

## Endoscopic management of biliary complications after liver transplantation: An evidence-based review

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**Author contributions:** Both authors contributed equally to the design of the review, literature research, interpretation of data, and writing of the manuscript.

**Conflict-of-interest:** No conflict of interest was reported by the authors.

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Received: September 24, 2014  
Peer-review started: September 24, 2014  
First decision: December 17, 2014  
Revised: February 22, 2015  
Accepted: March 16, 2015  
Article in press: March 18, 2015  
Published online: June 10, 2015

### Abstract

Biliary tract diseases are the most common complications following liver transplantation (LT) and usually include biliary leaks, strictures, and stone disease. Compared

to deceased donor liver transplantation in adults, living donor liver transplantation is plagued by a higher rate of biliary complications. These may be promoted by multiple risk factors related to recipient, graft, operative factors and post-operative course. Magnetic resonance cholangiopancreatography is the first-choice examination when a biliary complication is suspected following LT, in order to diagnose and to plan the optimal therapy; its limitations include a low sensitivity for the detection of biliary sludge. For treating anastomotic strictures, balloon dilatation complemented with the temporary placement of multiple simultaneous plastic stents has become the standard of care and results in stricture resolution with no relapse in > 90% of cases. Temporary placement of fully covered self-expanding metal stents (FCSEMSs) has not been demonstrated to be superior (except in a pilot randomized controlled trial that used a special design of FCSEMSs), mostly because of the high migration rate of current FCSEMSs models. The endoscopic approach of non-anastomotic strictures is technically more difficult than that of anastomotic strictures due to the intrahepatic and/or hilar location of strictures, and the results are less satisfactory. For treating biliary leaks, biliary sphincterotomy and transpapillary stenting is the standard approach and results in leak resolution in more than 85% of patients. Deep enteroscopy is a rapidly evolving technique that has allowed successful treatment of patients who were not previously amenable to endoscopic therapy. As a result, the percutaneous and surgical approaches are currently required in a minority of patients.

**Key words:** Biliary stricture; Bile leakage; Liver transplantation; Endoscopic retrograde cholangio-pancreatography; Plastic stents; Fully-covered self-expandable metal stents

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**Core tip:** One third of liver transplant recipients are

affected by biliary tract complications which are the major source of morbidity in these patients. Biliary-biliary (as opposed to bilio-enteric) anastomoses are first treated by endoscopy, with resolution of > 85% and > 75% of cases in deceased and living-donor transplant recipients, respectively. New stenting protocols and new designs of fully covered self-expandable metal stents are at the frontline of efforts aiming to reduce patient burden during treatment. Here, we discuss the latest developments in the endoscopic approaches to these complications.

Macías-Gómez C, Dumonceau JM. Endoscopic management of biliary complications after liver transplantation: An evidence-based review. *World J Gastrointest Endosc* 2015; 7(6): 606-616 Available from: URL: <http://www.wjgnet.com/1948-5190/full/v7/i6/606.htm> DOI: <http://dx.doi.org/10.4253/wjge.v7.i6.606>

## INTRODUCTION

Liver transplantation (LT) has become a standard of care in patients with end-stage liver disease. After LT, approximately one third of patients are affected by biliary tract complications and these result in significant morbidity and decreased patient survival<sup>[1]</sup>. Due to the scarcity of organ donors and the increasing number of patients waiting for LT, living donor liver transplantation (LDLT) has emerged as an alternative to deceased donor liver transplantation (DDLT). Even though surgical techniques are constantly improving, biliary complications are more frequent following LDLT compared with DDLT<sup>[2]</sup>; LDLT also remains characterized by its technical complexity and ethical controversies.

Biliary complications following LT include biliary leaks, strictures, choledocholithiasis and other less common conditions<sup>[3,4]</sup>. Approaches commonly used for treating biliary complications involve endoscopic retrograde cholangiopancreatography (ERCP), percutaneous transhepatic cholangiography (PTC) and surgery. ERCP is commonly regarded as the first choice treatment modality in most circumstances; if it fails PTC is often used, reserving surgery for severe complications or refractory conditions not manageable by less invasive techniques<sup>[5-8]</sup>.

Here we review the literature focusing on the endoscopic management of biliary complications, the different strategies for treating strictures and biliary leaks and summarize their outcomes.

## ETIOLOGY, RISK FACTORS AND DIAGNOSIS

### **Biliary reconstruction in LT**

It is essential for endoscopists to have a clear comprehension of the different types of surgical reconstruction during LT. Biliary reconstruction is performed at the

end of LT, once all vascular anastomoses have been completed. An end-to-end choledoco-choledocal anastomosis is the first choice procedure in most institutions following whole organ LT in patients with healthy native bile ducts of suitable caliber<sup>[6,9]</sup>. This technique produces physiological bilioenteric continuity, preserves the function of the sphincter of Oddi and allows for potential future endoscopic treatment of biliary complications. Bilioenteric reconstruction (Roux-en-Y hepaticojejunostomy) is performed in cases of previous biliary tract disease (*e.g.*, sclerosing cholangitis, biliary atresia), large disparity in size or small caliber of the bile ducts, and may be preferred in cases of retransplantation because of inadequate recipient duct length<sup>[10]</sup>. Due to the shortage of cadaveric livers, LDLT has gained popularity in adult patients. With LDLT, the living donor's right or left lobe or the left lateral segment is transplanted. Ductal anastomoses are more difficult to perform than in DDLT due to the small caliber of the intrahepatic ducts. In reduced size split-liver transplantation, a liver from a dead donor is splitted into two organs to permit two recipients to receive a graft; the anastomoses of both right and left lobe are alike to those of LDLT.

### **Risk factors for biliary complications**

Biliary complications may be promoted by multiple risk factors related to recipient, graft, operative factors and post-operative course: (1) among recipient-related factors, advanced recipient age and more advanced liver function impairment contribute to the development of biliary complications<sup>[11,12]</sup>; (2) among graft-related factors, prolonged cold and warm ischemia time, extended donor criteria grafts and donation after cardiac death, as opposed to brain death, are associated with a higher incidence of ischemic-type biliary lesions (ITBL)<sup>[13,14]</sup>. Nonetheless, a recent report by Vanatta *et al*<sup>[15]</sup> showed that, by carefully selecting donors and recipients, overall patient and graft survival as well as the incidence of ITBL were similar following donation after cardiac vs brain death<sup>[15]</sup>; (3) operative risk factors are different for DDLT and LDLT for various reasons: LDLT by itself is an important risk factor for biliary complications due to the small duct size, the presence of multiple biliary duct outlets and the devascularization of the bile ducts during hilar dissection of the graft<sup>[16-18]</sup>. In DDLT, T-tube placement for duct to duct (DD) reconstruction allows minimizing the incidence of anastomotic strictures<sup>[19]</sup> and it is unequivocally recommended by some authors<sup>[20]</sup>; however, this results in biliary leakage following T-tube removal in 5%-33% of cases<sup>[19]</sup>; (4) during the postoperative course, early hepatic artery thrombosis may lead to the severest forms of non-anastomotic strictures, at multiple sites of the donor biliary system, because blood supply to the bile ducts is fragile. This may result in partial or total biliary necrosis with the formation of typical biliary casts and multiple intraluminal filling defects at

cholangiography<sup>[5,21]</sup>; and (5) other documented factors, including ABO incompatibility, cytomegalovirus infection and chronic/acute rejection episodes have been reported to be potential risk factors for biliary complications in historical publications; more recently these factors have been strongly associated with non-anastomotic, rather than anastomotic, complications<sup>[22-24]</sup>.

### Diagnostic approach

The clinical presentation of biliary complications varies considerably; patients could present no symptom at all, jaundice, abdominal pain, biliary leak or cholangitis. In asymptomatic LT recipients, a biliary complication usually is first suspected because of elevations of serum bilirubin, alkaline phosphatase, and/or gamma-glutamyl transferase levels. In the case of cholestasis, the initial diagnostic step is to discriminate obstructive vs nonobstructive causes, like LT rejection (acute or chronic), recurrence of primary disease and drug-induced cholestasis.

The initial evaluation should include a liver ultrasound (US) with a Doppler evaluation of the hepatic vessels, due to the frequent association of biliary complications with the presence of hepatic artery thrombosis or stenosis<sup>[6,25]</sup>. If hepatic artery stenosis or occlusion is suspected by Doppler US, multidetector computed tomography should be used as the second-line modality of choice for the rapid assessment of major vascular complications requiring pre-treatment confirmation. If hepatic artery thrombosis is confirmed, angiographic intervention should be performed urgently to re-establish hepatic artery flow<sup>[26,27]</sup>. Magnetic resonance cholangiopancreatography (MRCP) has substantially facilitated the accurate recognition of biliary tract complications (sensitivity and specificity of 93%-97% and 92%-98%, respectively, compared with ERCP as the reference standard)<sup>[28-31]</sup>. MRCP provides the endoscopist with a map of the whole biliary tract and, unlike ERCP, consistently demonstrates ducts even upstream from a tight stricture, therefore it is especially useful for hilar or intrahepatic anastomotic strictures. When findings at MRCP were compared to other approaches, including ERCP, PTC, and surgery to diagnose post-LT biliary complications, the sensitivity, specificity, positive predictive value, and negative predictive of MRCP were 98%, 94%, 94%, and 98%, respectively<sup>[31]</sup>. Its main disadvantages include a low sensitivity in the case of sludge or small stones (< 5 mm). MRCP is noninvasive and is the technique of choice for diagnosing post-LT biliary complications.

### Etiology and types of biliary strictures

Post-LT biliary strictures are usually classified as anastomotic strictures (ASs) or non-anastomotic strictures (NASs), also called ischemic type biliary strictures (ITBSs)<sup>[32-34]</sup>. Biliary strictures complicate around 2%-14% of LT and can be categorized in to early or late (occurring within or after the first month

following LT, respectively). Strictures which appear soon after LT are commonly referable to technical problems, whereas late strictures are generally attributable to vascular insufficiency and problems with healing and fibrosis. In a recent systematic review, 1844 (12.8%) of 14359 LT patients had biliary strictures. The appearance of a stricture varies widely, from 7 d to 11 years after LT<sup>[35]</sup>.

**Anastomotic strictures:** ASs can present at any time after transplantation but most of them are diagnosed within one year following LT with a mean interval between LT and diagnosis of 5-8 mo. ASs complicate around 6%-12% and 34% of deceased and living donor LT procedures, respectively<sup>[33,36,37]</sup>. ASs pathogenesis is believed to include inadequate mucosa-to-mucosa anastomosis, local tissue ischemia, and the fibrotic nature of the healing process<sup>[33,38]</sup>. ASs are solitary and short in length (Figure 1A and B). They may involve a choledocho-jejunostomy or a choledocho-choledochostomy; they are considered clinically relevant only if cholestasis or cholangitis are present. A slight and transient narrowing of the biliary lumen occurs frequently within the first one to two months following biliary anastomosis due to postoperative edema and inflammation, but it is uncertain how many of these cases progress to clinically significant ASs (Figure 1A)<sup>[33]</sup>. ASs can generally be effectively treated by endoscopic means and do not decrease graft or patient survival.

**Non-anastomotic strictures:** Post-LT strictures are classified as NASs if they are located more than 5 mm proximal to the anastomosis (Figure 1D). They account for 10% to 25% of all strictures complicating LT, with an incidence in the range of 0.5% to 10%<sup>[19,38-40]</sup>. NASs are considered to derive from ischemic damage to the duct as it may occur following hepatic artery thrombosis. Conditions associated with NASs include a prolonged ischemia time (cold and warm), transplantation after cardiac death donation, prolonged vasopressor support for the donor, ABO-type incompatibility, primary sclerosing cholangitis, autoimmune hepatitis or hepatitis C virus infection in the recipient<sup>[41-48]</sup>. Furthermore, nowadays a wider acceptance of older and extended criteria donors has been suggested to contribute to an increased incidence of NASs<sup>[19]</sup>. True NASs, usually referred to as ITBSs, characteristically are diffuse and include the hilum and sectorial or segmental intrahepatic branches. The treatment of NASs is technically more difficult than that of ASs and, in the case of hepatic artery thrombosis, the endoscopic treatment is mostly ineffective if the arterial blood flow cannot be restored.

### Etiology and types of biliary leaks

Biliary leakage is the second most common complication after LT, with an incidence of 2%-21%<sup>[19,49,50]</sup>. In a recent meta-analysis, the rate of biliary leakage after LT



**Figure 1 Biliary strictures at endoscopic retrograde cholangiopancreatography.** A: Early and incipient anastomotic stricture (arrow) with upstream biliary dilation; B and C: Late and high-grade anastomotic stricture (arrow) > 1 year after deceased-donor liver transplantation, with a large stone located upstream from the stricture (arrow); D: Combination of anastomotic (arrow) and non-anastomotic (arrow heads) strictures.

was 8.2%, without significant difference between DDLT (7.8%) and LDLT (9.5%)<sup>[35]</sup>. Leakage may develop at the level of the anastomotic site, from the cystic duct remnant, from the cut surface of partial liver grafts in the case of LDLT, and following T-tube removal (Figure 2). Bile leaks can be classified into two categories: early bile leaks, which present within 4 wk following LT (these usually occur at the anastomotic site and are often related to technical issues, not to the type of biliary reconstruction), and late bile leaks, which present beyond this time (they are usually related to T-tube removal, resulting from delayed T-tube tract maturation possibly related to immunosuppression). A bile leak should be suspected in any patient who develops abdominal pain, fever or any sign of peritonitis following LT, especially after T-tube removal. Bile leaks can derive in collections of fluids and abscesses that might be related to strictured or disconnected ducts. Depending

on the size of the leakage and the clinical presentation, bile leaks can be managed conservatively, nonsurgically or surgically<sup>[4,51]</sup>.

#### **Etiology and type of intraluminal biliary filling defects**

Stones, sludge and casts occur in approximately 5% of patients after LT, with stones accounting for 70% of the cases. Biliary stone disease is associated with disorders that can reduce the flow of bile such as ASs or NASs. In addition, medications such as cyclosporine may play a role in bile lithogenicity by inhibiting bile secretion and promoting functional biliary stasis. Sludge is described as a thick collection of mucus, calcium bicarbonate and cholesterol crystals, which, when left untreated, can transform into biliary stones (Figure 3A).

Casts refer to the presence of multiple hard pigmented dark material that mold the bile ducts (Figure 4). These are thought to develop due to bile duct mucosal damage related to obstruction, ischemia, or bacterial infection. A history of hepatic artery thrombosis and a prolonged cold ischemia time are associated with debris formation<sup>[52-54]</sup>. This disorder occurs in 2.5% to 18.0% of LT recipients<sup>[32,54]</sup>. Casts are associated with increased morbidity, graft failure, retransplantation and mortality.

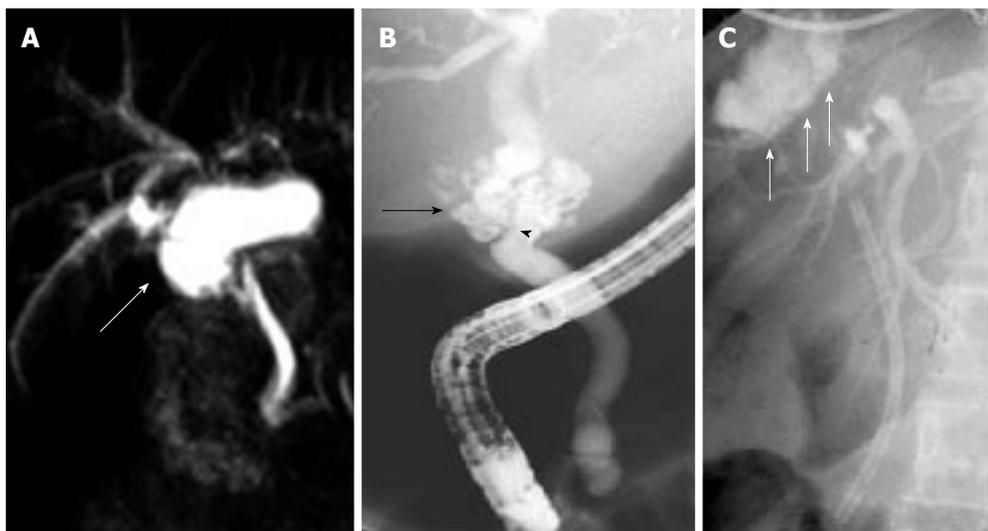
#### **Sphincter of oddi dysfunction**

Sphincter of oddi dysfunction (SOD) describes a clinical syndrome of biliary or pancreatic functional obstruction that may be responsible for cholestasis, pain, or pancreatitis.

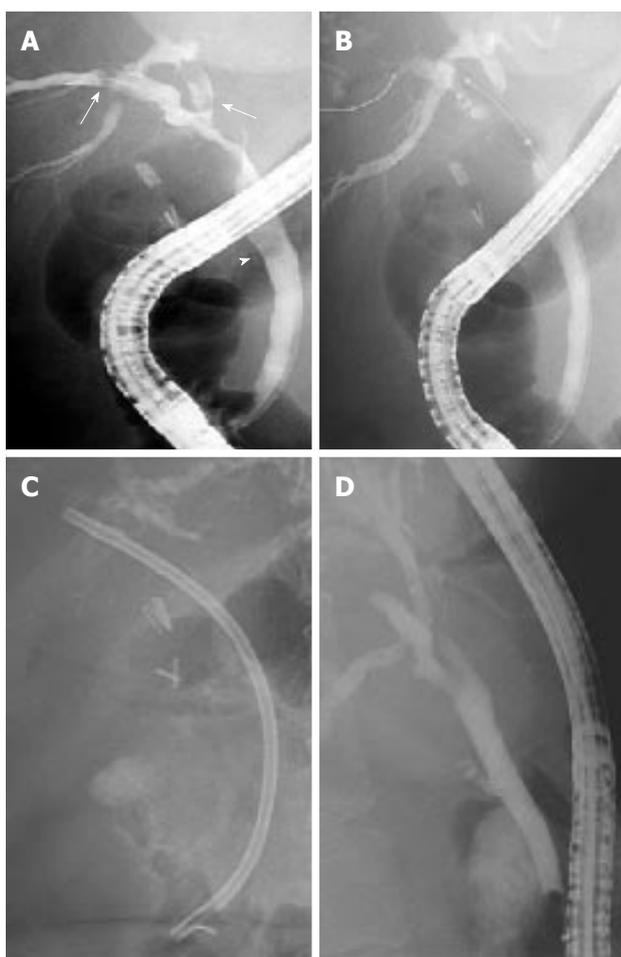
It is hypothesized that, in the post-LT setting, denervation of the ampulla (secondary to surgical intervention) might generate a hypertonic sphincter, resulting in increased intraductal biliary pressure. This complication has been reported in 2% to 7% of patients who have undergone LT<sup>[55,56]</sup>. Typically, patients present with cholestasis, dilation of the distal bile duct and no obstacle detected at cholangiography.

## **ENDOSCOPIC MANAGEMENT**

Managing post-LT biliary complications needs a multidisciplinary team involving transplant surgeons, hepatologists, endoscopists, and interventional radiologists. Endoscopic therapy is the first line therapy in most cases with a duct-to-duct anastomosis. With recent developments in enteroscopy, many patients with Roux-en-Y hepaticojejunostomy can also be treated endoscopically<sup>[57]</sup>, with PTC being mostly reserved for the salvage of failures. The spectrum of endoscopic therapies includes biliary sphincterotomy, balloon dilation of strictures, basket and balloon extraction of stones, sludge, and casts, and the placement of one or multiple, side-by-side, biliary plastics stents. Additionally, cholangioscopy allows the characterization of strictures by observation and tissue sampling, and therapy of difficult casts or stones by intraductal lithotripsy<sup>[58-62]</sup>. Endoscopic therapy is usually highly successful and has a low incidence of procedure-related complications,



**Figure 2 Biliary leaks.** A: Biloma (arrow) resulting from anastomotic leakage early after liver transplantation as shown at magnetic resonance cholangiopancreatography; B: Anastomotic leakage (arrow) at the level of an anastomotic stricture (arrow head) early after liver transplantation as shown at endoscopic retrograde cholangiopancreatography (ERCP); C: Multiple leak sites from the cut surface in a split liver transplantation patient (arrows) as shown at ERCP with a plastic biliary stent in place.

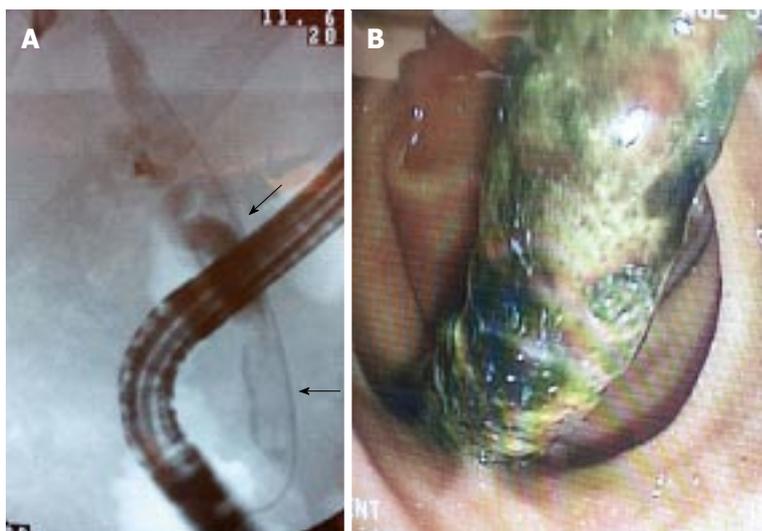


**Figure 3 Endoscopic treatment of an anastomotic biliary stricture with upstream sludge and downstream stone after living donor liver transplantation.** A: Anastomotic biliary stricture with upstream sludge (arrows) and downstream stone (arrowhead); B: Stricture dilation using a 10-mm indiameter balloon; C: 10-F plastic biliary stent in place; D: Absence of residual stricture at late follow-up.

reserving surgery as a last option intervention if endoscopic and/or percutaneous treatment is not feasible or is ineffective.

**Biliary leaks**

Traditionally, post-LT biliary leaks have been treated surgically with anastomotic revision or conversion to a Roux-en-Y hepaticojejunostomy if a duct-to-duct anastomosis is not technically feasible. With advances in endoscopic therapy, ERCP has now become the initial therapeutic option in the management of biliary leaks. Usually the leakage of bile is treated through biliary sphincterotomy followed by the placement of a transpapillary stent (Figure 2C) for 2 to 3 mo (in contrast to post-cholecystectomy leaks, where the stent can be removed in 4 to 6 wk) with the aim of ensuring the proper healing of the leaks. Prolonged stenting is advised because healing may be delayed by immunosuppressors. If the leak is associated with a biliary stricture, this can be prudently dilated before inserting one or more plastic stents upstream from both the stricture and the leak<sup>[63]</sup>. Biliary stenting provides faster leak resolution than sphincterotomy alone and it is equally effective whether sphincterotomy is performed or not. At the time of stent removal, a careful anatomical evaluation should be performed and duct cleansing should always be performed because biliary abnormalities (mostly sludge, stones, or persistent leak) can be found at this time in a significant proportion of patients<sup>[64]</sup>. Endoscopic therapy solves the leakage of bile in more than 85% of patients<sup>[38,63-66]</sup>. Recently, fully covered self-expandable metal stents (FCSEMS) have been used in a pilot study of 17 LT recipients with biliary leaks<sup>[67]</sup>. FCSEMS offered minimally invasive and low-morbidity short-term control of leaks but it resulted in a relatively high stricture rate. In this series of 17



**Figure 4** Elongated intraductal filling defects in the choledocus and common hepatic duct suggestive of biliary casts (arrows) (A) and endoscopic view of the successfully removed cast (B).

patients, 8 (47%) patients developed common bile duct strictures following FCSEMS removal; of these, 6 (35%) required repeat endoscopic treatment for a clinically significant stricture, therefore the use of current FCSEMS models cannot be recommended in the post-LT population. In specific situations, endoscopic therapy can be impossible or fail, for example, in the case of large anastomotic leaks associated with hepatic artery compromise or surgically altered anatomy (Roux-en-Y anastomosis). These patients will most often require surgical management.

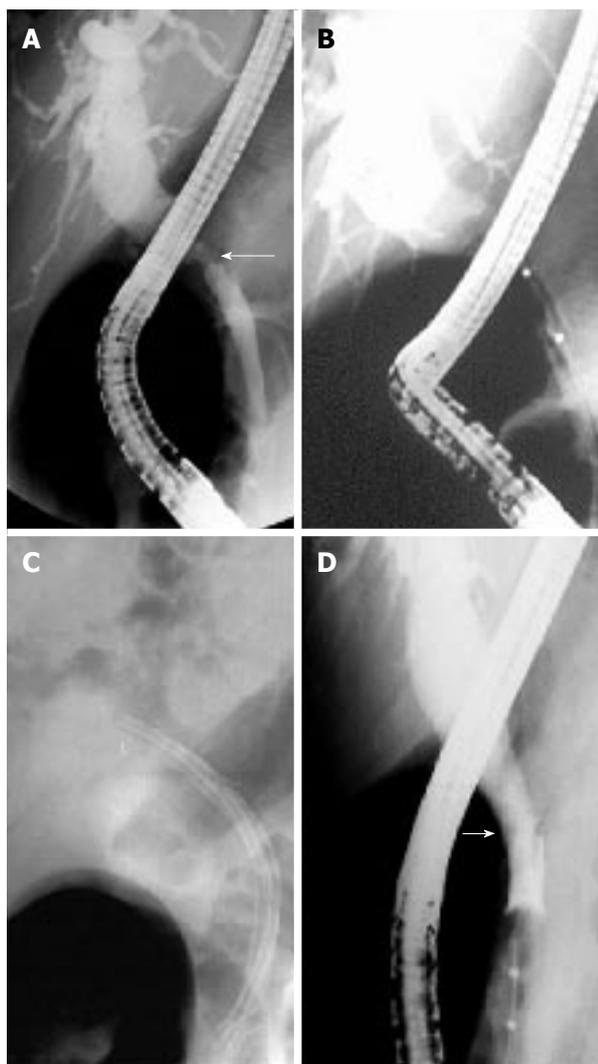
### **Biliary strictures**

**Anastomotic strictures:** No standard protocol has emerged for the endoscopic therapy of ASs. By analogy with the more frequent postcholecystectomy biliary stricture, endoscopic therapy of ASs usually requires biliary sphincterotomy plus balloon dilatation (BD) and stent placement (Figure 5). The use of BD alone in early onset anastomotic strictures (the first 2 mo following LT) may be effective. However, despite good initial success, BD alone led to a high rate of recurrent stricture formation<sup>[68]</sup>. Therefore, the combination of BD and stenting is a more adequate approach<sup>[33,65,68-71]</sup>.

Multiple 10-Fr plastic stents are usually maintained until stricture resolution or for a minimum of 12 mo, with stent exchange scheduled every 3-4 mo to reduce the chance of stent blockage and cholangitis. In a recent systematic review that included 440 LT-related ASs treated with multiple simultaneous plastic stents<sup>[72]</sup>, the mean AS resolution rate was approximately 85% for early as well as late ASs. Higher ASs resolution rates (97% vs 78%) and lower ASs recurrence rates (1.5% vs 14%) have been reported with stenting durations > 12 mo vs < 12 mo. This was observed despite the fact that shorter stenting durations were applied for early vs late ASs. Most cases of ASs recurrence were successfully managed with repeat plastic stenting.

Recently, different strategies of AS treatment have been described to decrease patient burden: (1) long-

term maximal stent therapy with stent exchange only when signs or symptoms of biliary obstruction are detected: this strategy has allowed minimizing the number of ERCPs needed to treat ASs without compromising success or patient safety. With this protocol, complete AS resolution was reached in 94% of patients and recurrence rate at a median follow-up of 11 mo was 3%<sup>[73]</sup>. The authors reported in a total of 83 patients 2 cases of post-ERCP pancreatitis, 2 cases of periprocedural bacteremia but no episodes of cholangitis caused by stent occlusion; (2) stent exchange every 2 wk: ERCP with rapid-sequence balloon dilatation followed by stenting with multiple stents over a short time period<sup>[74]</sup>. With this approach, mean stenting duration was 107 d and long-term stricture resolution was achieved in 33 (87%) of 38 patients; ERCP-related complications occurred in 2 (5%) patients. During a mean follow-up of one year after stent removal, 5 (13%) patients had a stricture recurrence, successfully retreated by endoscopic means in 4 cases; and (3) temporary placement of covered self-expandable metal stent (SEMSs). Covered SEMSs offer the advantage of longer stent patency and larger nominal diameter compared with a single plastic stent. Covered SEMSs should be maintained in place for a minimum of 3 mo as shorter stenting durations result in lower ASs resolution (72% vs 90%)<sup>[75-79]</sup>. In the systematic review cited above<sup>[72]</sup>, covered SEMSs had a much higher stent migration rate (16%) compared with simultaneous multiple plastic stenting. Furthermore, covered SEMS carry a low but real risk of tissue ingrowth and stent impaction. Therefore, the authors concluded that current evidence does not suggest a clear advantage of SEMS use over multiple simultaneous plastic stenting in the management of ASs. In a large prospective study that was not included in the systematic review<sup>[80]</sup>, the AS resolution rate using FCSEMSs was 68% of 42 LT patients and the migration rate was 17% and 75% at 3 and 6 mo, respectively. In this study, cholangitis was reported in 24% of patients with LT-related ASs and it



**Figure 5** Endoscopic treatment of an anastomotic biliary stricture after deceased donor liver transplantation. A: Late, high-grade, anastomotic stricture (arrow) with a stone partially concealed by the endoscope; B: Stricture dilatation with a 4-mm in-diameter balloon; C: Three 10-Fr plastic stents in place, no residual stone; D: Balloon occlusion cholangiogram showing stricture disappearance at the end of treatment (arrow).

was strikingly associated with stent migration. Finally, a recent randomized trial compared a new design of FCSEMS vs multiple simultaneous plastic stenting in 20 patients with LT-related ASs<sup>[81]</sup>. ASs resolution rates were similar with both stent models but complication rate and hospital stay duration were non-significantly higher with the plastic stent vs FCSEMS, suggesting that some FCSEMS designs that effectively prevent stent migration might be a cost-effective alternative to plastic stenting.

Endoscopic management of ASs seemed to be more challenging in LDLT vs DDLT due to the complexity of duct-to-duct anastomosis. However, using an aggressive strategy of maximal endoscopic stent placement, two studies reported high (75%-100%) AS resolution rates in LDLT patients<sup>[82,83]</sup>. The long-term resolution rates of biliary leaks and/or strictures reported in selected retrospective studies are summarized in Table 1<sup>[37,82-87]</sup>.

**Table 1** Retrospectives series showing living donor liver transplantation endoscopic anastomotic strictures treatment results

Ref.	Patients (n)	Stenting (m)	Success (%)	F/U (m)	Relapse (%)
Yazumi <i>et al</i> <sup>[37]</sup> (2006) <sup>1</sup>	75	6	68	20 (1-50)	10
Gómez <i>et al</i> <sup>[84]</sup> (2009)	10	NR	20	30.5 (2-23)	NR
Seo <i>et al</i> <sup>[87]</sup> (2009)	29	3-6	64.5	31	30
Chang <i>et al</i> <sup>[86]</sup> (2010)	113	3-6	26.5	33 (3-96)	NR
Kim <i>et al</i> <sup>[85]</sup> (2011)	112	12.7	36	42.8 ± 15.2	11.5
Chan <sup>[82]</sup> (2013)	8	NR	75	18 ± 8.7	NR
Hsieh <sup>[83]</sup> (2013) <sup>2</sup>	38	5.3	100	74	21

<sup>1</sup>Combination of percutaneous transhepatic biliary drainage plus endoscopic retrograde cholangiopancreatography (ERCP) in 9 patients and inside stents technique; <sup>2</sup>Combination of percutaneous transhepatic biliary drainage plus ERCP in 6 patients. NR: Not reported.

Factors identified as independent predictors of failed endoscopic treatment of LDLT-related ASs include higher LT recipient age, longer operation duration, and a pouched morphology of the AS<sup>[84,88]</sup>. Recurrent ASs occur in approximately 21% of patients and may be retreated by endoscopy<sup>[83]</sup>. PTC plays an important role when a guide wire cannot be inserted through the anastomotic stricture at the time of ERCP (e.g., disconnected duct, some refractory angulated or twisted strictures). For these patients, the rendez-vous technique (PTC + ERCP) may be useful to insert a stent above the stricture. This approach has been demonstrated to be feasible and relatively safe for the management of biliary strictures complicating LDLT with duct-to-duct anastomosis<sup>[89]</sup>. The endoscopic treatment of some ASs can be unsuccessful and may need long-term stenting or surgical hepaticojejunal anastomosis<sup>[87,90]</sup>.

**Non-anastomotic strictures:** The endoscopic therapy of NASs or ITBSs often involves the hilum and intrahepatic ducts and is notably more demanding than the therapy of ASs. The stenosis at the level of the sectorial or segmental branch ducts can result in a cholangiographic appearance that simulates primary sclerosing cholangitis. It is challenging to make general recommendations for managing NASs and treatment should be individualized. Treatment success depends upon stricture grade, number, and location. Extra-hepatic strictures generally respond better to therapy and altogether, in the few published reports of endoscopic treatment, the success rates ranged between 50% and 70%<sup>[50,91]</sup>. Finally, a few patients (especially the ones with complex ischemic intrahepatic strictures) may need surgical revision or retransplantation.

In patients who have undergone Roux-en-Y hepaticojejunostomy, a potential alternative to PTC is the use of various techniques of enteroscopy. In 25 pediatric patients with hepaticojejunal anastomoses, the bilioen-

teric anastomosis could be reached in 17 patients, a stent could be placed in 9 patients and AS resolution was obtained in 5 (20%) patients, showing the difficulty of this procedure<sup>[92]</sup>. In a series of 44 adults with choledochojejunal AS following various hepato-biliary-pancreatic surgery, temporary stenting (including stent removal) was achieved in 32 (73%) patients and restenosis occurred in 7/32 patients<sup>[93]</sup>.

### Other complications

**Biliary stones, sludge and casts:** In LT recipients, the endoscopic management of stones is similar to that performed in the nontransplant setting although the approach may be complicated by the presence of a stricture downstream from the stone. In such circumstances, delayed stone extraction (following biliary stenting) or advanced endoscopic techniques like intraductal lithotripsy or direct choledocopy may be required to achieve stone removal. In patients with serious coagulation disorders or thrombocytopenia where sphincter ablation may be relatively contraindicated, balloon dilatation of the intact sphincter can be applied.

For biliary casts, the endoscopic approaches are alike to those utilized in stone disease. However, the success rate is significantly lower owing to the multiplicity of filling defects located in intrahepatic bile ducts<sup>[39]</sup>. Treatment usually requires multiple ERCPs, possibly complemented with PTC and it may require retransplantation in a significant proportion of cases<sup>[39,94]</sup>. Cholangioscopy might aid to discriminate biliary casts from strictures<sup>[59]</sup>.

### Sphincter of Oddi dysfunction and papillary stenosis

As for SOD in the non-LT setting, biliary sphincterotomy is the common treatment and provides a high success rate<sup>[39]</sup>. The question of whether these patients are at similar risk of post-ERCP pancreatitis as those who are affected in the non-LT setting has not been formally studied; however it seems reasonable to consider prophylactic pancreatic stenting in addition to standard rectal administration of NSAIDs when performing sphincterotomy in these patients<sup>[95]</sup>.

## SUMMARY

Biliary complications remain a burden in LT patients and continue in some cases to be a challenging aspect of the multidisciplinary care of LT patients. As biliary complications are the most frequent complication following LT, the index of suspicion for requesting further investigations should be low. MRCP is the most useful examination to establish the diagnosis, especially because the low sensitivity of US may be more detrimental in LT as compared to the average patient. Successful endoscopic treatment is achieved in most cases, with the notable exceptions of ASs in LDLT patients, NASs and biliary casts. For ASs, temporary simultaneous multiple plastic stenting for a

minimum of 12 mo (except in some cases of early AS) remains the standard of care; FCSEMS have yielded disappointing results up to now. In patients with choledochojejunostomy, deep enteroscopy techniques may allow successful treatment but success rates are lower. Nowadays PTC and surgery are reserved for a small minority of patients.

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**P- Reviewer:** Boucek C, Uchiyama H **S- Editor:** Ji FF  
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