ORIGINAL ARTICLE

Hepaticojejunostomy Using Short-Limb Roux-en-Y Reconstruction

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Importance: When performing biliary reconstruction, one of the long-standing tenets of surgery is that Roux-en-Y (RY) reconstruction should use a long hepatic limb to decrease the risk for postoperative cholangitis. However, this practice is not well supported and may also make postoperative biliary endoscopy difficult. While some authors recommend Roux limbs of up to 75 cm, we have routinely used a Roux length of 20 cm to facilitate possible postoperative endoscopic access.

Objective: To review our experience with short-limb RY hepaticojejunostomy (HJ) and examine the short-term and long-term outcomes following this procedure, as well as the success of future biliary interventions.

Design: Retrospective medical record review of all patients who underwent short-limb RYHJ by 2 surgeons (N.N.N. and S.D.C.).

Setting: Tertiary care, university-affiliated teaching hospital.

Participants: One hundred patients who underwent RYHJ were identified, with 30 of those patients being excluded owing to creation of an RYHJ to intrahepatic bile ducts with concomitant liver resection.

Main Outcomes and Measures: Patient records were reviewed to determine the incidence of postoperative cholangitis and biliary stricture. Secondary outcomes were the need for postoperative biliary endoscopy and success rates for endoscopic biliary interventions.

Results: Seventy patients underwent short-limb RYHJ over an 11-year period (2001-2012). Indications included benign stricture (n=18), malignant stricture (n=12), choledochal cyst (n=5), choledocholithiasis (n=3), idiopathic cholangitis (n=2), and deceased donor or live donor liver transplant (n=30). Seven patients, including 4 liver transplant patients, developed clinical or radiographic evidence of postoperative biliary stricture, and all patients underwent successful endoscopic cholangiography. Four of these patients required dilation and/or stone extraction, which were accomplished endoscopically in all cases.

Conclusions and Relevance: Short-limb RYHJ is safe and associated with a low incidence of postoperative complications. In addition, biliary intervention, when indicated, can be performed endoscopically with a high degree of success. In the absence of any evidence demonstrating longer limbs to be superior, we recommend using short-limb RY reconstruction for HJ.

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The creation of a Roux-en-Y (RY) hepaticojejunostomy (HJ) is a critical component of many types of hepatobiliary operations. Indisputable tenets of this procedure include the creation of a durable jejunojejunostomy, followed by the creation of a tension-free anastomosis between the hepatic duct and the defunctionalized jejunal limb. However, other technical considerations, including the ideal length of the defunctionalized jejunal limb and the distance from the ligament of Treitz to the jejunojejunostomy, are open to question. Surgical textbooks describe creating a long jejunal hepatic limb of up to 75 cm, purportedly to decrease the risk for enterobiliary reflux–causing cholangitis.[1-4] Because of variability in training programs and regional dogma, the practicing surgeon is left without clear guidelines in how best to create the RYHJ.

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With the recent advent of increasingly sophisticated and facile endoscopic tech-

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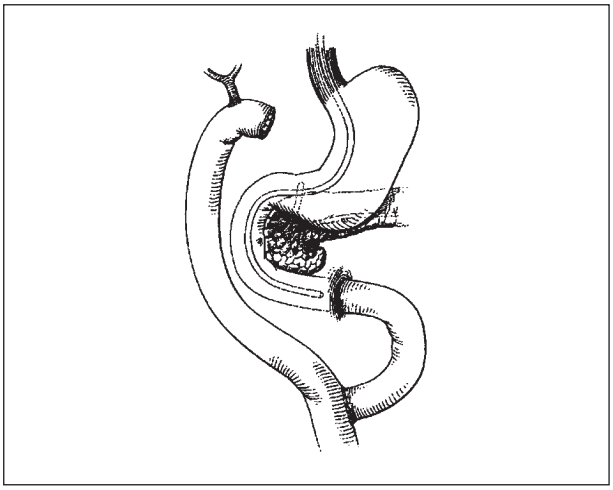

Figure 1. Roux-en Y hepaticojejunostomy anatomy. Reprinted with permission from Elsevier.[6]

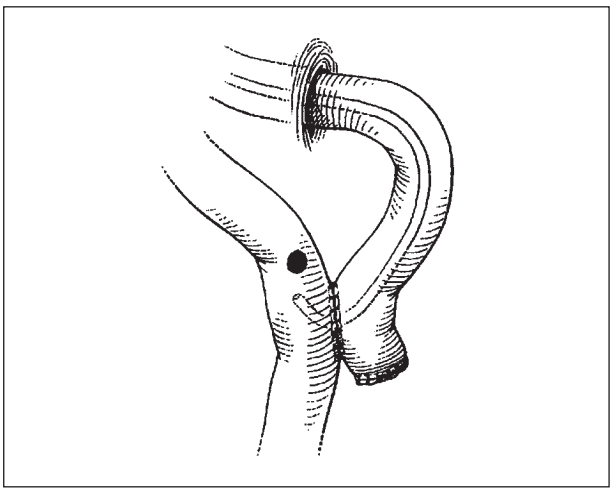

Figure 2. Endoscope navigating jejunojejunostomy; afferent limb tattooed. Reprinted with permission from Elsevier.[6]

niques, the RYHJ reconstruction has taken on added relevance.[5] The development of single-balloon and double-balloon enteroscopy to treat biliary pathology after HJ highlights the significance of limb length in gastrointestinal reconstruction. The length of an RY-afferent limb has been found to increase the difficulty of biliary endoscopy after RYHJ.[5] Because of this, our practice has been to create short-limb RYHJ for biliary reconstruction. In this technique, both the distance of the jejunojejunostomy from the ligament of Treitz and the length of the defunctionalized hepatic jejunal limb are deliberately kept as short as possible (**Figure 1**). The current study was undertaken to review our experience with short-limb RYHJ and to specifically examine the short-term and long-term outcomes after this procedure, as well as the success of future biliary interventions.

METHODS

This study is a retrospective institutional review board–approved review of consecutive patients who underwent RYHJ by 2 specialized hepatobiliary surgeons (N.N.N. and

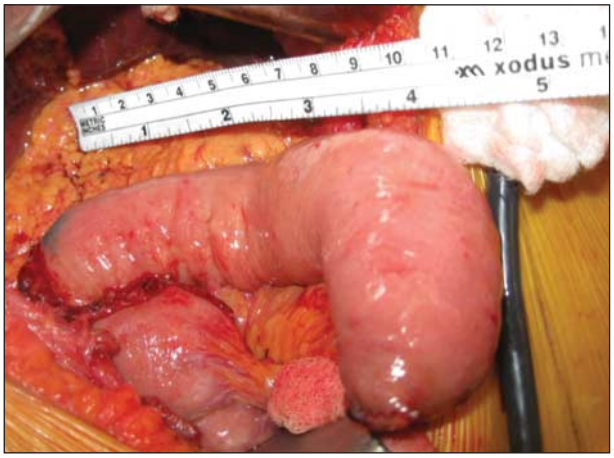

Figure 3. Short Roux limb with tattoo on afferent limb.

S.D.C.) between 2001 and 2012. Patient medical records were reviewed to determine the indication for operation; details of the operative procedure; occurrence of postoperative biliary complications including cholangitis, biliary stricture, and Roux limb revision; and the need for future biliary intervention. Complications were classified as immediate if they occurred within 90 days of operation and were deemed delayed if they occurred after 90 days. In patients requiring biliary intervention, the type and number of treatments, as well as the success of treatment, were reviewed. Endoscopic success was defined as the ability to reach the HJ anastomosis on first attempt without excessive technical difficulty, as reported in the procedure note.

To examine the most uniform population possible, we excluded patients who underwent HJ with concomitant liver resection and anastomosis to intrahepatic ducts (except in the case of live donor liver transplantation) and patients without specifically documented limb lengths. The complexity of transected liver parenchyma introduces the possibility for additional biliary complications not specific to Roux limb length, potentially obscuring outcomes of the area of interest—the length of Roux limb construction.

Roux-en-Y HJ was performed by first creating a hand-sewn or stapled jejunojejunostomy approximately 20 cm from the ligament of Treitz in a manner that created a defunctionalized jejunal segment of approximately 20 cm (**Figures 1**, **2**, and **3**). The general approach was to keep both the distance from the ligament of Treitz and the length of the Roux limb as short as possible but as long as necessary to avoid tension. The Roux limb was typically brought retrocolic to keep the length short unless the anatomy was prohibitive and, in these cases, it was brought antecolic. The HJ anastomosis was performed with interrupted, absorbable monofilament suture using Loupe magnification and selective silastic internal stenting (4 French). Stents were left in place until spontaneous migration or clinical need to endoscopically remove them. In our recent experience, the afferent limb was tattooed submucosally with an endoscopic India ink dye at the level of the jejunojejunostomy to provide the endoscopist a clear roadmap to navigate toward the bilioenteric anastomosis should endoscopy be required at a later date (Figure 2 and Figure 3).

RESULTS

One hundred patients who underwent RYHJ reconstruction were identified; however, 30 patients were excluded owing to the creation of an RYHJ to intrahepatic bile ducts

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with concomitant liver resection, leaving 70 patients for analysis. No patient was lost to follow-up. Patient demographics and the indication for RYHJ are presented in **Table 1**. The mean and median follow-up times for the group were 56 months and 49 months, respectively.

Immediate biliary complication occurred in 2 of the 70 patients reviewed (3%), with both patients requiring surgical revision in the early postoperative period. One patient underwent orthotopic liver transplantation and required revision of the HJ anastomosis for biliary leak on postoperative day 14. The other patient underwent short-limb RYHJ following common bile duct injury during cholecystectomy and returned on postoperative day 2 for HJ revision secondary to a bile leak. Neither of these patients developed clinical evidence of biliary stricture in long-term follow up.

Delayed biliary complications occurred in 7 patients (10%), including cholangitis in the absence of biliary stricture in 1 patient (1%), anastomotic biliary strictures in 2 patients (3%), and intrahepatic (nonanastomotic) biliary strictures in 4 patients (6%) (**Table 2**). The 2 patients with anastomotic strictures included 1 patient who had undergone live donor liver transplantation for primary sclerosing cholangitis (PSC) and 1 patient who had undergone 2 prior bile duct resections for papillary cholangiocarcinoma. Of the 4 patients with nonanastomotic strictures, 3 patients developed intrahepatic biliary strictures after undergoing liver transplantation. Two of these 3 patients had undergone liver transplantation for a diagnosis of PSC and, in these cases, the intrahepatic strictures were attributed to recurrent PSC. The third liver transplant patient with an intrahepatic stricture experienced postliver transplantation biliary caste syndrome. The fourth patient with an intrahepatic stricture after short-limb RYHJ had a history of bile duct injury during laparoscopic cholecystectomy and had undergone an attempt at operative repair prior to biliary reconstruction at our center. No patient with antecolic reconstruction experienced a complication requiring reoperation or endoscopy.

Endoscopic retrograde cholangiography (ERC) was attempted in all 7 patients with delayed biliary complications after short-limb RYHJ. The techniques and instrumentation used in these patients included balloon enteroscopy in 4 patients, a variable stiffness colonoscope in 1 patient, and push enteroscopy in the remaining 2 patients. In all patients, the ERC successfully reached the biliary anastomosis on the first attempt and was considered an adequate diagnostic study (100% diagnostic success rate). Four patients required therapeutic endoscopic interventions including anastomotic needle-knife stricturoplasty and dilatation in 1, biliary stenting for intrahepatic stricture, and anastomotic balloon dilation. One of the 4 patients who underwent endoscopic intervention experienced clinical cholangitis; however, no abnormalities were found on repeated ERC. In the 2 patients with recurrent PSC, no intervention was performed given that there was no therapeutically applicable stricture on ERC. Two patients required repeated ERC for diagnosis and treatment of recurrent cholangitis; this was again successful in both cases (**Table 3**).

Table 1. Patient Characteristics

Variable	
Age, median (range), y	56.3 (11.5-89.6)
Sex, No.	
Male	35
Female	35
Diagnosis, No.	
Liver transplant (ESLD)	30
Benign stricture	18
Malignant stricture	12
Choledochal cyst	5
Common bile duct stones	3
Cholangitis	2
Follow-up, mo	
Median	48.8
Mean	56.2

Abbreviation: ESLD, end-stage liver disease.

Table 3. Outcomes and Treatment

Variable	No./No. (%)
Total biliary complications	9/70 (12.9)
Immediate	2/70 (2.9)
Delayed	7/70 (10.0)
Intervention rate	6/9 (66.7)[a]
Liver transplant patients with complications	5/30 (16.7)[b]
Endoscopic success rate	7/7 (100.0)[c]
Patients with >1 procedure	2/9 (22.2)

[a] Four endoscopic retrograde cholangiography interventions and 2 surgical revisions.
[b] One immediate and 4 delayed complications.
[c] Seven diagnostic and 4 were also therapeutic.

Table 2. Postoperative Biliary Complications

Patient No.	Type of Stricture	Presence of Cholangitis	Procedure	Procedures, No.	Endoscopic Intervention
1	Intrahepatic (nonanastomotic)	Yes	SBE, ERCP, biliary stent	1	Diagnostic/therapeutic
2 (LT)	Intrahepatic	Yes	SBE, ERCP, sphincterotomy, biliary stent	2	Diagnostic/therapeutic
3 (LT)	Intrahepatic	Yes (PSC)	Push enteroscope, ERCP	1	Diagnostic
4 (LT)	Intrahepatic	Yes (PSC)	Push enteroscope, ERCP	1	Diagnostic
5	Anastomotic	No	DBE, ERCP, biliary dilation	1	Diagnostic/therapeutic
6 (LT)	Anastomotic	No	ERCP, sphincterotomy, stone extraction, biliary dilatation	1	Diagnostic/therapeutic
7	None	Yes	ERCP, SBE	2	Diagnostic

Abbreviations: DBE, double-balloon enteroscopy; ERCP, endoscopic retrograde cholangiopancreatography; LT, liver transplantation; PSC, primary sclerosing cholangitis; SBE, single-balloon enteroscopy.

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The first patient (patient 2) underwent endoscopy with placement of biliary stents for clinical cholangitis. This procedure documented no anastomotic stricture. The patient returned 14 days later for removal of the biliary stents, as the patient's liver enzymes remained elevated. It was felt that the stents were not beneficial and could potentially become problematic. The second patient (patient 7) underwent endoscopy without intervention for clinical cholangitis on 2 separate occasions, with a time interval of 38 months. No evidence of stricture, biliary debris, or other pathology was identified and no endoscopic intervention was performed.

Of the 12 patients with malignant strictures included, 10 were diagnosed as having cholangiocarcinoma and the remainder as having hepatocellular carcinoma. One patient with cholangiocarcinoma developed a benign anastomotic stricture 17 months postoperatively and was treated successfully with endoscopy.

COMMENT

The creation of an RYHJ is vital to the success of many hepatobiliary surgical endeavors. We have adopted the approach of short-limb RYHJ in which a deliberate effort is made to keep the distance from the ligament of Treitz to the HJ anastomosis as short as possible. In our practice, we routinely keep this aggregate distance at or less than 40 cm. These results show that this approach is associated with a very low incidence of both early and late biliary complications. In light of this, short-limb RYHJ appears to be a safe method for biliary reconstruction. Our overall rate of biliary complications of 13%, which includes both early and late complications, compares favorably with the literature in which biliary complications following standard RYHJ ranges from 7% to 38%.[7-11] Equally important, this short-limb construction has allowed for 100% endoscopic success in patients who have required postoperative biliary intervention. Although the number of cases requiring ERC was low in our series, the high success rate was significant. In comparison, several small series cite endoscopic success rates varying from 60% to 90% for reaching the biliopancreatic limb in patients with standard RYHJ, with successful ERC ranging from 46% to 80%.[12-19]

The short-limb RYHJ described has been part of our standard practice for more than 10 years, but we have found no prior description of this approach. In fact, surgical textbooks continue to espouse a long-limb reconstruction, suggesting that the defunctionalized jejunum should range from 40 to 75 cm in length. We have similarly found no reports comparing short-limb and long-limb reconstruction. To our knowledge, our report is the first to describe this technique and its associated short-term and intermediate-term results.

The historical descriptions of the RY configuration warrant some consideration. Cesar Roux's 1893 report of RY reconstruction to divert biliopancreatic fluids following gastric surgery described his experience with 50 patients, in which the jejunum was divided 15 to 30 cm below the ligament of Treitz and a jejunojejunostomy was created about 12 cm below the gastrojejunostomy.[20,21] This RY configuration was later applied to biliary reconstruction. Later, contemporaries of Whipple in the 1940s attempted to determine the optimal length of a Roux limb using an animal model. The report concluded 30 cm to be the optimal length for a Roux limb because at this length, enteric reflux was avoided.[22] Several surgical texts[1,2] and atlases depict a long jejunal limb ranging from 40 to 75 cm in length; however, the evidence to justify such a length is omitted.

The rationale for the longer length of defunctionalized jejunum relates to concern of cholangitis secondary to reflux of food particles into the hepatic ducts. The assumption is that a longer limb will prevent this phenomenon. However, this logic breaks down at 2 levels. First, there is little evidence that reflux of food or enteric contents causes cholangitis.[23] Second, there is no evidence that a longer limb prevents enterobiliary reflux.[24,25] Choledochoduodenostomy and hepaticoduodenostomy are examples of procedures that should allow easy reflux of proximal enteric contents into the biliary tree and yet the risk for cholangitis with these procedures is quite low.[26-28]

A very important consideration in the construction of RYHJ is forethought to address future complications and potential interventions.[5] For example, we routinely tattoo the biliary limb of the reconstruction to help guide the endoscopist should biliary intervention become necessary (Figure 2 and Figure 3). Our endoscopists have reported the landmark to be useful when navigating up the Roux limb, minimizing inadvertent intubation of the blind or distal jejunal limb. Similarly, we believe short-limb RYHJ facilitates successful endoscopic biliary intervention in the few patients who have biliary complications. In our series, all patients who required biliary intervention underwent successful ERC with no need for percutaneous intervention. Standard RYHJ with a longer limb of jejunum may make ERC more complex and pose greater risk. While the need for biliary endoscopy will only occur in a minority of patients after RYHJ, the short-limb reconstruction described here makes this eventuality less worrisome. Although the number of cases requiring ERC was low in our series, the high success rate of this procedure was significant.

In conclusion, short-limb RYHJ can be performed in a wide variety of biliary conditions with excellent short-term and long-term outcomes and with a rate of biliary complications that appears similar to or better than standard RYHJ. In addition, endoscopic biliary interventions have a high rate of success in patients with short-limb RYHJ. These findings suggest that long-limb RYHJ, which has long been part of the surgical canon, is obsolete and that short-limb RYHJ should be the preferred method of biliary reconstruction when an RY configuration is used.

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ing of the manuscript: Felder, Menon, and Nissen. *Critical revision of the manuscript for important intellectual content:* Felder, Nissen, Margulies, Lo, and Colquhoun. *Statistical analysis:* Felder, Menon, and Nissen. *Study supervision:* Nissen, Margulies, Lo, and Colquhoun.

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INVITED CRITIQUE

Nullius in Verba

Much (perhaps most) of our day-to-day surgical practice is rooted in tradition and dogma. Hepatobiliary surgeons around the world routinely construct their Roux limb in preparation for a biliary anastomosis at anywhere between 40 cm and 70 cm to prevent reflux of enteric contents into the biliary tree and thus cholangitis. This practice makes basic sense and most everybody does it—thus, it is not often questioned.

Felder and colleagues[1] challenge this basic tenet of hepatobiliary surgery. They describe a series of 70 patients over a decade that required Roux-en-Y hepaticojejunostomy for a breadth of indications. The authors' practice has been to minimize the distance between the ligament of Treitz and the enteroenterostomy and to create a short Roux limb of only 20 cm. With a respectable median follow-up of 49 months, their rate of complications was comparable with published series using the more standard Roux length. And, notably, their rate of cholangitis was very low. Certainly these data are vulnerable to critics of any retrospective case series. But the authors do not overanalyze or oversell it. And these data are as good or better than any of the sparse data supporting the tradition of a longer Roux.

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