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REVIEW

Endoscopic management of benign biliary strictures

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Abstract

Endoscopic management of biliary obstruction has evolved tremendously since the introduction of flexible fiberoptic endoscopes over 50 years ago. For the last several decades, endoscopic retrograde cholangiopancreatography (ERCP) has become established as the mainstay for definitively diagnosing and relieving biliary obstruction. In addition, and more recently, endoscopic ultrasonography (EUS) has gained increasing favor as an auxiliary diagnostic and therapeutic modality in facilitating decompression of the biliary tree. Here, we provide a review of the current and continually evolving role of gastrointestinal endoscopy, including both ERCP and EUS, in the management of biliary obstruction with a focus on benign biliary strictures.

Key words: Gastrointestinal endoscopy; Endoscopic cholangiopancreatography; Bile ducts; Biliary tract; Stricture; Stents

Core tip: Benign biliary strictures (BBSs) are commonly encountered by advanced endoscopists. As our understanding of longstanding techniques involving biliary dilation and plastic stent placement evolves, newer therapeutic options such as self-expandable metal stents and endoscopic ultrasound have become available. Here we review the literature pertaining to the most common etiologies of BBSs with current considerations for their respective endoscopic management.

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INTRODUCTION

Benign biliary strictures (BBSs) originate from a variety of etiologies (Table 1), most commonly post-operative

Table 1 Etiologies of benign biliary strictures

Postsurgical
Cholecystectomy (open or laparoscopic)
Liver transplantation (*i.e.*, anastomotic biliary stricture)
Bilio-enteric anastomosis
Sphincterotomy
Inflammatory
Chronic pancreatitis
Primary sclerosing cholangitis
Immunoglobulin G4-related cholangiopathy
Acquired immune deficiency syndrome cholangiopathy
Vasculitis
Other
Ischemia (*e.g.*, post-liver transplantation)
Trauma
Portal biliopathy
Infection (*e.g.*, Clonorchiasis)
Radiation injury
Idiopathic

injury (*e.g.*, post-cholecystectomy), chronic pancreatitis, and chronic cholangiopathies (*e.g.*, primary sclerosing cholangitis). The clinical presentation of BBSs depends greatly on the context, including the onset, degree, and sterility of obstruction, and ranges from subclinical (*i.e.*, incidentally detected biochemical abnormalities) to severe and life-threatening[1,2]. The diagnostic evaluation to determine the etiology of a BBS and exclude the possibility of underlying malignancy generally entails cholangiography *via* magnetic resonance (MRCP) and/or endoscopic retrograde cholangiopancreatography (ERCP) (with biliary brushings for cytology and/or intraductal biopsies for histology) in addition to serologic testing with serum liver tests and tumor marker carbohydrate antigen 19-9 (CA 19-9). Therapeutic interventions are aimed at providing durable biliary decompression, with options including ERCP, percutaneous, and surgical techniques.

Given its efficacy, safety, and less disruptive nature, ERCP has become the first-line therapeutic option for management of most cases of biliary obstruction, including but not limited to BBSs[3]. Since the introduction of ERCP in the 1970s, this technique has progressively evolved and enhanced the management of a variety of disorders of the biliary tract[4]. Currently, a wide array of catheters, guidewires, papillotomes, stents, and other accessories are available to facilitate diagnostic and therapeutic maneuvers in the management of BBSs.

In this review, we discuss the current role of, evidence for, and approach to endoscopic management in patients with BBSs.

PRINCIPLES OF BBS MANAGEMENT

Pre-procedure preparation

Owing to advancements in non-invasive imaging, ERCP has largely been supplanted by cross-sectional imaging for purposes of initial diagnosis. MRCP, facilitated by the high T2-signal intensity of bile as well as improvements in MR imaging methods and post-processing tools, has essentially become the preferred modality for diagnostic cholangiography, with relatively few indications remaining for diagnostic ERCP[5]. Not all patients require cross-sectional imaging with MRCP or computed tomography prior to ERCP; however, having such data available can provide a useful roadmap and clarify the pre-procedural plan by shedding light on the patient's pancreatobiliary anatomy, which often does not follow the conventional teaching (Figure 1), and underlying disease. Patients who proceed to ERCP should, as with other endoscopic procedures, be fasting for a sufficient amount of time to allow gastric emptying (*e.g.*, 4-6 h), and careful review and management of antithrombotic medications (if applicable) should be undertaken[6]. Pre-procedural antibiotics should be administered in selected patients in whom adequate drainage is not anticipated such as those with complex hilar strictures and PSC.

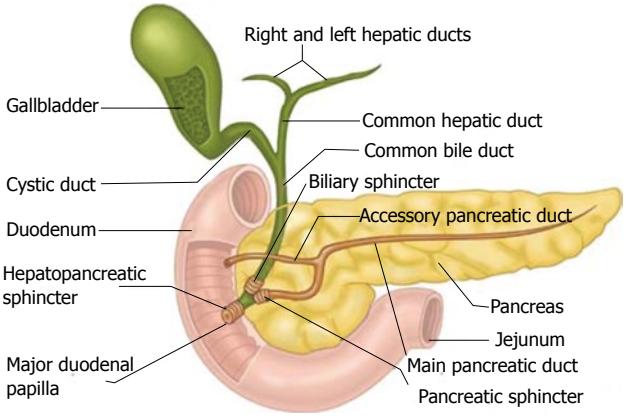

Figure 1 Normal biliopancreatic anatomy.

Deep biliary access

Once bile duct cannulation has been achieved, attempts at guidewire passage beyond the BBS may prove challenging depending on the severity and anatomic location of obstruction. BBSs can be more difficult to traverse than neoplastic strictures due to greater asymmetry, angulation, and density of fibrous tissue[7]; nevertheless, forceful maneuvers should be avoided, as these may result in the creation of a false tract or perforation. If necessary, guidewire passage can be facilitated by: (1) positioning an inflated stone extraction balloon just below the stricture and withdrawing it, which allows for traction and better alignment between the guidewire and stricture axes; or by (2) selection of an alternative guidewire tailored to the particular stricture anatomy.

Multiple types of guidewires are commercially available and vary in their properties, including diameter, construction material (nitinol, stainless steel), type of coating (hydrophilic *vs* nonhydrophilic), and tip morphology (straight, angled) (Table 2). Comparative studies between guidewires are lacking, but standard 0.035-inch hydrophilic guidewires can be used for most BBSs, whereas tighter strictures may require

Table 2 Commonly used guidewires in endoscopic retrograde cholangiopancreatography

	Diameter (inch)	Length (cm)	Core material	Sheath material	Tip material/ properties	Tip shape	Comments	Cost ($)
Monofilament								
Amplatz (Boston Scientific)	0.038	260	Stainless steel	Uncoated	Platinum	Straight	Extremely stiff	149[1]
Coiled								
Standard (Cook Medical)	0.035	480	Stainless steel	Uncoated	Stainless steel coil	Straight	Must remove prior to sphincterotomy	90
Coated								
Tracer metro direct (Cook Medical)	0.021, 0.025, 0.035	260, 480	Nitinol	Teflon	Platinum; hydrophilic (5 cm)	Straight, angled	Kink resistant, graduated endoscopic markings	196
Delta (Cook Medical)	0.025, 0.035	260	Nitinol	Polyurethane	Hydrophilic (fully)	Straight	Kink resistant, fully hydrophilic, must remove prior to sphincterotomy	151
Roadrunner (Cook Medical)	0.018	260, 480	Nitinol	Teflon	Platinum	Straight, angled	Kink resistant, must remove prior to sphincterotomy	184
Jagwire (Boston Scientific)	0.025, 0.035 0.038 (260)	260, 480	Nitinol	Endo-Glide™	Tungsten, hydrophilic (5 cm)	Straight, angled; trim, round	Kink resistant, guidewire extension (0.035, 200) available	357/box of 2
Hydra Jagwire (Boston Scientific)	0.035	260, 450	Nitinol	Endo-Glide™	Tungsten, two hydrophilic tips (5 cm, 10 cm)	Straight, angled; round	Kink resistant; two tips of varying stiffness on a single guidewire	536/box of 2
NaviPro (Boston Scientific)	0.018, 0.025, 0.035	260	Nitinol	Endo-Glide™	Hydrophilic (fully)	Straight, angled	Fully hydrophilic; 0.035-in also available in stiff	1124/box of 5
Visiglide (Olympus)	0.025, 0.035	270, 450	Superelastic alloy	Fluorine	Hydrophilic (7 cm)	Straight; angled	0.025-in has same stiffness as 0.035-in guidewire	255
XWire (ConMed)	0.025, 0.035	260, 450	Regiliant™ Nitinol	PTFE	Nitinol and Tungsten and PTFE, hydrophilic (5 cm)	Straight; angled	5 cm radiopaque tip; 0.035-in also available in stiff	460/box of 3 (260 cm) 583/box of 3 (450 cm)

Other less commonly used guidewires include Dreamwire (Boston Scientific), Savary-Gilliard (Cook Medical), Tracer Metro (Cook Medical), Fusion (Cook Medical), FXWire (ConMed), and Flex-Ez (Hobbs Medical). [1]Cost data obtained from ASGE "Guidewires for use in GI endoscopy," Table 1[97]. PTFE: Polytetrafluoroethylene.

guidewires with a smaller diameter and/or angled tip. Once a stricture has been traversed, the guidewire can be exchanged, if needed, for a stiffer or nonhydrophilic guidewire to facilitate dilation and stenting. Biliary sphincterotomy (*i.e.*, papillotomy) is also frequently necessary if large (cumulative) caliber stenting is anticipated.

Stricture dilation

Stricture dilation (*i.e.*, stricturoplasty) is primarily performed using a dilating balloon or bougie-like tapered catheter. Typical dilating balloon sizes range from 4 to 12 mm, and selection can generally be guided by upsizing 1-2 mm from the diameter of the distal bile duct. In the case of post-liver transplantation (LT) anastomotic biliary strictures (ABSs), dilating to the size of the adjacent donor or recipient duct, whichever is smaller, can be used as a guide[8]. Particular caution should be taken, however, when dilating ABSs during the early post-operative period (< 30 d after surgery) or while a patient is still on high dose immunosuppression, as both of these scenarios may be associated with a higher risk for anastomotic injury or disruption[8-12]. In such instances, less aggressive dilation using a smaller balloon or alternatively a tapered dilating catheter is advisable. With respect to duration of dilation intraprocedurally, most endoscopists adhere to 30 to 60 s of dilation, or until the stricture waist is fractured, before balloon deflation.

Stenting

Balloon dilation alone, although immediately effective, is associated with a high rate of stricture recurrence (up to 47%) depending on the underlying nature of the BBS[13]. Therefore, insertion of biliary stents is frequently required to maintain stricture patency while permitting ductal remodeling. Moreover, placement of several, large-bore plastic stents side-by-side (*i.e.*, multiple or "maximal" endoscopic stenting[8,14]) for up to 1 year has been shown to be superior than inserting only a single stent; this is therefore the currently recommended approach for the majority of BBSs[8,14-18].

The main limitation of endoscopic stenting in this setting is the need to undergo multiple ERCPs for stent exchange. This stems from the relatively short patency time of plastic biliary stents, although there is evidence to support that occlusion rates are similar between stents with dwell times shorter and longer than 6 mo[19]. In addition, and as alluded to above, placement of maximal stents may lessen the need

Table 3 Commonly used partially-covered and fully-covered self-expandable metal stents

Stent name (manufacturer)	Covering	Core material	Diameter (mm)	Length (cm)	Delivery system (Fr)	Features
Wallflex RX	Partial	Platinol	8, 10	4, 6, 8	8.5	Closed cell construction; retrieval loop; looped and flared ends; restrainable
(Boston Scientific)	Full	Platinol	8, 10	4, 6, 8	8.5	
Wallstent (Boston Scientific)	Partial	Elgiloy	8, 10, 12	2, 4, 4.2, 6, 6.8, 8, 9, 9.4	6, 7, 9	Closed cell construction; restrainable
Niti-S ComVi	Partial	Nitinol	6, 8, 10	4, 5, 6, 7, 8, 9, 10, 12	8	Open cell; triple layered construction: mesh, membrane, and mesh to reduce migration
(Taewoong Medical)	Full	Nitinol	6, 8, 10	4, 5, 6, 7, 8, 9, 10, 12	8	
Niti-S Kaffes (Taewoong Medical)	Full	Nitinol	6, 8, 10	4, 5, 6, 7, 8	9	Long retrieval string
Niti-S	Partial	Nitinol	6, 8, 10	4, 5, 6, 7, 8, 9, 10, 12	8	Retrieval string at proximal end
(Taewoong Medical)	Full	Nitinol	6, 8, 10	4, 5, 6, 7, 8, 9, 10, 12	8.5	
Niti-S Bumpy (Taewoong Medical)	Full	Nitinol	6, 8, 10	4, 5, 6, 7, 8, 9, 10, 12	8.5	Irregular cell sizes; retrieval string at proximal end; flared ends
Nitinella Plus	Partial	Nitinol	8, 10	4, 6, 8, 10	9	Reconstrainable; kink-resistant
(ELLA-CS)	Full	Nitinol	8, 10	4, 6, 8, 10	9	
Hanarostent (M.I. Tech)	Full	Nitinol	8, 10	4, 6, 8, 10	8	Larger flared ends
Micro-Tech	Partial	Nitinol	10	4, 6, 8, 10	9	
(Micro-Tech)	Full	Nitinol	10	4, 6, 8	9	
Gore Viabil	Full (with sideholes)	Nitinol	8, 10	6, 8, 10	8.5	Sideholes allow branch drainage; anchoring fins
(CONMED)	Full (without sideholes)	Nitinol	8, 10	6, 8, 10	8.5	
Allium BIS (Allium Medical)	Full	Nitinol	8, 10	6, 8, 10, 12	10	Anchoring segment; non-shortening

for frequent stent exchange, as biliary drainage can continue to occur even after stent occlusion *via* the inter-stent spaces (*i.e.*, "wick effect")[8]. Avoiding multiple ERCPs can also be facilitated by placement of one or more (covered) self-expandable metal stents (SEMSs) instead of plastic stents. SEMSs offer an attractive alternative because of innate properties that allow them to self-expand to diameters 3 times that of 10-Fr plastic stents, thus resulting in longer duration of patency. SEMSs can also be delivered using smaller deployment systems (*i.e.*, 8-8.5-Fr) that do not require as aggressive dilation at the time of stent placement or biliary sphincterotomy. SEMSs of various configurations and properties are currently available[1]; to date, however, none are approved by the United States Food and Drug Administration for the treatment of BBSs. The three major categories of stents, uncovered, partially-covered, and fully-covered, are briefly reviewed below.

Uncovered SEMSs are plagued by the ingrowth of reactive tissue (*i.e.*, epithelial hyperplasia), which can lead to stent occlusion as well as irretrievable embedding of a stent in the ductal wall[20]. As a result, uncovered SEMSs should not be used in the treatment of BBSs[17]. Partially-covered stents, which leave proximal and distal ends bare, are consequently less prone to becoming embedded in issue and thus have improved ease of retrieval. In the largest study of partially-covered SEMSs used to treat BBSs of various etiologies (n = 79), Kahaleh *et al*[21] reported a stricture resolution rate of 90% following a 4-mo stenting period and 12-mo follow-up time. Although all attempted stent retrievals were successful in this study, the potential for tissue hyperplasia involving the bare ends, as reported in other studies, still exists[22,23]. In an effort to further reduce the risk of stent ingrowth and improve removability, fully-covered SEMSs (lined with silicone, polyether polyurethane, polyurethane, expanded polytetrafluoroethylene, or other materials) have been developed and investigated in the treatment of BBSs (Table 3). Most studies of fully-covered SEMSs, barring those with a predominance of patients with particularly refractory strictures (*e.g.*, chronic pancreatitis), have reported favorable clinical success rates, ranging 80% to 90%, as well as low recurrence rates ($\leqslant$ 10%)[24-33]. A tradeoff of this stent design, however, is their predilection for migration, with several studies reporting fully-covered SEMS migration rates between 20% to 40%[24,25,28,31-33]. Of particular concern is the potential for a migrated SEMS to complicate stent removal (proximal migration) or cause bowel obstruction (distal migration). Recent studies investigating anti-migratory modifications to fully-covered SEMSs (*e.g.*, anchoring fins) have reported reduced albeit not clinically insignificant rates of migration[27,29,30]. The role of fully-covered and partially-covered SEMSs is described further in forthcoming sections.

CONSIDERATIONS FOR SPECIFIC BBS ETIOLOGIES

Post-operative strictures

Post-cholecystectomy: Cholecystectomy remains a common etiology of BBSs, with an incidence of 0.2% to 0.7% among patients undergoing laparoscopic cholecystectomy[34]. Post-cholecystectomy BBSs develop as a consequence of bile duct injury that may occur intraoperatively (dissection, electrocautery, clip

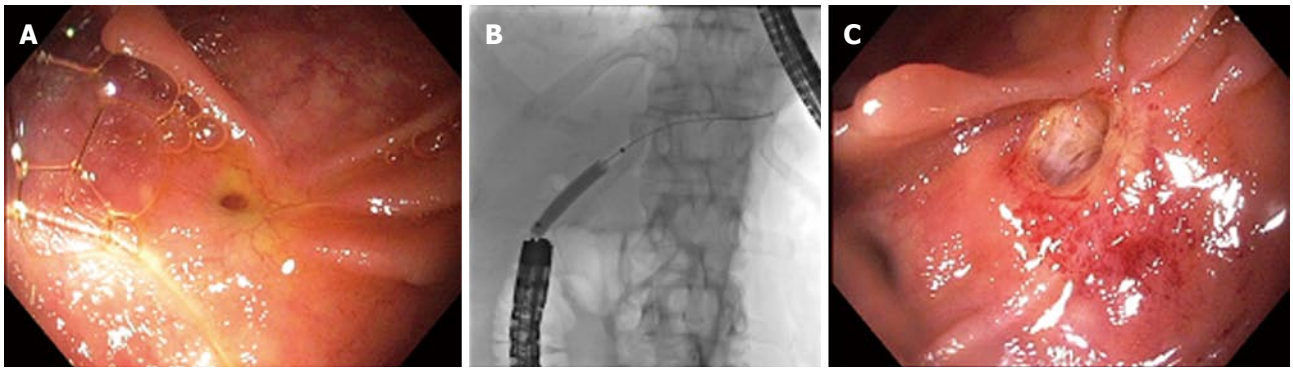

Figure 2 Anastomotic biliary stricture at the site of hepaticojejunostomy in a liver transplantation patient. A: Endoscopic view of hepaticojejunal anastomotic biliary stricture; B: Radiographic image taken during balloon dilation demonstrating the stricture waist; C: Endoscopic view immediately post-dilation of the anastomotic biliary stricture.

or suture placement, ligation) and/or post-operatively (adhesion formation)[35]. Long-term data of post-operative BBSs treated with multiple plastic stents and intermittent stent exchange (approximately every 3 mo) over the course of a year have demonstrated promising success rates ranging from 80% to 100%[15,18,36,37]. This approach has thus become the current standard of care when treating post-operative BBSs[38]. It should be noted, however, that post-operative strictures located at the hepatic ductal confluence may be less responsive to endoscopic stenting than strictures located more distally (25% *vs* 80% resolution rate)[15].

There are limited data regarding the use of fully-covered and partially-covered SEMSs in the treatment of post-cholecystectomy strictures. These data are derived from a small subset of patients with post-cholecystectomy strictures included in SEMSs studies. For example, in a large, multicenter study of fully-covered SEMS (n = 187), 18 patients with post-cholecystectomy strictures (14 of which were previously treated with plastic biliary stents) underwent SEMS placement. After 10-12 mo of stenting, 13 patients (72%) experienced stricture resolution without need for immediate re-stenting. Two-thirds, however, experienced stent migration by 12 mo, and 6 patients (33%) experienced cholangitis, fever or pancreatitis[39]. Based on these findings, SEMSs cannot be routinely recommended for treatment of post-cholecystectomy strictures.

Post-LT: Among patients who have undergone LT, BBSs are among the most common post-operative complications, with their incidence ranging from 5% to 15% and 28% to 32% following deceased donor and living donor LT, respectively, and even higher rates in cardiac death donor LT[12,40,41]. Post-LT BBSs can manifest early (< 30-90 d) or late (> 90 d) in the post-LT course and may occur at the anastomosis (*i.e.*, ABS) or elsewhere in the biliary tree (*i.e.*, non-anastomotic biliary stricture, NABS). Endoscopic therapy is the first line management approach for ABSs and for select NABSs, with percutaneous intervention and surgical revision or redo-LT being reserved for endoscopic treatment failures. ABSs and NABSs are further discussed below.

ABSs are a consequence of local trauma at the surgical juncture between the recipient's and donor's extrahepatic ducts (most commonly CBD-CBD choledocho-choledochostomy) and account for 80% of post-LT biliary strictures[42]. They appear as a short, single stricture localized to the anastomosis. Earlier presentations (< 30-90 d) generally respond well to endoscopic dilation (Figure 2) and a relatively brief period of plastic stenting (approximately 3 to 6 mo), whereas later presentations may require up to 1-2 years of stenting to avoid stricture recurrence based on the few available published series[42-44]. Unfortunately, most studies regarding management of ABSs are retrospective and heterogeneous (*e.g.*, in stricture etiology, severity, and other variables), yet several have shown consistent long-term success rates of approaching 90% to 100% with balloon dilation and multiple or maximal plastic stent therapy[8,45-49]. ABSs may also be treated with SEMSs, but this has been less studied and seldom practiced for a variety of reasons[23-26]. For example, a multicenter trial of partially-covered SEMSs was associated with a modest long-term success rate of 53%, and removal of the stent was technically demanding in 6 out of 21 (29%) patients due to embedding of the bare ends[23]. Conversely, studies using fully-covered SEMSs have reported more promising success rates (ostensibly due to longer dwell times), ranging 92% to 100%, but with higher stent migration rates (as high as 24%)[24-26].

NABSs account for 10%-25% of post-LT biliary strictures[50,51] and are typically a sequela of donor-recipient ABO incompatibility, prolonged graft ischemic time peri-LT, or post-LT hepatic artery thrombosis[52]. NABSs are often referred to as ischemic strictures, although it should be noted that not all NABSs have a clearly ischemic etiology. In contrast to ABSs, NABSs may be either unifocal or distributed diffusely throughout the extra- and/or intrahepatic biliary tree (Figure 3), are more technically challenging to access and treat, and have lower long-term endoscopic treatment success rates (50% to 75%)[45,53]. Nevertheless, maximal

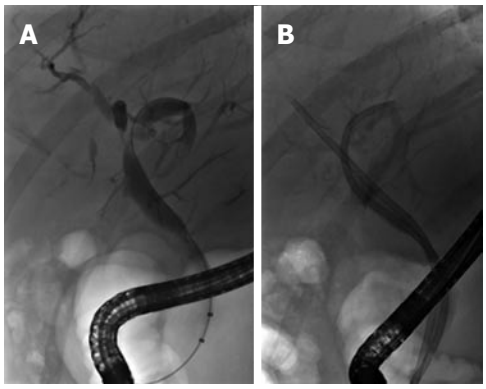

Figure 3 Anastomotic and nonanastomotic biliary strictures in a liver transplantation patient. A: Anastomotic biliary stricture and hilar nonanastomotic biliary strictures are present; B: Radiographic image taken immediately following placement of a 10-Fr 15 cm Cotton-Leung (Cook Medical) and a 10-Fr 22 cm (cut down to 16 cm) Johlin (Cook Medical) plastic biliary stent.

stenting, as with ABS, may result in graft preservation and overall favorable outcomes in a considerable proportion of patients with NABSs[14,45,53-55], although some will ultimately require re-transplantation[10,45,56].

Chronic pancreatitis

BBSs develop in approximately 25% of patients with chronic pancreatitis and represent a major clinical challenge[1]. These strictures occur in the distal CBD, and their refractory nature is largely attributable to robust periductal fibrosis secondary to the underlying chronic inflammatory process[57]. It is important to rule out underlying malignancy in this context, as it can have an initial presentation similar to BBSs and pancreatic cancer can occur in the setting of established chronic pancreatitis. With respect to treatment of chronic pancreatitis-associated BBS, biliary decompression is indicated in patients who are symptomatic (*e.g.*, cholangitic, deeply jaundiced), and as with post-operative BBSs, insertion of multiple plastic stents with 3-4 exchanges over a year appears to offer the highest likelihood of long-term benefit. Studies range in overall success of endoscopic therapy from 44% to 92%, with lower rates among those with dystrophic calcification of the pancreatic head[15,58-60]. Surgical intervention (*e.g.*, Puestow pancreaticojejunostomy, Traverso-Longmire pancreaticoduodenectomy[61]) is indicated in patients who fail endoscopic management and are fit for surgery[57,60].

A number of studies have investigated the role of fully as well as partially-covered SEMSs in chronic pancreatitis. Fully-covered SEMSs have demonstrated success rates ranging from 43% to 77% in patients with chronic pancreatitis-associated BBSs, but stent migration have historically been a common problem, as is the case with post-operative BBSs[21,27,62,63]. A recent, multicenter study of 118 patients with chronic pancreatitis-associated BBSs, however, found that fully-covered SEMS placement was associated with an 80% stricture resolution rate (median stent dwell time 11 mo) and a more acceptable stent migration rate (19% at 12 mo)[39]. Studies using fully-covered SEMSs with antimigratory modifications, or partially-covered SEMSs, have also reported encouraging stricture resolution rates (approximately 90%), and with even lower rates of stent migration[29,63,64].

Primary sclerosing cholangitis

Primary sclerosing cholangitis (PSC) is an idiopathic disorder characterized by periductal inflammation and fibrosis involving the intrahepatic and/or extrahepatic biliary tree. Up to 50% of patients with PSC will develop "dominant" strictures, which are loosely defined as a CBD stenosis of $\leqslant$ 1.5 mm in diameter or hepatic duct stenosis $\leqslant$ 1 mm in diameter, during their disease course[65,66]. A major challenge in the setting of a PSC-associated dominant stricture is excluding underlying malignancy (*i.e.*, cholangiocarcinoma), which develops in up to 20% of patients with PSC[67-70]. At a minimum, brush cytology and/or intraductal biopsies, are required. If available, advanced cytologic and imaging methods should also be considered.

The overarching goal of endoscopic therapy in PSC-associated dominant BBSs is to improve signs, symptoms and sequelae of biliary obstruction; when performed appropriately (including both patient selection and procedural technique), endoscopic therapy can improve Mayo PSC risk score, which has been shown to translate into improved survival[68,71-74]. Biliary (balloon) dilation alone is the preferred therapeutic approach, as stenting has been shown to result in slightly higher rates of complications (*i.e.*, stent occlusion and cholangitis) in some series[75,76]. Repeated dilation (*i.e.*, multiple ERCP sessions) may be necessary in some patients to achieve maximal clinical benefit[77]. If dilation is unsuccessful (*i.e.*, persistent stricture waist), short-term stentings with plastic biliary stents has been shown to be safe and effective with durable benefit[78]. Prophylactic antibiotics should also be administered periprocedurally to reduce the risk of ERCP-related cholangitis unless full biliary drainage is highly anticipated[79,80].

Altered anatomy after hepatobiliary surgery

Biliary-enteric strictures can occur following pancreaticoduodenectomy (Whipple procedure), partial liver resection, and liver transplantation with Roux-en-Y hepaticojejunostomy in 12%-28% of patients[81,82]. Endoscopic therapy of these strictures was once felt to be impossible due to surgical alterations in intestinal anatomy that precluded access *via* conventional endoscopic methods. However, the use of colonoscopes and more recently, device-assisted enteroscopes (single, double, and short double balloon), combined with more widespread training of advanced endoscopists have brought these strictures within reach[83]. In patients post-standard Whipple, the hepaticojejunostomy is almost always reachable, whereas pylorus preserving Whipple, and choledocho- and hepaticojejunostomy

Roux-en-Y render more challenging, but often still conquerable anatomy in the hands of an experienced endoscopist with balloon-enteroscopes. A recent meta-analysis included 15 studies and 461 patients with surgically altered pancreaticobiliary anatomy (Roux-en-Y bypass, Roux-en-Y reconstruction, and standard and pylorus preserving Whipple) undergoing single-balloon enteroscopy-assisted ERCP. The pooled enteroscopy, diagnostic, and procedural success rates were 81%, 69%, and 62%, though a high degree of heterogeneity was reported[84]. Limiting analysis to patients with Roux-en-Y reconstruction or Whipple yielded higher diagnostic and procedural success rates at 79% and 63% with much lower heterogeneity[85]. In a retrospective study of patients with biliary-enteric strictures following surgical repair of iatrogenic cholecystostomy injuries (n = 32), Lee *et al*[86] reported balloon dilation alone to be successful in 66% of patients with only 1 (5%) recurrence over a mean 13.1 years of follow-up.

An endoscopic approach can be limited by time, availability, and endoscopist expertise. When unsuccessful, percutaneous transhepatic access (with or without rendezvous techniques)[86], percutaneous drains, and surgical revision remain alternative therapeutic options.

ENDOSCOPIC ULTRASOUND IN BBS MANAGEMENT

Even in expert hands, attempts at therapeutic ERCP for BBSs may fail in 2% to 10% of cases due to inability to cannulate the bile duct (*e.g.*, surgically altered anatomy, tumor infiltration) or traverse a tight bile duct stricture. In select cases, endoscopic ultrasound (EUS) may serve as ancillary therapeutic techniques prior to proceeding with options such as percutaneous or surgical intervention. EUS can be employed in a rendezvous technique that establishes transpapillary guidewire access, thereby allowing conventional ERCP with balloon dilation of a BBS followed by stent placement (if indicated).

EUS-guided biliary access and drainage can also be performed by needle puncture of the gastric wall and advancement into the left hepatic duct tributaries (*i.e.*, hepaticogastrostomy)[87-90] or through the duodenal wall into the CBD (*i.e.*, choledochoduodenostomy)[91,92]. Thereafter, drainage can be internalized through the papilla without requiring a rendezvous approach (although combination approaches can be useful as well)[93,94]. As alluded to before, this technique is particularly useful when biliary cannulation or access to the papilla cannot be achieved due to duodenal obstruction or other causes[95,96].

Adverse events

Adverse events related to endoscopic management of biliary strictures may occur secondary to stricture access or dilation, and stent placement or dwell time (early or late). Sphincterotomy can be associated with pancreatitis, luminal perforation, or bleeding, as seen in patients undergoing ERCP for other indications. Stricture dilation (particularly in the setting of a fresh surgical anastomosis) and stent deployment also run the risk of perforation. Stent-related adverse events include early or late migration, impaction or embedment (metal stents), or occlusion with the potential for cholangitis. Plastic stents therefore necessitate removal or exchange in 3 mo with concurrent removal of all stones and sludge.

CONCLUSION

Endoscopic therapy provides a minimally invasive, safe, and reliable first-line management option for most BBSs. An approach involving multiple plastic stent placement and intermittent stent exchanges works well in post-cholecystectomy strictures and ABSs, whereas other stricture types, such as NABSs and chronic pancreatitis-associated strictures, tend to be more challenging, with some patients ultimately requiring surgical intervention. The recent and rapid evolution of SEMSs may provide an alternative means to treat some BBSs while reducing the need for frequent ERCPs, but additional studies that better define their application, complications, and cost-effectiveness remain needed. Lastly, applications of therapeutic EUS for biliary disease are becoming increasingly recognized and implemented, and continued advancements in both ERCP and EUS are anticipated.

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