

## PHYSIOLOGIC STUDIES IN CASES OF STRICTURE OF THE COMMON BILE DUCT\*

WALTMAN WALTERS, M. D.

FROM THE DIVISION OF SURGERY, MAYO CLINIC, ROCHESTER, MINNESOTA

MY INTEREST in the treatment of strictures of the common and hepatic bile ducts dates back to 1924. From that time until January 1, 1949, I have operated on 186 patients for stricture of the extrahepatic ducts. I have divided these cases into two groups: (1) a series of 98 cases in which operations were performed from 1924 through 1939 (Table I), and (2) a series of 88 cases in which 113 operations were done from 1940 through 1948 (Table II). Lewis, Friedell and I reported on the first group in three papers in 1940 and 1942.<sup>1, 2</sup> In the study of this second group I have had the help of my first assistants, Drs. Spencer Phillips<sup>3</sup> and John Cameron, and Dr. Joseph Berkson of the Section on Biometry and Medical Statistics of the Mayo Clinic.

In the first series, the hospital mortality rate was 10.2 per cent and in the second series it was 3.4 per cent (or 2.6 per cent on the basis of 113 procedures). This reduction in mortality rate, I think, can be directly attributed to a better understanding of the pathologic physiology of the liver in cases of biliary obstruction and the institution of adequate methods of treatment before, during and subsequent to operation in order to compensate for the disturbances, rather than to any particular improvement in the technic of the surgical procedure. There are, perhaps, a few exceptions to this statement; the first is that I have been able to find remnants of extrahepatic ducts above the stricture more frequently in the second series of cases than in the first, because I have searched more diligently for them; even incising the parenchyma of the liver. The same is true of the identification of the lower end of the common duct. For this reason the proportion of duct-to-duct anastomoses to those of a duct to the duodenum has increased. In 11 of the 27 cases of stricture in which I performed operations in 1948, choledochocolocostomy was performed, in 13 hepaticoduodenostomy, in 1 choledochoduodenostomy and in 2 hepaticostomy. The incidence of duct-to-duct anastomosis in 1948 was 40 per cent in contrast to 11.2 per cent in the cases from 1924 through 1939 and 18.6 per cent in the cases from 1940 through 1947. Assuming that an anastomosis of the end of the duct to the intestine is possible, the problem that will concern the surgeon is whether to anastomose the stump of the duct to an opening made in the duodenum or to one of the loops of the jejunum. With the latter procedure the duct is anastomosed to the jejunum either with an entero-anastomosis or with a Roux-Y type of anastomosis, as recommended by Allen<sup>4</sup> and Cole.<sup>5</sup>

Before considering this question, let me return briefly to a discussion of the pathologicphysiologic changes associated with biliary obstruction and the

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preoperative and postoperative methods directed to their treatment. Although I would like to discuss tests of liver function, time does not permit more than saying that studies of the response of the prothrombin time of the blood to vitamin K, the amount of serum globulin and its relation to the serum albumin have proved in our experience, the most practical indicators of the degree of

TABLE I.—*Results According to Operation: Stricture of Common and Hepatic Ducts; 1924 Through 1939*

Operation	Cases	Well When Last Heard From		Recurrence of Biliary Obstruction		Hospital Deaths		Subsequent Deaths	
		No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
Common duct to duodenum	34	28	82.4	2	5.9	1	2.9	3	8.8
Hepatic duct to duodenum	31	13	41.9	8	25.8	2	6.5	8	25.8
Duct to duct	11	6	54.5	2	18.2	1	9.1	2	18.2
Hepaticostomy	9	2	22.2	2	22.2	3	33.4	2	22.2
Transplantation of external biliary fistula	9	2	22.2	4	44.5	1	11.1	2	22.2
Other	4	1	25	..	....	2	50.0	1	25
Total	98	52	53.0	18	18.4	10	10.2	18	18.4

liver damage associated with a stricture. If the blood contains globulin in excess, and an elevated prothrombin time does not promptly return to normal after the administration of vitamin K, more than the average amount of injury to the liver parenchyma is likely to have occurred. The frequency with which intrahepatic biliary block may simulate extrahepatic block must be remembered in all cases in which jaundice occurs; and this is especially important when

TABLE II.—*Types of Operation for Stricture of Biliary Ducts: 1924 Through 1948*

Type of Operation	1924-1939		1940-1947		1948	
	No.*	Per Cent	No.†	Per Cent	No.†	Per Cent
Duct to duct	11	11.2	16	18.6	11	40.7
Hepatic duct to duodenum	31	31.6	39	45.4	13	48.2
Common duct to duodenum	34	34.7	10	11.6	1	3.7
Hepaticostomy	9	9.2	11	12.8	2	7.4
Other	13	13.3	10	11.6	..	....
Total	98	100	86	100	27	100

\* Number of patients.  
† Number of operations.

jaundiced patients have had previous operations on the biliary tract. The concentration of blood lipids are increased in the presence of obstructive jaundice and decreased in the presence of severe hepatic injury. When hepatic damage has occurred, the concentration of gamma globulin in the serum is increased and that of serum albumin is decreased. These findings are extremely reliable and the tests are not difficult to perform.

At the Mayo Clinic all patients who have jaundice are hospitalized for at

least three days prior to surgical intervention. In this period, study of hepatic function is made and the patient is prepared for operation by administration of vitamin K or some other similarly acting substance and a forced increase in the intake of carbohydrate and protein. In addition, parenteral injections that are necessary are given. If the prothrombin time is elevated and is not reduced after administration of vitamin K, blood transfusions are employed before operation. I cannot remember a single case of stricture of the bile ducts in which I have refused to operate when recurrence of the stricture has taken place, regardless of how deeply jaundiced the patient was or, how many previous operations had been performed for correction of the biliary stricture. I mention this not to emphasize particularly the success that may be obtained by a properly performed procedure, even after as many as three to five previous unsuccessful attempts at repair, but to illustrate that reduction of the hospital mortality rate in my two series of cases can be attributed mainly to recent preoperative and postoperative study of the patient and his liver, institution of treatment indicated by this study both before and after operation, and the performance of a proper surgical procedure which completely relieves the biliary obstruction.

In recent years the question of effect of regurgitation of food and of gastric, duodenal and pancreatic secretions into the biliary ducts has been a matter of considerable speculation and some study. I have followed carefully all of the patients on whom I have operated since January, 1924, that is, for 25 years. In my experience now with approximately 118 cases in which the common or hepatic duct has been anastomosed to the duodenum (in 65 for more than ten years), I have been unable to prove that any reflux from the duodenum was productive of either asymptomatic or symptomatic infection of the liver. A similar observation was made on animals by Soupoult in France.<sup>6</sup> Moreover, in my patients, when fever or jaundice with and without pain has led to speculation on this possibility, reoperation has always shown recurrence of the obstruction, usually of a considerable degree, at the site of the previously performed hepaticoduodenostomy, choledochoduodenostomy or choledochocolocostomy.

Of the 98 patients operated on from 1924 through 1939, 34 had sufficient duct above the stricture to anastomose it accurately to the duodenum. When these cases were studied by Lewis, Friedell and me in 1940, 82.4 per cent of these 34 patients were living and well. This group of cases, as well as the entire series, is under intensive investigation to determine the percentage in which obstruction has been cured for ten years or more.

Roentgenographic studies of the duodenum and anastomosed duct after the oral ingestion of barium have shown both air and barium in the ducts, to a greater or less degree in the cases in which the anastomosis was not obstructed. On the other hand I have found recurring obstruction, when, because of pain or fever with or without jaundice, I have reoperated on patients who have had a previous operation or operations for stricture and who have not had this reflux of barium or air from the duodenum into the common

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or hepatic ducts. In a few cases even though air and a small amount of barium were noted in the ducts, attacks of pain with or without fever, and mild transient jaundice, have occurred. At operation, contraction of the duct, sometimes to a few millimeters in diameter at the site of the anastomosis, has been found in these cases.

I presented two examples of this before the members of the Chicago Surgical Society at their meeting in Rochester, Minnesota, on January 19, 1949. I shall only mention one of these cases here, however. In this case I performed hepaticoduodenostomy 11 years ago at which time only a fringe of hepatic duct was found to anastomose to the duodenum. The patient was well for ten years and then had attacks of biliary colic with questionable slight jaundice of skin and sclera. At operation, contraction of the duct at the site

TABLE III.—Results According to Operation for Stricture of Common and Hepatic Ducts: 1940 Through 1947

Operation	Total Cases	Hospital Deaths		Cases Traced*	Well When Last Heard From		Recurrence of Biliary Obstruction		Died Elsewhere	
		No.	Per Cent		No.	Per Cent†	No.	Per Cent†	No.	Per Cent†
Common duct to duodenum	9	0	0	7	5	71.4	1	14.3	1	14.3
Hepatic duct to duodenum	32	1	3.1	25	16	64.0	3	12.0	6	24.0
Duct to duct.....	12	0	....	8	4	50.0	4	50.0	0	....
Hepaticostomy.....	8	1	12.5	6	0	....	5	83.3	1	16.7
Others.....	4	0	....	4	4	100.0	0	....	0	....
Total.....	65	2	3.0	50	29	58.0	13	26.0	8	16.0

\* Patients operated on too recently for judgment of results and cases in which follow-up information was not available at this date are omitted.  
† Per cent of cases traced.

of the anastomosis had reduced the lumen to a few millimeters in diameter. Plastic enlargement of the stoma was carried out and the patient has been well since.

The operation, anastomosis of the end of the biliary duct to the duodenum, when the lower segment of the duct cannot be found, is a relatively simple operation compared to that required to anastomose the duct to the jejunum. The simplicity of choledochoduodenostomy or hepaticoduodenostomy makes these procedures my operations of choice since many of the patients on whom I operate have had at least one unsuccessful attempt at repair (Table III). In point of fact, of the 27 patients I operated on during 1948, one had five previous procedures on the biliary tract, four had four, six had three, nine had two, and seven had one operation (Tables IV and V).

I have seen identical symptoms, that is pain, chills, fever or jaundice alone or in various combinations, not only in cases of contracture at the site of the biliary-duodenal anastomosis but also in cases of contracture of anastomosis between the reconstructed ends of the common duct. This brings up the question as to whether, in order to preserve the mechanism of the sphincter of Oddi at the lower end of the common duct and to prevent reflux of duodenal con-

tents into the biliary tree, it is worth while to subject the patient to diligent search for the end of the common duct below the stricture. It is debatable whether stricture does not recur more frequently when the continuity of the duct itself is re-established than when the proximal end of the duct is anastomosed to the duodenum. This problem is being investigated at present. Of

TABLE IV.—*Analysis of Procedures (Operations): Author's Series, 1948*

Operation	Cases	Prosthesis Used		
		T Tube	Polythene Tube	Catheter
Duct to duct.....	11	7	..	4 (McArthur)
Hepatic duct to duodenum.....	13	7	6	..
Common duct to duodenum.....	1	..	1	..
External hepaticostomy.....	2	..	..	2
<b>Total.....</b>	<b>27</b>	<b>14</b>	<b>7</b>	<b>6</b>

course the type of end-to-end anastomosis employed will make a difference in the number of recurrences when ductal continuity has been re-established. In all circular anastomoses, concentric contraction tends to occur whereas after an angulated anastomosis, that is, in one in which triangular shaped ends are sutured, concentric contraction does not occur. Unfortunately, as a rule, insufficient duct ends are present to perform an angulated anastomosis. Therefore, the problem usually is to determine what type of indwelling casting or

TABLE V.—*Relation of Number of Previous Operations to Procedure: Author's Series, 1948*

Procedure	Cases	Pervious Operations				
		1	2	3	4	5
Duct to duct.....	11	6	3	1	1	..
Hepatic duct to duodenum.....	13	1	3	5	3	1
Common duct to duodenum.....	1	..	1	..	..	..
External hepaticostomy.....	2	..	2	..	..	..
<b>Total.....</b>	<b>27*</b>	<b>7</b>	<b>9</b>	<b>6</b>	<b>4</b>	<b>1</b>

\* 6 previous operations by author.

tubing will prevent contracture of the circular type of anastomosis and how long it should remain in place to accomplish this purpose. McIndoe<sup>7</sup> has stated that a period of three months is necessary to prevent contracture of tubular grafts of skin. In my opinion three months is the minimal period that splinting tubes should be kept within the common duct and from six to twelve months is probably better. Any tube used to splint the ductal anastomosis will sooner or later have its lumen occluded by bile pigment and salts and will obstruct the duct unless removed. I have removed Vitallium and rubber tubes from the common duct which were filled and encrusted with bile pigment or salts and which could not pass the sphincter of Oddi. A rubber catheter, most of which extends beyond the sphincter of Oddi into the duodenum, has seemed the best type of splint to me. It can be held in place for as long as desired by a silk thread passed through it and attached to the surface of the skin as

recommended by McArthur. When the silk suture is removed, intestinal peristalsis will pull the catheter into the duodenum and it will pass through the intestinal tract without stopping or obstructing. Tubes of rubber, Vitallium, or polythene can be used in a choledochoduodenostomy or hepaticoduodenostomy. Bile, however, accumulates in the lumina and about the exterior of rubber and Vitallium tubes. This happens less frequently when polythene tubes are used. These tubes will pass spontaneously into the duodenum in a few weeks unless fixed in position with the long silk suture used to fix a catheter.

In the surgical procedure, I employ an upper right rectus incision. I have been able to see no clinical indications that a general anesthetic or combined nitrous oxide, ethylene, oxygen and ether is disturbing to liver function and have preferred this type of anesthesia. I keep the dissection close to the under surface of the liver; I extend it as far laterally as possible and expose Morrison's pouch. From this starting point the dissection is carried mesially until the structures of the hepaticoduodenal ligament are reached. It is then carried from the mesial part of the right lobe of the liver at a deep level to the hepaticoduodenal ligament in order to expose the hepatic artery. After exposure of the hepatic artery in the hepaticoduodenal ligament, it is nearly always possible, by upward traction on the under surface of the liver and by dissecting along the hepaticoduodenal ligament into the hilus of the liver, to find the proximal stump of the common or hepatic duct of sufficient length to use in an anastomosis either to the lower part of the duct or to the duodenum. This I was able to do in 25 of the 27 cases in which operations for stricture of the biliary ducts were performed in 1948.

#### SUMMARY

A study of the 186 cases of stricture of the common and hepatic bile ducts in which operations were performed, has given evidence of the beneficial effects of studies of liver function and preoperative and postoperative treatment directed toward compensating for the disturbances resulting from the biliary obstruction. Prevention of bleeding has been accomplished by the administration of vitamin K and blood. As a result, the syndrome of hepatorenal insufficiency does not occur. More diligent search for both ends of the duct beyond the stricture has been productive of a greater percentage of cases in which anastomosis of the duct to the duct or the duct to the duodenum could be accomplished. As an indication of the benefits of this routine the mortality rate of 10 per cent in the 98 cases in which operation was performed from 1924 to 1939 inclusive has been reduced to 3.4 per cent in the 88 cases in which operation was performed from 1940 to 1948 inclusive. If the mortality rate in the last group is figured on the basis of operative procedures, since reoperations were performed for recurrence of the stricture in some cases, it is only 2.6 per cent.

During these years evidence accumulated indicates that after a biliary-duodenal anastomosis, reflux of food (barium or air) into the common and

hepatic ducts is not responsible for pain, fever or jaundice but that these symptoms are the result of recurring obstruction of varying degree at the site of the previously made anastomosis. This is important because of the simplicity and ease of these operations in comparison to the operation needed to anastomose the duct to the jejunum, especially if the Roux-Y principle of jejunal anastomosis is used.

Studies are under way to determine whether results of anastomosing the ends of the duct are as good, better or worse than those of anastomosing the proximal end of the duct to the duodenum. Involved in this problem is the fact that concentric contraction occurs at the site of most circular or tubular ductal anastomoses to a greater or less degree unless prevented by a tubular prosthesis until the usual period of such contracture has passed. Whether this applies to a greater degree in anastomosis of duct to intestine remains to be determined. Hence the question arises whether in order to preserve the function of the sphincter of Oddi an operation should be performed which may be followed by a higher incidence of recurring obstruction at the anastomosis than follows choledochoduodenostomy.

To prevent contracture of a circular biliary ductal anastomosis, a rubber catheter extending from the hepatic duct into the duodenum may be used as a splint. The catheter which will be pulled into the duodenum by peristalsis can be maintained in position by a silk suture passing through it and brought out to the skin where it is anchored to a button as advised by McArthur. Other short tubes, even of Vitallium, placed within the duct will have their lumina plugged and obstructed by bile and bile will accumulate about them. This foreign body will obstruct the common duct unless removed, for they will not pass through the sphincter of Oddi. Hence they should not be used. Prostheses of any type used to prevent contracture in anastomosis of duct to intestine will likewise become obstructive agents if they remain in place too long. Fortunately this practically never occurs because they will pass into the intestine within a few weeks unless prevented from doing so by fixation with a silk suture brought to the exterior.

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