OBSERVATIONS ON THE HISTOLOGIC AND PATHOLOGIC ANATOMY OF THE HEPATIC, CYSTIC, AND COMMON BILE DUCTS*

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The gall-bladder is looked on as the most important part of the extrahepatic biliary passages. An enormous amount of experimental and clinical data have accumulated concerning it. Its susceptibility to disease has made it prominent from a surgical standpoint. The effects of its removal, especially those of a mechanical nature, have received attention probably because its apparent and most easily understood function is mechanical. Much less attention has been paid to the extrahepatic bile ducts, and one can search in vain the standard text-books of anatomy for a detailed description of them, although their gross appearance and anatomic relations are well known. The constantly increasing frequency of operations for removal of diseased gall-bladders and the many more instances of untreated disease of the biliary tract serve to emphasize the importance of the ducts. In fact, the gall-bladder is almost insignificant when compared with the essential nature of the hepatic and common ducts.

According to Heisler, the liver begins as a single evagination from the gut tube which quickly bifurcates into the anlagen of the right and left lobes. It grows between the layers of the ventral mesentery into the septum transversum and the liver ridge. The latter forms the connective-tissue part of the liver, but the hepatic cells and the epithelial cells of the ducts come from the original evagination of the gut. The hollow stalk by which connection is maintained with the gut forms the common duct. That the original diverticulum is single is the opinion of His, Kölliker, Hertwig, Minot, and Piersol. The gall-bladder takes origin as an outpouching of this diverticulum. It should be noted that the extrahepatic bile ducts have a common origin with the liver and the gall-bladder. In this respect they are different from the urinary system, in which the ureter, pelvis of the kidney, and collecting tubules do not take origin from the same anlage as the parenchyma of the kidney, and they serve merely to carry off the excretory products of the kidney.

REVIEW OF LITERATURE ON THE BILE DUCTS

To obtain any idea of the histologic structure of the bile ducts one must consult books which have long since been swept by in the current of medical literature and are almost forgotten. The German anatomist Theile, in 1844, described certain glands which he found in the walls of the bile ducts. He examined specimens from the pig, the sheep,

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the horse, and from man. By injecting the ducts with cinnabar and oil of turpentine he was able to distend the glands so that they appeared on the surface as minute round clusters. He noted that in the pig, the sheep, and the horse the glands of the bile duct are very similar; they are numerous, and open into the cavity of the duct on all sides. In man, however, they are entirely different. In the large as well as in the small duct, which could be opened with scissors, he observed two opposite rows of openings crowded very closely together, but the glands were not so numerous as in the horse, the pig, and the sheep. In general they consisted of a large duct with short twists. On the periphery of the duct there were alternating small cæcal diverticula and short-stalked clusters. He compared them with the meibomian glands and said that the branches formed an anastomosing network in the wall of the duct.

Kiernan was perhaps the first to direct attention to the many small pouches, or parietal sacculi, which project out from the lumen of the duct.

Beale, in 1856, and again in 1889, published his views on the bile ducts. He said that in man the openings of the sacculi form two rows on opposite sides of the duct. The greater number, however, are openings not of sacculi, but of small irregular tubes which run obliquely in the coats of the ducts and anastomose with each other. The vasa aberrantia are irregular ducts with cæcal pouches, and are most numerous in the transverse fissure of the liver. They are probably altered secreting tubes which at one time formed a part of the secretory structure of the liver. He did not believe that the glands of the ducts secrete mucus, because the bile of the rabbit in which the sacculi are almost absent contains as much mucus as that of the pig, in which animal they are very numerous. He looked on the parietal sacculi as diverticuli in which the bile might be temporarily retained and inspissated, and therefore considered them little gall-bladders appended to the ducts.

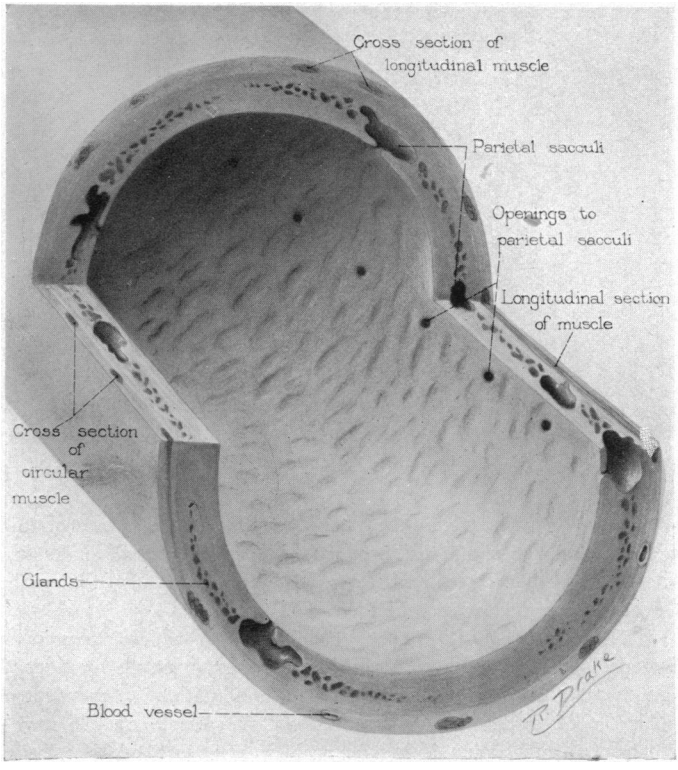

FIG. 1.—Reconstruction of the common duct showing the typical appearance of the mucous membrane, the parietal glands with their ampulla-like openings arranged in four rows, and the isolated bundles of circular and longitudinal muscle.

Keibel and Mall stated that the embryologic development of the glands of the ducts had not been studied. They are considered to be epithelial pockets rather than mucous glands.

Riess, in 1863, said that the glands are most numerous in the hepatic duct, rarer

in the upper part of the common duct and in the lower cystic duct, and absent from the lower portion of the common duct. The largest are branched tubes with rounded terminations and the small ones are simply pockets. They are less developed in children than in adults.

The views of Beale have been recently revived by Sweet, who has brought forth experimental data to support his contentions. He noted that after removal of the gall-bladder in the dog there was an immediate rise in total blood cholesterol, which after a period of forty days returned to the normal level. He observed that the parietal sacculi which in the normal dog appear flattened, became elongated and hypertrophied after the

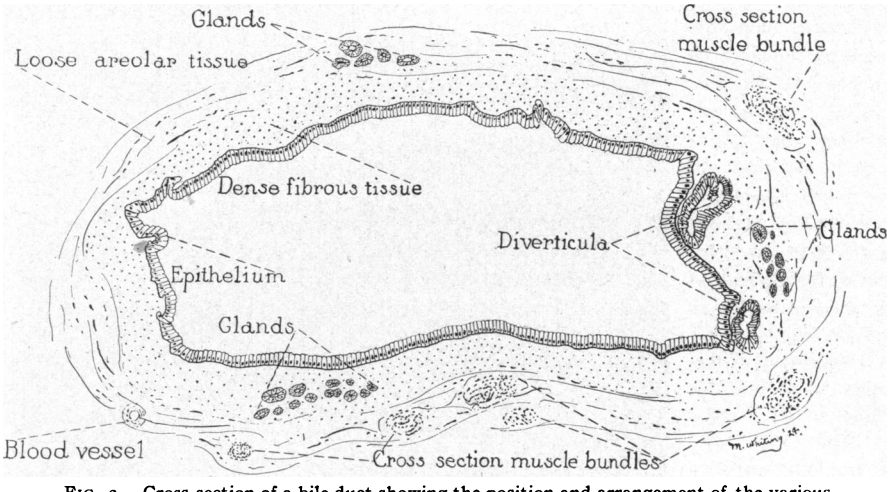

FIG. 2.—Cross-section of a bile duct showing the position and arrangement of the various structures found in the wall.

operation, coincident with the return of the blood cholesterol to the normal level. He believes that the numerous little gall-bladders appended to the ducts not only take over the function of the removed large gall-bladder, but also that pathologic processes which affect one extend to the other.

There is much in Sweet's conclusions to which exception might be taken. For instance, Judd and Mann have shown by experiments on dogs that the common duct dilates after cholecystectomy and that this dilatation is dependent on the intactness of the sphincter of Oddi. The enlargement of the parietal sacculi may be only a part of this mechanical dilatation. It has never been demonstrated that the parietal sacculi contain bile either before or after cholecystectomy.

In other words, in the human subject the walls of the bile ducts are richly supplied with epithelium-lined evaginations. These structures are variously spoken of as diverticula, parietal sacculi, and glands.

Another structure of the ducts which has received attention is the musculature. In 1888, Oddi described a sphincteric apparatus at the termination of the common duct which he believed was maintained in a state of tonic contraction by a nervous mechanism in the duodenum. My study did not include the sphincter of Oddi, and therefore this structure will not be further discussed. Regarding the musculature of the ducts themselves, there are conflicting observations. Beale says that in man there is no evidence of a distinct muscular coat. Matsumo concludes from his study that the common duct has a well-developed musculature only at the lower end. Muscle occurs in the duct above but is very irregular. He says that the common duct is a tube of connective tissue with a strong sphincter muscle at its mouth.

Hendrickson, in 1898, in a study of the musculature of the entire extrahepatic biliary system in man, found that longitudinal sections of the common duct revealed only a small amount of muscle. The fibres were longitudinal, diagonal, and transverse, and separated by much connective tissue.

Aschoff says: "All these distal bile passages (distal cystic duct, hepatic and common ducts) have practically no smooth muscle, being built from only connective tissue and elastic fibres, and are very rich in specific glands."

Aschoff's statement that the cystic duct proper begins at the termination of the true neck of the gall-bladder and does not contain the folds of Heister but resembles in structure the hepatic and common ducts is accepted. In any subsequent reference to the cystic duct the distal portion will be understood. The various theories regarding the variations of position and the function and dysfunction of the cystic duct in relation to the formation of gall-stones, as well as the question of a sphincter in this region, are not included in this study.

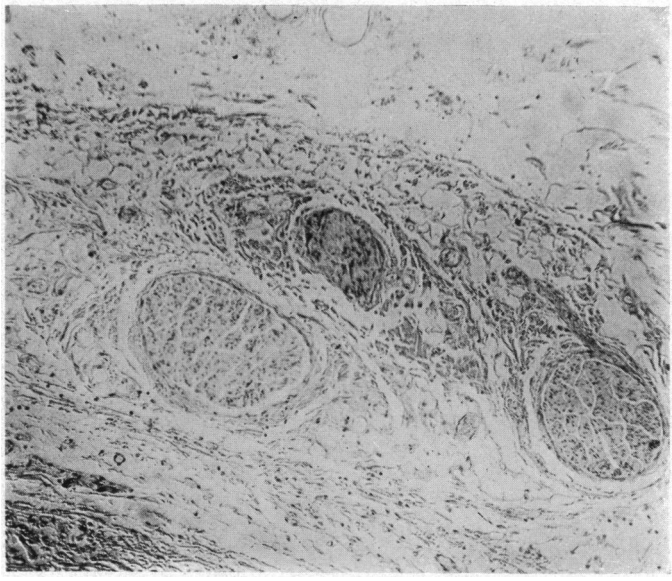

FIG. 3.—Cross-section of muscle bundles in the wall of the common duct. (X 60.)

The physiology of the bile ducts is indeed very incomplete and mostly theoretical. Holmes believed that the glands of the ducts secrete mucus, and Robinson says that the glands of the cystic duct secrete fluid and bile salts. It was the opinion of Beale that the glands of the ducts do not form mucus but serve, as the gall-bladder does, to concentrate the bile. Sweet has shown that these glands in the dog hypertrophy after cholecystectomy, but on the evidence that he submits I cannot concur in his deduction that the glands take over the function of the excised gall-bladder. Rous and McMaster [20] conclude from their experiments that the gall-bladder and ducts exert opposite influences on the bile. The ducts do not concentrate and thicken it with mucus as does the gall-bladder, but dilute it slightly with a thin secretion of their own which is colorless and devoid of cholates and cholesterol. They do not state whether the secretion is a product of the glands of the ducts or of the lining epithelium. When the obstructed duct system was connected with the gall-bladder they found that the ducts, as well as the bladder, were filled with thick concentrated bile. Apparently these authors take it for granted that the thick bile in the ducts becomes concentrated in the gall-bladder and then passes out into the ducts.

Rost found dilatation of the ducts in all of his animals after cholecystectomy and divided them into two groups. In one group the duct was dilated and had a long functioning sphincteral part; the animal was continent for bile and the function of the sphincter like that in animals with a gall-bladder. In the other group the ducts were only slightly dilated, the sphincteric part short, and the animals not continent. From

the examination of necropsy cases he concluded that absence of gall-bladder function alone was not sufficient to lead to compensatory dilatation of the ducts, nor was dilatation of the ducts in the presence of an atrophied gall-bladder due to the absence of the bladder's function.

Klee and Klüpfel noted, as did Rost, that after cholecystectomy some dogs became continent and others incontinent, and that in the continent dogs the bile was thick like gall-bladder bile, whereas in the incontinent dogs it was thin and watery.

Kausch says that three factors enter into the nature and condition of the bile: secretion from the liver, secretion from the bile ducts, and resorption from the bile ducts.

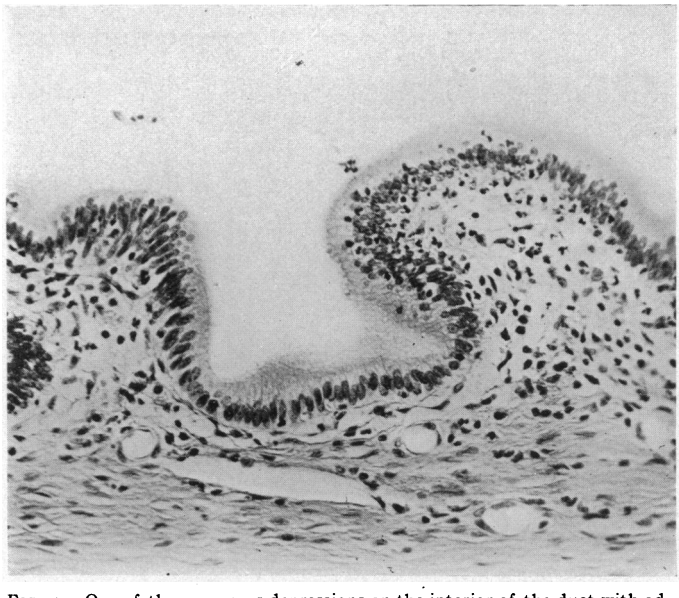

FIG. 4.—One of the numerous depressions on the interior of the duct with adjacent folds of mucous membrane. (X 120.)

It is apparently the unanimous opinion that the bile ducts have a secretion of their own. It is not specifically stated that it is a product of the glands of the ducts. Regarding the question of the resorption of fluid from the bile by the ducts as it occurs in the gall-bladder,[21] opinions are divided.

That the muscle tissue along the ducts plays a part in their activities seems to have been demonstrated by Westphal, who found that slight electric and pharmacologic stimulation of the vagus produced contraction of the gall-bladder and dilatation of the upper and middle portions of the common duct.

The present study was undertaken to determine the histologic structure of the extrahepatic bile ducts, not including the sphincter of Oddi, and to determine the nature of the pathologic processes that occur in the ducts. Only the ducts of man were studied.

Method of Study.—Specimens were obtained from one hundred routine necropsies, regardless of the ages of the subjects or the causes of death. In each case one or more specimens were taken from the hepatic, cystic, and common ducts and placed in formalin solution. The specimens were obtained as soon as possible after death. In the case of the common duct only sections from the supraduodenal portion were studied. Most of the specimens were examined both in the gross and under the dissecting microscope. Microscopic sections were then cut, some longitudinal and others transverse, and stained with hæmatoxylin and eosin. Some sections were stained for elastic fibres. Serial sections were made of a number of specimens.

Results of Study.—Most of the ducts were normal, but in specimens from forty cases there were pathologic changes. The structure of the ducts did not vary with the ages of the subjects; the youngest was eleven and the oldest seventy-five years. According to my observations, the hepatic, cystic and common ducts have essentially the same histologic appearance. Therefore it seems best to combine my collective notes into a description of a normal bile duct, and then to describe the pathologic changes.

When the duct is laid open the internal surface presents a characteristic appearance and at first seems to be reticulated, but on closer inspection and under the dissecting microscope it is seen to be covered by minute pits or shallow depressions, some of which contain plugs of mucus (Fig. 1). The purpose of these pits is, apparently, to increase the surface area of the interior of the ducts. The appearance of the pits in ducts which have dilated because of obstruction will be described under pathologic anatomy.

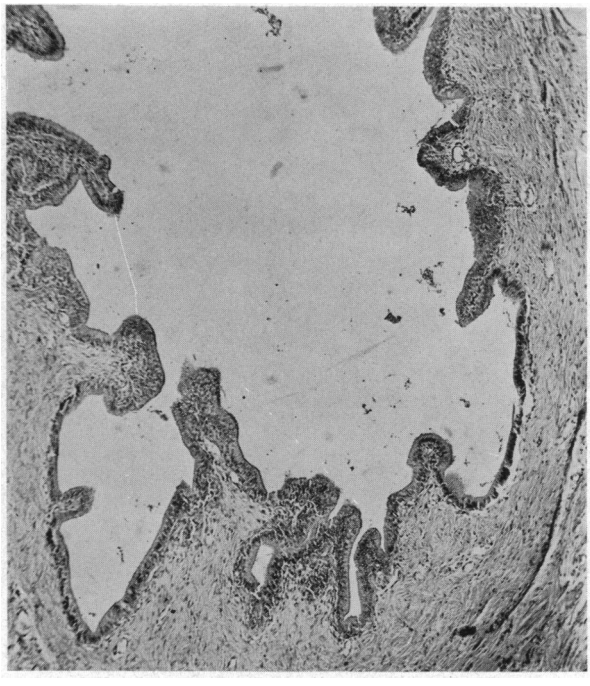

FIG. 5.—Portion of a cross-section of a bile duct showing folds of mucous membrane and a typical so-called parietal saccule. (X 60.)

Cross-sections of the duct show that the lining is covered with a layer of tall columnar epithelium. The nucleus of the cell is large, vesicular, well-stained, and situated at the base of the cell. The epithelium is similar to that which covers the rugæ of the gall-bladder. The epithelial layer was found intact in comparatively few specimens, and in some instances it had disappeared within an hour after death. Its loss has been attributed to the action of the bile. During life the epithelium readily regenerates to replace any defects in its continuity. Horsley showed, in an experimental reconstruction of the common duct, that the new channel formed from transplanted tissue is quickly lined by epithelium which grows into it from the edges of the normal duct, but the reconstructed duct later becomes almost completely obliterated in spite of the presence of lining epithelium. The process of fibrous obliteration takes place in the connective-tissue layer of the duct. This layer is found just beneath the lining epithelium and contains considerable elastic tissue, as was shown by special stain. The connective-tissue layer is thick and compact, and there can be no question but that it is the chief strength of the wall of the duct. The outer coat of the duct is composed of a loose layer of areolar connective tissue in which are found blood-vessels, lymphatics, and muscle (Fig. 2). I did not make special efforts to identify nerve tissue.

In spite of the opinions of others relative to the rarity and even absence of muscle tissue in the ducts, my observations showed that the bile ducts of the human subject are supplied with a well-developed musculature. It was almost constantly present in all specimens and was particularly evident in the cross-sections. Serial sections demonstrated

its presence along the course of the duct. The muscles are situated in the outermost layer of the wall and are made up of good-sized, isolated, oval bundles of unstriped fibres (Fig. 3). There are longitudinal and circular bundles, the former being the larger and better developed. A cross-section will usually reveal three or four large round bundles about equidistant in the periphery of the duct and separated by connective tissue which may contain several smaller bundles. I have not been able to find a description of peristalsis in the human bile duct, but from the anatomic standpoint it is possible, as it is seen in the ureter.

It should be pointed out that the majority of the pits which appear on the internal surface of the duct are not the openings of glands, but are shallow epithelium-lined depressions between folds of mucous membrane (Fig. 4). Occasionally these depressions take on the appearance of pouches (Fig. 5). However, after numerous microscopic sections have been studied, and the development of structures as brought out in serial sections of the duct has been observed, it is evident that besides the pits there are deep sacculi or diverticula which communicate by narrow openings with the lumen of the duct. These diverticula occur with definite regularity and seem to be arranged in four equidistant rows around the circumference of the duct (Fig. 1). Emptying into the sacculi are numerous glands which ramify in the wall of the duct, chiefly in longitudinal and circular directions, and seem to form almost a complete glandular layer around the duct. Near the sacculi the glands seem to be simple tubes but near the outer wall of the duct, where they are most numerous, they assume more the character of mucous glands and the acini are usually arranged in nests. In contrast to the frequent absence of the lining epithelium of the duct, caused by the action of the bile after death, the epithelium of the sacculi, tubes and glands are invariably intact. This observation helps to support the belief that the sacculi and glands do not retain bile. When their course is traced through serial sections of the duct, they appear to originate in acini in the outer wall of the duct from which tortuous tubes course through the walls to empty in common with other tubes into an ampulla-like opening which in turn communicates with the lumen of the duct. From the structure and arrangement of the diverticula and glands, it seems just as impossible for bile to be retained in them, as it would be for the contents of the duodenum to be retained and resorbed in Brunner's glands. In other words, the current is from the glands into the duct.

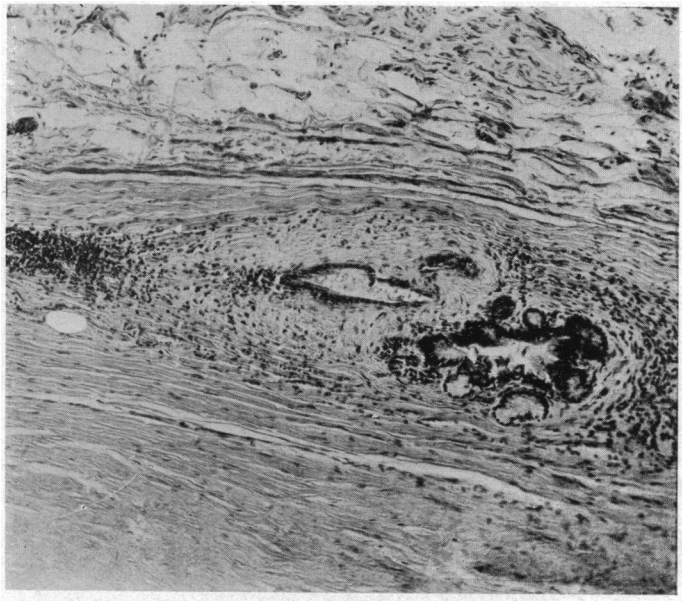

FIG. 6.—Nest of glands surrounded by marked inflammatory changes. (X 120.)

There are many variations in the appearance of the glands in apparently normal ducts. They are usually well developed and made up of cells similar to the lining epithelium of

the duct. Sometimes they seem to be almost atrophic and the cells small and flat. Glands were present in all specimens of ducts examined.

An accidental finding was the presence in several specimens of accessory pancreatic tissue in the wall of the common duct.

PATHOLOGIC ANATOMY OF THE BILE DUCTS

In a search through the text-books and recent literature no account of the pathologic anatomy of the ducts was found. The late post-operative complications of cholecystitis in which the common duct is sometimes constricted or completely obliterated by fibrous tissue can be explained only after an understanding of the early changes in the ducts. In discussing the pathologic anatomy of the cystic duct, Else says that the mucous glands may harbor infection and that the secondary changes in the duct following inflammation may cause hydrops and empyema of the gall-bladder.

FIG. 7.—A group of cystic acini in the wall of the hepatic duct. (X 60.)

Disease of the gall-bladder was associated with the diseased ducts in most of the forty cases. No attempt will be made here to correlate the histologic and clinical significance of the lesions in the ducts, but merely to describe the changes as they appeared in the specimens. The epithelium is very delicate and is usually absent in post-mortem specimens but not as a result of desquamative catarrh.

Inflammation in the duct is usually characterized by lymphocytic infiltration, an increase in connective tissue, and changes in the appearance of the glands. The infiltration by small round cells is sometimes seen just beneath the surface, but more often it is either diffused through the wall of the duct or confined particularly to the area around the glands (Fig. 6). In the later stages of inflammation an increase in connective tissue causes the wall to thicken, and the glands are often encased by a dense wall of fibrous tissue. From their characteristic distribution in the wall of the duct, it can be readily understood that inflammation in or around the glands would cause disease of the duct in its entire circumference. The fibrous tissue laid down during the

repair of a severe grade of inflammation changes the duct into a rigid inelastic tube. In some specimens the wall of the duct is thick and composed almost entirely of fibrous tissue. When the inflammation and fibrosis are localized in a short segment, a stricture of the duct may occur. A more extensive process may be followed by obliteration of a large portion of the duct. The glands, besides being surrounded by a zone of lymphocytes, are often dilated and cystic with flattening of their lining cells (Fig. 7). Sometimes the glands were small and atrophic as if choked by fibrous tissue.

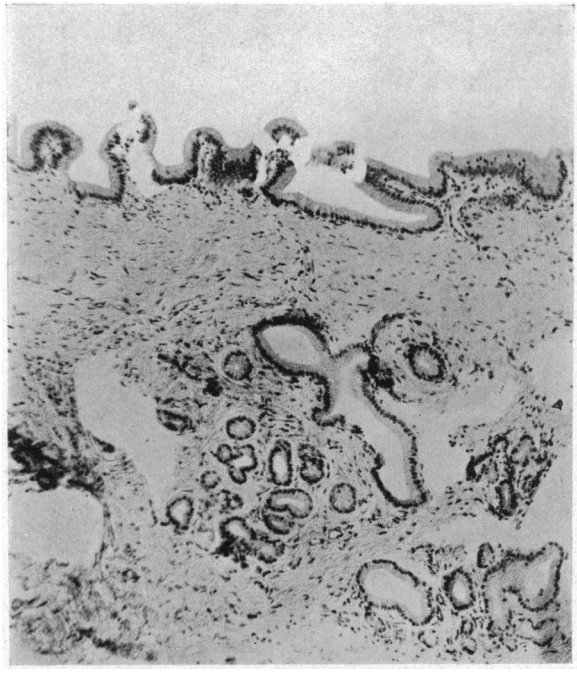

FIG. 8.—Cross-section of cystic duct from a case of cholecystitis showing folds of mucous membrane like those of the gall-bladder and dilatation of the intra-mural glands with round-cell infiltration. (X 60.)

Even in uncomplicated cholecystitis the hepatic and common ducts show evidence of inflammation, but, as might be expected, the cystic duct shows the most marked changes (Fig. 8). The importance of the effects of infection in the wall of the cystic duct should be borne in mind whenever cholecystostomy for cholecystitis is considered as an operation of choice.

Dilatation of the common duct may be caused by obstruction, or it may be the result of infection sufficient to destroy the function of the gall-bladder, or it may follow cholecystectomy. Examination of the duct in the last two conditions may throw some light on the question of compensatory function of the duct. The cystic and common ducts which were markedly dilated as the result of obstruction low in the common duct are shown in Fig. 9. The ducts have been laid open, and it will be noted that the cystic and common ducts are identical in gross appearance. The pits on the surface of both ducts are plainly evident and it can readily be seen that these pits are mere shallow depressions between folds of mucous membrane and certainly are not dilated nor hypertrophied pouches or parietal sacculi.

DETAILED FINDINGS IN PATHOLOGICAL SPECIMENS

CASE I.—A woman, aged thirty-seven, died following a radical operation for carcinoma of the right breast with glandular involvement. The patient had never been jaundiced. At necropsy the gall-bladder contained forty-two stones and the mucosa had a strawberry appearance. The common duct was markedly dilated and contained

seven stones. Sections were made of the ducts. These showed lymphocytic infiltration throughout. Just beneath the surface of the common duct there was a marked inflammation; the glands showed proliferation and were dilated and filled with mucus. The epithelial lining of the duct was intact (Fig. 10). There was no evidence of dilated sacculi in communication with the lumen of the duct.

CASE II.—A woman, aged forty-six, gave a history of gall-stone colic. Operation revealed a stone in the common duct and a fistulous opening between the gall-bladder and duodenum. The stone was removed from the duct and a rubber catheter inserted for drainage. The cholecystoduodenal fistula was closed. Death occurred five days after operation. Necropsy revealed a small contracted gall-bladder which was buried in adhesions to the under surface of the liver. There was extreme dilatation of the common duct. Microscopic sections of the duct revealed thick walls with marked lymphocytic infiltration. The glands were cystic.

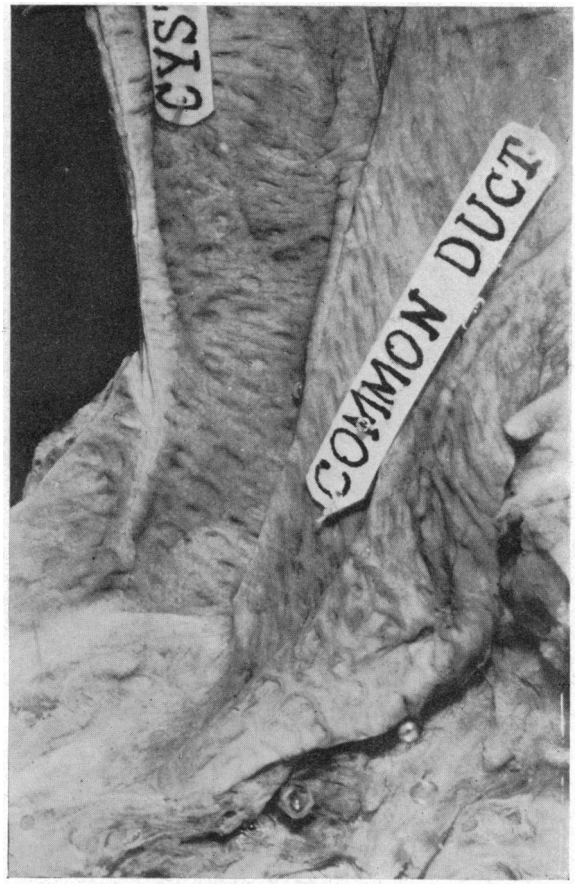

FIG. 9.—Interior of the cystic and common ducts which were markedly dilated as the result of obstruction.

CASE III.—A woman, aged sixty-three, came for examination because of repeated attacks of gall-stone colic. Operation revealed acute cholecystitis and stones in the common duct. Cholecystectomy was performed, three stones were removed from the common duct and a rubber catheter inserted into the duct for drainage. The patient died four days after operation. At necropsy a stone was found in one of the larger intrahepatic ducts and also a stone in the common duct at the juncture of the cystic duct which had ulcerated through from the cystic duct. The common duct was markedly dilated, and measured 2.5 cm. in circumference. The microscopic sections of the duct showed inflammatory changes and great proliferation and dilatation of the glands just beneath the lining epithelium.

CASE IV.—A woman, aged forty-nine, gave a history indicative of cholecystitis. At operation an old empyema of the gall-bladder was found and there were stones in the common duct. Cholecystostomy and choledochostomy were performed. Death occurred five days after operation. Examination of the biliary tract revealed one large and many small stones in the lower end of the common duct just above the ampulla. All the extrahepatic ducts were dilated and the common duct measured 3.5 cm. in circumference. The intrahepatic ducts were not dilated. The microscopic sections showed that the walls were thick, œdematous and infiltrated with lymphocytes. Very few glands were seen.

CASE V.—A man, aged seventy-two, came for examination complaining of stomach trouble. He was found to have a carcinoma of the stomach which in the röntgenogram appeared to be operable. The patient died following resection of the stomach. At necropsy stones were found in the gall-bladder and in the common duct. The gall-bladder was small and contracted as a result of chronic infection, and the common duct was markedly dilated and contained stones just above the ampulla. Microscopic examination of the ducts showed that the walls were thick, œdematous, and infiltrated with round cells. The glands of the ducts were only moderately dilated.

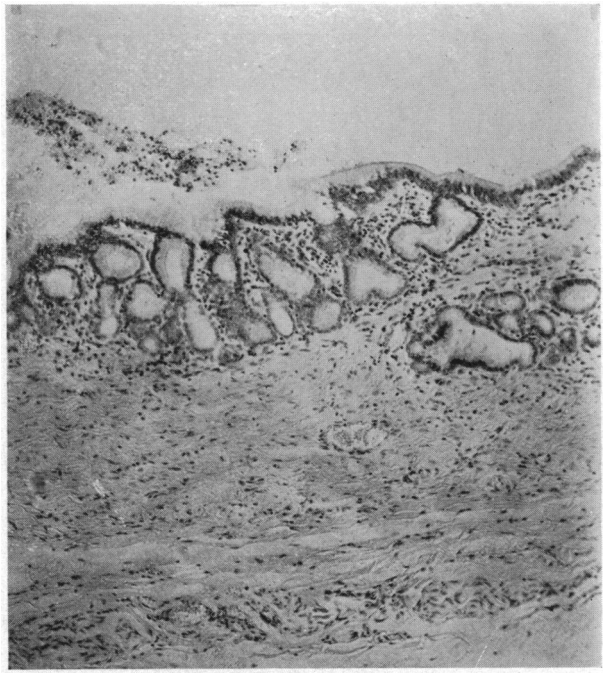

FIG. 10.—Section of common duct from a case of stone in the common duct, showing marked proliferation and dilatation of glands just beneath the surface, with evidence of inflammatory reaction in the tissues. (X 60.)

CASE VI.—A man, aged sixty-five, gave a history of repeated attacks of severe colic in the right hypochondrium. He was definitely jaundiced and appeared to be very ill, so that it seemed best to keep him under observation for a time until surgical intervention could be more safely undertaken. He became progressively worse and died without having been operated on. Necropsy showed that the gall-bladder had been almost completely destroyed by infection. The extrahepatic bile ducts were markedly dilated and their walls thickened. The ampulla of the common duct was dilated, swollen and œdematous. There was no demonstrable obstruction in the ducts and they were free from stones. Microscopic sections of the ducts showed that the walls were thickened by fibrous tissue, the glands dilated, and the mucous membrane thrown into folds.

These six typical cases show the presence of inflammatory changes in the ducts in association with infection in the rest of the biliary tract. While the cases illustrate extreme features of biliary disease with active clinical symptoms, many examples could be cited in other cases of ancient and apparently quiescent disease of the gall-bladder, in which less marked but still well-defined pathologic changes appeared in the ducts. It was very exceptional to find the ducts normal in the presence of an obviously diseased gall-bladder. It does not necessarily follow that involvement of the ducts is secondary to that of the gall-bladder, although it is the most plausible explanation. It is possible that the two may be affected simultaneously. The possibility of an ascending infection in the wall of the duct from the duodenum must be also borne in mind, particularly when there is obstruction to the drainage of the ducts by a stone.

The gall-bladder, because of its peculiar form and position, is unable to deal adequately with infection, and once infected readily becomes reinfected, because the ability to empty its contents has been seriously impaired; at best it is a diverticulum that drains poorly. On the other hand, the ducts should speedily recover from infection because of their excellent drainage, unless there is obstruction by stone or a focus of infection in another part of the duct system as in the gall-bladder.

A characteristic feature of the inflammatory changes in the ducts is the dilatation of the glands. They become distended with mucus which they pour into the duct. They never contain bile. Irritation of the glands is followed by overproduction of mucus. Others beside these six cases were examined in which the gall-bladder had been rendered functionless by chronic infection. A careful study of the ducts in these cases did not reveal any structural changes that might be considered compensatory for the loss of function of the gall-bladder. The question of compensatory function of the ducts after cholecystectomy can be solved for man only by the gross and microscopic study of the ducts after the removal of a normal gall-bladder. From the evidence before me, which is based on a comparison of normal ducts with those in cases of advanced disease of the gall-bladder, it would seem that the theory is not supported by the facts.

Discussion.—There can be no doubt that, from the embryologic and anatomic standpoints, the gall-bladder is a part of the duct system. There is also a very evident similarity in minute structure, especially in the type of lining epithelium. Langenbuch, who performed the first cholecystectomy in man in 1882, observed that gall-bladder bile is concentrated, and Rous and McMaster [21] were able to measure this function of the gall-bladder in the dog. It is probably safe to assume that the lining epithelium of the gall-bladder is responsible for its concentrating activity. It is well known that the gall-bladder and ducts secrete mucus. In the case of the former, this function is also probably carried on by the surface epithelium and perhaps aided by the glands of Luschka. In the case of the ducts, mucus is formed mainly in the parietal glands. These similarities between the gall-bladder and ducts, and the observations of Klee and Klüpfel that duct bile may be concentrated after cholecystectomy, seem to justify the belief that the ducts are also able to concentrate bile, although this function may be insignificant compared to the greater function of the gall-bladder. White bile occurs in the obstructed ducts from which the gall-bladder has been excluded, probably because the concentrating activity of the ducts, being handicapped by a very limited surface area, cannot keep pace with the excretion of bile from the liver. The residual bile present in the duct after cessation of the flow, disappears through absorption and is replaced by mucus.

The dilatation of the ducts which follows removal of the pressure regulatory function of the gall-bladder, either by disease or by operation, is probably mechanical in origin, because it does not occur when the sphincter of Oddi is not intact. The ducts do not dilate when there is incontinence of the

sphincter which accounts for the relatively normal size of the ducts, sometimes seen with cholecystitis and occasionally after cholecystectomy. The findings in this group indicate that absence of the function of the gall-bladder is not solely responsible for dilatation of the ducts and also that the ducts do not take over the function of the ablated gall-bladder.

SUMMARY

The hepatic, cystic (distal part), and common bile ducts are identical in structure. They are lined by a layer of tall columnar epithelium which covers a surface made uneven by numerous shallow depressions. The epithelium rests directly on a thick compact layer of elastic connective tissue which makes up most of the thickness of the wall and on which the tensile strength of the duct is mainly dependent. The outside coat of the duct is composed of a loose layer of areolar tissue in which are found bundles of unstriped muscle, blood-vessels, and lymphatics.

The walls of the ducts are richly supplied with glands which are situated for the most part in the outer coat, but the ducts of the glands, coming together from all directions, finally empty into ampulla-like openings which are arranged in a regular manner around the duct and communicate with its lumen. There is no evidence of true parietal sacculi or diverticula.

The ducts are provided with a well-developed musculature which is composed of isolated longitudinal and circular bundles situated in the outer layer of the duct and separated from each other by connective tissue. The muscle does not form a compact layer but is arranged as a loose network.

The most frequent pathologic changes in the ducts are those of inflammation. Cholecystitis is nearly always accompanied by infection in the walls of the ducts. The lesions are those of the usual chronic inflammatory type, characterized by lymphocytic infiltration and the production of fibrous tissue. The glands may retain infection and aid in its dissemination through the duct. The glands respond to the irritation by an overproduction of mucus and become dilated and cystic. The process of repair is attended by the formation of fibrous tissue which results in a thick and inelastic tube.

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