Biliary Tract Complications after Liver Transplantation: A Review

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Key Words

Duct-to-duct anastomosis • Hepaticojejunostomy • Biliary leak • Biliary stricture • Ischemic-type biliary lesions

Abstract

Biliary complications continue to be a major cause of morbidity in liver transplant recipients with an incidence of 10–30% following whole-organ transplantation and a mortality rate of up to 10%. Biliary leaks and strictures are most common but sphincter of Oddi dysfunction, hemobilia, and biliary obstruction are also observed. Biliary complications may be related to various factors such as hepatic artery patency, preservation injury, cytomegalovirus infection, chronic ductopenic rejection, ABO incompatibility, and technical reasons. The latter include imperfect anastomosis, T-tube-related complications and the use of partial liver grafts when cut surface biliary leaks or inadvertent bile duct injuries may occur during parenchymal division. The usage of a T-tube for duct-to-duct anastomosis in whole-organ liver transplantation remains controversial, mainly because of the high rates of T-tube-related complications observed in many series. In this article we review the etiology, as well as the main types of biliary complications according to the technique of biliary reconstruction and liver transplant procedure performed. Their management is also discussed with interventional radiology and endoscopic techniques emerging as the preferred treatment option, obviating the need for surgery in a selected majority of patients.

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Introduction

Biliary complications, once considered as the technical ‘Achilles heel’ of orthotopic liver transplantation (OLT) [1–3], still remain a common source of morbidity and mortality. In early reports by Starzl et al. [2] and Calne et al. [4], they resulted in morbidity rates of 34–50% and mortality of 25–30%. With improvements in organ selection, retrieval, preservation, and implantation techniques such complications have been reduced dramatically. Biliary complications, however, still occur in 10–30% following whole-organ OLT resulting in mortality rates up to 10% of cases [5–11] (table 1).

Biliary leaks and strictures are the most common biliary complications, but sphincter of Oddi dysfunction, hemobilia, and biliary obstruction from cystic duct mucoceles, stones, sludge or casts have also been observed [5, 12, 13]. The risk of specific biliary complications is related to the technique of biliary reconstruction, use of a biliary drain following duct-to-duct anastomosis, and the type of a liver transplant procedure performed. Reduced size, split-liver transplantation and living-donor liver transplantation are associated with an increased risk of these complications with a reported incidence of 10–60% [14–25]. This may be as a result of devascularization of the bile duct at the hilar dissection, failure to recognize anomalies of the biliary tree, technically challenging biliary reconstruction (small-size ducts, multiple ducts), and biliary leaks from the cut edge.

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Table 1. Biliary complications after cadaveric whole-organ OLT with duct-to-duct anastomosis and Roux-en-Y hepaticojejunostomy

Reference	Center	Year	n	Total, %	Leaks, %	Strictures and obstructions, %
Greif et al. [5] ¹	Pittsburgh	1994	1,792	12	3	5
Verran et al. [6] ¹	Ontario	1997	502	14	2	7
Duct-to-duct anastomosis						
Lebeau et al. [119]	Pittsburgh	1990	193	20	2	18
Belli et al. [120]	Milan	1991	100	4	2	2
Neuhaus et al. [7]	Berlin	1994	300	9	0.3	4
O'Connor et al. [8]	Boston	1995	147	33	22	12
Rabkin et al. [9]	Portland	1998	227	30	19	12
Davidson et al. [10]	Royal Free	1999	100	31	17	14
Roux-en-Y hepaticojejunostomy						
Ringe et al. [26]	Hannover	1989	84	24	12	2
Rouch et al. [86]	Chicago	1990	72	21	13	6
Lebeau et al. [119]	Pittsburgh	1990	187	12	9	3

The percentages are based on the total number of cases.

¹ Both duct-to-duct anastomoses and Roux-en-Y hepaticojejunostomies included.

Biliary Reconstruction at Liver Transplantation

Biliary reconstruction is the final step of OLT which is done after all the vascular anastomoses have been completed. An end-to-end duct-to-duct anastomosis is the procedure of choice in most institutions following whole-organ OLT in patients with healthy native bile ducts of suitable caliber [5, 6]. This technique yields a physiological bilioenteric continuity and allows biliary complications to be treated endoscopically. A side-to-side variant of duct-to-duct anastomosis has also been used by some groups and good results have been obtained [7, 26]. The gallbladder conduit technique used in the early years utilized the gallbladder as a pedicle graft conduit between the donor and recipient bile ducts [1]. It has largely been abandoned because of the associated bile stasis with stone formation and frequent episodes of cholangitis which lead to the inferior outcome [27, 28].

Roux-en-Y hepaticojejunostomy is utilized in cases of preexisting biliary tract disease (sclerosing cholangitis, biliary atresia), large disparity in size or small caliber ducts, and may be preferred in case of retransplantations because of inadequate recipient duct length [29, 30]. In the early years of living-donor liver transplantation and split liver transplantation, Roux-en-Y hepaticojejunostomy was the standard biliary reconstructive technique. With growing experience of surgical technique and more emphasis placed on preserving the blood supply around the

native common bile duct [31, 32], duct-to-duct anastomosis with or without a biliary drain has been increasingly reported in right lobe living-donor transplants [33–38], as well as in right lobe split transplants [39–45]. Initially, duct-to-duct anastomosis in right lobe living-donor transplants was only performed when a single donor duct was available, whereas more recently, the use of the recipient right and left hepatic ducts, as well as the cystic duct has been reported when multiple anastomoses are needed [46–48]. Alternatively, both duct-to-duct and bilioenteric reconstructions may also be used in the same patient. Hepaticojejunostomy remains the method of choice for biliary reconstruction in the left lateral segment split liver grafts, as well as in a left lateral segment or left lobe living-donor grafts [39, 41–43, 49, 50]. However, duct-to-duct anastomosis in left lobe living-donor liver transplants has also been shown to be feasible [51, 52].

Classification and Etiology of Biliary Complications

Biliary complications appear attributable to various factors, including hepatic artery thrombosis or stenosis, technical reasons, as well as ischemia-reperfusion injury and immunological injury, which may lead to the ischemic-type biliary lesions [53–61]. The classification of biliary complications should mainly refer to the etiology which appears most relevant for data analysis and its fur-

ther interpretation. In this respect, biliary strictures should be clearly distinguished from bile duct obstructions, which may be intrinsic or due to extrinsic compression of the biliary tree [62] (table 2). In this article we propose to classify biliary complications according to the criteria of their etiology and frequency after OLT (table 3).

Technical reasons for biliary complications include imperfect anastomosis leading to a leak and/or stricture, T-tube-related complications and the use of partial liver grafts when cut surface biliary leaks or inadvertent bile duct injuries may occur during parenchymal division. With ex vivo splits, biliary complication rates of 15–40% in the early years [15–17, 19, 20], and 9–26% in more recent series [40, 41, 45, 49] have been reported. A new technique of in situ liver splitting has been developed and has reduced biliary complication rates in partial graft transplantation [39, 63]. However, the incidence of complications following in situ liver splitting varies from 0 to 41%, which may reflect center experience and its volume as a predominant factor (table 4) [39, 42–44, 63–65]. The excellent results from in situ splits come from centers with large experience in liver transplantation and previous experience with ex situ splitting [39, 42].

Ischemic-type biliary lesions appear to be a broad pathological entity characterized by intrahepatic strictures and dilatations seen on cholangiogram, which by definition occur in the absence of hepatic artery thrombosis or stenosis [54]. The pathogenesis of ischemic-type biliary lesions remains unclear; however, an increased frequency of such lesions in patients with prolonged cold ischemia time [54, 66–69], delayed rearterialization of the graft [70] or transplants from non-heart-beating donors [71] suggests ischemia-reperfusion injury as a causative factor. Immunologically related ischemic-type biliary lesions comprise injury to the biliary epithelium and/or vascular endothelium in the course of chronic rejection, cytomegaloviral infection, recurrent sclerosing cholangitis and ABO incompatible transplantation [54–61]. It has also been suggested that bile salts within the biliary tree can be cytotoxic to the ductal epithelium of allografts with long preservation times, resulting in intrahepatic stricture formation [54]. For this reason most surgeons routinely flush the donor biliary tree to remove stagnant bile at the time of organ procurement in order to prevent direct chemical injury of the biliary epithelium by bile during cold storage. Pressurized aortic perfusion as well as the use of low viscosity preservation solutions have also been proposed as additional important measures that may limit the incidence of biliary strictures in the liver transplant setting [72–74].

Table 2. Etiology of bile duct obstruction after liver transplantation

Intrinsic
Biliary sludge, cast, or stones
T-tube obstruction
T-tube/stent remnants
Thrombus in hemobilia
Nematodes
Extrinsic
Biloma/hematoma/abscess
False aneurysm
Cystic duct mucocele
Recurrent/de novo cancer
Post-transplant lymphoproliferative disease

Table 3. Classification of biliary complications after liver transplantation

I	Ischemic biliary complications due to hepatic artery thrombosis or stenosis
	Stricture
	Leak
	Bile collection (biloma)
	Biliary abscess
II	Technical biliary complications
	Anastomotic stricture
	Anastomotic leak
	T-tube related
	Cut surface leak ¹
	Missed segmental duct leak ¹
	Kinking
	Cystic duct mucocele
III	Ischemic-type biliary lesions
	Ischemia-reperfusion injury related
	Immunological ²
	Idiopathic
IV	Infectious biliary complications/cholangitis
V	Uncommon biliary complications
	Sphincter of Oddi dysfunction
	Biliary stones, sludge, and casts
	Hemobilia
	Roux limb stasis or torsion
	Roux limb bleeding or perforation
	Post-transplantation lymphoproliferative disease
	Recurrent/de novo cancer

¹ Partial liver grafts.

² Strictures related to chronic rejection, ABO incompatibility, recurrent primary sclerosing cholangitis or cytomegalovirus-induced ductopenia.

Table 4. Biliary complications after split-liver transplantation

Reference	Center	Year	n	Total, %	Leaks, %	Cut-edge leaks, %	Strictures %
Left lateral segment split-liver grafts							
Rogiers et al. [39] ¹	Hamburg	1996	7	0	0	0	0
Rela et al. [41]	King's	1998	22	14	9	5	0
Yersiz et al. [42] ¹	Los Angeles	2003	94	9	7	7	1
Renz et al. [43] ²	US	2004	207	13 ³	10	9	3
Right lobe split-liver grafts							
Rogiers et al. [39] ¹	Hamburg	1996	7	0	0	0	0
Azoulay et al. [40]	Villejuif	1996	21	19	11	4	7
Rela et al. [41]	King's	1998	22	14	14	14	5
Yersiz et al. [42] ¹	Los Angeles	2003	71	10	7	4	3
Renz et al. [43] ²	US	2004	152	11 ⁴	9	9	2
Sampietro et al. [24] ²	Brussels	2005	36	35	20	11	26
Spada et al. [44] ¹	Palermo	2005	15	27	–	–	–
Wojcicki et al. [45]	Birmingham	2006	70	26	21	11	4
Corno et al. [65] ¹	Bergamo	2006	22	41	–	–	–

The percentages are based on the total number of cases.

¹ In situ splits. ² Both in situ and ex vivo splits included. ³ 12% for in situ and 15% for ex vivo splits. ⁴ 17% for in situ and 5% for ex vivo splits.

Cholestasis in a liver transplant patient may also be caused or aggravated by biliary sludge formation [75–78]. Biliary sludge consists of inspissated and thickened bile and/or connective tissue originating from destroyed bile duct walls. It may lead to a serious biliary obstruction due to a cast formation and life-threatening cholangitis. Biliary casts are more likely to develop in the setting of liver graft ischemia, biliary strictures, ischemic-type biliary lesions, and when stagnant bile in the donor biliary tree had not been flushed out prior to cold storage.

Clinical Presentation and Diagnosis

The majority of biliary complications are diagnosed within 6 months after OLT with an estimated one third occurring within 1 month and two thirds within 3 months of surgery [5]. Most of them are biliary strictures which present commonly with cholestasis and associated abnormalities in liver function tests, with pyrexia or septicemia in the presence of coexistent cholangitis. Clinical features are often nonspecific and may be masked by steroid and immunosuppressive therapy. They may include abdominal discomfort or the absence of peritoneal signs even in the case of diffuse biliary peritonitis due to a biliary leak in the immediate postoperative period. For this

reason, any clinical deterioration of the patient in the early postoperative period including pain, fever, prolonged ileus or ascites and/or liver allograft dysfunction necessitates algorithmic use of diagnostic modalities in order to make a proper diagnosis and start treatment promptly [12]. Doppler ultrasonography is the first-line investigation of choice because of the frequent association of biliary complications with the presence of hepatic artery thrombosis or stenosis [5, 53]. Abnormal or absent signals are further investigated by conventional visceral angiography [12], or more recently by noninvasive computed tomography (or magnetic resonance) angiography [79, 80]. Cholestasis early after OLT can be caused by many pathologic conditions like acute cellular rejection, vascular thrombosis, preservation injury, ascending cholangitis, drug toxicity, hemolysis, recurrent hepatitis, steatosis from parenteral nutrition, and generalized sepsis [12, 81]. This underscores the need for a multidisciplinary approach to the care of liver transplant recipients, and histopathological expertise is required. While rejection is the most common cause of liver allograft dysfunction within the first 2–4 weeks after transplantation, biliary complications predominate as the leading cause of abnormal liver function more than 3 months after OLT and occur in up to 15% of cases [82]. Ultrasound evaluation of the biliary tree is of limited value because bile duct

Table 5. Incidence of biliary complications after liver transplantation with duct-to-duct anastomosis with (T-tube) and without a T-tube (non-T-tube)

Reference	Total		Strictures		Leaks	
	T-tube	non-T-tube	T-tube	non-T-tube	T-tube	non-T-tube
Rouch et al. [86]	9/25 (36%)	7/38 (18%)	–	–	5/25 (20%)	1/38 (3%)
Rolles et al. [87]	4/16 (25%)	20/90 (22%)	0	10/90 (11%)	4/16 (25%)	10/90 (11%)
Randall et al. [93]	13/59 (22%) ^b	7/51 (14%)	8/59 (14%)	7/51 (14%)	5/59 (8%) ^d	0
Vougas et al. [88] ¹	5/30 (17%)	6/30 (20%)	2/30 (7%)	6/30 (20%)	1/30 (3%)	0
Nuno et al. [89] ¹	5/50 (10%) ^c	16/48 (33%)	1/50 (2%)	6/48 (13%)	3/50 (6%)	8/48 (17%)
Rabkin et al. [9]	43/124 (35%)	11/44 (25%)	7/124 (6%) ^a	10/44 (23%)	36/124 (29%)	1/44 (2%)
Scatton et al. [90] ¹	30/90 (33%) ^d	14/90 (15%)	3/90 (3%)	6/90 (7%)	9/90 (10%)	2/90 (2%)

^a $p < 0.05$; ^b $p = 0.01$; ^c $p < 0.01$; ^d $p < 0.005$.

¹ Prospective randomized trials.

dilatation may be absent in the presence of biliary obstruction in liver transplant patients [83]. The indication for endoscopic retrograde cholangiopancreatography or percutaneous transhepatic cholangiography must therefore often be based on the clinical presentation and histologic findings of biliary obstruction and/or chronic cholangitis in liver biopsy [12]. Magnetic resonance cholangiography is a noninvasive and very promising diagnostic modality that can detect pathologic biliary tract changes and provide information for planning invasive therapeutic procedures [84].

Use of T-Tube and Biliary Complications

There is ongoing discussion regarding the use of a T-tube for duct-to-duct anastomosis in whole-organ liver transplantation. A T-tube drainage at OLT has traditionally been used to provide easy access to the biliary tree and lower the pressure in the biliary system, which may be elevated in the case of stenosis at the anastomotic site or due to sphincter of Oddi dysfunction [7, 9, 85]. Additionally it aids monitoring of the quality and output of bile and may reduce the incidence of late anastomotic biliary strictures [9, 86–90] (table 5) and the need for their surgical repair [9, 89, 91]. Biliary drains, however, may increase complication rates by frequently observed leaks following bile drain removal, its dislodgement, cholangitis and biliary obstruction [5, 8, 90, 92, 93]. The incidence of biliary drain-related biliary complications range between 10 and 22%, with bile leak after bile drain removal occurring in 5–15% of patients [82, 90, 94–96]. This is due

to inadequate development of a fibrous fistulous tract along the course of the drain as a result of impaired fibrogenesis under immunosuppression with the use of steroids [97]. Several measures have been proposed to reduce the incidence of biliary leaks following bile drain removal. These include the use of rubber tubes instead of silicone ones [7], leaving a counter drain or the T-tube in the tract under fluoroscopic guidance [98, 99], or delayed removal of biliary drains until 4–6 months after OLT [100, 101]. Transcystic or internal endobiliary stents, as well as routine interventional radiologic procedures have also been proposed to overcome these problems [11, 100, 102–104]. Many groups have abandoned the use of a T-tube at whole-organ OLT, which has been shown to be safe, efficacious, and cost-effective, as compared to biliary reconstruction over a T-tube [86, 87, 105, 106]. This practice conforms with the results from two prospective, randomized trials showing no advantage of biliary drainage at whole-organ OLT [88, 90]. According to some authors and our own experience, biliary decompression of duct-to-duct anastomosis may be more indicated in partial-liver graft transplantation when it may reduce the risk of both cut surface and anastomotic biliary leaks [25, 32, 43, 45, 63]. However, this has not been confirmed in a prospective randomized study.

Biliary Leaks

Biliary leaks after OLT are seen in 0.3–22% of patients, and may be anastomotic and non-anastomotic in site, i.e. originating from the T-tube exit site or from the cut sur-

Fig. 1. Bile drain cholangiogram showing multiple hilar biliary strictures and dilatations in a patient with hepatic artery thrombosis 4 months after orthotopic liver transplantation.

Fig. 2. Endoscopic cholangiogram showing ischemic-type biliary lesions 11 months following orthotopic liver transplantation.

face of the graft in case of partial liver graft transplantation [5, 6, 8, 9, 107, 108]. As a general rule, the majority occur early in the postoperative period and mandate operative or endoscopic intervention to avoid sepsis [5]. Anastomotic leaks are mainly related to errors in surgical technique and/or ischemic necrosis at the end of the bile duct. They occur at a similar rate after duct-to-duct and bilioenteric anastomosis [7, 62, 109], and the incidence also appears to be equal in patients with duct-to-duct anastomosis with or without a T-tube [9, 89, 90].

Anastomotic leaks frequently resolve on their own after a short course of unclamping of the T-tube, endoscopic sphincterotomy and stenting [109], or percutaneous transhepatic cholangiography-guided drainage [110], but may be a risk factor for subsequent development of an anastomotic stricture [11, 111, 112]. Larger leaks, particularly those associated with bilioenteric anastomosis, tend to be less amenable to non-operative treatment and immediate or early operative revision should be strongly considered [100, 108, 113, 114].

Biliary leaks following T-tube removal are managed by either an urgent relaparotomy and suture closure of the leak or non-operative endoscopic treatment first [5, 95, 109, 115]. Endoscopic sphincterotomy and stenting or nasobiliary drainage, however, appear to emerge as the preferred treatment options in case of both leaks after T-

tube removal and cut surface biliary leaks, restricting surgery to patients with frank peritonitis and/or large leaks [116–118]. Endoscopic placement of nasobiliary catheters may offer the advantage of access for cholangiography and easy removal [104]. In any case, associated intra-abdominal bile collection (biloma) should be treated by percutaneous ultrasound-guided or CT-guided drainage [101, 110].

Biliary Strictures

Biliary strictures complicate around 2–14% of OLT and are classified as anastomotic and non-anastomotic in site [5–11, 86, 119, 120]. They may be due to technical causes, ischemia of the biliary tree due to hepatic artery thrombosis or stenosis (fig. 1), or fall into the category of ischemic-type biliary lesions (fig. 2) [54–61, 66]. Anastomotic strictures that appear early in the postoperative period are usually related to errors in the surgical technique, whereas later onset most likely indicates fibrotic healing due to ischemia at the end of the donor or recipient bile duct [107, 108, 121]. According to some series of whole-organ OLT, they are reported to be more common after hepaticojejunostomy than after direct duct-to-duct anastomosis [5, 8, 13], as well as following duct-to-duct anas-

Fig. 3. Percutaneous cholangiogram showing a stricture at the duct-to-duct anastomosis 11 days after orthotopic liver transplantation (A) treated by percutaneous drainage (B) with endoscopic and percutaneous stenting (C).

tomosis in non-T-tube recipients, as compared to the anastomosis over a T-tube (table 5) [9, 86–90]. In right lobe living-donor transplants, the incidence of duct-to-duct anastomotic strictures has been consistently higher, as compared to recipients of whole liver grafts [24, 25, 32, 34, 44]. This is considered to be related to the blood sup-

ply of the anastomosis and often the presence of multiple and small caliber donor ducts.

Uncomplicated anastomotic strictures usually respond well to either endoscopic or percutaneous dilatation and/or stenting (fig. 3) with a long-term success rate of more than 50–70% [107, 108, 116, 122–124]. Surgical

Fig. 4. Extrinsic compression on the distal common hepatic duct of the graft (arrow) by a cystic duct mucocele.

revision and biliary reconstruction with the formation of a hepaticojejunostomy is indicated when endoscopic or percutaneous treatment fails. Recurrent anastomotic strictures following biliary reconstruction develop in around 20% of patients and can still be effectively treated by balloon dilatation and/or stenting [114, 121, 125, 126].

The majority of non-anastomotic biliary strictures in liver transplant recipients are due to arterial insufficiency (fig. 1) or ischemic-type biliary lesions (fig. 2) [5, 53, 66, 107]. The strictures resulting from hepatic artery thrombosis have a much worse prognosis and a nonsurgical interventional treatment should be considered. This may be a definitive solution but more often can bridge the patient to liver retransplantation [62, 107, 127]. Ischemic-type biliary lesions occur in 2–20% of patients, are localized proximal to the anastomotic site, and on cholangiogram are indistinguishable from strictures caused by hepatic artery thrombosis [66, 68, 69]. They usually manifest themselves 1–6 months after OLT with most patients showing destroyed intrahepatic as well as extrahepatic bile ducts, while a few develop only extrahepatic or intrahepatic lesions [54, 66, 68–70]. In patients with changes located primarily in the extrahepatic bile duct and the duct bifurcation, complex surgical reconstruction with resection of the bifurcation and Roux-en-Y hepaticojejunostomy can be a successful treatment [125]. Intrahepatic ischemic-type biliary lesions tend to be more diffuse and difficult to manage and may require repeat transplantation or a permanent indwelling percutaneous

transhepatic cholangiography-guided drainage in up to 50% of cases [66, 68, 125, 127–129]. As a result of biliary stasis, early formation of gallstones, sludge, and casts in the biliary tree with an increased risk of ascending cholangitis has been reported [77, 78, 125].

Cystic Duct Mucocele

A tension mucocele of the cystic duct can develop when the outflow end of the blind donor cystic duct remnant is incorporated into the suture line of a biliary anastomosis [130]. This creates the blind mucosa-lined sac which can later on become distended by accumulated mucus, leading to bile duct obstruction by extrinsic compression (fig. 4). Prevention of this complication includes either complete excision of the cystic duct remnant prior to the anastomosis or obligatory division of the common septum between the donor cystic and common hepatic ducts before incorporating the remnant into the anastomotic suture line. The therapy of choice is surgical excision of the cystic duct remnant and a bilioenteric reconstruction [121, 130].

Sphincter of Oddi Dysfunction

Sphincter of Oddi dysfunction, also termed ampullary dysfunction, occurs in 3–5% of liver transplant recipients, and presents with cholestasis, dilatation of the distal bile duct, and cholangiography failing to show any anatomic cause for biliary obstruction [5, 7, 131]. It may be due to operative denervation of the sphincter of Oddi during recipient hepatectomy, leading to subsequent impairment of ampullary relaxation and increased intraductal biliary pressure [132]. The diagnosis may be confirmed clinically by decreasing cholestasis with T-tube unclamping, delayed drainage of contrast medium after cholangiography, and manometry [133]. Endoscopic sphincterotomy and/or biliary stenting is usually a successful treatment, but conversion to a hepaticojejunostomy may occasionally be required [5].

Hemobilia

Hemobilia after OLT affects approximately 0.03% of recipients after liver biopsy and 3–6% of patients submitted to percutaneous transhepatic cholangiography [62, 134]. It may also occur in case of a common hepatic artery

pseudoaneurysm rupturing into the common bile duct or Roux limb [135, 136]. Clinical symptoms may include right upper quadrant pain, upper gastrointestinal bleeding and biliary obstruction, whereas signs of peritonitis may follow a rupture of arterial pseudoaneurysm [62, 107]. The treatment may require both selective embolization of the vessel (angiographic or percutaneous) and endoscopic or percutaneous biliary drainage and/or thrombus extraction [137, 138]. The hepatic artery pseudoaneurysm is treated with surgical resection and revascularization [62, 139, 140].

Recurrent Primary Sclerosing Cholangitis

Primary sclerosing cholangitis recurs after OLT in 5–20% of patients [60, 141–145] and the risk of recurrence appears to be increased in males and recipients having an intact colon before transplantation [141]. The recurrence has been difficult to prove as it can be indistinguishable from ischemic-type biliary lesions due to other causes [144]. The diagnosis is based on the confirmed diagnosis of primary sclerosing cholangitis before transplantation and either cholangiographic or histologic evidence, showing fibrous cholangitis and/or fibro-obliterative lesions, ductopenia, biliary fibrosis, or biliary cirrhosis. Cholangiographic findings are non-anastomotic biliary strictures of the intrahepatic and/or extrahepatic biliary tree with beading and irregularity occurring more than 90 days after transplantation [60]. Differential diagnosis includes hepatic artery thrombosis or stenosis and ischemic-type biliary lesions of other etiology. As of today, patient and graft survival does not appear to be negatively affected by the recurrent primary sclerosing cholangitis in the intermediate term of follow-up [146].

Biliary reconstruction during OLT for primary sclerosing cholangitis has been routinely performed using a Roux loop with the aim to reduce the risk of disease recurrence within the distal native bile duct [29]. Some groups, however, perform duct-to-duct anastomosis in these patients if there is no evidence of distal duct stricturing or inflammation, and comparable results (duct-to-duct versus hepaticojejunostomy) in terms of the rates of biliary complications and patient and graft survival have been reported [147–149]. This is in contrast with the recently published UK transplant data of more than 360 patients transplanted for primary sclerosing cholangitis between 1994 and 2003 in seven UK transplant centers [150]. An increased incidence of biliary strictures and reduced graft and patient survival were

observed in patients with duct-to-duct anastomosis, as compared to those undergoing hepaticojejunostomy reconstruction.

Conclusions

Biliary complications after OLT may be related to many factors including hepatic artery thrombosis or stenosis, ischemia-reperfusion injury, immunologic injury, infections, and technical reasons. The latter include imperfect anastomosis, T-tube-related complications and increasing use of partial liver grafts in living-donor and split-liver transplantation. Meticulous surgical technique of both performing the arterial and biliary anastomosis, as well as when dissecting the bile ducts during donor and recipient hepatectomy, is paramount. In view of the high rates of T-tube-related biliary complications, many groups have abandoned the use of the T-tube at whole-organ OLT, which was shown to be safe, efficacious, and cost-effective, as compared to biliary reconstruction over a T-tube [84, 85, 102, 103]. This conforms with the results from two prospective, randomized trials showing no advantage of biliary drainage at whole-organ OLT [86, 88]. The non-operative management of biliary complications following OLT has become standard practice with interventional radiology and endoscopic techniques emerging as the preferred treatment option, obviating the need for surgery in a selected majority of patients.

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