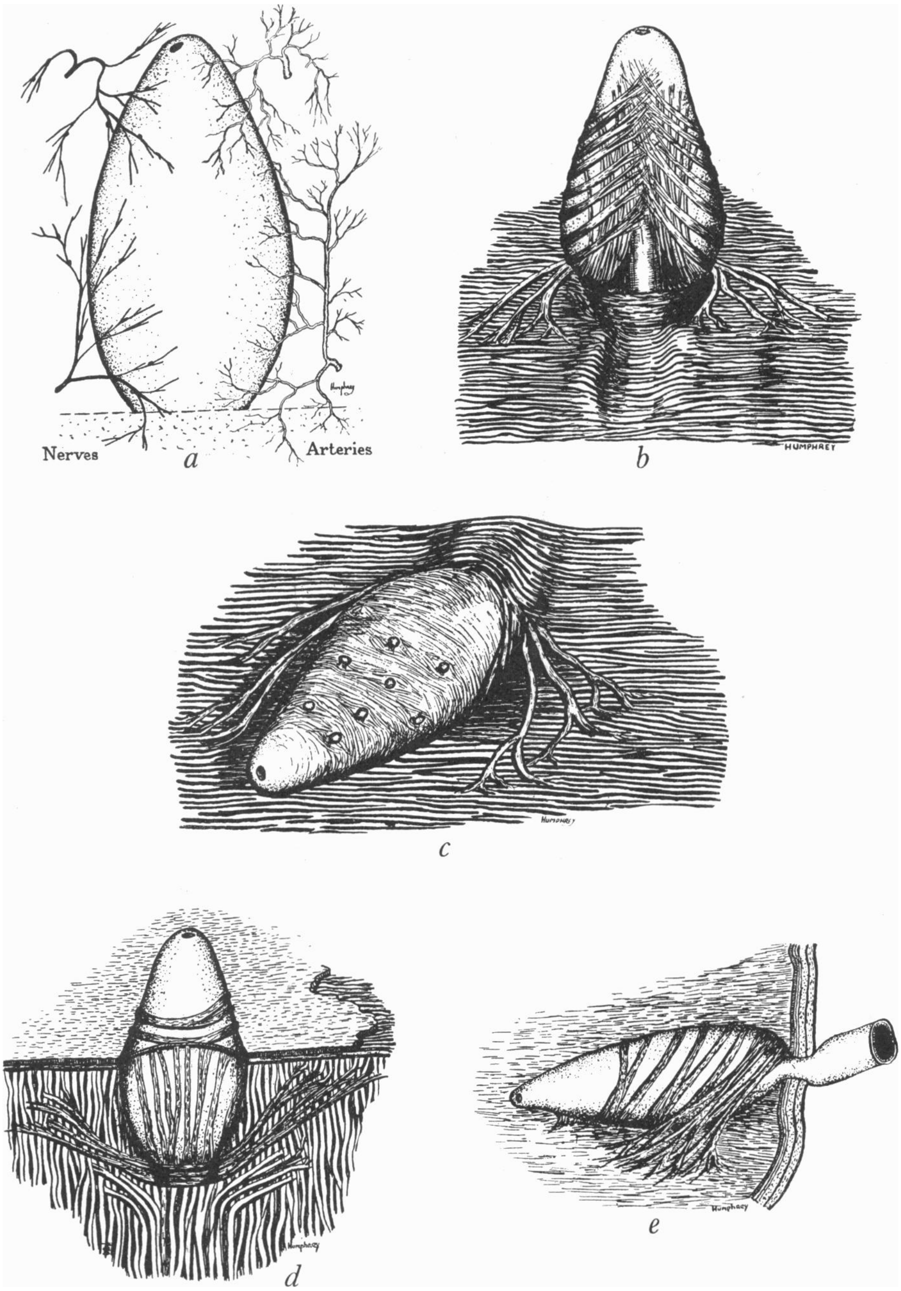
Separating the fibres of the layer of longitudinal intestinal muscle and cutting the attachment of the few fibres extending from the base of the papilla to the circular intestinal muscle, the entire papilla can be removed without difficulty. The pancreatic duct is now seen on the ventral surface of the common duct (text-fig. 3*b*). It passes forward in this position next to the common duct, and the groove described around the common duct, formed by the circular intestinal muscle, is also found around the pancreatic duct, just before it comes to lie in apposition to the common duct. Both ducts are now seen running forward through the papilla and are enclosed by dense connective tissue and loosely arranged muscle fibres which are next to be described (text-fig. 2).

Dissection of the removed papilla can easily be made by pinning it down. The mucosa and submucosa having already been removed, its surface is found covered with dense connective tissue. By careful dissection and removal of this connective tissue, very small, white nodules, 1–2 mm. in diameter, can be seen scattered over the surface of the papilla. These are found to be attached to the papilla by a short narrow neck which is surrounded by smooth muscle fibres (text-fig. 3*c*). On section these nodules are found to be racemose mucous glands (Plate I, fig. 2), and they empty into the lumen of the papilla

---

Explanation of text-fig 3.

Text-fig. 3. *a*, the nerve and blood supply of the papilla. Since the same arrangement is found on both sides, one figure is used to indicate the nerve supply on one side and the blood supply on the other. The small swellings at the point of branching of the nerves represent the ganglia that were first mentioned by Oddi. *b*, the papilla elevated from the trough formed by the duodenal wall showing the arrangement of fibres on the under surface. In the centre of the lower portion of the papilla can be seen the pancreatic duct which gradually becomes invisible as it passes toward the tip of the papilla. *c*, the papilla and part of the duodenal wall from which the mucosa and submucosa have been removed. The surface of the papilla is covered with numerous white nodules which are the racemose mucous glands. These empty into the lumen of the papilla by way of a short neck. Around the necks of these glands can be seen the muscle fibres of the papilla, which by their arrangement no doubt have some effect on the outflow of secretion from these glands. *d*, the papilla lying on the duodenal wall. The mucosa, submucosa, and most of the obliquely coursing fibres have been removed from the papilla to show the deeper-lying longitudinal fibres. At the base of the papilla is the bundle of fibres which would correspond to the sphincter of Oddi. The mucosa, submucosa, and the inner circular muscle of the intestine have been removed to show the arrangement of the longitudinal muscle fibres of the intestine. *e*, the common duct as it passes through the central wall. The constriction of the duct can readily be seen. The mucosa and submucosa have been removed from the papilla to show the arrangement of the obliquely coursing fibres.



Text-fig. 3.

by way of the neck. Further dissection through the thick layer of connective tissue reveals many narrow, thin, loosely arranged muscle fibres through which the glands just mentioned penetrate (text-fig. 3*c* and *e*). These fibres encircle the papilla in an oblique course, extending over the sides to the under surface of the papilla where they become lost in connective tissue or interdigitate as do the fibres previously described (text-fig. 3*b*). Beneath these fibres and intermixing with them are fibres of similar size that run in a longitudinal direction (text-fig. 3*b* and *d*); these extend backward along the surface of the common and pancreatic ducts and become lost in the dense connective tissue of the wall in the extraduodenal portions of the ducts. Tracing these fibres forward toward the tip of the papilla they become invisible, under the dissecting microscope, at the points where the bases of the longitudinal mucous folds on the inside of the papilla are attached. Many of the obliquely coursing fibres previously described have a similar termination.

From a study of the serial sections made, it can be seen that the various fibres mentioned are found extending into the longitudinal mucous folds on the inside (Plate I, fig. 3). The sections reveal that the epithelial lining of the folds is of a tall columnar variety similar to that found in the common duct, also that the mucous glands previously mentioned on the surface of the papilla are more numerous around the terminal part of the common duct.

From the work here presented a logical explanation of the function of the duodenal papilla is suggested. It is entirely hypothetical and is based on the structure of the papilla and its muscular arrangement.

The flow of bile appears to be controlled by the tonicity of the inner circular muscle of the intestine. When, by peristalsis or nerve control, this tonicity is relaxed, the fibres extending from the base of the papilla to the wall of the intestine, as seen in text-fig. 3*c*, *d* and *e*, contract, and this contraction probably occurs at the same time that the tone of the inner circular muscle is relaxed. When these fibres contract they pull the papilla forward, thereby tending to straighten out the duct at the point where it had been constricted by the surrounding intestinal muscle. This action would naturally open up the lumen of the duct at this point of constriction and allow the bile, which is always present in the duct, to flow into the lumen of the papilla. Here the bile is held back in the pockets surrounding the lumen of the papilla and accumulates until the muscle fibres which surround the papilla contract. By this contraction the pockets on the inside are reduced to a minimum, and at the same time there is squeezing of the papilla that expels the bile in a spurt.

The effect on the pancreatic duct is probably the same, that is, the contraction of the fibres tends to straighten out the duct and allows the retained secretion to flow out into the papilla from which it is expelled mixed with the bile.

CONCLUSIONS

1. The greatest constriction of the common duct is produced by the intestinal muscle. This would seem to be the most logical point of the sphincteric action, if there is any, and would seem to be produced by the intestinal muscle.

2. The independent muscle fibres, described by Oddi as being responsible for sphincteric action, are not circular in their arrangement but oblique, and the point of greatest constriction of the common duct is not outlined by these fibres.

3. The longitudinal mucous folds within the papilla have a definite arrangement, and the presence of muscle fibres in these folds would indicate that they have an active part.

4. The mucous glands present are direct outgrowths of the epithelial lining of the papilla.

REFERENCES

(1) Auster, L. S. and Crohn, B. B. (1922). "Notes on studies in the physiology of the gall bladder." *Amer. J. Med. Sci.* vol. CLXIV, pp. 345–60.

(2) Bidloo, Govert. Quoted by Baldwin, W. M. (1911), in "The pancreatic ducts in Man, together with a study of the microscopical structure of the minor duodenal papilla." *Anat. Rec.* vol. V, pp. 197–228.

(3) Gage, S. H. (1878–9). "The ampulla of Vater and the pancreatic ducts in the domestic cat (*Felis domestica*)." *Amer. Micro. J.* pp. 123–31, 169–80.

(4) Giordano, A. S. and Mann, F. C. (1927). "The sphincter of the choledochus." *Arch. Path. Lab. Med.* vol. IV, pp. 943–57.

(5) Glisson, Francis. Quoted by Hendrickson.

(6) Helly, K. K. (1898). "Beitrag zur Anatomie des Pankreas und seiner Ausführungsgänge." *Arch. mikr. Anat.* Bd. LII, S. 773–93.

(7) Hendrickson, W. F. (1898). "A study of the musculature of the entire extrahepatic biliary system, including that of the duodenal portion of the common bile duct and of the sphincter." *Bull. Johns Hopk. Hosp.* vol. IX, pp. 221–32.

(8) Job, T. T. (1926). "The anatomy of the duodenal portion of the bile and pancreatic ducts." (Abstr.) *Anat. Rec.* vol. XXXII, pp. 212–13.

(9) Judd, E. S. and Mann, F. C. (1917). "The effect of removal of the gall bladder." *Surg. Gynec. Obstet.* vol. XXIV, pp. 437–42.

(10) Letulle, Maurice and Nattan-Larrier, L. (1898). "Région vaterienne du duodénum et l'ampoule de Vater." *Bull. Soc. anat. Paris*, t. LXXVIII, pp. 491–506.

(11) Mann, F. C. (1920). "A comparative study of the anatomy of the sphincter at the duodenal end of the common bile duct, with special reference to species of animals without a gall bladder." *Anat. Rec.* vol. XVIII, pp. 355–60.

(12) —— (1924). "The functions of the gall bladder." *Physiol. Rev.* vol. IV, pp. 251–73.

(13) Matzuno, Y. (1923). "Über die Muskulatur des Ductus choledochus." *Virchows Arch.* Bd. CCXLVII, pp. 208–15.

(14) Oddi, Ruggeri and Marcacci (1887). "D'une disposition à sphincter spéciale de l'ouverture du canal cholédoque (1)." *Arch. ital. biol.* vol. VIII, pp. 317–22.

(15) —— Quoted by Luciani, Luigi, in *Human Physiology* (1913), vol. II, p. 214. London: Macmillan and Co., Ltd.

(16) Opie, E. L. (1903). "The anatomy of the pancreas." *Bull. Johns Hopk. Hosp.* vol. XIV, pp. 229–32.

EXPLANATION OF PLATE I

Fig. 1. The intrapapillary and extraduodenal portions of the common bile duct.

Fig. 2. Section through one of the white nodules found on the surface of the papilla, showing many alveoli. The cells are columnar and contain mucus (× 72).

Fig. 3. Section of the longitudinal mucous fold on the inside of the papilla, showing the presence of many smooth muscle fibres running in a longitudinal direction. The fibres in the photograph are stained black in contrast with the remainder of the section (× 96).

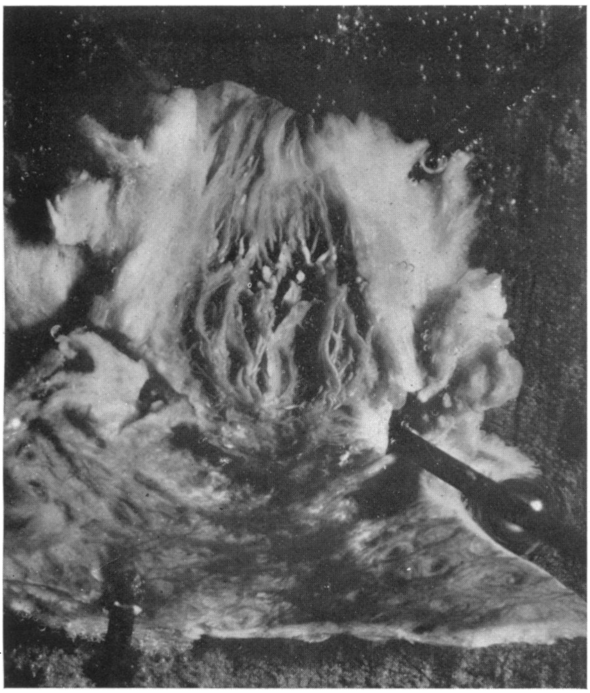


Fig. 1.

Fig. 2.

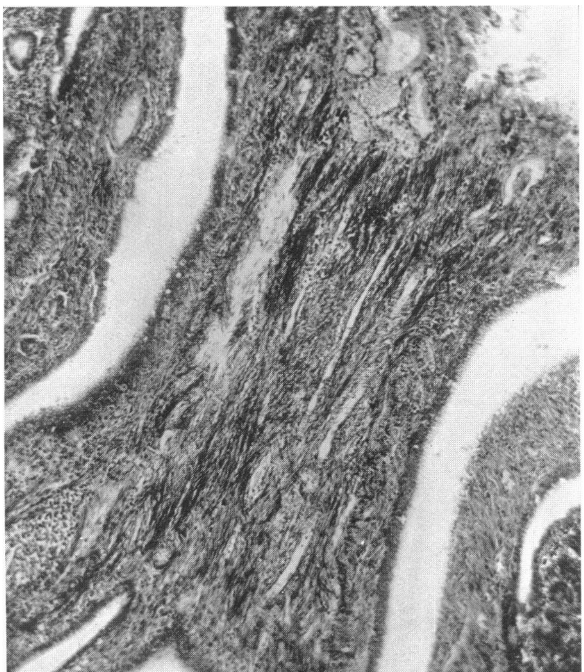


Fig. 3.