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ORIGINAL ARTICLE

Surgical revision of biliary strictures following adult live donor liver transplantation: patient selection, morbidity, and outcomes

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Summary

Biliary strictures after live donor liver transplantation (LDLT) are frequent and difficult to manage. The outcomes of surgical correction of biliary anastomotic complications remain unclear. Clinical outcomes of patients requiring surgical revision of their biliary anastomosis following LDLT were analyzed. Of 296 consecutive right lobe LDLTs, approximately 21% of patients developed biliary strictures. Of these patients, twelve required surgical revision of a biliary anastomotic stricture. For patients who had operative repair, the average time from transplantation to stricture diagnosis was 7.6 months. Mean time to surgical correction was 8.2 months from the time of stricture diagnosis. Eight of 12 (67%) patients no longer require any intervention with a mean follow-up of 43.7 months. Two of 12 patients require intermittent medical treatment for presumed cholangitis, but have not required biliary interventions. Two patients have required chronic PTC catheter drainage. The 30-day postoperative morbidity was 58%, with four serious (Grade 3) complications occurring in three patients. Early stricture repair (<6 months from diagnosis of stricture) and younger donor grafts were associated with better surgical outcomes. Timely surgical correction of biliary strictures is successful and durable in appropriately selected patients. However, operative repair is associated with significant postoperative morbidity.

Introduction

Long-term outcomes following right lobe live donor liver transplantation (LDLT) have been shown to be equivalent to deceased donor liver transplantation [1–3]. Despite excellent recipient and graft survival, biliary complications continue to be a significant morbidity. Biliary strictures occur in approximately 20–30% of all recipients, regardless of program experience [2,4–7]. Endoscopic and percutaneous interventions are the mainstay of management for these biliary complications. The failure rate of endoscopic and percutaneous approaches is variable, but significant (ranging from 0% to 66%), and patients typically require multiple interventions [8–14]. Strictures will recur in >40% of patients, and all of these patients require repeat endoscopy with stent changes or uncomfortable, long-term percutaneous biliary stents [14].

For a select group of patients, an alternative to repeated drainage procedures is surgical revision of the anastomosis. As a rule, this modality has been reserved for patients who fail endoscopic and percutaneous management. Detailed studies of patient selection, technique, postoperative morbidity, and long-term outcomes of surgical management of these strictures are lacking. The present study directly addresses these issues, and closely examines a cohort of right lobe LDLT patients who underwent surgical revision at a single high-volume, experienced center in North America.

Methods

Patient selection and results

We interrogated our prospectively maintained LDLT database to identify patients who had operative correction of an anastomotic biliary stricture at Toronto General Hospital from April 2000 to December 2009. Twelve patients were identified and were referred for surgical management. Patient demographics, operative details, and complications, were collected. Complications were defined using the 5-tier Clavien classification system [15].

Approval for this study was obtained from the Research Ethics Board at Toronto General Hospital/University Health Network (REB#09-0082-AE).

Statistics

Statistics calculations were performed using SPSS software (version 17.0, SPSS Inc, Chicago, IL, USA). Categorical variables were compared using a fisher's exact test; continuous variables were tested using a Mann–Whitney *U* test.

Results

Patient demographics

All patients underwent LDLT with a right lobe graft (with or without the middle hepatic vein). Both donor and recipient techniques have been previously described [16,17]. The biliary system was reconstructed preferentially as a duct-to-duct. Temporary biliary stents (fashioned from a 5 Fr. silastic catheter) are placed at the time of transplant at the discretion of the attending surgeon, and typically fall out in the early postoperative period. No patients required catheter removal post transplant. A hepaticojejunostomy was performed in patients who received a graft with multiple ducts that could not be plastied together, as described previously [17].

Abnormal laboratory values (elevated alkaline phosphatase, elevated bilirubin) or symptoms of cholangitis (e.g. fever) prompted a radiological workup (ultrasound, MRCP) leading to the diagnosis of a biliary stricture. Asymptomatic strictures were followed with serial imaging to monitor for progression. Patients with symptomatic strictures (cholangitis, elevated bilirubin) are referred for endoscopic intervention when possible. If this fails or is not possible (usually in the setting of an existing roux-en-Y biliary reconstruction), percutaneous inventions are carried out. Regardless of the approach, patients on average require multiple interventions. As a general rule, surgical revision is considered in any patient who has failed multiple (>2) attempts at nonsurgical management.

Of the 296 LDLT patients, 12 required surgical revision of their biliary anastomosis (Table 1). The median age was 55 (range 40–67). The initial cause of end-stage liver disease (ESLD) was primary biliary cirrhosis (2), HCV (5), fulminant hepatic failure (1), HBV (1), and alcohol (3). Fifty percent of patients had multiple ducts at the time of their initial transplant. Eleven of 12 patients had primary duct-to-duct biliary reconstruction at the time of transplantation. One of these patients who initially had a duct-to-duct biliary anastomosis, was converted early to a roux-en-Y anastomosis following revision of the hepatic artery secondary to early thrombosis. One patient had a roux-en-Y anastomosis at their initial surgery because of multiple donor ducts. Three of 12 patients (25%) had a temporary silastic stent placed at the time of transplant. Six of 12 patients (50%) had a bile leak in the initial post-LDLT period. One patient developed an early hepatic artery thrombosis. The artery was successful revascularized and remained patent postoperatively. There were no additional vascular complications (either portal vein or hepatic vein) recorded in this group.

Table 1. Patient demographics.

	n = 12
Age at Transplant	
Median; range	55; 40–67
Gender	
M	6
F	6
Cause of liver failure	
Primary biliary cirrhosis	2
Hepatic C	5
Fulminant hepatic failure	1
Hepatitis B	1
Alcohol	3
Initial biliary reconstruction	
Duct-to-duct	11
Roux	1
Initial number of ducts	
1	6
2	6
Bile leak post transplant	
Yes	6
No	6
Biliary stent placed at time of transplant	
Yes	3
No	9
Time to stricture	
Mean; range (months)	7.6; 1.2–21.1

The mean time to stricture diagnosis post transplant was 7.6 months (range: 1.2–21.1 months). All patients underwent nonsurgical intervention first. Nine patients had 1–3 interventions, and three patients had more than three interventions. The maximum number of interventions was seven. The mean time to surgical repair was

15.8 months post transplant (range: 3–40.5 months) and 8.2 months post stricture diagnosis (range: 0.5–27.2).

Operative revision of the biliary anastomosis

For those patients who required surgical revision of their biliary anastomosis, an extensive preoperative workup was performed. One of the critical aspects of this workup is the careful delineation of the nature of the biliary stricture via MRCP or cholangiogram. A CT arteriogram or doppler study should be performed to rule out the possibility of hepatic artery thrombosis, the presence of which excludes an attempt at surgical revision. We have reserved the surgical approach for patients with isolated, short anastomotic strictures (Fig. 1a). Exclusion criteria include long strictures or the presence of multiple intrahepatic strictures (Fig. 1b). Long strictures are typically not amenable to revision, as they usually extend intrahepatically, and healthy duct cannot be obtained. In select cases, retransplantation is considered.

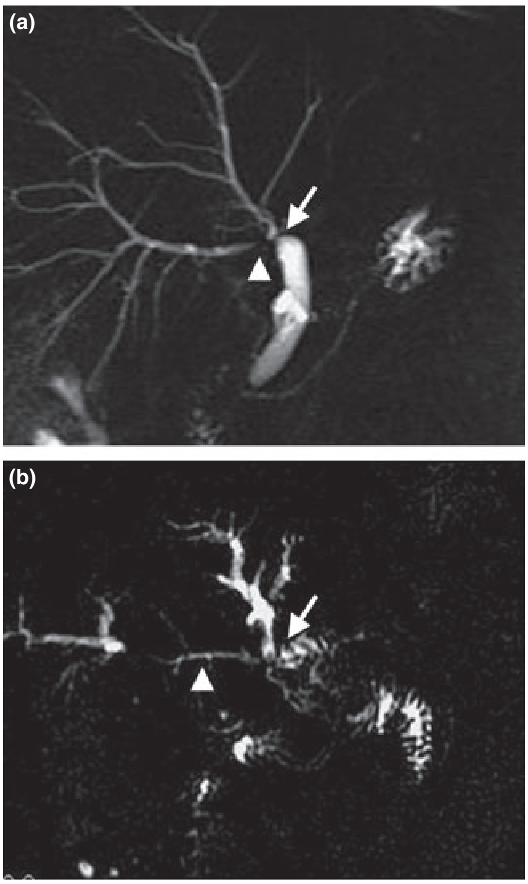

Figure 1 (a) MRCP image of a right lobe graft with a short biliary stricture (arrow) present in the anterior duct, and slightly longer stricture (arrowhead) present in the posterior duct. This patient was successfully treated with surgical revision (b) MRCP imaging of a right lobe graft with a short biliary stricture (arrow) present in the anterior duct, and a long anastomotic and intrahepatic stricture (arrowhead) present in the posterior duct. Marked dilatation is noted in both the anterior and distal posterior ducts. This patient was referred on for retransplantation.

Abdominal exploration is generally carried out through the previous LDLT incision. Adhesions were taken down, and careful dissection was performed to identify the portal structures. Great care was taken to identify the hepatic artery and trace it out as it approached the biliary anastomosis. One of the principal risks of this operation is injury to the vascular structures, particularly the artery, as it tends to runs immediately adjacent to the biliary plate. Once the bile duct (or roux limb) is freed from the distal hepatic artery, the distal common bile duct (or biliary-enteric anastomosis) is then transected. One very useful technique is to place four to six 6-0 PDS II (polydioxanone; Ethicon©, Somerville, NJ, USA) sutures circumferentially around the proximal transected bile duct and use these to gently pull the bile duct and plate complex away from the liver cut surface. In this manner, the duct can be dissected high into the hilar plate and then cut sharply. The hydrojet dissector may be useful for mobilizing the intrahepatic portion of the duct; however, this dissection should not be more extensive than it has to be. The goal should be to gently tease out the area of the stricture, and divide the duct (or ducts) just proximal to the stricture so as to limit any additional compromise of the biliary arterial supply. The ducts are then extensively probed and examined to ensure healthy tissue. Additional duct is taken as needed until healthy tissue is reached, although as noted earlier, this dissection should be as limited as possible. We do not advocate trying to resect the surrounding liver parenchyma for similar reasons, unless absolutely required for visualization of the ducts. A roux limb is then fashioned measuring 40–50 cm in length. The biliary-enteric anastomosis is then performed with interrupted 6–0 PDS II sutures. A duct-to-mucosa anastomosis is performed whenever possible. If the ducts are too small or numerous, the anastomosis is performed to the hilar plate. Previously placed percutaneous transhepatic cholangiogram (PTC) catheters are left in place and used for imaging postoperatively. A Hudson loop is created at the discretion of the surgeon. A Hudson loop allows for easy access to the biliary anatomosis through the roux limb, and avoids the use of percutaneous transhepatic tubes. It is constructed by tacking a portion of the roux limb to the anterior abdominal wall. The site is marked with large metallic clips for easy identification by the interventional radiologist.

The patients tolerating a regular diet are discharged home, and are put on their previously prescribed immunosuppression treatment. Serial imaging of the biliary tree

Table 2. Operative and postoperative characteristics.

	n = 12
Time to surgical repair (post transplant)	
Mean; range	15.8; 3–40.5
Time to surgical repair (post stricture diagnosis)	
Mean; range	8.2; 0.5–27.2
Preoperative intervention	
1–3	9
>3	3
Operative intervention	
Roux limb	9
Roux limb + hudson loop	3
Duration of surgery (h)	
Mean; range	6.8; 4.5–10.2
Estimated blood loss (ml)	
Median; range	400; 250–5000
Length of hospital stay (days)	
Stepdown – median; range	2; 0–7
Total (postoperative) – median; range	7; 5–24
Postoperative intervention	
0	4 (33%)
1–3	7
>3	1
Patient free of biliary intervention	
Yes	10 (83%)
No	2
Follow-up – post stricture repair (months)	
Mean; range	42.7; 12.7–88.4

is performed, generally with MRCP. If the PTC is left in place during the surgery, it is removed after normal imaging several weeks post operatively.

Peri-operative details

Ten duct-to-duct biliary anastomoses were converted to a hepaticojejunostomy (Table 2). Two patients had revision of their prior hepaticojejunostomy. Three patients had a Hudson loop constructed. Average length of procedure was 6.8 h (range 4.5–10.2 h). Median estimated blood loss was 400 ml (range 250–5000). Almost all patients (11/12, 92%) went to an acute care (''stepdown'') unit after the procedure. Patients spent a median length of 2 days in this unit, and were then transferred to the general ward. The median length of stay after surgery was 7 days (range 5–24 days).

Mean follow-up time was 42.7 months (range 12.7–88.4 months). One-third of patients required no further interventions following revision of their biliary anastomosis. Seven patients required at least one intervention, including postoperative cholangiograms and percutaneous drainage catheter exchanges. In 10 of 12 patients (83%), these catheters have been removed permanently; two patients require long-term stenting for residual stricture.

Table 3. Postoperative complications.

Complication grade (<30 days post op)	Complication	n = 8 (7 patients)
Grade I		0
Grade II		
	Cholangitis	3
	Postoperative hemorrhage requiring blood transfusion	1
Grade III		
	Bile leak requiring perc drain	1
	Bile leak requiring laparotomy	2
	Hemorrhage requiring laparotomy	1
Grade IV		0
Grade V		0
Complication grade (>30 days post op)	**Complication**	**n = 11 (9 patients)**
Grade I		0
Grade II		
	Recurrent HCV	2
	Recurrent cholangitis	2
	Persistent pruritis	1
Grade III		
	Recurrent stricture	3
	Ventral hernia	1
	Segmental bile duct requiring prolonged drainage	1
Grade IV		0
Grade V	Death	1

The 30-day morbidity (Table 3) was 58% with eight complications (four Grade II, four Grade III) occurring in seven patients. Two patients required reoperation: one for bile leak (POD# 2 and 15) and one patient for hemorrhage and bile leak (POD#1). One patient had postoperative hemorrhage that was treated nonoperatively with blood transfusions. One patient required percutaneous drainage for a bile leak. Three patients developed fever and were presumed to have postoperative cholangitis. These were treated with antibiotics and resolved. One of these episodes occurred after manipulation of a PTC catheter.

Long-term postoperative morbidity and outcomes

The >30-day morbidity (Table 3) in our cohort was 11 complications occurring in nine patients (75%). Two patients have developed recurrent HCV. One patient developed a ventral hernia requiring repair; and one patient had a cut surface bile leak that required prolonged percutaneous drainage. Another patient had persistent pruritis despite a normal bilirubin and alkaline phosphatase. This symptom is currently managed with ursodiol. One patient developed narrowing of one of the two intrahepatic biliary anastomoses and was subsequently balloon-dilated; this patient is now free from any interventions. Two additional patients developed recurrent strictures that were not correctable via percutaneous interventions. One of these patients had previously developed a hepatic arterial thrombosis (HAT) post transplant, with immediate revision, revascularization, and graft salvage, at the time of the original transplantation. This patient has now developed multiple intrahepatic strictures, and has refused retransplantation. They are currently alive with a PTC catheter in place. The other patient with a recurrent stricture developed recurrent HCV, and was not a candidate for retransplantation. Unfortunately, this patient progressed to graft failure and died 2 years post transplant (1 year post revision).

In summary, ten of the twelve patients who underwent surgical repair of a biliary stricture post-LDLT are currently free from percutaneous or endoscopic intervention. Of these ten patients, two have been intermittently treated for fevers with antibiotics. These episodes have been attributed to recurrent bouts of cholangitis on the basis of clinical presentation, although neither have had any progression of their ductal dilatation post stricture repair. Thus, 8/12 patients had a successful repair (free of any bile duct related issues), whereas 4/12 have either recurrent strictures or recurrent episodes of cholangitis. We consider these four patients to be unsuccessfully managed surgically.

Risk factors for failure of operative repair of biliary strictures

Long-term success of the surgical revision was neither related to the recipient age, number of interventions preoperatively, the presence of a bile leak at the time of the initial transplant, and multiple ducts at the time of transplant, nor to a documented CMV infection post transplant (Table 4). However, all four unsuccessful operative repairs (100%) were performed >6 months from the diagnosis of the stricture ($P = 0.081$). This approached, but did not reach statistical significance. We also observed a trend that suggested that strictures which occur early after transplant (<6 months) are not amenable to successful repair. Three of the four unsuccessful stricture repairs were performed on strictures that were detected <6 months after transplant. In addition, patients with younger donor grafts had a significantly better outcome post surgical correction when compared with patients who obtained a graft from an older donor (30.8 ± 4.4 years vs. 48 ± 9.3 years, $P = 0.008$). The one patient who had an arterial complication post liver transplant also failed surgical revision of their biliary anastomosis. This patient had an early hepatic arterial thrombosis that was successfully revascularized. Post stricture revision, this patient developed multiple intrahepatic biliary strictures and refused retransplantation.

Table 4. Factors associated with successful repair of biliary strictures.

Variable	Successful (n = 8)	Unsuccessful (n = 4)	P value
Time to stricture			
<6 months	2	3	
≥6 months	6 (86%)	1	
Time to repair			
<6 months	5 (100%)	0	0.081*
≥6 months	3	4	
Bile leak post-LDLT			
Yes	5	1	
No	3	3	
Number of preoperative interventions			
≤2	3	2	
>2	5	2	
CMV infection			
Yes	2	0	
No	6	4	
Age of donor (mean ± SD)	30.8 ± 4.4	48 ± 9.3	0.008†
Age of recipient (mean ± sd)	50.5 ± 11.5	53.4 ± 3.0	
Initial number of ducts			
=1	3	3	
≥2	5	1	
LDLT vascular complications			
Yes	0	1	
No	8	3	

*Fisher's exact test.
†Mann–Whitney U test.

Discussion

Biliary strictures continue to be a significant complication after LDLT, and are typically managed nonoperatively. Surgery involving stricture excision and conversion to a hepaticojejunostomy is usually reserved for patients who have failed nonoperative measures. We reviewed our experience with surgical revision at the Toronto General Hospital, a Western center experienced in both LDLT and hepatobiliary surgery. Revision was successful in 67% of cases, but was associated with significant early and late postoperative morbidity. Factors associated with improved surgical outcomes included: (i) younger donor grafts, (ii) absence of a vascular complication post-LDLT, and (iii) early surgical intervention (<6 months after diagnosis of the stricture). An algorithm for the treatment of biliary strictures is presented (Fig. 2).

The etiology of biliary strictures remains largely unknown, but is probably related to a compromised arterial blood supply to the ducts or a bile leak. The blood supply to the biliary plate is known to be quite precarious

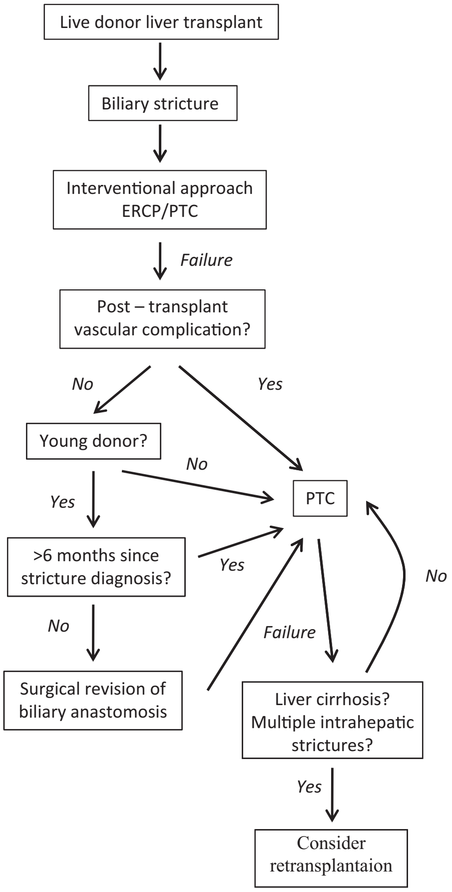

Figure 2 Proposed algorithm for optimal management of biliary strictures after live donor liver transplant. However, these are recommendations only and multiple exceptions will probably occur.

and complex [18]. Although strictures are typically thought to be related to arterial blood flow to the biliary tree, recently, portal venous flow has been implicated in contributing to ischemic-type biliary strictures post liver transplant [19]. The contribution of portal vein thrombosis to the development of anastomotic biliary strictures has not been well studied.

The development of biliary strictures post right lobe LDLT appears to be inherent to the operation, as the rate of biliary strictures remains static with experience [2,4–7]. Donor age (>50 years), >1 bile duct, and the presence of a bile leak postoperatively, all appear to be positively associated with biliary strictures [17]. The use of temporary biliary stents at the time of the initial biliary reconstruction does not appear to contribute to the occurrence of strictures post LDLT [17]. Whether stricture occurrence changes with the type of anastomosis is controversial. Some groups report no difference in stricture rates [17], whereas, others have reported a better stricture rate with the use of Roux-en-Y anastomosis versus a duct-to-duct anastomosis (8.3% vs. 26.6%, respectively). However, this group still favors a duct-to-duct anastomosis, as 74.5% of the strictures that developed in patients with duct-to-duct anastomoses were successfully treated using endoscopic techniques [4].

The optimal management of biliary strictures post LDLT continues to evolve. At many transplant centers, the practice has been to manage biliary strictures after LDLT largely with nonoperative interventions [12,13]. In patients with duct-to-duct biliary reconstruction, endoscopic management of strictures is preferred. The results of endoscopic stenting and dilatation have been mixed, and success rates vary between 40% and 71%, and are probably related to patient selection [8,10,11,14]. Many patients require multiple interventions, and recurrence rates are high. Initial examination of our right lobe LDLT patients with a biliary stricture demonstrated that the median number of interventions per patient with a biliary stricture was three ERCPs and four PTCs [17]. Recently, the use of double balloon endoscopy has allowed for endoscopic treatment of strictures in patients with roux-en-Y anastomoses [20,21]. In addition, the technique of magnetic compression has also been used to successfully revise strictured biliary anastomoses [21,22].

In right lobe LDLT, the outcomes associated with operative conversion of the biliary anastomosis remain largely unknown. Results of small numbers of patient have been reported with little information regarding outcome [9,12,13,17,23]. These cohorts of patients were parts of large series examining overall outcomes following endoscopic, percutaneous, and surgical intervention of post-transplant biliary strictures. Details regarding patient characteristics, selection, operative technique, and perioperative morbidity, are lacking.

Recently, Melcher *et al.* [24] reported their outcomes following operative repair of biliary complications after right lobe LDLT at the University of California San Francisco. They considered 10 patients with either an early bile leak and an associated biliary stricture ($n = 5$) or a late biliary stricture ($n = 5$); all were treated with surgical revision of their biliary anastomosis. The authors report that successful repair of strictures (100%) appears to be associated with the absence of biliary leak, and hypothesize that a biliary leak is associated with severe ductal ischemia, and therefore lower rates of successful repair. Although interesting, this study does not provide a detailed review of the criteria for patient selection and an analysis of postoperative morbidity. In contrast, the present study highlights all of these issues. In addition, Melcher *et al.* conclude that bile leak is highly associated with unsuccessful repair. In our series, 6/12 patients who underwent revision of their biliary stricture had early bile leaks; of these, five of the six were successfully repaired.

The hypothesis that bile leaks are associated with worse ischemia to the biliary tree is intriguing from a theoretical point of view. Although this association did not seem to hold true in our data set, we agree that it is likely that the degree of ischemia to the duct (which may or may not manifest as a clinically significant bile leak) and the timing of the repair that is important in determining if operative correction, will be successful. However, it is important at the time of repair to determine that the new duct is healthy and that the blood supply is not compromised by too much dissection around the duct.

Operative repair of biliary strictures has also been examined in deceased donor liver transplantation. In one series of 46 patients (13 anastomotic strictures), 48% of the patients with strictures had postoperative complications, with one death [25]. Ten patients (22%) developed late recurrent strictures [25]. In at least one study, the role of nonoperative versus operative intervention for the treatment of biliary complications in cadaveric liver transplants has also been reviewed. In this nonrandomized, retrospective study, surgical intervention was found to be superior to nonsurgical intervention [26].

For successful operative stricture repair, appropriate patient selection is critical. Short anastomotic strictures, presumably reflecting a confined area of ductal ischemia, are probably ideal for surgical repair. Long strictures in which a larger area of vascular compromise is present are less amenable to repair. In addition, patients who have a global hypoxic insult to the liver graft [e.g. hepatic artery thrombosis (HAT)] are also poor candidates. These patients potentially have other sites of stricturing (possibly intrahepatic) that will continue to be problematic even if the main stricture is repaired. One of the patients who failed operative bile duct revision developed HAT early after transplantation, and now suffers from multiple intrahepatic strictures. It is also plausible that the two of our postrepair patients, who have intermittent bouts of cholangitis, have small undetectable intrahepatic strictures whose segments of liver become intermittently infected despite the main anastomotic biliary stricture having being successfully repaired. In our series, strictures that occurred early post transplant (<6 months) tended to be less amenable to repair. In contrast, successful repair was obtained for 83% of patients who developed a stricture >6 months after transplantation. It is not surprising that grafts from younger donors appear to be more amenable to stricture repair. The mean age of donor grafts in recipients who had a successful revision was significantly lower when compared with recipients whose biliary stricture revision was unsuccessful (30.8 ± 4.4 years vs. 48 ± 9.25 years, $P = 0.008$). This is not surprising, as older donors (≥50 years old) have been previously shown to be at higher risk for the development of strictures [17]. Recipient age appeared to be of little importance, as both young and old recipients failed surgical revision.

Our study also suggests that the timing of the surgery from the diagnosis of the stricture is important. All of the patients who failed intervention underwent correction for more than 6 months from the diagnosis of the stricture. Cumulative insult and scarring from chronic infection and inflammation in the obstructed duct probably occurs over time from prolonged failure of percutaneous and endoscopic interventions. Early surgical treatment of strictures probably prevents this cumulative damage and appears to yield better results. Further studies are needed to validate these trends.

Although surgical intervention appears to offer excellent results in this highly selected group of patients, the morbidity from this intervention is high. Greater than 58% of patients had at least one grade II or III complication. There were no perioperative deaths; one patient died approximately 1 year after stricture repair of liver failure. These complications are reflective of the difficulty of reoperative surgery in patients after liver transplantation. From a technical standpoint, we believe it is important to emphasize that a clear understanding of the anatomy of the porta following LDLT is essential to prevent a catastrophic injury to the blood supply (mainly the hepatic artery) to the graft. Such an injury would almost certainly result in graft loss. No compromise of vascular flow to the liver was reported in this series. Given the high morbidity and potential for catastrophic mistakes, these repairs should only be attempted at experienced centers.

We recognize that there are both strengths and weaknesses to our study. There are no large series examining the technique of surgical revision of biliary anastomosis with chronic strictures after LDLT. This article carefully reviews the technique, describes what we feel is the ideal patient for surgical repair, and describes some of the pitfalls. In addition, the outcomes of a series of 12 patients are reviewed in depth including complications. However, the data were reviewed retrospectively, although the data are maintained prospectively. In addition, although this is the largest series examining surgical repair of biliary strictures to date, it is a heterogeneous group of patients, and it is difficult to perform robust statistics with this relatively small sample size. Extending the study to encompass multiple centers would increase the number of patients treated, but would also increase the heterogeneity of the study, making the data difficult to analyze.

In conclusion, a multidisciplinary approach to the treatment of biliary strictures after LDLT is essential. Nonoperative intervention continues to be the mainstay for management of chronic strictures following LDLT, but timely referral of appropriate candidates for surgical revision is critical for postoperative success. In a highly selected group of patients, surgical revision is a durable and definitive procedure that should be considered sooner rather than later. However, surgery is associated with significant early and late postoperative morbidity, and should only be performed in experienced centers.

Authorship

TWR, DRG and IDM: responsible for study design. TWR and CS: performed data collection and analysis. TWR, PDG, DRG and IDM: wrote the Paper. MSC and GL: carried out critical revision.

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