Devices and techniques for ERCP in the surgically altered GI tract

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The American Society for Gastrointestinal Endoscopy (ASGE) Technology Committee provides reviews of existing, new, or emerging endoscopic technologies that have an impact on the practice of GI endoscopy. Evidence-based methodology is used, performing a MEDLINE literature search to identify pertinent clinical studies on the topic and a MAUDE (U.S. Food and Drug Administration Center for Devices and Radiological Health) database search to identify the reported adverse events of a given technology. Both are supplemented by accessing the related articles feature of PubMed and by scrutinizing pertinent references cited by the identified studies. Controlled clinical trials are emphasized, but in many cases, data from randomized, controlled trials are lacking. In such cases, large case series, preliminary clinical studies, and expert opinions are used. Technical data are gathered from traditional and Web-based publications, proprietary publications, and informal communications with pertinent vendors. Technology Status Evaluation Reports are drafted by 1 or 2 members of the ASGE Technology Committee, reviewed and edited by the Committee as a whole, and approved by the Governing Board of the ASGE. When financial guidance is indicated, the most recent coding data and list prices at the time of publication are provided. For this review, the MEDLINE database was searched through January 2015 for relevant articles by using the key words "ERCP," "altered anatomy," "Billroth II," "Roux-en-Y," "double balloon enteroscopy ERCP," "bariatric surgery," "pancreaticoduodenectomy," and "hepaticojejunostomy," and "Roux-en-Y gastric bypass." Technology Status Evaluation Reports are scientific reviews provided solely for educational and informational purposes. Technology Status Evaluation Reports are not rules and should not be construed as establishing a legal standard of care or as encouraging, advocating, requiring, or discouraging any particular treatment or payment for such treatment.

BACKGROUND

The endoscopist performing ERCP in the surgically altered GI tract is faced with several challenges. These include (1) identifying the pancreaticobiliary enteral limb; (2) reaching and identifying the major papilla or the pancreaticoenteric and/or bilioenteric anastomoses, which may require deep enteroscopy or surgical assistance, depending on the type of surgery performed; (3) selectively cannulating the bile or pancreatic duct from an altered orientation (often from a caudal approach); and (4) performing therapeutic interventions with devices designed for standard ERCP while possibly using forward-viewing endoscopes that lack an elevator. These procedures also may need to be performed from potentially unstable endoscope positions.

The success of ERCP in patients with surgically altered anatomy depends on multiple factors including the postoperative anatomy, expertise of the endoscopist, and availability of specialized endoscopes and devices to perform endotherapy. These procedures ideally should be planned by using multidisciplinary collaboration with interventional radiologists and surgeons.

TECHNOLOGY UNDER REVIEW

This document reviews the techniques, endoscopes, and devices necessary for performing ERCP in patients with common forms of surgically altered anatomy.

Preprocedure planning and general considerations

Preprocedure planning should include perusal of the relevant operative reports to review the extent of anatomic resection, type of surgical reconstruction, length of surgically created pancreaticobiliary limb, and type of

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TABLE 1. Tips for successful ERCP in surgically altered anatomy

Understand the postsurgical anatomy, review the operative note and available imaging, and consider discussion with the surgeon.
Determine the appropriate endoscope to use based on the anatomy and availability of local expertise (Table 4).
Know what devices are compatible with the chosen endoscope (Table 2).
Consider use of a clear cap to aid in cannulation of the native papilla and to aid in visualization of pancreatic and/or biliary anastomoses in patients with a Whipple resection.
Consider use of fluoroscopy to help identify the pancreaticobiliary limb.
Consider changing patient position, endoscope straightening maneuvers, and application of external abdominal pressure to minimize loop formation and assist in advancement of the endoscope.
Tattoo the afferent limb to aid in future identification.
Consider use of anesthesia assistance and CO_2 insufflation.
Consider manual reshaping ("grooming") of accessory devices to facilitate cannulation.
Allow adequate time for these complex and often lengthy procedures.

anastomosis. This information will guide the selection of appropriate endoscopes and compatible devices necessary to successfully perform the procedure. A list of tips to facilitate successful ERCP in patients with surgically altered anatomy is contained in Table 1.

TECHNICAL CONSIDERATIONS

Postsurgical anatomy compatible with conventional ERCP techniques that use duodenoscopes

After esophagectomy with gastric pull-up, sleeve gastrectomy, vertical banded gastroplasty, laparoscopic adjustable gastric band placement, Billroth I, and choledochoduodenostomy, the duodenum and major papilla are endoscopically accessible via the stomach. Thus, ERCP may be performed with a duodenoscope and conventional devices for cannulation and intervention. Success rates of ERCP in these postsurgical patients are similar to those performed in patients with normal anatomy.[1-5]

Postsurgical anatomy requiring nonstandard ERCP techniques

The most commonly encountered postoperative anatomic variations are discussed, including Billroth II gastrectomy, classic, and pylorus-preserving pancreaticoduodenectomy (Whipple procedure), Roux-en-Y hepaticojejunostomy, and Roux-en-Y gastric bypass (RYGB). Biliopancreatic diversion with or without a duodenal switch is not a commonly encountered weight loss surgery in the United States and, given the length of the surgically altered limb, ERCP in these patients usually is performed with laparoscopic assistance.

Billroth II gastrectomy

Most endoscopists are familiar with conventional Billroth II anatomy (Fig. 1A). In the Braun variation (Fig. 1B) of Billroth II, a side-to-side jejunojejunostomy is created between the afferent and efferent limbs to divert bile from the gastric stump. This may create confusion regarding which enteral limb the endoscope is traversing. The operation may result in sharp luminal angulations and a longer afferent limb.[6]

Compatible endoscopes and devices. Given the generally short distance (30-50 cm) from the gastrojejunal anastomosis to the major papilla, ERCP in post-Billroth II anatomy usually can be accomplished with a duodenoscope or gastroscope that uses standard ERCP devices.[5] In patients with excessively long afferent limbs or a Braun anastomosis, a pediatric colonoscope or enteroscope may be required to perform ERCP. Shorter length (152 cm), double-balloon enteroscopes (EC-450B15; Fujinon, Saitama, Japan) have been shown to be effective in performing ERCP in patients with Billroth II.[7]

The amount of bile, which may be greater in the afferent limb, and observation of peristalsis, away from the endoscope in the efferent limb, may help identify the endoscopic route to the ampulla. Neither of these observations is reliable, and more commonly, the anatomy is defined by traversing each limb as far as possible. The use of fluoroscopy may aid in identifying the pancreaticobiliary limb.

Cannulation can be challenging in Billroth II anatomy, given that the approach to the papilla is from the caudal direction. The biliary orifice will be toward the 5 o'clock position on the ampulla compared with the 11 or 12 o'clock position in patients with normal anatomy (Fig. 2). Therefore, the orientation of a standard sphincterotome will be unsuitable for biliary access. Devices that improve orientation for cannulation include rotatable sphincterotomes (Autotome Rx, TRUEtome; Boston Scientific, Boston, Mass),[8] and a bendable-tip cannula (Swing tip; Olympus America Inc, Center Valley, Pa). Cook Medical (Bloomington, Ind) manufactures a Billroth II sphincterotome (PTG-20-6-BII-NG) 6F tapered to a 5F tip (Table 2). This device is manufactured for optimal cutting orientation in Billroth II anatomy. Cook Medical also manufactures a

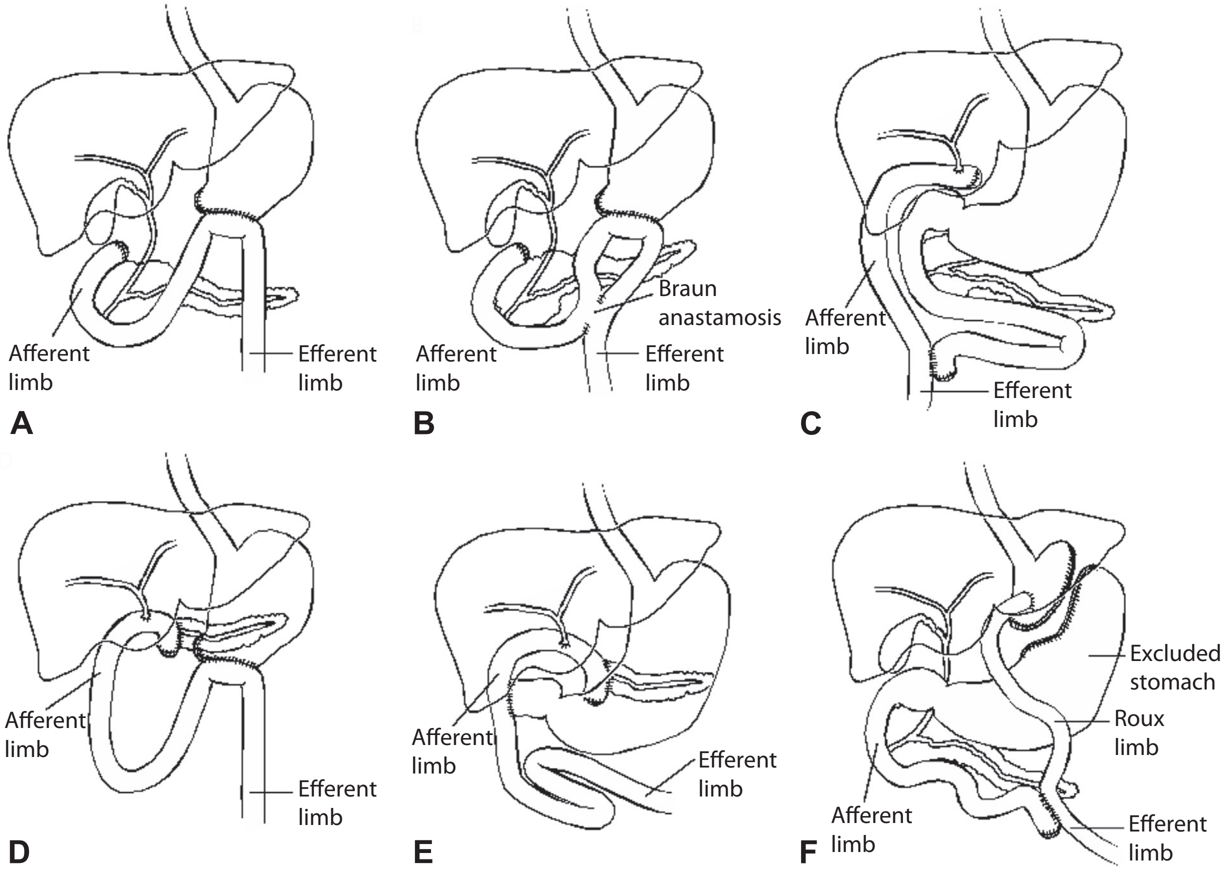

Figure 1. Various common surgical reconstructions for altered anatomy ERCP.

non-wire–guided sphincterotome (PT-5.5-BII-Soehendra), which may facilitate sphincterotomy with the aid of a reverse-curved radiopaque tip. Some endoscopists use a straight catheter with the distal tip reshaped (groomed) to assist with orientation for cannulation. An S-shaped sphincterotome (Storz, Tutlingen, Germany) also has been described for Billroth II cannulation. When a forward-viewing endoscope is used, exposure of the papilla may be improved, with a clear cap fitted on the tip of the endoscope.[3]

After cannulation, insertion of a biliary stent may act as a guide for needle-knife biliary sphincterotomy where necessary. Balloon sphincteroplasty of the papilla with or without a small preceding sphincterotomy has been described as an alternative to biliary sphincterotomy in patients with Billroth II with choledocholithiasis.[9-11]

Pancreaticoduodenectomy

There are 2 main variations of pancreaticoduodenectomy: (1) classic Whipple and (2) pylorus-preserving Whipple (Figs. 1D and E). The length of the afferent limb varies but in general is approximately 40 to 60 cm. The choledochojejunal anastomosis usually is about 10 cm proximal to the pancreaticojejunal anastomosis in the afferent limb.

Compatible endoscopes and devices. In general, given the relatively short lengths of the afferent limb in patients who have post-Whipple anatomy, ERCP may be performed with a duodenoscope, forward-viewing gastroscope, or colonoscope. The pancreaticojejunal anastomosis may be difficult to identify, especially when strictured. Use of fluoroscopy as well as a clear cap fitted at the tip of the endoscope may facilitate pancreatic cannulation and therapy.[12]

Device-assisted enteroscopy has been used to perform ERCP in post-Whipple anatomy (Table 3). A full discussion of balloon and spiral enteroscopy-assisted ERCP is contained under the RYGB section. Depending on the endoscope chosen, compatible devices will need to be selected (Table 2).

Roux-en-Y hepaticojejunostomy

A bilioenteric anastomosis is created at the end of a Roux limb leading from a jejunojejunostomy (Fig. 1C). The jejunojejunal anastomosis usually is encountered just distal to the ligament of Treitz. If the biliary anastomosis is performed above the bile duct confluence, more than 1 biliary opening may be encountered endoscopically, corresponding to the right and left main ducts at the hepaticojejunal anastomoses.

Compatible endoscopes and devices. A colonoscope or enteroscope is necessary to reach the

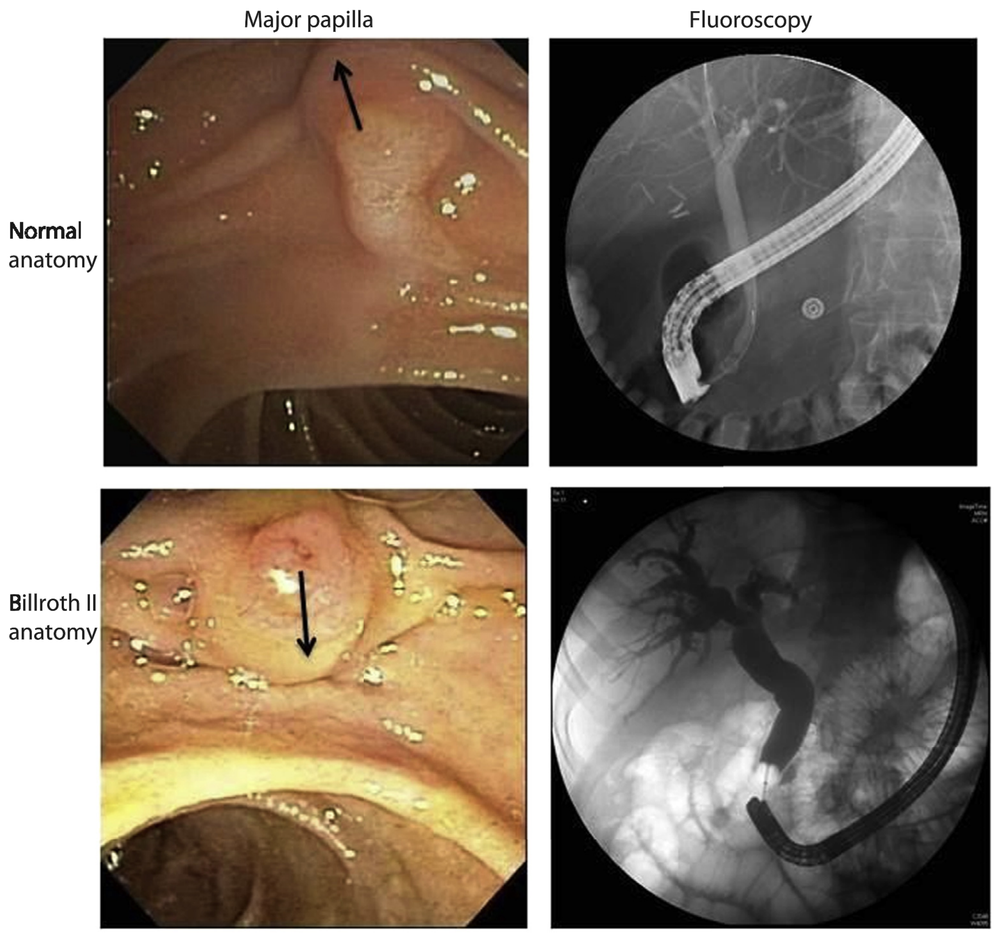

Figure 2. Endoscopic and fluoroscopic views during ERCP in patients with normal anatomy and after Billroth II gastrectomy.

hepaticojejunostomy.[13,14] This surgery does not alter the anatomy of the duodenum and major papilla, so if ERCP is being performed for a pancreatic indication, a standard duodenoscope should be used.[2]

RYGB

Laparoscopic RYGB is 1 of the most commonly performed weight loss surgeries (Fig. 1F).[15] The most prevalent indication for ERCP in the postbariatric surgery patient is choledocholithiasis.[3,16] The length of the Roux limb typically ranges from 100 to 150 cm, but sometimes is as long as 200 cm.[1,17]

Several approaches can be used to perform ERCP in patients with RYGB and pancreaticobiliary disease, depending on the severity of illness and indication of procedure. Common approaches include per-oral ERCP by using enteroscopes, surgically assisted ERCP, or percutaneous transgastric ERCP. Per-oral ERCP with enteroscopes in RYGB anatomy is perhaps the most challenging of all altered anatomy ERCPs for several reasons: (1) reaching the papilla may be difficult because of potentially long Roux limbs, sharp luminal angulations, adhesions, internal hernias, and looping; (2) cannulating the major papilla from a caudal approach creates challenges in achieving adequate orientation; (3) lack of an elevator limits control of the cannulation device; and (4) the array of ERCP accessory devices compatible with long-length enteroscopes is limited.

Compatible endoscopes and devices. Device-assisted enteroscopy is necessary to reach the papilla in these patients. Single-balloon, double-balloon, and spiral enteroscopy have all been shown to be effective with similar success rates in reaching the papilla.[18] A recent ASGE Technology Committee Status Evaluation Report details the various enteroscopy techniques and specifications of the different enteroscope systems.[19]

Device-assisted enteroscopes and devices. The long, double-balloon enteroscope (DBE) has a length of 200 cm and a 2.8-mm working channel (EN-450T5/W; Fujinon). Initial reports highlighted the increased success of DBE in reaching the major papilla compared with pediatric colonoscopes and push enteroscopes.[20-25] The short DBE (EC-450B15; Fujinon) also has a 2.8-mm working channel; however, its shorter working length of 152 cm allows the use of standard ERCP devices, which broadens its therapeutic capability.[20,26-28]

TABLE 2. Accessory devices for ERCP, compatible with long enteroscopes

Device model	Length, cm	Minimum required channel diameter, mm	List price	Comments
Sphincterotomes and cannulas				
Cook Medical				
CCPT-25ME	320	2.8	$355	Classic Cotton Cannulatome 6F catheter tapered to 5F, monofilament 25-mm cutting wire
GT-1-TE	320	2.8	$181	Glo-Tip Catheter 5.5F tapered to 4.5F tip
Needle-knife				
Cook Medical				
PTW-1E	320	2.0	$344	Zimmon needle-knife
Extraction balloons				
Cook Medical				
TXR-ME	275	2.8	$246	Tri-Ex extraction balloon with multiple sizing 8.5-12-15 mm, 6.6F catheter with injection above balloon
Guidewires				
Cook Medical				
METII-35-600E	600		$323	Tracer Metro wire guide, .035 inch
Stents, introducers, pushing catheters				
Cook Medical				
OA-10E	320	3.2	$173	Oasis Stent Introducer system 10F stent
OA-8.5E	320	3.2	$173	Oasis Stent Introducer system for 8.5F stent
PC-7E	320	2.8	$116	Pushing catheter for 7F stent
PC-5E	320	2.0	$116	Pushing catheter for 5F stent
Dilating balloons and catheter dilators				
Cook Medical				
QBD-6 × 3-E	320	2.8	$378	Dilation balloon, 6-mm diameter × 3-cm length, catheter is 6.8F to 4.5 taper tip
QBD-8 × 3-E	320	2.8	$378	Dilation balloon, 8-mm diameter × 3-cm length, catheter is 6.8F to 4.5 taper tip
QBD-10 × 3-E	320	2.8	$378	Dilation balloon, 10-mm diameter × 3-cm length, catheter is 6.8F to 4.5 taper tip
SBDC-7E	275	2.8	$116	Soehendra biliary dilation catheter, 7F catheter with 4F taper tip 3 cm in length
Boston Scientific				
CRE wire guided esophageal/ colonic/Biliary balloon	240	2.8	$360	Available in 6-8 mm, 8-10 mm, 10-12 mm, 12-15 mm, 15-18 mm
Billroth II sphincterotomes				
Cook Medical				
PTG-20-6-BII-NG	200	2.8	$313	Billroth II, 6F tapered to 5F
PT-5.5-BII-Soehendra	200	2.8	$313	Billroth II, 5.5F, not wire guided

Standard ERCP accessories are 200 cm in length and are generally compatible with duodenoscopes, colonoscopes, and short enteroscope lengths (152 cm); the diameter of the accessory device will need to be compatible with the diameter of the working channel of the chosen endoscope.

The single-balloon enteroscope (SBE) (SIF-Q180; Olympus) has a 200-cm working length and a 2.8-mm diameter working channel.

Few studies that use spiral enteroscopy for ERCP have been published, but the limited available data demonstrate equivalent efficacy to balloon-assisted enteroscopy.[29,30]

There are a limited number of devices available for performing ERCP with enteroscopes of 200 cm in length. The commercially available ERCP devices compatible with long-length enteroscopes are detailed in Table 2. Increased success in ERCP in RYGB anatomy may be accomplished with the use of a flexible soft cap (DH-17EN; Fujifilm or D-201-13404, Olympus, Tokyo, Japan) fitted on the tip of the

TABLE 3. Efficacy of enteroscopy-assisted ERCP

Technique	Study type	No.	Anatomy	Endoscopy success
Long-scope DBE				
Aabakken[55]	Retrospective	13	Variable	100% (13/13)
Emmett[24]	Retrospective	14	Variable	85% (17/20)
Maaser[58]	Retrospective	11	Variable	73% (8/11)
Mönkemüller[59]	Retrospective	11	Variable	94.1% (16/17)
Moreels[60]	Retrospective	22	Variable	86.7% (13/15)
Parlak[56]	Retrospective	14	RYHJ	92.9% (13/14)
Raithel[57]	Retrospective	31	Variable	74% (23/31)
Short-scope DBE				
Shimatani[27]	Retrospective	68	Variable	97% (100/103)
Tsujino[63]	Retrospective	6	Variable	100% (6/6)
Cho[20]	Retrospective	20	Variable	86.2% (25/29)
Itoi[61]	Retrospective	9	Variable	100% (9/9)
Osoegawa[21]	Retrospective	28	Variable	96% (47/49)
Park[62]	Retrospective	10	Variable	80% (8/10)
Siddiqui[28]	Retrospective, U.S. multicenter	79	Variable	89% (71/79)
Single-balloon enteroscopy				
Neumann[92]	Retrospective	13	Variable	77% (10/13)
Itoi[10]	Retrospective	13	Variable	92.3% (12/13)
Itoi[61]	Retrospective	15	Variable	100% (15/15)
Wang[67]	Retrospective	13	Variable	81.3% (13/16)
Saleem[65]	Retrospective	50	Variable	75% (42/56)
Kianicka[69]	Retrospective	15	Variable	100% (15/15)
Azeem[68]	Retrospective	36	Variable	91.4% (53/58)
Tomizawa[70]	Retrospective	14	Variable	68% (15/22)
Spiral enteroscopy				
Wagh[30]	Prospective	7	Variable	77% (10/13)
Comparative studies				
Moreels[90]	Variable	327 patients	Variable	SBE 69%-100%
Lennon[29]		416 ERCPs		DBE 72%-75%
Schreiner[64]				Spiral 72%
Chua[74]				
Shah[18]				
Itokawa[91]				

DBE, Double-balloon endoscopy; *SBE,* single-balloon endoscopy.

endoscope, which may help in achieving adequate orientation with the papilla, promote stabilization of the endoscope, and improve chances of cannulation in patients with an intact papilla and RYGB anatomy.[21] The cap may assist in navigating sharp turns and in manipulating jejunal folds to improve visualization of biliary and pancreaticojejunal anastomoses. Supine or left-lateral positioning of the patient allows an easier application of external abdominal counter-pressure, which occasionally is needed to overcome endoscope looping. Use of CO_2 insufflation improves depth of insertion of enteroscopes and thus should be used for these long and complex procedures. Finally, placement of a submucosal tattoo at the entry to the afferent limb, or next to a biliary or pancreatic anastomosis can assist in future identification, decreasing the procedure time for subsequent ERCPs.[21,31] Table 1 and Table 4 provide suggestions for successful ERCP in patients with postsurgical anatomy.

Alternatives to per-oral ERCP in surgically altered anatomy

Alternatives to per-oral ERCP include combined surgical-endoscopic procedures (laparoscopic-assisted gastrostomy with transgastric ERCP), percutaneous gastrostomy with

TABLE 3. Continued

Cannulation success	Therapeutic success	Adverse events
84.6% (11/13)	100% (6/6)	0%
94% (16/17)	100% (6/6)	0%
87.5% (7/8)	100% (7/9)	0%
87.5% (14/16)	81.2% (13/14)	5.8% (1/17); Perforation necessitating surgery (1)
92.3% (12/13)	90% (9/10)	6.6% (1/15); Perforation requiring surgery (1)
100% (13/13)	92.3% (12/13)	4.8% (1/21); Retroperitoneal air
91.3% (21/23)	91.3% (21/23)	5.8% (5/86); Perforation necessitating surgery (2); bleeding (1); pancreatitis (2)
98% (98/100)	100% (98/98)	5% (5/103); Perforation (5), 1 requiring surgery
83% (5/6)	100% (5/5)	33% (2/6); Cholangitis (1); retroperitoneal air (2)
96% (24/25)	100% (24/24)	0% (0/29)
67% (6/9)	100% (6/6)	0%
89% (40/45)	100% (40/40)	2.1% (1/47); Perforation necessitating surgery (1)
75% (6/8)	100% (4/4)	0%
90% (64/71)	100% (64/64)	5% (4/79); Pancreatitis (3); bleeding (1)
90% (9/10)	89% (8/9)	0%
83% (10/12)	100% (10/10)	0%
100% (15/15)	100% (15/15)	0%
100% (13/13)	90% (9/10)	12.5% (2/16); Pancreatitis (2)
93% (39/42)	91.3% (21/23)	0%
80% (12/15)	90% (9/10)	0%
75.9% (44/58)	100% (41/41)	0%
Not available	76% (11/15)	0%
89% (8/9)	90% (9/10)	0%
SBE 75%-100%	SBE 87%-100%	3.5%-5%; Cholangitis, pancreatitis, perforation, bleeding, death
DBE 85%-100%	DBE 78%-100%	
Spiral 90%	Spiral 87%-90%	

transgastric ERCP, percutaneous transhepatic cholangiography (PTC), or surgical exploration.

Laparoscopic-assisted transgastric ERCP. Laparoscopic-assisted transgastric ERCP is a combined surgical and endoscopic procedure in which a duodenoscope is advanced through a surgically created gastrostomy into the distal excluded stomach (Fig. 3). It may be performed as a primary intervention, if enteroscopy-assisted ERCP has failed or if expertise or equipment for enteroscopy-assisted ERCP are not available. A 15-mm trocar (to allow passage of a standard duodenoscope) is surgically inserted into the excluded stomach, secured by a purse-string suture, following which the stomach is pulled adjacent to the abdominal wall. The patient may be redraped to maintain sterility, with the trocar exposed externally for endoscopic access.[32,33] ERCP can then be performed in a standard manner via the gastrostomy; however, the papilla's orientation will be slightly different, because the patient is in the supine position, and the duodenoscope has an anterior approach into the stomach.

The option to perform a cholecystectomy in the same setting, if indicated, is an advantage of laparoscopic-assisted transgastric ERCP. This may be the preferred approach in cases where additional evaluation by EUS is needed. An

TABLE 4. Suggested endoscopes and anatomic and accessory device considerations for performing ERCP in patients with postsurgical anatomy

Surgery	Recommended endoscope	Biliopancreatic anatomical considerations	Accessory device considerations
Billroth II	Duodenoscope	Caudal approach to major papilla (papilla is 180° inverted)	Dedicated Billroth II or rotatable sphincterotome, needle-knife sphincterotomy over stent, balloon sphincteroplasty
	Gastroscope		Lack of elevator
Classic and pylorus-preserving Whipple	Duodenoscope	Consider exploring with forward-viewing scope first, strictured anastomoses may be challenging to find, especially PD	Consider air cholangiogram or retrograde contrast opacification by syringe flush or occluding balloon to identify afferent limb or duct anastomosis
	Pediatric or adult colonoscope/ device-assisted enteroscopy		Lack of elevator Consider cap-fitted endoscope
Roux-en-Y hepaticojejunostomy	Pediatric vs adult colonoscope	Bilioenteric anastomosis in the afferent/Roux limb; PD at the major papilla	Consider air cholangiogram or retrograde contrast opacification by syringe flush or occluding balloon to identify afferent limb or duct anastomosis
	Device-assisted enteroscopy		Ensure compatible length and diameter devices
Roux-en-Y gastric bypass	Device-assisted enteroscope system, short (152 cm) or long (200 cm) DBE or SBE scope (200 cm)	Caudal approach to major papilla with enteroscopy	Use of transparent flexible cap on tip of scope, sphincteroplasty, lack of elevator
	Laparoscopy-assisted ERCP		Can use standard ERCP accessories with short DBE scope Use long wires and long accessories for long DBE and SBE scopes

PD, Pancreatic duct; *DBE,* double-balloon enteroscopy; *SBE,* single-balloon enteroscopy.

additional advantage is the ability to use a duodenoscope and standard devices with a standard approach to the ampulla.

A limitation of this approach, however, is the need for a repeat surgical procedure if subsequent access to the papilla is needed, either for adverse events such as post-sphincterotomy bleeding or retained stones or for repeated therapeutic interventions. For patients in whom a repeat procedure is anticipated, a large-diameter gastrostomy tube can be placed to maintain the gastrostomy. Once the tract is mature, dilation can be performed to allow for passage of a duodenoscope. After each ERCP, the gastrostomy tube is replaced.[34-36] This hybrid surgical-endoscopic approach also can be performed in separate sessions in which ERCP is performed several weeks after maturation of the surgical percutaneous tract. The staged approach can be considered for non-urgent indications or when multiple sequential ERCPs are anticipated.

Potential disadvantages include the relative invasiveness of the combined surgical-endoscopic procedure, the risks associated with surgery, the negative impact on quality of life of a gastrostomy tube[37] if placed for repeat ERCP, and the challenges associated with coordinating surgeon and endoscopist schedules. From the perspective of the endoscopist, endoscopic ventures that involve coordination with operating rooms and other specialists may be time consuming, resource intensive, and logistically challenging.

Evolving techniques

Several additional techniques have been described in small case series from single centers to accomplish ERCP in patients with RYGB. These require further study to establish their safety and efficacy. After successful DBE ERCP, a PEG tube has been placed into the excluded distal stomach via DBE to facilitate subsequent ERCP without having to repeat enteroscopy.[38] Another technique describes the placement of a transgastric self-expandable metal stent (SEMS) that uses SBE or DBE guidance to allow antegrade ERCP in a single session.[39] For patients in whom a small communication exists between the gastric pouch and remnant stomach, and the stomach has been divided but not separated, endoscopic balloon dilation of the communicating tract with or without placement of a fully covered metal stent across the gastrogastric fistula has been performed to facilitate ERCP.[40,41]

A few EUS-assisted ERCP techniques have been described in patients who have undergone RYGB. In 1 technique, EUS-guided transgastric FNA puncture is performed from the proximal gastric pouch into a dilated intrahepatic

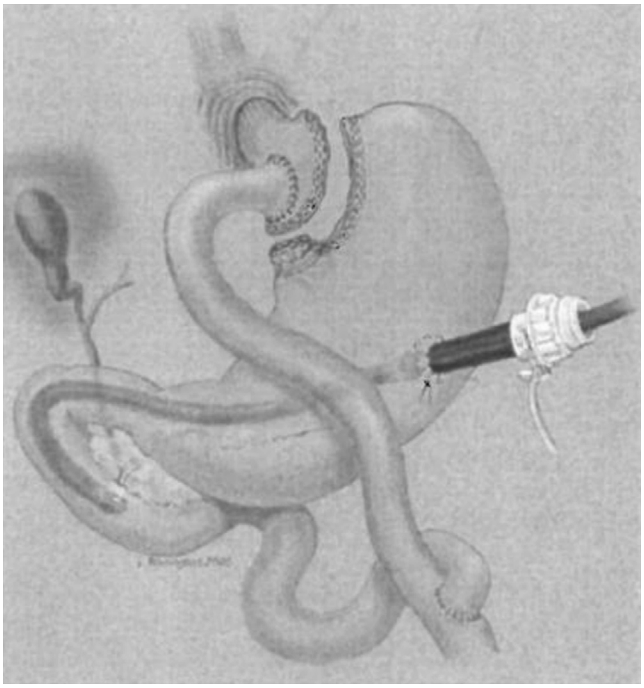

Figure 3. Laparoscopic-assisted ERCP. Reprinted with permissions from Doug Howell.

duct in the left lobe of the liver.[42] Contrast material is injected through the needle to obtain a cholangiogram, followed by antegrade guidewire advancement across the major papilla and dilation of the gastrohepatic tract to facilitate advancement of devices for subsequent antegrade sphincteroplasty and stone advancement across the major papilla. In another technique, EUS is used to guide puncture with an FNA needle into the remnant stomach from the gastric pouch or Roux limb, followed by contrast material injection to confirm location, then injection of 300 to 600 mL of air to insufflate the gastric remnant, which, in turn, facilitates percutaneous placement of a gastrostomy tube to allow for subsequent ERCP.[43] Finally, the bypassed stomach has been accessed through the gastric pouch under EUS guidance, followed by placement of a fully covered lumen-apposing stent (AXIOS; XLumena, Mountain View, Calif) to create a gastrogastric fistula to allow for subsequent duodenoscope advancement.[44]

PTC

PTC reliably accomplishes biliary drainage optimally in the setting of a dilated intrahepatic biliary tree. This is an appropriate interventional radiology approach in patients with surgically altered anatomy in need of an urgent biliary decompression (eg, cholangitis) where there is lack of access to a tertiary-care center or even in a tertiary-care center in the setting of severe cholangitis with hemodynamic instability.

Open surgical common bile duct exploration is rarely performed in modern clinical practice, given the availability of less-invasive alternatives.

EFFICACY, COMPARATIVE STUDIES, AND EASE OF USE

Most studies evaluating ERCP in patients with surgically altered anatomy report on heterogeneous groups of patients who have undergone various surgeries. Parameters of success reported in the altered anatomy setting include (1) gaining access to the major papilla or biliopancreatic anastomoses (enteroscopy success); (2) cannulation of the desired duct (cannulation success); and (3) completion of the intended therapeutic intervention (therapeutic success). Some studies report an overall ERCP success rate that is inclusive of all the previously mentioned parameters including enteroscopy success. The underlying anatomy is a major determinant of procedural success, with highest success rates reported in patients with Billroth II anatomy and lowest in those with RYGB anatomy. Reported ranges of success rates are often wide because of the small numbers of patients in these studies.

ERCP in Billroth II anatomy

ERCP studies in Billroth II anatomy by using duodenoscopes report a 70% to 97% success rate in reaching the papilla and a 60% to 91% rate of selective biliary cannulation.[45-47] Reported success rates of cannulation by using a forward-viewing endoscope are 81% to 87%.[47,48] One prospective randomized trial compared the use of gastroscopes with duodenoscopes in 45 patients with Billroth II anatomy. Overall cannulation rates were lower in the duodenoscope group (68% vs 87%); however, the majority of cannulation failures in the duodenoscope group were due to the inability to reach the papilla. Fewer perforations were noted with the use of the forward-viewing endoscope when compared with the duodenoscope (0/23 vs 4/22).[48] In a case series of 10 patients with Billroth II anatomy, successful biliary cannulation and intervention was achieved in all patients (100%) with the use of a gastroscope fitted with a transparent cap.[49]

Successful sphincterotomy (>92%) with low adverse event rates (<5%) has been described by using modified S-shaped or sigmoid-shaped sphincterotomes.[50,51] However, these Billroth II sphincterotomes may not always exit the endoscope with appropriate orientation for cannulation of the papilla. In a small series of patients with Billroth II, use of a rotatable sphincterotome (Autotome RX; Boston Scientific) was associated with a sphincterotomy success rate of 89%.[8] Needle-knife sphincterotomy over a biliary stent is an additional method, with a reported success rate of 83% to 95% and an adverse event rate of 3% to 5%.[52] Many experts prefer this approach in patients with Billroth II. Transpapillary balloon dilation has been shown to have success rates of 89% to 100% in facilitating stone removal without adverse events in several small series of patients with Billroth II.[8,9,53] A study randomizing

34 patients with Billroth II anatomy with choledocholithiasis to balloon sphincteroplasty or biliary sphincterotomy (performed with stent and/or guided needle-knife technique) indicated similar success rates (88% for sphincteroplasty vs 78% for sphincterotomy) with low rates of bleeding (0/16 for sphincteroplasty vs 3/18 for sphincterotomy) and pancreatitis (1/16 for sphincteroplasty vs 0/18 for sphincterotomy) in both groups.[52] In a recent Korean series of 13 patients with Billroth II with choledocholithiasis undergoing balloon sphincteroplasty without preceding sphincterotomy for stone extraction, no patients developed acute pancreatitis, and duct clearance was achieved in 100%.[11]

Enteroscopy-assisted ERCP: DBE versus SBE versus spiral enteroscopy

A systematic review of 679 patients with surgically altered anatomy who underwent 945 device-assisted enteroscopy ERCPs in 23 individual studies indicated an overall success rate of 74%.[54] There were no significant differences in the success rate of ERCP across the 3 enteroscopy methods.[18,54] Table 3 contains a comprehensive list of the literature on the efficacy of enteroscopy-assisted ERCP.

DBE-ERCP has been studied extensively, but mainly in retrospective analyses. The success rates of long and short DBE systems are similar: 74% to 100% in reaching the major papilla, 85% to 100% in successful cannulation, and 81% to 100% in successful intervention in various postsurgical anatomy.[20,21,27,28,55-63] Notably, the reported therapeutic success rate with use of the short DBE enteroscope was 100% in all 3 published studies, which has been attributed to the ability to use the wide array of standard length ERCP accessory devices (Table 2).[20,27,28] Schreiner et al[64] found no difference in total procedural success between short and long DBE enteroscopes (40% vs 50%; $P = .733$) in a study designed to compare balloon-assisted ERCP with transgastric ERCP. No study to date has directly compared the efficacy of short versus long DBE enteroscopes in ERCP.

SBE-ERCP has been reported to have similar success rates of 70% to 80% in reaching the ampulla as DBE-ERCP[10,59,64-67] and similar cannulation and therapeutic success rates as other device-assisted enteroscopy methods. SBE-ERCP alone has been reported in 8 case series, each recruiting between 13 and 50 patients. The biliary orifice was reached in 68% to 100%, successful cannulation achieved in 76% to 100%, and successful therapeutic intervention accomplished in 76% to 100%.[53,59,61,65,67-70]

Data on spiral enteroscopy–assisted ERCP are limited to a single published case series of 7 patients who underwent 13 ERCPs, which reported a success rate of 77% in reaching the biliary orifice, an 89% cannulation rate, and a 90% therapeutic success rate.[30] Several additional case series published only in abstract form (5-13 patients) evaluated spiral enteroscopy–assisted ERCP and reported an overall ERCP success rate of 62% to 90%.[71-73]

Six studies have compared different enteroscopy methods for ERCP (Table 3). Overall, there are no significant differences in rates of reaching the biliary orifice, cannulation success, or therapeutic success with the different enteroscopes. Spiral enteroscopy was compared with SBE in ERCP efficacy in a retrospective series of 34 patients (54 procedures) with Roux-en-Y anatomy.[29] There was no difference in cannulation (48.3% SBE vs 40% spiral) or therapeutic success rates (100% SBE vs 87.5% spiral). Similarly, mean procedure times were similar between the 2 groups and only 1 adverse event (perforation) occurred in the SBE ERCP group. The largest multicenter U.S. study to date, including 129 patients with altered anatomy undergoing 180 enteroscopy-assisted ERCPs (45 SBE, 27 DBE, 57 spiral enteroscopy) reported an overall success rate in reaching the papilla of 71% and an overall ERCP therapeutic success rate of 63%; however, ERCP success (defined as accomplishing the intended therapeutic intervention) was 88% when the biliary orifice was reached.[18] There was no difference in enteroscopy (reaching the papilla) or ERCP success (cannulation and therapy) ($P = .89$ and $P = .88$, respectively) among single-balloon, double-balloon, or spiral enteroscopy (SBE 69% and 87%; DBE 74% and 85%, spiral 72% and 90%, respectively). Similarly, no difference has been reported in other studies in overall ERCP success between SBE and DBE ERCP.[18,74] Mean procedural duration for enteroscopy-assisted ERCP was 90 to 120 minutes.[18]

A recent systematic review of 23 studies evaluated 945 procedures performed in 679 patients[54] indicated an enteroscopy success rate of 85%, with a native papilla cannulation rate of 90%, which was similar to cannulation of biliary and/or pancreatic-enteric anastomoses (92%). Enteroscopy success rates (reaching the papilla) were similar for all 3 enteroscopy methods (DBE 89%, SBE 82%, spiral 72%). However, overall ERCP success rates were highest with DBE (DBE 82%, SBE 68%, spiral 65%). Total procedure time for DBE ERCP ranged from 30 to 240 minutes, compared with 15 to 212 minutes for SBE ERCP. However, as previously noted, there are no direct comparative studies between the enteroscopy modalities.

Enteroscopy-assisted ERCP versus transgastric laparoscopic–assisted ERCP

Transgastric ERCP cannulation and therapy rates have ranged between 90% and 100% in several small case series including 4 to 41 patients.[32,33,35,36,75-79] In a single tertiary-care center experience of 24 transgastric laparoscopic-assisted ERCPs, compared with 32 DBE (long and short DBE) and/or SBE ERCPs in patients with RYGB anatomy, transgastric ERCP had significantly higher success rates in reaching the major papilla (100% vs 72%; $P = .005$), successful cannulation (100% vs 59%; $P < .001$) and successful therapy (100% vs 59%; $P < .001$) compared with balloon enteroscopy.[64] The mean total procedure time for transgastric ERCP was higher than for balloon enteroscopy (172 minutes vs 106 minutes; $P < .001$) in this study. However, the mean endoscopist time (total endoscopist time in the operating room) was shorter in the transgastric ERCP group compared with SBE and DBE-ERCP (75 minutes vs 106 minutes; $P < .006$).[80] The mean length of stay and frequency of adverse events were similar in both groups. The study also indicated that a Roux limb length of >150 cm independently predicted procedural failure in the enteroscopy-assisted ERCP group, compared with shorter Roux limb lengths (25% success rate vs 88%, respectively; $P = .024$) and was associated with increased costs. These data suggest that in patients with long limb (>150 cm) RYGB, laparoscopic-assisted ERCP should be the preferred initial approach.[64]

Another single-center study at a large, tertiary-care medical center compared the success rates and adverse events associated with surgical gastrostomy–assisted ERCP (n = 44) versus DBE ERCP (n = 28).[78] In most patients, surgical gastrostomy–assisted ERCP was done in a 2-stage manner with a delay in ERCP by 4 to 6 weeks. Notably, the procedural indications differed significantly between the groups, with sphincter of Oddi dysfunction (77%) and recurrent pancreatitis (18%) being the most common indications in the transgastric ERCP group, compared with choledocholithiasis (57%) and pancreaticobiliary malignancy (15%) in the DBE ERCP group. Endoscopist procedure duration was significantly shorter in the transgastric group compared with the DBE group (46 ± 27 minutes vs 101 ± 37 minutes; $P < .001$). Compared with DBE ERCP, transgastric ERCP was more successful in reaching the major papilla (97% vs 78%; $P = .003$), in cannulation (97% vs 63%; $P < .001$), and in successfully accomplishing therapy (97% vs 56%; $P < .001$). Transgastric ERCP, however, was associated with greater morbidity, largely because of gastrostomy-related adverse events (14.5% vs 3.1%).[78]

SAFETY

In addition to the risks associated with conventional ERCP such as bleeding, pancreatitis, and perforation,[80] ERCP in the postsurgical setting is associated with the added risks of perforation at the gastrojejunal anastomosis, jejunojejunal anastomoses, and Roux-en-Y reconstruction.

ERCP in Billroth II anatomy

Adverse event rates in patients with Billroth II anatomy undergoing ERCP are similar to those of ERCP in patients with normal anatomy at major referral centers.[9,10,45,47] Other older studies have demonstrated an overall adverse event rate of 5.1% to 8%, largely attributable to intestinal perforations.[46,50,81] A randomized prospective trial comparing ERCP using gastroscopes versus duodenoscopes in 45 Billroth II patients reported a higher perforation rate with duodenoscopes (18%, 4/22 vs 0%, 0/23).[48] Subsequent larger series (110-138 patients each) have reported lower perforation rates, between 2% to 6%, with duodenoscopes.[23,46,81] Perforations may occur within the afferent limb related to advancing the duodenoscope with limited visibility.[46] In Billroth II patients, balloon sphincteroplasty is reported to have significantly lower risks of bleeding compared with sphincterotomy (2% vs 17%; $P < .05$).[52,53]

Enteroscopy-assisted ERCP

The largest systematic review to date, including 23 studies with a total of 945 enteroscopy-assisted ERCPs, reported an overall adverse event rate of 3.4%.[54] These included perforation (1.4%, 13 patients, 6 requiring surgical intervention), pancreatitis (1.1%), bleeding (0.3%), cholangitis (0.1%), and death (0.1%, 1 patient; embolic stroke). In a large series of DBE-assisted ERCP procedures (86), perforation was reported in 2.3%, pancreatitis in 2.3%, and bleeding in 1.1% of patients.[57] Studies on SBE and spiral enteroscopy-assisted ERCP have demonstrated similar pancreatitis and perforation rates to those seen with DBE.[28,29,65,72,73] In a multicenter U.S. study comparing DBE, SBE, and spiral enteroscopy in 129 patients with long-limb Roux-en-Y anatomy, the overall adverse event rate for all enteroscopy-assisted ERCPs was 12.4% (abdominal pain requiring hospitalization in 2%, throat pain in 3%, pancreatitis in 3%, perforation in 1.6%, bleeding in 0.8%, with 1 death which occurred in the spiral enteroscopy group, 0.8%).[18]

Transgastric ERCP

In a series of 41 patients with RYGB who underwent 85 laparoscopic or percutaneous gastrostomy–assisted ERCPs mainly for pancreatic indications, the overall adverse event rate was 19%, with 88% of adverse events related to the gastrostomy that was required for access rather than to ERCP itself.[79] These gastrostomy-related adverse events included gastric or duodenal bulb injury related to Savary dilation of the existing gastrostomy tract, pneumoperitoneum from tract dilation, gastrostomy site infections or leakage, and persistent gastrocutaneous fistula after gastrostomy tube removal. Schreiner et al[64] described a transgastric ERCP adverse event rate of 8% (2/24) compared with 3% (1/32) in the balloon enteroscopy–assisted ERCP group; however, this difference was not statistically significant.

FINANCIAL CONSIDERATIONS

The costs associated with ERCP will vary, based on the patient anatomy, the need for device-assisted enteroscopy, and for specialized devices for cannulation and therapy. An ASGE technology review document[19] contains a table with list prices for the various enteroscopy systems. Performance of ERCP with long enteroscopes will necessitate the purchase of compatible-length devices. Endoscopy units will need to weigh the relative cost of stocking these special-order items, some of which may not be used by their expiration dates, given the relative infrequency with which ERCP in patients with altered anatomy is performed.

A cost analysis of the optimal approach to ERCP in post-RYGB patients concluded that overall, there was a cost savings of $1015 when balloon-assisted ERCP was the initial approach (with laparoscopic-assisted ERCP used if balloon-assisted ERCP was unsuccessful), rather than with laparoscopic-assisted ERCP as the primary approach.[64] In patients with Roux limbs of <150 cm length, starting with balloon-assisted ERCP resulted in a cost savings of $2388, compared with initial laparoscopic-assisted ERCP. In patients with Roux limbs of >150 cm length, starting with balloon-assisted ERCP, resulted in an added cost of $593; this was likely related to the costs associated with having to perform salvage laparoscopic-assisted ERCP in a proportion of these patients to achieve therapeutic success. These data support the use of balloon enteroscopy–assisted ERCP as the first step in management in patients with Roux limbs <150 cm, followed by laparoscopic-assisted ERCP if unsuccessful.

Coders are instructed to use the existing ERCP codes when the procedure is performed via altered postoperative anatomy such as post-Billroth II gastroenterostomy in which the procedure is carried out retrograde back through the afferent jejunal limb of the reconstruction. However, an ERCP via gastrostomy (laparoscopic or open) or Roux-en-Y anatomy (eg, postbariatric gastric bypass, post-total gastrectomy) should be reported with either code 47999, *unlisted procedure, biliary tract* or 48999, *unlisted procedure, pancreas* depending on which ductal system is the chief focus of the examination or is examined. Although not stated in the Current Procedural Terminology (CPT), if both ductal systems are visualized in these situations, it seems most appropriate to bill only 1 of these 2 codes, depending on the major focus of the procedure. Because the definition of ERCP involves visualization of at least 1 ductal system, in the event of an unsuccessful cannulation, the codes to use would be either EGD series codes for an approach via Billroth II limb or an enteroscopy code (series 44360-44370); if the unsuccessful procedure occurred via laparoscopy, then either 43999, *unlisted procedure, stomach* or 44799, *unlisted procedure, intestine* are most applicable.

When reporting unlisted or miscellaneous codes, supporting documentation should be included with each claim. The information should detail the nature, extent, and need for the procedure and the time, effort, and equipment necessary to provide the procedure. Additional items to include are the complexity of symptoms, final diagnosis, pertinent patient findings, diagnostic and therapeutic procedures, concurrent problems, and follow-up care. It is helpful in such a cover letter to compare the work relative value unit (RVU) or total RVU for the procedure to an existing code of similar intraservice time and intensity. Such a statement in this context might state, for example, "For comparison to existing service, the intraservice time (scope into scope out) and intensity for this procedure was approximately twice that of 43264 (*ERCP with removal of calculi and/or debris from biliary and/or pancreatic ducts*)." A single unlisted code can be submitted to describe the entirety of the procedure or added in addition to the ERCP code(s) most applicable, such as 43262 if sphincterotomy is performed.

EMERGING TECHNOLOGY

Several enteroscopes and endoscopes have been developed internationally that may impact the performance of ERCP in patients with surgically altered anatomy. These include a motorized modification to the spiral enteroscopy system,[82] a short SBE with a wider 3.2-mm working channel (SIF-Y0004; Olympus Medical Systems, Tokyo, Japan),[7,83,84] a long DBE with a wider 3.2-mm working channel (EN580T; Fujinon, Düsseldorf, Germany), an oblique-viewing gastroscope with an elevator (XK-240; Olympus), and a working channel diameter of 2.8 mm.[85] Other prototype endoscopes include the swan necked multi-bending backward-oblique viewing duodenoscope (M-D scope, TJF Y0011; Olympus),[86] the variable stiffness duodenoscope (TJF0Y0011; Olympus),[87] and the multi-bending, forward-viewing endoscope with 2 working channels (M-scope, GIF 2T260M; Olympus).[88,89] However, none of these enteroscopes or endoscopes are currently available in the United States.

AREAS FOR FUTURE RESEARCH

Randomized clinical trials comparing clinical efficacy and cost effectiveness of different endoscopic techniques in different postsurgical anatomies would help better define the optimal management approach to various postsurgical patients.

Multicenter studies comparing transgastric ERCP versus enteroscopy-assisted ERCP in patients with RYGB may assist in defining a cost-effective and practical algorithmic approach to pancreaticobiliary disease in these patients.

There is a need for dedicated studies evaluating the safety of various EUS-guided biliary access techniques.

There is a need for increased development of devices compatible with long enteroscope systems as well as those that are designed to maneuver efficiently through the long and often tortuous working channel of an enteroscope.

SUMMARY

ERCP in postsurgical patients is a technically challenging endeavor usually performed at high-volume tertiary-care centers. Different endoscopic approaches have evolved for the different types of postsurgical anatomy. The selection of ERCP approach and feasibility in these patients differs substantially depending on several factors, including the postoperative anatomy, operator expertise, and availability of device-assisted enteroscopy. Knowledge of the postsurgical anatomy, review of the operative report and imaging, and following a multidisciplinary approach with close collaboration with the surgeon and interventional radiologists when needed are recommended to allow selection of the optimal approach and to maximize the odds of successful ERCP.

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DISCLOSURES

J. Hwang is a consultant for Covidien and U.S. Endoscopy. All other authors disclosed no financial relationships relevant to this publication.

Abbreviations: ASGE, American Society for Gastrointestinal Endoscopy; DBE, double-balloon enteroscopy; ERCP, endoscopic retrograde cholangiopancreatography; PTC, percutaneous transhepatic cholangiography; RYGB, Roux-en-Y gastric bypass; SBE, single-balloon enteroscopy; SEMS, self-expandable metal stent.

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