PAPER

Long-term Biliary Function After Reconstruction of Major Bile Duct Injuries With Hepaticoduodenostomy or Hepaticojejunostomy

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Hypothesis: Normal biliary function can be achieved after reconstruction for major bile duct injuries using either hepaticoduodenostomy (HD) or Roux-en-Y hepaticojejunostomy (HJ).

Design: Retrospective analysis of consecutive patients requiring biliary enteric reconstructions from February 1, 1993, through January 1, 2002, for bile duct injuries.

Setting: Academic multispecialty referral clinic.

Patients: Twenty-seven consecutive patients were evaluated who underwent biliary enteric reconstruction for bile duct injury caused during cholecystectomy. Patients were reconstructed either by HD (18 patients) or HJ (9 patients).

Interventions: Patients' medical records were reviewed and long-term evaluations were obtained via telephone questionnaire by 2 separate observers (R.J.M. and F.T.L.). Biliary function was evaluated in all using symptoms and liver function test results. Cholangiography was obtained, if indicated clinically. These were reviewed for stricture or dilatation. Any biliary interventions were recorded.

Main Outcome Measures: Comparison of long-term biliary function after HD vs HJ reconstructions.

Results: All patients were contacted after a median postoperative time of 54 months. Excellent or good results were observed for biliary function in 25 (92%) of the 27 patients. These results were obtained regardless of the type of reconstruction—HD (18 patients) or HJ (9 patients).

Conclusions: We found biliary function to be normal at more than 4 years after biliary-enteric reconstruction for bile duct injury. When surgically feasible, we prefer HD to HJ.

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ANY INJURY to the bile duct during cholecystectomy is a dreaded complication. Major bile duct injuries may require biliary-enteric reconstruction. Many patients, their consultants, and their lawyers believe these treatments result in a lifetime of disability. Only a few series report long-term evaluation for biliary function after biliary-enteric reconstruction for bile duct injury. All of these series report Roux-en-Y hepaticojejunostomy (HJ) as the reconstruction of choice.[1-4] The goal of this study is to report long-term biliary function after biliary-enteric reconstructions for injury to the bile duct during cholecystectomy. We wanted to test our bias that reconstruction by hepaticoduodenostomy (HD) is preferable to reconstruction by HJ. Our opinion is that HD is the procedure of choice because it is more physiological, easier and faster to perform, and has ease of cholangiographic evaluation postoperatively.

RESULTS

These injuries presented in a variety of ways as outlined in **Table 1**. This table is divided into 2 major sections: those repaired using HD or HJ. The injuries were also divided into the following general categories of presentation: (1) transection, immediate recognition, and then transfer; (2) transection, delayed recognition, and then transfer; (3) delayed stricture of bile duct and then transfer; and (4) prior repair, strictured anastomosis, and then transfer. The 4 categories had mean intervals from cholecystectomy to our reconstruction of 1 day (range, 1 day), 34 days (range, 2-135 days), 6 years (range, 4 months to 15 years), and 20 months (range, 7-48 months), respectively.

The average age was 45 years and 22 (81%) of the 27 patients were women. Note that 23 (85%) of the 27 patients had an initial attempt at laparoscopic cholecystectomy, 13 (48%) had acute cholecystitis, and

PATIENTS, MATERIALS, AND METHODS

PATIENT REVIEW

We conducted a retrospective clinical review of major bile duct injuries repaired by biliary-enteric reconstruction at the Virginia Mason Medical Center, Seattle, Wash, from February 1, 1993, through January 1, 2002. Excluded were bile duct injuries that resolved after temporary biliary fistulas, intervention with stents or balloons, or those having operative removal of obstructing clips. Also excluded were those patients with bile duct strictures secondary to other inflammatory or malignant diseases. Reconstructions were either HD (18 patients) or HJ (9 patients).

All patients were referred from outside our multispecialty referral center as none of these injuries requiring biliary reconstruction occurred at the Virginia Mason Medical Center. Twenty-seven consecutive patients were evaluated. In January 2001 a surgical resident (R.J.M.) conducted a standardized telephone interview with each patient to assess long-term outcomes. The patients were reinterviewed in January 2002 by a registered nurse (F.T.L.) when patients underwent serum liver function tests (LFTs), which included measurement of alkaline phosphatase, transaminase, and bilirubin levels. Postreconstruction biliary imaging tests were reviewed.

Specific information sought was the following: age, sex, gallbladder pathologic status, type of cholecystectomy, use of intraoperative cholangiography, clinical presentation of bile duct injury, prereconstruction management, clinical condition at time of reconstruction, presence of coexisting arterial injury and/or intrabiliary stones, the level of bile duct injury (below vs at or above the bifurcation), and details of reconstructive technique, including the postoperative length of stay and complications.

Long-term outcome for biliary function was derived from both patient interview and review of objective serum values, diagnostic imaging, or the need for postreconstruction therapeutic interventions. Abnormal LFT results were defined using the normal values of the testing laboratory, except for alkaline phosphatase values that were considered abnormal only if they were more than 2 times the established normal value (normal value in our laboratory, <128 U/L). Outcomes were classified as *excellent* if patients had normal LFT results, did not have a history of cholangitis, did not have an anastomotic stricture if a cholangiogram had been obtained, and anastomotic interventions had not been done. The results were deemed *good* if a patient had a stricture in the biliary tree above the anastomosis but had normal LFT results, no history of cholangitis, and the anastomosis was not strictured. Outcomes were classified as *poor* if patients had any of the following—abnormal LFT results, cholangitis, or an anastomotic stricture that responded to nonoperative intervention. The outcome was considered a *failure* if any operative procedure to revise the anastomosis was required or if liver failure was observed.

OPERATIVE TECHNIQUE

Variations in operative technique occurred over the 9 years of this study. However, several principles of repair were uniformly applied. A generous incision was used for exposure with full mobilization of the inferior surface of the liver, to identify the site of bile duct injury. We avoided dissection that might devascularize the remaining bile duct, that is, of the hepatic arterial and portal venous systems. Sharp debridement was used for damaged or devitalized bile duct wall to the level of normal mucosa. We identified each patient's unique anatomy for the right and left hepatic ducts and their relationship to the bifurcation by surgical instrumentation, cholangiography, or choledochoscopy. Biliary-enteric anastomoses were performed using magnification for a mucosa-to-mucosa anastomosis with the use of a single layer of multiple, fine, interrupted, absorbable sutures for a watertight closure. Temporary transanastomotic stents were variously used including percutaneous transhepatic, percutaneous transenteric, internal small silicone stents anchored to the enteric mucosa, or no stent.

For hepaticoduodenostomy, wide Kocherization of the duodenum to create a tension-free anastomosis end-to-side was accomplished. Roux-en-Y jejunal limbs were made intentionally short so that postoperatively endoscopic inspection of the anastomotic site could be attempted when indicated. Hepaticojejunostomy was done end-to-side. Closed suction drains were placed near the biliary-enteric anastomosis. All transanastomotic stents were removed postoperatively within 3 weeks after cholangiography demonstrated patent anastomoses. Internal anastomotic stents anchored to the mucosa of the enteric reconstruction were allowed to pass spontaneously once the absorbable sutures dissolved. Specifically, no long-term stenting of the anastomosis was desired. Patients with HJ were treated with long-term prophylactic medication to avoid peptic ulceration.

16 (59%) did not have intraoperative cholangiography. The level of injury was at the bifurcation or above in 13 patients (48%).

The first telephone interview conducted in January 2001 acquired only data regarding the patients' current symptoms. No significant change in patient symptoms was noted when the second interview was conducted.

The long-term outcomes are given in **Table 2** with a follow-up rate of 100% and a median follow-up time of 54 months when the second interview was conducted in January 2002. Note that all but 2 patients had LFT results that were measured within 1 month of their last telephone interview. One patient had died of metastasis lung cancer (patient 7) and her LFT results were normal at 54 months postoperative and the other patient (patient 19) was symptomatic at 84 months postoperative but an LFT was not performed. All of the patients' serum transaminase and bilirubin levels were normal. Serum alkaline phosphatase levels were normal in all but 8 patients. In these patients, the levels were less than 2 times elevated, as listed in Table 2. Therefore, by the definition of this study, we considered all LFT results of these 26 patients to be normal at the time of the most recent measurement. No patient required reoperation; no patient developed liver failure. These results are summarized in **Table 3** where biliary function and outcome were classified as excellent (21 patients [78%]), good (4 patients [15%]), poor (2 patients [7%]), or failure (0%).

Table 1. Clinical Presentation of Bile Duct Injuries Grouped by Eventual Reconstruction*

Hepaticoduodenostomy						Roux-en-Y Hepaticojejunostomy					
Patient No./ Sex/Age, y	OP	GB	IOC	Interval to Repair	Level of Injury	Patient No./ Sex/Age, y	OP	GB	IOC	Interval to Repair	Level of Injury
Transection, Immediate Recognition, Transfer											
1/F/70	Lap†	A	Yes	1 d	H[A,S]	. . .	. . .	. . .	. . .	. . .	. . .
2/F/42	Lap†	C	No	1 d	B[A]	. . .	. . .	. . .	. . .	. . .	. . .
3/F/40	Lap†	C	Yes	1 d	B	. . .	. . .	. . .	. . .	. . .	. . .
4/F/31	Lap†	C	Yes	1 d	H	. . .	. . .	. . .	. . .	. . .	. . .
Transection, Delayed Recognition, Transfer											
5/M/28	Lap	C	No	21 d	H[S]	19/M/30	Lap	A	No	16 d	H
6/M/59	Lap†	A	No	37 d	B	20/F/71	Lap	A	No	2 d	B[A]
7/F/65	Lap	C	No	29 d	H	21/M/73	Lap†	A	Yes	22 d	B
8/F/39	Lap	A	No	7 d	H	. . .	. . .	. . .	. . .	. . .	. . .
9/M/46	Lap	A	No	135 d	B[A]	. . .	. . .	. . .	. . .	. . .	. . .
10/F/33	Lap	C	No	27 d	H	. . .	. . .	. . .	. . .	. . .	. . .
11/F/23	Lap	A	No	67 d	H	. . .	. . .	. . .	. . .	. . .	. . .
12/F/24	Lap	A	No	15 d	H	. . .	. . .	. . .	. . .	. . .	. . .
Delayed Stricture of Bile Duct, Transfer											
13/F/31	Open	C	Yes	6.0 y	H[S]	22/F/37	Open	C	No	4.5 y	B
14/F/44	Lap	A	No	0.7 y	H	23/F/83	Open	C	Yes	10 y	H[S]
15/F/52	Lap†	C	No	0.3 y	H[S]	. . .	. . .	. . .	. . .	. . .	. . .
16/F/61	Open	C	Yes	15 y	B[S]	. . .	. . .	. . .	. . .	. . .	. . .
Prior Repair, Strictured Anastomosis, Transfer											
17/F/26	Lap†[P]	BC	Yes	2.4 y	B	24/F/42	Lap†[HJ]	C	No	1.8 y	B
18/F/26	Open[1]	A	Yes	4.0 y	B	25/F/22	Lap[HD]	A	Yes	1.5 y	B
. . .	. . .	. . .	. . .	. . .	. . .	26/F/53	Lap†[HJ]	A	Yes	0.9 y	H
. . .	. . .	. . .	. . .	. . .	. . .	27/F/59	Open[CD]	C	No	0.6 y	B[A]

*OP indicates type of operation; GB, gallbladder pathology; IOC, intraoperative cholangiogram; Lap, laparoscopic; dagger, convert to an open procedure; A, acute cholecystitis; H, hepatic duct; C, chronic cholecysitis; B, bifurcation or above; BC, biliary colic; and ellipses, not applicable. Superscript alphabet letters indicate the following: A, right hepatic arterial injury; S, bile duct stones found at the time of reconstruction; P, primary repair; HJ, Roux-en-Y hepaticojejunostomy; HD, right hepaticoduodenostomy; and I, appendiceal interposition.

A difference was not observed between the outcomes for HD vs HJ.

COMMENT

We were pleased to find excellent long-term results from biliary-enteric reconstruction after bile duct injury during cholecystectomy. None of our patients had to be reoperated on, and only a few have had postreconstruction biliary interventions. No patient developed long-term cholangitis, jaundice, or liver failure. No difference was seen between the 2 types of reconstruction.

In general, we preferred HD, but certain patients had indications for HJ. Hepaticojejunostomy was chosen in the following scenarios: cases in which previous HJ had been performed resulting in strictures, injuries above the bifurcation of the bile duct that required a long anastomosis involving 2 to 4 ducts because of the fear of making a large opening in the duodenum, or when duodenal inflammation suggested that primary healing may not occur. An anastomotic leak after HD is a major surgical concern because it means a lateral duodenal fistula compared with a temporary bile leak after HJ. Using these indications no major complications were noted although 2 temporary anastomotic leaks (1 each for HD and HJ) were observed that resolved. Regardless of the reconstruction type, factors common to successful reconstruction have been outlined by others[5] and include control of sepsis and biliary decompression. We also emphasize wide exposure, minimal dissection to preserve blood supply to the biliary system, debridement of devitalized tissue, and a tension-free mucosa-to-mucosa anastomosis with a fine, single layer of interrupted absorbable sutures.

We preferred HD because of the normal physiology of having bile drain into the duodenum. Diverting bile from the duodenum by HJ theoretically leads to more ulcer formation and malabsorption. Hepaticoduodenostomy is easier and faster to perform, since only one anastomosis is necessary and the dissection is limited to the area of the injury. In those patients who require postoperative cholangiography or biliary intervention, HD gives easy access through the endoscope. If cholangiography or biliary intervention is necessary after HJ, the procedure is often difficult to perform endoscopically and the patients may require the more complicated percutaneous transhepatic technique. Many of our reconstruction patients reported abdominal discomfort or bloating and underwent cholangiography even though they were asymptomatic for cholangitis and their LFT results were normal. We were surprised to note that endoscopists found and dilated strictures above the anastomosis in several asymptomatic patients.

Secondary biliary cirrhosis is a feared long-term complication after bile duct reconstruction. None of our

Table 2. Long-term Outcomes of Biliary-Enteric Reconstructions*

Hepaticoduodenostomy					Roux-en-Y Hepaticojejunostomy				
Patient No.	Follow-up, mo	Result of Anastomosis Studies	Alkaline Phosphatase Level, U/L	Result†	Patient No.	Follow-up, mo	Result of Anastomosis Studies	Alkaline Phosphatase Level, U/L	Result†
Transection, Immediate Recognition, Transfer									
1	78	Normal	87	Excellent					
2	33	Normal[1]	**158**	Good					
3	27	Normal[2]	**148**	Good					
4	1	None	106	Excellent					
Transection, Delayed Recognition, Transfer									
5	96	None	81	Excellent	19	84	None	NA	Excellent
6	84	None	122	Excellent	20	15	None	108	Excellent
7	54	None	**162**	Excellent[8]	21	8	None	**229**	Excellent[8]
8	69	Normal[3]	90	Good					
9	52	None	**149**	Excellent[8]					
10	14	None	84	Excellent					
11	11	None	85	Excellent					
12	12	None	86	Excellent					
Delayed Stricture of Bile Duct, Transfer									
13	72	None	88	Excellent	22	90	None	79	Excellent
14	64	None	74	Excellent	23	66	None	93	Excellent
15	53	None	119	Excellent					
16	12	None	84	Excellent					
Prior Repair, Strictured Anastomosis, Transfer									
17	84	Normal	79	Excellent	24	108	Stricture[5]	**194**	Poor
18	90	Normal[4]	88	Good	25	60	Normal[6]	120	Poor[7]
					26	27	None	**163**	Excellent[8]
					27	40	Normal	**126**	Excellent

*Superscript numbers indicate the following: 1, left intrahepatic hepatic duct stricture, endoscopic retrograde cholangiography (ERC) dilated; 2, right intrahepatic duct stricture, ERC dilated; 3, left intrahepatic duct stricture, ERC, temporary stent, normal ERC at 4 years; 4, right intrahepatic duct stricture, ERC dilated, no stricture on last ERC; 5, symptomatic, anastomotic stricture, ERC, dilation, no stricture on last ERC; 6, right hepatic duct stricture, one episode of cholangitis, ERC dilated; 7, one episode of cholangitis; 8, asymptomatic with less than 2 times the elevation in the alkaline phosphatase level; ellipses, not applicable; NA, not available; and boldfaced values, significant.

†See the "Patient Review" subsection of the "Materials and Methods" section for a definition of the grading of outcomes.

Table 3. Overview of 27 Bile Duct Injury Biliary-Enteric Repairs

Variable	Hepaticoduodenostomy (n = 18)	Roux-en-Y Hepaticojejunostomy (n = 9)	Combined Total (N = 27)
Sex			
Male	3	2	**5**
Female	15	7	**22**
Age, mean, y	41	53	45
Level of injury			
Bifurcation or above	7	6	**13**
Hepatic duct	11	**3**	**14**
Right hepatic artery injury	3	2	**5**
Short-term complications	3*	1†	**4**
Length of stay, mean, d	9.0	8.1	8.7
Follow-up (range), mo			
Mean	50 (1-96)	55 (8-108)	52 (1-108)
Median	54	60	54
Outcomes, No. (%)‡			
Excellent	14	**7**	**21** (78)
Good	4	0	**4** (15)
Poor	0	2	**2** (7)
Failure	0	0	**0**

*These complications were an infected biloma from the surface of the liver at an old percutaneous transhepatic biliary drainage (PTBD) site, purcutaneously drained; a bile leak through a drain that resolved in 2 days with a PTBD insertion; and postoperative uncomplicated pneumonia with no delay of discharge from the hospital.

†A bile leak through a drain that resolved in 30 days.

‡See the "Patient Review" subsection of the "Materials and Methods" section for a definition of the grading of outcomes.

patients demonstrated intraoperative or biochemical evidence of cirrhosis and, therefore, no liver biopsy specimens were obtained.

Excellent results in our series and in those of others[1-3] for long-term biliary function underscore the advantage that modern surgeons have over surgeons from earlier eras who tried to fix injured bile ducts in an environment of uncontrolled sepsis, biliary peritonitis, longstanding jaundice, or cholangitis. Today we have the tools to understand the anatomy of the biliary injury. We can control bile leaks with computed tomographic–guided abdominal drainage and decompress the biliary tree with endotherapy or percutaneous transhepatic bile duct tubes which gives time for resolution of peritoneal inflammation and/or sepsis, as well as eliminating jaundice or cholangitis. These are all important in our confidence in using the duodenum for reconstruction.

CONCLUSIONS

In the decade of the 1990s with sophisticated preoperative diagnosis and therapy and with careful technique, biliary enteric reconstruction after cholecystectomy-associated bile duct injury should have a successful long-term outcome. We believe that HD is preferable to HJ when technically feasible because it is a better physiologic operation, is easier and faster to perform, and gives the ability for postoperative cholangiography and intervention, if necessary. We observed good long-term results with either reconstruction.

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DISCUSSION

Lawrence W. Way, MD, San Francisco, Calif: Thirty-five years ago, bile duct reconstructions were performed in every imaginable way: end-to-end repair, HD, hepaticogastrostomy, loop hepaticojejunostomy, and HJ. Analysis of the results showed that HD and HJ produced the lowest rates of recurrent stricture formation, and these 2 have been the accepted operations ever since.

As indicated by the current report, however, the choice between anastomosis to the duodenum or to the jejunum is still worthy of discussion. While we usually recommend using the jejunum, we also use the duodenum on occasion, so the question comes down to deciding which variables are important in making the choice. In my opinion the primary objectives are to (1) construct a precise anastomosis, and (2) avoid tension on the anastomosis. For me, the quality of the anastomosis is of overriding importance. Where the 2 methods are equivalent in these respects, HD would be preferable, for it is simpler and faster. It could be misleading, however, if other factors were accorded undeserved importance based primarily on theoretical grounds. I am thinking here about the ideas that preserving bile drainage into duodenum is (1) "more physiologic" and results in better digestion, and (2) protects against peptic ulcer formation. Actually, malabsorption and malnutrition are not genuine adverse effects of HJ, and peptic ulcer, which has been occasionally reported after HD as well as HJ, is so uncommon that the combination, when it occurs, is more likely to be coincidental than causal. We do not recommend prophylactic acid-suppressing medication after HJ, and peptic ulcer disease is not encountered.

Most (approximately 75%) bile duct injuries following laparoscopic cholecystectomy are located somewhere between the midcommon hepatic duct and the branching of the lobar ducts. Performing an anastomosis to the duodenum at this level is unquestionably more awkward than if the jejunum is used. Furthermore, even the most thorough Kocher maneuver still leaves the duodenum firmly tethered to its original midline position by attachments of the pancreas to the aorta and other retroperitoneal structures. Consequently, if one emphasizes quality of the anastomosis and the injury is near the bifurcation, HJ would be the default choice. Hepaticoduodenostomy would be reserved for lower bile duct anastomoses (eg, from the cystic duct junction distally) or in other cases where the default circumstances were absent. The point is not to question the authors' excellent results, but to suggest that other surgeons with less experience in complex biliary reconstructions might do better using HJ than HD.

There are several easy ways to provide for instrumentation of the bile duct following HJ. Percutaneous access is possible if the Roux-limb of jejunum is tacked up to the abdominal wall, placing metal clips to mark the location of the tacking sutures. The radiologist can then catheterize the jejunal lumen under fluoroscopy at the site of the clips and pass instruments into the biliary tree (eg, to remove intrahepatic gallstones, dilate a stricture, etc). Endoscopic access can be preserved by connecting the end of the Roux-limb to the duodenum instead of closing it. These adjunctive techniques, which have been in use for over 25 years, are needed uncommonly but prove useful in special circumstances.

Edward Phillips, MD, Los Angeles, Calif: Did you note the mechanism of injury? We found if electrocautery is the cause of injury, the extent of injury can be underestimated, especially in the group you repair within 48 hours, whereas clipping and cutting the duct with scissors has a better outcome. Did you evaluate the data to see if the mechanism of injury played a role in the patients who had postprocedure stricture?

James E. Goodnight, Jr, MD, PhD, Sacramento, Calif: Are you using your robotic device to perform those very high anastomoses?

Dr Traverso: I would also like to focus the audience on 2 issues of bile duct injuries. First, as we looked at in this study, we looked at the status of our anastomosis and its clinical presentation through LFTs. We did not look at the overall well-

being of these patients, which in the literature, has a lot more variables. These patients are focused on their right upper quadrant once they have sustained a bile duct injury. Both the families and the patients have a lot of issues. We simplified this presentation by only dealing with the effects of our anastomosis and our clinical outcomes. Whether they were excellent, good, or poor, the outcomes were mainly based on the function of their liver and the status of their anastomosis, and we showed that regardless of how the patient presented, that liver function was preserved following the principles that Dr Moraca outlined.

Regardless of the repair, one of the most important items as Dr Way points out is the experience of the surgeon indicating that perhaps some of these bile duct injuries may best be repaired in the transfer centers with experience.

Dr Way, we routinely use acid suppressors after HJs. The default choice for very high injuries is HJ. However, some of these less high biliary injuries are able to be reconstructed with the duodenum and that was the surgeon's choice. I would like to point out that all of these injuries were mainly repaired by 2 surgeons (Drs Ryan and Traverso), both with daily surgical experience in the right upper quadrant.

Another way to obtain a tension-free anastomosis with the duodenum is to mobilize the liver, bring the liver down, and bring the duodenum up that appears to allow some of these repairs to be done with the duodenum being tension free.

One of our patients had a Dwayne-Hutson loop and she was one of our poor results. We anticipated problems in having to do imaging studies in her and as you indicated, selected patients may benefit by other nontraditional routes of accessing the biliary tree.

Dr Phillips, the mechanism of injury in almost all cases were clean cuts of excising the biliary tree except for those few cases that had biliary stricture on delayed presentation. Dr Goodnight, although we do have a robot, we are using it for laparoscopic operations. There does appear to be a role for better magnification. That can be done with the robot, or alternatively, using finer suture, finer instruments, and higher magnification, with a surgical microscope.

Surgical Anatomy

Ladd bands are dense, fibrous bands that form from the cecum to the posterior body wall, typically in the right upper quadrant. They often pass anterior to the duodenum, jejunum, and colon in malrotation.

Source: Blackbourne LH, Fleischer KJ, eds. *Advanced Surgical Recall*. Baltimore, Md: Williams & Wilkins; 1997:861.