Facts and Fiction Regarding Strictures of the Extrahepatic Bile Ducts *

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THE GREAT MAJORITY of strictures of the common bile duct are man made and result from surgical trauma. Injuries to the common bile duct are usually the result of surgical procedures associated with cholecystectomy, but they may be secondary to gastrectomy, choledochostomy, or radical operations on the pancreas. Although a stricture of the bile ducts may result from an accumulation of bile or a pericholedochal abscess, it is more probable that these accumulations are the result rather than the cause of the stricture. In rare instances, a stricture may result from an erosion of a gallstone into the common or right hepatic duct.[2] A stricture in the intrapancreatic portion of the common bile duct resulting from necrotizing pancreatitis secondary to spontaneous or postoperative pancreatitis is also a rare occurrence. Spontaneous sclerosing choledochitis is an uncommon disease of unknown etiology, and it may produce severe stricturing of the hepatic and common bile ducts. Thirty-nine patients with this disease have not been included because they present a problem unrelated to this discussion. The special problem of malignant strictures of the extrahepatic bile ducts is also excluded from this discussion.

When the common bile duct is deliberately divided and anastomosed to a segment of the gastro-intestinal tract as part of a definitive procedure such as pancreaticoduodenectomy, a secondary benign stricture may occasionally occur. This possibility should be recognized and the assumption that a stricture is secondary to recurrent tumor should not be made too quickly.

An analysis of 895 patients with postoperative stricture treated at the Lahey Clinic between 1919 and 1963 shows that 97 per cent could definitely be related to surgical trauma, while 0.4 per cent were the result of an erosion of a bile duct by a gallstone. A total of 3 per cent of these patients had benign biliary strictures not directly the result of previous surgery in the area.

Anatomical Location of Stricture

The classical concept that injury to the common bile duct during a cholecystectomy is usually the result of distortion or *tenting* of the common bile duct by traction applied to the cystic duct is not confirmed by a careful analysis of a large number of cases. In a study of 200 consecutive patients with bile duct strictures treated at the Lahey Clinic in the years 1958 to 1963, the stricture was the result of operative trauma in 190. In 97 patients (51%) the injury definitely involved the common hepatic duct or the right or left hepatic duct. The injury most commonly involved the common hepatic duct where the cystic duct is apposed to its right lateral margin. When the hepatic ducts united distal to the hilus of the liver, they were particularly prone to surgical injury.

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In determining the possible influence that anatomical abnormalities may have in the etiology of common bile duct injuries, it is worth considering the reported incidence of variations [10] in the anatomy of the cystic artery, the right and left hepatic ducts, the union of the cystic duct, and its site of origin.

Cystic Artery. Typically, the cystic artery arises from the right hepatic artery to the right of the hepatic duct in Calot's triangle. The boundaries of this triangle are the cystic duct which is inferolateral, the hepatic duct which is medial, and the inferior surface of the liver which forms the cephalic side of the triangle. The right hepatic and the cystic arteries are located in the cephalic part of the triangle. The cystic artery is single in 75 per cent of the population and duplicate in 25 per cent. In 70 per cent of the population, the single cystic artery originates from the right hepatic artery and in only 5 per cent does it arise from some other source such as the left hepatic, retroduodenal, or gastroduodenal artery. In 55 per cent of the population, the single artery arises within the cystic triangle, in 40 per cent taking origin from a right hepatic, in 15 per cent from a replaced right hepatic, and only occasionally from an accessory right hepatic artery. The cystic artery arises to the left of the hepatic duct from the right hepatic artery in 15 per cent of the population and from some other source in 5 per cent. That is, in a total of 20 per cent the single cystic artery originates to the left of the bile duct system and crosses the hepatic duct or the common bile duct to reach the gallbladder. It usually crosses anteriorly.

The cystic artery is duplicated in 25 per cent of the population, but it is very rare to find more than two vessels. In practically all instances, one or both of the duplicated cystic vessels take origin from the right hepatic or an aberrant right hepatic artery in Calot's triangle.

Therefore, in approximately one-fifth of the population, the cystic artery or one of the branches of a duplicated cystic artery does not take origin in Calot's triangle and has to cross the hepatic ducts to reach the gallbladder. In three-fifths of the population, the cystic artery arises from a typical celiac right hepatic artery while in one-fifth the cystic artery arises from some other vessel in Calot's triangle.

Extrahepatic Junction of Right and Left Hepatic Ducts. The common hepatic duct has an average length of 4 cm. (range 2 to 7 cm.). This variation in length is determined by the early or late confluence of the right and left hepatic ducts to form the common hepatic duct and its union with the cystic duct. The former can occur either within the porta hepatis or below the margin of the liver. In approximately a fourth of the population, two ducts issue from the right lobe of the liver to unite independently with the left hepatic duct, but on the left side this is rare. The right and the left branches of the hepatic duct usually unite high in the portal fissure, but should the junction occur caudal to the liver margin, the right hepatic or the cystic artery may pass through the angle. The aberrant course of these vessels has occurred with a high union of the ducts.

Abnormal Course of Right Hepatic Duct. The anterior and posterior segmental branches of the right hepatic duct do not unite to form a common trunk in 25 per cent of people. The segmental ducts enter Calot's triangle and unite independently with the common hepatic duct, and are prone to surgical damage during cholecystectomy. Occasionally the aberrant course taken by these ducts may simulate an accessory hepatic duct.

Site of Union of the Cystic Duct with the Hepatic Duct. The union of these two structures can occur anywhere along the bile duct, and the site of union may be at or below the duodenal margin. In such

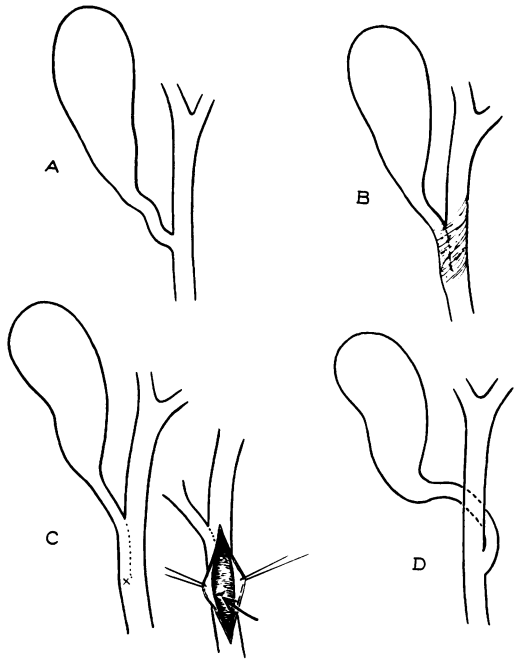

FIG. 1. The cystic duct may unite with the common hepatic duct by angular, parallel or spiral apposition. *A*, Angular union with the point of junction clearly seen. *B*, Angular union with the distal cystic duct apposed to the common hepatic duct by loose fibrous connective tissue which obscures the actual site of union. *C*, Parallel union—the precise point of entrance is seen only after opening the common bile duct. *D*, Spiral union.

cases no supraduodenal portion of the common bile duct exists, or what may appear to be a common bile duct in many instances will be found to be the cystic duct firmly united to the common hepatic duct.

Angular, Parallel and Spiral Apposition of the Cystic Duct to the Common Hepatic Duct. The union of the cystic and common hepatic ducts may take place by an angular, a parallel, or a spiral apposition. The angular union may occur at any level, and the cystic duct may have almost any length. In the parallel type of apposition, the duct is usually bound lateral or posterior to the hepatic duct for variable distances (1 cm. to more than 5 cm.), while in the spiral type, the cystic duct pursues a spiral course anterior or posterior to the hepatic duct to open into it after any part of a complete full spiral twist has been accomplished. Usually the cystic duct opens to the right of the hepatic duct, but as any variation can occur, it should be emphasized that the cystic duct may open anywhere along the course of the hepatic duct. The cystic duct may even enter a segmental duct when the union with the common hepatic duct is very low (Fig. 1).

The variations are so numerous that no standard deviation can be assumed. If any anomaly is observed in the region of the gallbladder, the hepatic or cystic arteries, or the extrahepatic ducts, no structures should be clamped or divided until the union of the common hepatic duct, cystic duct, and common bile duct, and the course of the cystic artery have been absolutely identified by careful dissection. Intraluminal probing or operative cholangiography may help to identify the course of the various bile ducts in difficult cases.

Pathologic Processes That May Favor Injury

Cholecystitis in two of its pathologic phases predisposes to an injury of the extrahepatic bile ducts during cholecystectomy. In the acute edematous phase of cholecystitis, the gallbladder and surrounding tissues may be so turgid and vascular that obliteration of the cleavage planes in the triangle of Calot makes difficult the identification of the cystic artery, the common hepatic and the common bile ducts. In the chronic fibrotic phase of cholecystitis with a contracted gallbladder, the scarring of the tissues in the triangle of Calot can be so dense that dissection of the individual anatomic structures is extremely difficult. The erosion of a gallstone into the extrahepatic biliary tree is rare, but should this condition be recognized during an operation, the common bile duct should be opened immediately in its supraduodenal course and the position of the right and left hepatic ducts should be predetermined.

Diagnosis

The telltale signs of postoperative strictures of the bile duct are jaundice, biliary fistula, or both.

Jaundice. This most commonly occurs within 24 to 48 hours after the operation and is of an obstructive type with bile pigment found in the urine.

Biliary Fistula. From four to seven days after operation, bile may suddenly escape from the wound, and a persistent or intermittent biliary fistula may be established.

There is a reciprocal relationship between the volume of bile drained and the depth of the jaundice. The operating surgeon frequently entertains the fiction that the jaundice is the result of hepatitis or that the biliary drainage is due to the slipping of the ligature on the cystic duct or the division of a small subvesical bile duct. Although a subvesical duct exists in 35 per cent of the population, damage to this is a rare cause of biliary fistula. The true facts can be determined by the biochemical demonstration of obstructive jaundice or by the visualization of an obstructed common bile duct after the injection of radiopaque media into the fistula through a Foley catheter.

If the fistula closes spontaneously, the patient may have chills, fever, pain and progressive jaundice. The severity of these signs may be less evident if an internal fistula develops.

We have found that the diagnosis of a stricture of the bile duct can usually be made on clinical grounds. The onset of obstructive jaundice possibly associated with biliary drainage from the wound during the immediate postoperative period is indicative of injury to the bile duct. Postoperative pancreatitis is rarely severe enough to obstruct the distal common duct without obvious clinical manifestations of the disease. The roentgenographic demonstration of a fistulous tract to an obstructed common bile duct is probable evidence of a stricture.

Patients may present with symptoms of jaundice, chills, and sweats, arising years after an uneventful cholecystectomy. Choledocholithiasis is the most frequent cause of the symptoms as this condition develops subsequently in from 2 to 10 per cent of patients who have had a cholecystectomy for cholelithiasis. The discovery of a biliary stricture with an internal choledochoduodenal fistula is not uncommon at this clinic, and choledocholithiasis is frequently present proximal to the stricture. Careful questioning of these patients regarding the details of the preceding cholecystectomy very often brings to light a history of prolonged biliary drainage occurring after the previous operation.

A variable degree of jaundice will be seen on examination, dependent upon whether an external or internal biliary fistula is present. An external fistula is obvious, and marked excoriation of the skin indicates associated pancreatic or duodenal injury. A palpably enlarged, finely nodular liver is common if the obstruction is of long standing, and splenomegaly may also be present if portal hypertension has occurred. The feces appear normal if the jaundice is mild or if there is an internal fistula, but clay colored if the obstruction or external fistula is complete.

Laboratory Tests. Biochemical tests demonstrate bile pigment in the urine. The serum alkaline phosphatase activity is increased, and the serum cholesterol concentrations and bilirubin are raised in cases of long standing. Abnormal changes in the flocculation and turbidity studies of the serum proteins are not usually seen unless the obstructive jaundice is of long standing.

Roentgenography. Intravenous cholangiography is rarely of help in the presence of severe jaundice, but it may be of some aid in incomplete strictures occurring soon after injury to the duct or when symptoms

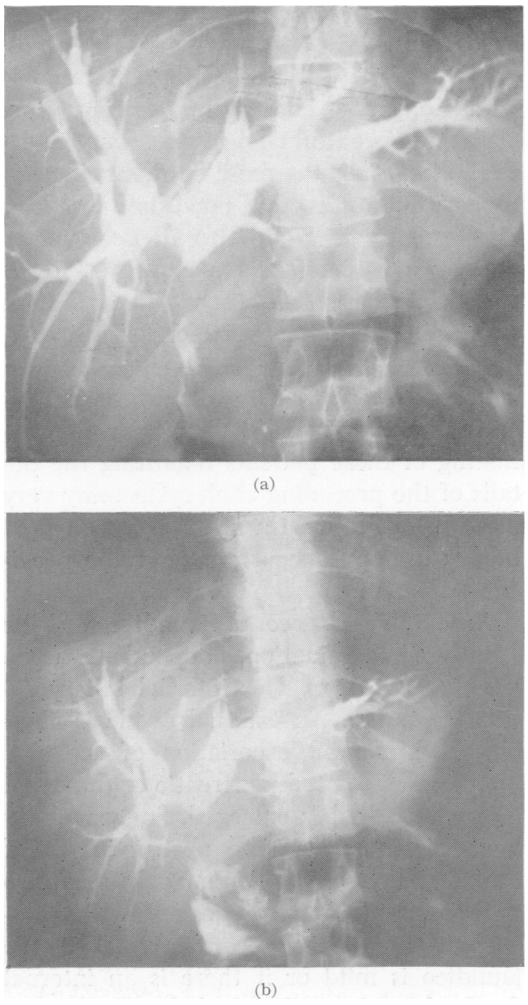

FIG. 2. *a*, Percutaneous cholangiogram showing stricture of common hepatic duct. The right and left hepatic ducts are greatly dilated. A minute fistulous tract permits passage of the contrast medium into the jejunum. *b*, Roentgenogram taken 15 minutes later shows decreasing concentration of contrast medium in the hepatic ducts and diminishing distention of the ducts as more contrast medium has passed into the jejunum.

recur after previous definitive procedures for a stricture. Visualization of the biliary tree is obtained only if the jaundice and hepatocellular damage are minimal. Percutaneous cholangiography gives the best nonoperative visualization of the biliary tree (Fig. 2a, b). This should be attempted only if the clotting mechanisms are normal. In most instances this test is done immediately prior to exploratory laparotomy. A stricture or internal fistula may be accurately demonstrated, but apart from determining the type of stricture and possible fistula, this test does not influence the procedure which will be carried out. Glenn and his associates [7] have employed a polyethylene tube inserted at the time of percutaneous cholangiography to decompress the biliary system preoperatively. The caliber of these tubes rarely permits sustained decompression. The demonstration of a point of obstruction in the common duct or the actual failure of filling of the distal common bile duct may be possible by instilling radiopaque dye through an external fistulous opening.

Prevention

In only 20 of the 706 patients treated at the Lahey Clinic, including 501 patients reported by Cattell and Braasch,[4] was there a nontraumatic cause of the biliary stricture (Table 1). In the remaining 686 patients, the injury followed a surgical procedure on the gallbladder, common bile duct, or organs in the right upper quadrant of the abdomen. This tragedy can be prevented by attention to detail in the execution of the surgical procedure. First and foremost the surgeon must have the training and ability to perform safely the sur-

TABLE 1. *Extrahepatic Biliary Stricture*
Benign Biliary Stricture

	Number
Stones eroded from duct to duodenum	2
Inflammatory obstruction of duct	10
Followed cholecystectomy 3	
Followed pancreatitis 6	
External trauma to upper abdomen	2
Congenital causes	4
Cobalt radiation for hepatic metastases from seminoma	1
* Hydatid cystectomy	1
Total	20

* Possible cause of stricture.

gical procedure undertaken. He must have the surgical judgment to know when a procedure will endanger a patient and to perform a less demanding and less hazardous operation if the pathologic process is not favorable for definitive treatment. For example, cholecystostomy instead of cholecystectomy for acute cholecystitis may be preferable, knowing that it may be necessary to reoperate at a later date to complete the treatment.

Certain facets of the operation are worthy of emphasis. An incision of adequate length and ideal location which enables faultless exposure and illumination of the operative field is essential if visualization and dissection of the anatomical structures are to be achieved with certainty and confidence. The initial incision was not ideally situated in a high percentage of the patients with biliary strictures as seen at the Lahey Clinic. If a paramedian incision had been used at the previous operation, it is frequently found to be too low, too short, and too lateral. If a subcostal incision had been used, it is frequently too close to the costal margin, too short, and too lateral to obtain ideal exposure at the initial surgical procedure. The junction of the cystic duct with the common hepatic duct and the common bile duct must be visualized in all cases (Fig. 3). The cystic artery must be identified and carefully clamped close to the gallbladder in such a way that the tip of the forceps will not endanger the common

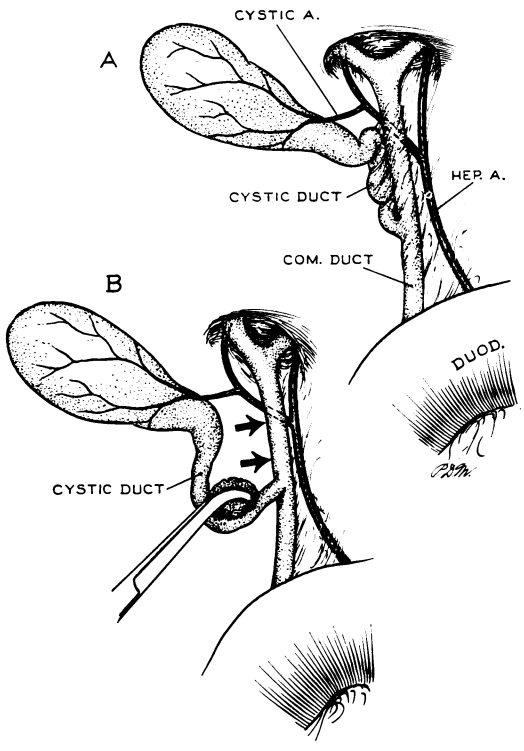

FIG. 3. The precise point of junction of the cystic duct with the common hepatic duct must be demonstrated in all cases. Division of the connective tissue binding these two structures together releases a far greater length of cystic duct than is usually anticipated. Early division of the cystic artery may allow easier dissection of this area and less danger of inadvertent tearing of the vessel by manipulation. The arrows demonstrate a common point of injury of the common hepatic duct.

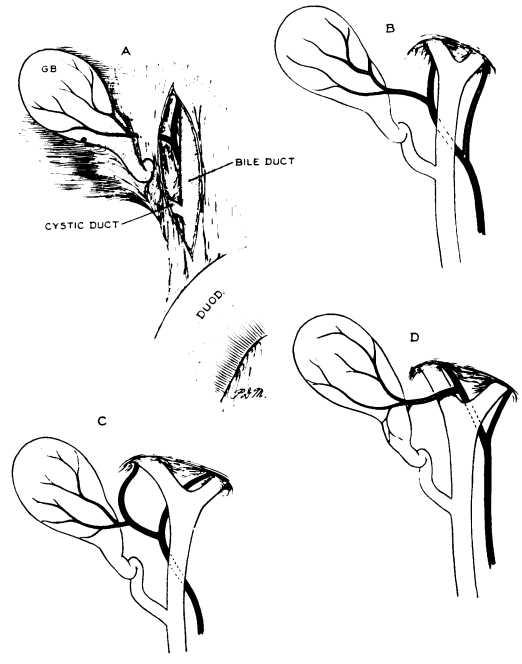

FIG. 4. Dissection must allow visualization of the cystic artery up to the gallbladder wall as well as the point of junction of the cystic duct to the common hepatic duct. *A*, Opening the peritoneal roof of Calot's triangle demonstrates a vessel passing toward the gallbladder. *B*, Normal path of the cystic artery. *C*, The right hepatic artery makes a loop across Calot's triangle, giving origin to the cystic artery adjacent to the gallbladder. *D*, The cystic artery may pass between the right and left hepatic ducts, exposing them to possible injury.

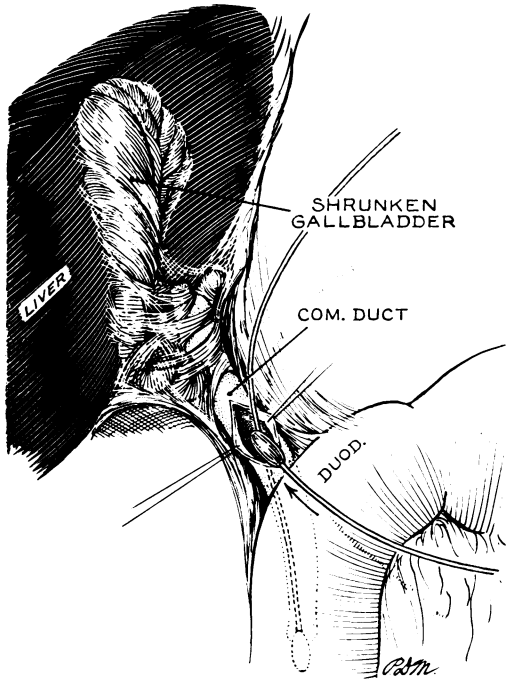

FIG. 5. Both acute edematous and chronic fibrotic cholecystitis might obliterate normal cleavage planes. The common bile duct should be opened in its supraduodenal portion and a Bakes dilator passed up or down the bile duct to identify and protect the common hepatic duct and common bile duct while the cystic artery and cystic duct are dissected out.

hepatic duct, the right hepatic duct, or the right hepatic artery (Fig. 4). Traction on the gallbladder must be adequate but not excessive so that avulsion of the cystic artery or tenting of the common duct does not occur. Clamps or ligature of the cystic duct stump must be applied without tension on the cystic duct. Each step of the procedure must be deliberate and unhurried. If the turgidity of the gallbladder and of the tissues in Calot's triangle prevents the visualization of the anatomical structures, the common bile duct should be opened and a Bakes dilator inserted into the common hepatic duct to permit safe dissection (Fig. 5). If a local abscess is present or if the vascularity is greatly increased, the performance of a cholecystostomy may become the hallmark of surgical judgment.

In the pathologic stage of cholecystitis, when the cystic duct and cystic arteries are buried in a dense fibrous mat, the common bile duct should be opened in the supraduodenal segment and a Bakes dilator inserted to the approximate site of the cystic duct and cystic artery. Often it is only by this means that a satisfactory delineation of the common hepatic and right hepatic duct can be obtained. The arterial supply can then be precisely visualized and safely clamped and ligated as the vessels enter the viscus. Following the removal of the gallbladder, if hemostasis is not complete, the exposure should be reassessed, the field adequately illuminated, and by using suction to clean the field, the bleeding point can be accurately and delicately secured with a fine hemostat or suture. Fine silk suture without the application of a hemostat is usually safer. Blind clamping of an area of tissue is fraught with danger and the bile duct or the right hepatic artery may be injured. An arterial injury in this region may be a serious complication as these are end arteries and necrosis of a lobe of the liver may result.

If the operation is being carried out for a duodenal ulcer or a pancreatic lesion, damage to the common bile duct must be anticipated. The opening of the common bile duct and insertion of a Bakes dilator in the distal common bile duct must be carried out if the duct is likely to be injured. The morbidity associated with draining the common bile duct by means of a long arm T-tube of appropriate caliber is small when compared to the increased morbidity and mortality associated with a common bile duct injury (Fig. 6).

Treatment

Progressive attrition of the duct occurs with each succeeding operation and the initial repair is the golden chance for success. The eventual success depends upon: 1) the anatomical location of the stricture;

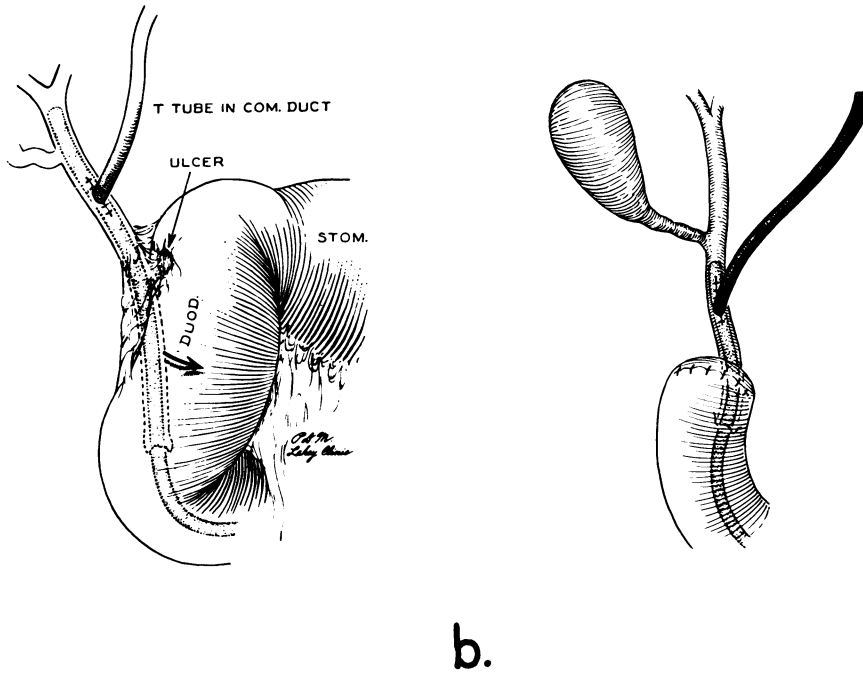

FIG. 6. *a*, A posterior penetrating duodenal ulcer may be so situated that the mobilization of the duodenum necessary to enable closure during subtotal gastrectomy may endanger the retroduodenal portion of the common bile duct. *b*, A long arm T-tube inserted into the supraduodenal portion of the common bile duct enables identification of the duct, with safe mobilization and closure of the duodenal stump.

2) the caliber of the proximal duct; 3) the degree of cholangitis and scarring or local abscess formation; 4) the time interval between injury and correction; 5) the degree of damage to the hepatic parenchyma; and 6) the experience of the surgeon in assessing, selecting, and executing the procedure of choice.

Various attempts have been made to bridge a defect in the duct by interposing homogenous or foreign material, such as vein graft, skin graft, acrylate amide prosthesis or vitallium tube between the duct ends.[11] Experience gained from operating on many patients who have this type of injury has taught us that it is not the mere presence of a defect in the duct which is the problem, but the quality and accessibility of the proximal duct that govern the practicality of all corrective procedures. Although a primary end-to-end ductal anastomosis is the ideal treatment, it is doubtful whether the choice of end-to-end ductal anastomosis or choledochoduodenostomy or choledochojejunostomy, with or without Roux-en-Y anastomosis (as advised by Allen[1] and Cole *et al.*[6]), plays a decisive part in the ultimate result. Both the deliberate division of the common bile duct during the performance of a pancreaticoduodenectomy and its subsequent implantation into the jejunum, and an end-to-side or side-to-side choledochoduodenostomy performed for chronic pancreatitis which is obstructing the intrapancreatic portion of the common bile duct, carry a good prognosis against subsequent stricturing. In these situations, the surgeon usually utilizes cleanly cut, healthy duct with minimal cholangitis, choledochitis, and pericholedochitis.

This is a different picture from that seen in patients with biliary strictures. The proximal duct is scarred and gross cholangitis

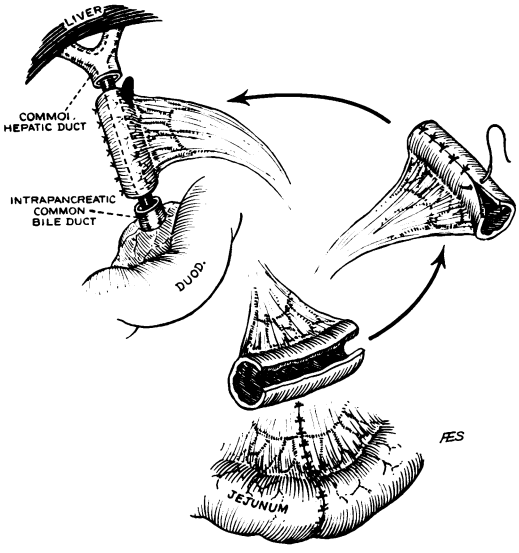

FIG. 7. Theoretically, a jejunal pedicle graft would be the ideal material to bridge a gap in the bile duct. However, the length, the quality, and the caliber of the proximal duct will decide the eventual outcome.

or pericholedochitis is present, so the chance of subsequent anastomotic stricture is increased. If, in addition, the proximal duct has been severed high in the transverse fissure of the liver, despite cautery excision of liver substance and mobilization of the hepatic duct, it is frequently difficult to achieve an ideal anastomosis. The scarred duct and thickened periductal connective tissue present very different technical problems from those found in the virgin operative field of the experimental animal. From our experience, the interposition of homogenous grafts or prostheses of foreign material is extremely difficult in most instances, and the final result will still be determined by the characteristics of the proximal duct. The ideal interposition would theoretically be a pedicle graft of jejunum reduced in caliber to approximately that of the ductal system; but again the qualities of the proximal duct will determine the eventual result (Fig. 7).

In nearly all cases, bile stasis has brought about the establishment of a virulent infection in the bile ducts, and in a large proportion of patients many strains of organisms, including the formidable *Clostridium welchii,* can be cultured from it. The risks of establishing small abscesses or chronic granulomas about nonabsorbable sutures are by no means minimal and persistent fistulous discharges are frequently seen. The scarred area with poor blood supply and the presence of infection is an unfavorable site for a free graft to become established

TABLE 2. *Benign Biliary Stricture: Results Three or More Years After 447 Primary Repairs**

Procedure	Operations, No.	Inadequate Follow up,** No.	Results: Dead: After Operation, %	Results: Dead: Of Disease, %	Results: Alive +: Poor, %	Results: Alive +: Satisfactory, %
End-to-end	207	15	2	4	42	51
Hepatico-jejunostomy	142	21	5	5	45	43
Hepaticoduodenostomy	15	1	0	13	36	50
Plastic	46	2	4	2	25	68
Dilatation	37	2	5	11	29	54
Total	447					

* From Cattell, R. B. and Braasch, J. W., Surg., Gynec. & Obst., **109**:536, 1959.
** The majority (30 of 41) had satisfactory results, but operation was performed less than three years previously.
+Excluding those with inadequate follow up.

or a prosthesis of foreign material to be accepted. Even if the ideal graft material were available, its use would be limited as the quality, length, and caliber of the proximal duct determine the ultimate result.

In the extremely debilitated patient, with long-standing obstruction, cholangitis and hepatic parenchymal damage, a staged procedure is often indicated. An abscess or extravasation of infected bile or hematoma in the region of the injured duct may be so extensive that a definitive corrective procedure is inadvisable at the initial operation. Simple drainage of the proximal ducts should be continued until the patient's clinical condition has improved and gross infection has been eradicated.

Cattell and Braasch,[5] in a review of primary repair of benign strictures of the bile duct performed on 501 patients at the Lahey Clinic, excluded 41 patients who had inadequate follow up. They reported that end-to-end repair gave satisfactory results in 51 per cent of 192 patients, hepaticojejunostomy gave satisfactory results in 43 per cent of 121 patients, and hepaticoduodenostomy gave satisfactory results in 50 per cent of 14 patients. Plastic procedures performed on 44 patients gave 68 per cent satisfactory results and dilatation of strictures in 35 patients gave 54 per cent satisfactory results (Table 2).

There is no doubt that re-establishing the physiologic state by an end-to-end anastomosis is ideal.[9] The anastomosis of the severed duct ends, too often an impractical procedure, should not be attempted if there is great discrepancy in the size of the proximal and distal portions of the duct or if the length of the defect between the proximal and distal duct is such that despite adequate mobilization of the duodenum, an anastomosis cannot be performed without tension. If the strictured portion or the defect is short but the proximal ductal system is dilated out of proportion to the size of the distal duct, an end-to-end anastomosis is contraindicated and a choledochojejunostomy is the preferred procedure. A T-tube should be inserted into the common bile duct and the distal end should pass through the stoma into the jejunum. The exit limb of the tube should not pass through the anastomosis line.[8] This procedure is necessary when the distal duct is small in comparison to the proximal duct, when the distal duct is obliterated by fibrous reaction, when the distal duct cannot be located, or when the intrapancreatic mobilization of the distal duct endangers the pancreatic ducts (Fig. 8, 9).

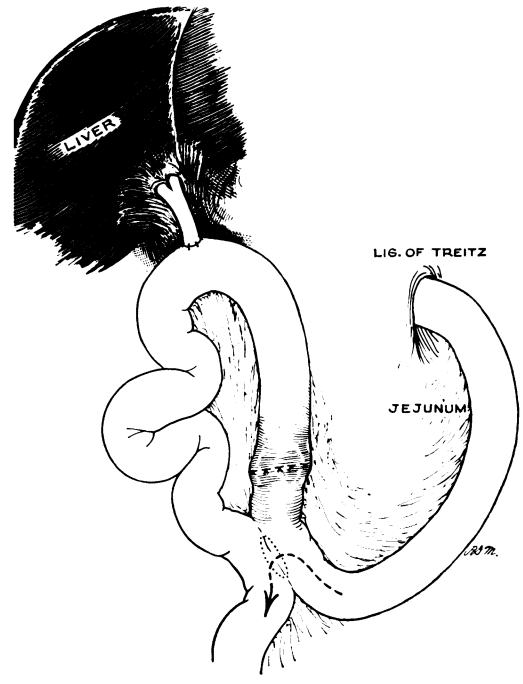

FIG. 8. When the proximal bile duct is not suitable for end-to-end anastomosis, a hepatodochojejunal anastomosis is favored. A jejunojejunostomy should be created and the afferent loop may be defunctionalized by inserting interrupted sutures across its lumen. The efferent loop should be long enough to prevent regurgitation. A T-tube with the external limb coming out through the duct wall or a Y-tube within the hepatic ducts should be used as an internal splint.

If the site of injury is the proximal common hepatic duct or the right hepatic duct, it is rarely possible to achieve a satisfactory primary end-to-end anastomosis. The primary injury is to the lateral margin of the duct and usually extends over a consider-

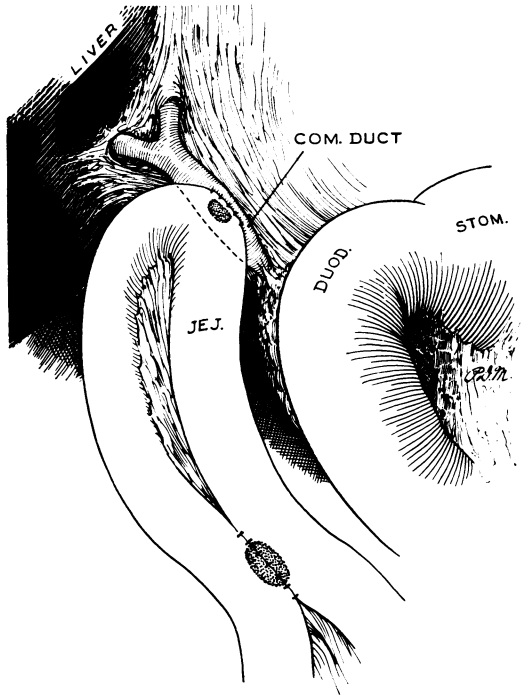

FIG. 9. In patients with sclerosing choledochitis or pancreatitis involving the intrapancreatic portion of the common bile duct, a side-to-side choledochojejunostomy with a distal jejunojejunostomy is indicated.

able length. The most favorable procedure in these cases is the establishment of a hepaticojejunostomy over a Y-tube or a modified T-tube.

Internal Splint. The necessity for the use of an internal splint through an anastomosis and, if used, the optimum time it should be left in place have often been disputed. We are of the opinion that unless the duct is greatly dilated, an internal splint is advisable and should remain in place for at least six to eight months.

Several types of internal splints have been used. Each has its indication for use, but each has some disadvantages. The vitallium tube and *bouncing clay* silicone tube are no longer used. The forms in common use at present are the straight rubber tube, the rubber T-tube, and the rubber Y-tube. If any of these tubes are employed, they should always lie loosely within the lumen of the anastomosis and should never be brought out through the anastomosis line. Each of these tubes has the disadvantage that it may become displaced or occluded.

A straight tube is rarely used through an anastomosis. It is occasionally used in the lumen of the common bile duct after transduodenal retrograde dilatation of a stricture. It is easily displaced from the duct. It has been used and its use may still be indicated for a defect in the ducts high in the hilus of the liver which makes it impossible to insert a Y- or T-tube.

The long arm T-tube is the favored splint in end-to-end bile duct repairs. This type of T-tube has the advantage that it usually does not become accidentally displaced—a common problem with the short arm form. If a T-tube splint is used through a hepatodochojejunostomy the external vent must be brought out through the hepatic duct, which is the preferable site, or through the jejunal wall. If the proximal bile duct has sufficient length, the external arm should be brought out through a separate incision in the duct wall. If the external limb of the T-tube is brought out through the jejunum, the site of exit should be close to the anastomosis to minimize the likelihood of dislodgment of the splint by peristaltic activity. This external vent can be used for irrigating and draining the ductal system. A T-tube has the definite advantage that it can easily be removed at a time of election.

The Y-tube has been used in both end-to-end duct anastomoses and hepatodochojejunal anastomoses. Its use is indicated when the damage is to the common hepatic duct or right or left hepatic duct near or within the hilus of the liver. The shape of the union of the hepatic ducts may be such that a modified T-tube can be made to lie in the ducts better than a standard Y-tube. In this type of repair, the splint is allowed

to lie completely within the lumen. Unfortunately, the presence of a foreign body within the bile duct predisposes to stasis and infection and as a result, calculus and debris deposits occur in, around, and proximal to the splint. This inevitably occurs in many patients and removal of the Y-tube by a second stage procedure is then necessary. Despite this, however, our experience with the Y-tube has proved its value. In a review of 168 patients operated on between 1940 and 1958, a Y-tube was used 179 times. In the series, a vitallium Y-tube was used in 12 patients, a silicone (bouncing clay) tube in 34 patients, and rubber Y-tubes in 133 patients. Eleven per cent of all tubes passed spontaneously and 2 per cent moved from their initial position through the anastomosis. Of these patients, 161 were available for evaluation. Sixty-three patients (39%) had a satisfactory result, but 90 patients (56%), although alive, had frequent, recurring symptoms of biliary obstruction. Of the patients who had satisfactory results, only one had a follow up study of less than four years. Of the 90 patients with poor results, 97 per cent had recurrent symptoms of biliary obstruction within four years of implanting the tube. Approximately one-half of the tubes became occluded and were removed, but nearly 30 per cent of these patients still have their tubes in situ after four years. A previous survey at the Lahey Clinic[3] showed that biliary obstruction recurred most commonly within the first three years.

Patients who required the removal of the obstructed Y-tube have had very satisfactory results. Only three of 42 patients who had this second stage of the procedure at this institution have had recurrent symptoms. To study the long-term value of this tube, if the number in this series is corrected by eliminating the operative and postoperative deaths, and deaths from liver failure, but with patent splints, a good result was obtained in 97 per cent of the patients who had had the two stages of the procedure (Table 3).

In an endeavor to avoid the second stage procedure, we have recently used a long arm Y-tube and brought the distal limb out through the duct wall or the jejunal wall and the anterior abdominal wall (Fig. 10). This type of tube enables regular irrigation of the hepatic ducts with saline, drainage of sludge and debris from the ducts, the performance of tube cholangiography when indicated, and the deliberate removal of the tube without operation at

TABLE 3. *Cumulative Results after First and Second Stages of Operation Using Y-Tube Splint*

		Indeterminate Cases	
		Postoperative deaths	10
First stage operations	179	Later death	24*
Indeterminate cases	74	Poor results after first stage; no second stage	37
Cases for evaluation	105	Result unknown	3
		Total	74

105 Cases for Evaluation

Poor result after second stage	3	(3%)
Satisfactory result after:		
First stage	63	(97%)
Second stage	39	

* Includes 3 patients who died after first stage with obstructed ducts.
There were no deaths with known obstructed ducts after second stage.

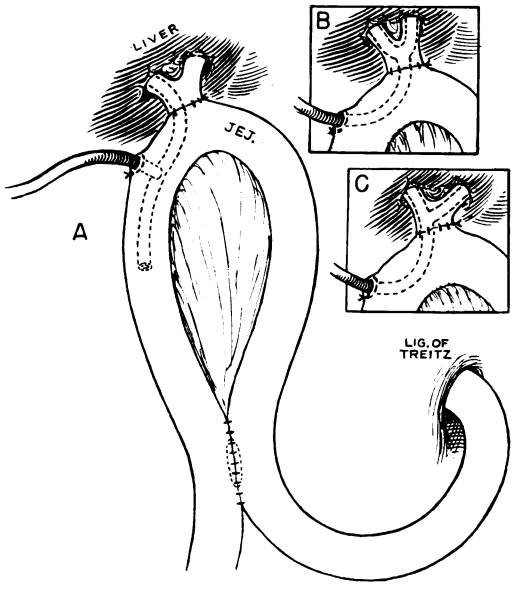

FIG. 10. Anastomosis of the common hepatic duct to the jejunum usually requires an internal splint. Three types of splint have been developed which can be removed without further surgery. *A*, A T-tube is used with the stem being brought through the jejunal wall. *B*, A Y-tube is used and the stem is brought out through the jejunal wall. *C*, A modified long arm T-tube may lie better than a Y-tube within the right and left hepatic ducts. The remaining long arm can be brought out through the jejunal wall.

a time of election. Any tube that is brought to the exterior may become accidentally dislodged before the scar tissue at the anastomosis has matured, and these tubes should be securely anchored into place by a nonabsorbable suture at the site of the anastomosis. An early spontaneous displacement of a splint may jeopardize the long-term result of the procedure.

It frequently is necessary to mobilize the right and left hepatic ducts within the liver substance to obtain satisfactory duct ends for anastomosis. Resection of the hepatic parenchyma is carried out above and to the right of the transverse fissure. Frequent needle aspirations of this area must be made to locate any major arterial or venous structures which may be injured during the dissection. Unfortunately, it is not always possible to isolate the main right and left hepatic ducts as they may exist as segmental branches outside the hilus of the liver. Nevertheless, the same principles of repair over a splint are applied using two Y- or T-tubes or straight tubes.

Occasionally it is necessary to anastomose the right and left hepatic ducts sepa-

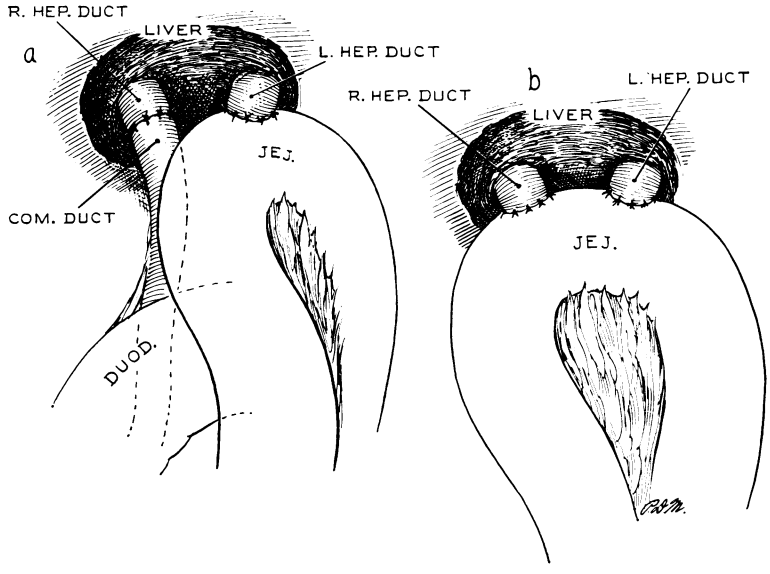

FIG. 11. Individual anastomosis of right and left hepatic ducts is occasionally necessary. *a*, Anastomosis of right hepatic duct to common bile duct and left hepatic duct to jejunum. *b*, Hepatic ducts may be anastomosed individually to jejunum. (From: Cattell, R. B. and Braasch, J. W., Surg., Gynec. & Obst., 110:57, 1960.)

rately. If the distal segment of the common bile duct is identified and is of appropriate caliber and length, it may be anastomosed to one of the hepatic ducts; the other hepatic duct is anastomosed to the jejunum. When the hepatic ducts have been divided separately, each may be anastomosed to the jejunum (Fig. 11, 12).

Summary and Conclusions

The management of injuries of the extrahepatic bile ducts remains a challenge to the surgeon. The choice of the technical procedure undertaken and its eventual success will depend on the experience of the surgeon in assessing the patient's general condition, in evaluating the precise anatomic pathology, and executing the necessary surgical procedures. Individualizing the operation according to the findings at laparotomy is imperative. The ever-increasing range of technics currently used indicates the ingenuity necessary to meet the challenge of this condition. There is probably no greater surgical tragedy than the production of an extrahepatic biliary stricture, and there are few surgical procedures quite as gratifying as the successful permanent relief of this condition.

The teaching that the common site of injury is at the confluence of the cystic duct and common hepatic duct is not supported by an analysis of 190 patients with postoperative injury of the bile ducts treated at the Lahey Clinic. In at least 52 per cent the injury involved the common hepatic duct or the right or left hepatic duct. The interposition of replacement tubes to bridge defects in the duct is discussed, and the practical limitations of these procedures are pointed out. The relative value and the indications for the use of various types of internal splints are reviewed. The value of the long arm T-tube in end-to-end ductal anastomosis is emphasized. Experience with the Y-tube splint is reviewed; although this type of splint is reserved for the more difficult strictures located in the hilar area, the long-term result of the two stage procedures associated with the Y-tube splint are impressive. Recent modifications in the type of Y-tube are recommended in selected cases.

FIG. 12. Tube cholangiogram illustrating the successful use of the method outlined in Figure 11 *a*.

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Discussion

Dr. George D. Lilly (Miami): I certainly hesitate to comment on Dr. Warren's paper with his vast experience, but Dr. John Turner of Miami brought back a prophylactic modality which was new to me. He attributed it to Dr. West of New York.

Rather than trying to control a rampaging cystic artery by a finger in the foramen, he enters the lesser sac from the lower border of the stomach and has his assistant control the bleeding by digital compression of the celiac axis, leaving the surgeon free to carefully locate the bleeding point in a dry field.

I have seen this employed twice where the residents got in trouble and I do believe it is a valuable prophylactic thing in controlling hemorrhage, which I believe is responsible for a major part of these common duct injuries.

Dr. William M. McDonald (Boston): A previously unrecognized feature of this injury brought to light by the recent survey of patients who presented at the Lahey Clinic with extrahepatic duct strictures was the frequent involvement of the common hepatic duct as the primary site of injury. We had suspected this from clinical observation.

This frequent involvement of the common hepatic duct indicates that *tenting* of the duct may not be as frequent an etiologic cause now as was previously taught, although this still undoubtedly occurs in too large a percentage of patients.

The injury to the common hepatic duct might theoretically arise either at the time of mobilization of a firmly apposed cystic duct or when control of bleeding from the cystic artery is managed in such a way as to damage the duct.

Therefore, it seems necessary that teaching of the technic of cholecystectomy must emphasize the correct surgical management of the cystic duct, the cystic artery, and the control of bleeding as well as the prevention of *tenting* of the common bile duct and common hepatic duct by excessive traction.

Dr. Kenneth W. Warren (closing): I would like to thank Dr. Lilly for the suggestion he has made. I think it has merit and I can assure him that within a very short time we will probably use it.