Impact of Scope Exchange from a Long Single Balloon Enteroscope to a Gastroscope during Enteroscopy-Assisted Endoscopic Retrograde Cholangiopancreatography in Patients with Surgically Altered Anatomy

Eunae Cho, Chang Hwan Park, Youngjung Kim, and Seo Yeon Cho

Division of Gastroenterology, Department of Internal Medicine, Chonnam National University Medical School, Gwangju, Korea

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Corresponding Author

Chang Hwan Park

ORCID <https://orcid.org/0000-0002-2995-8779>

E-mail p1052ccy@hanmail.net

Background/Aims: Endoscopic retrograde cholangiopancreatography (ERCP) in patients with surgically altered anatomy (SAA) is challenging to gastrointestinal endoscopists. The aim of this study was to evaluate the impact of scope exchange from a long single balloon enteroscope (SBE) to a gastroscope during SBE-assisted ERCP (SBE-ERCP) in patients with SAA.

Methods: Patients who underwent SBE-ERCP between February 2019 and October 2020 were retrospectively identified. Intubation success, scope exchange success, cannulation success, and therapeutic success were analyzed along with complications.

Results: Fifty-six patients with various SAAs underwent SBE-ERCP procedures, including Billroth II subtotal gastrectomy (B-II, n=13), pylorus-preserving pancreato-duodenectomy (PPPD, n=6), Roux-en-Y hepaticojejunostomy (REY HJ, n=4), and total gastrectomy with REY anastomosis (TG REY, n=33). Overall intubation, cannulation, and therapeutic success rates were 89.3%, 82.1%, and 82.1%, respectively. Therapeutic success rates did not differ significantly among the type of SAA. Successful scope exchange rate after successful intubation was significantly higher in native papilla (B-II and TG REY, 83.3%, 35/42) compared to bilioenteric anastomosis (PPPD and REY HJ, 0%, 0/8, $p<0.001$). Intubation success, scope exchange, and cannulation success were associated with therapeutic success ($p<0.001$). In multivariate analysis, successful scope exchange was the only factor related to cannulation success ($p=0.02$). The major complication rate was 1.8% (one perforation).

Conclusions: SBE-ERCP is a safe and effective procedure to treat biliary problems in patients with SAA. Successful scope exchange may lead to higher therapeutic success by way of cannulation success. (*Gut Liver* 2022;16:308-316)

Key Words: Cholangiopancreatography, endoscopic retrograde; Enteroscopy; Altered gastrointestinal anatomy

INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP) is currently the norm in endoscopic management of various pancreatobiliary diseases. The success rate of ERCP exceeds 95% in patients with a normal anatomy.¹ However, ERCP for patients with surgically altered anatomy (SAA) is challenging. The success rate of ERCP with conventional duodenoscopes is around 60% in patients with SAA.¹ Potential impediments for successful ERCP in these patients include long afferent limbs, angulation and

adhesion of intestines, and an inverted intact ampulla of Vater (AOV) without dedicated accessories. Recent studies have reported successful ERCP using device-assisted enteroscopy (DAE) in patients with SAA.^{2,3} Most of the accessories including cannulas and baskets used in ERCP are originally made for duodenoscopes (length of 1,520 mm) and are less than 2,000 mm in length. These accessories can be used with a gastroscope (length of 1,030 mm) but not with a long enteroscope (SIF-Q180), which has a working length of 2,000 mm. Without dedicated accessories for DAE-ERCP, scope exchange between a long enteroscope

and a gastroscope can be used to achieve a high rate of successful ERCP in patients with SAA.⁴ However, detailed data are limited on the impact of scope exchange on DAE-ERCP. Thus, the objective of this study was to evaluate the impact of scope exchange between a long single balloon enteroscope (SBE) and a gastroscope on SBE-assisted ERCP (SBE-ERCP) in patients with SAA.

MATERIALS AND METHODS

1. Patients

Patients who underwent SBE-ERCP between February 2019 and October 2020 were retrospectively identified. Only naïve patients who underwent SBE-ERCP were included. Fifty-six naïve patients with SAA underwent SBE-ERCP procedures, including Billroth II anastomosis (B-II) with various reconstructions, pylorus-preserving pancreatoduodenectomy (PPPD), Roux-en-Y hepaticojejunostomy (REY HJ), and total gastrectomy with REY anastomosis (TG REY). For patients in the B-II group, prior ERCP was performed with a cap-fitted forward-viewing gastroscope or a pediatric colonoscope. However, it failed to reach AOV due to post-surgical intestinal adhesion, Braun anastomosis, or REY anastomosis. For other SAAs, SBE-ERCP was tried first. The primary endpoint was the rate of therapeutic success. Secondary endpoints included intubation and cannulation success rates, intubation, intervention, and total procedure time, and rates of adverse events. Written informed consent was obtained from each patient before SBE-ERCP. This study was approved by the Institutional Review Board of Chonnam National University Hospital (IRB number: CNUH-2020-394).

2. SBE-ERCP procedures

All procedures were executed under conscious sedation using a combination of pethidine, diazepam, and propofol with patients in a prone or a semi-prone position. The procedure was performed by two experienced endoscopists (C.H.P. and E.C.). The SBE system consisted of an enteroscope (XSIF-Q260Y; Olympus Medical Systems, Tokyo, Japan), an overtube with a balloon (ST-SB1; Olympus Medical Systems), and a balloon controller (OBCU; Olympus Medical Systems). The enteroscope had a working length of 200 cm, an outer diameter of 9.2 mm, and a working channel diameter of 2.8 mm. The overtube had a working length of 132 cm, an outer diameter of 13.2 mm, and inner diameter of 11 mm. A transparent cap (Disposable Distal Attachment, Model D-201-10704; Olympus Medical Systems) was attached to the tip of the enteroscope to facilitate endoscopic insertion, visualization of AOV or bilioenteric anastomosis, and selective cannulation.

When the AOV or bilioenteric anastomosis was reached with the SBE, scope exchange to a conventional forward-viewing gastroscope (GIF-XQ 260; Olympus Medical Systems) was tried (Fig. 1). If it failed, the SBE was remained in situ and self-assembled accessories or those for colonoscopic usage (e.g., balloon dilatator, needle knife) were used for further procedures because long accessories for ERCP were not commercially available in Korea at the time (Fig. 2). Scope exchange was performed when shortening of loops was easily achieved without persistent resistance. After shortening loops, the overtube was remained with its balloon inflated and the SBE was removed. Because of the shorter length of the gastroscope (working length of 103 cm, outer diameter of 9 mm, and working channel diameter of 2.8 mm), an aperture was made on the overtube at a point of 100 cm and the gastroscope was inserted into the

Fig. 1. The endoscope exchange technique procedure in a patient with total gastrectomy with Roux-en-Y anastomosis. (A) Fluoroscopy exam shows the single balloon enteroscope trying to enter the afferent loop. Note the air in the afferent loop. (B) The single balloon enteroscope is removed through the indwelling overtube while its balloon is inflated. (C) A conventional forward-viewing gastroscope is inserted through the overtube, and endoscopic papillary balloon dilatation is performed.

Fig. 2. The procedure of single balloon enteroscopy-endoscopic retrograde cholangiopancreatography in a patient with hepaticojejunostomy (HJ) stricture after pylorus preserving pancreaticoduodenectomy. Fluoroscopic exam showing the single balloon enteroscope in the afferent loop (A). Note the air in the biliary tree and the sharp angled loop of the enteroscope. Enteroscopic view showing the small hole indicating the HJ site (B). Fluoroscopic (C) and enteroscopic (D) exam showing balloon dilatation of the HJ stricture site. Fluoroscopic (E) and enteroscopic (F) exam showing plastic stenting into the biliary tree.

overtube through the aperture as previously described by Itoi *et al.*⁴ (Fig. 3).

Selective biliary cannulation was tried with a catheter (MTW Endoskopie Manufaktur, Wesel, Germany) using the wire-guided cannulation method. If selective biliary cannulation failed, precut technique with a needle knife (Microknife XL; Boston Scientific, Marlborough, MA, USA) was performed after a 5-F 3- to 4-cm plastic stent was deployed into the pancreatic duct. Endoscopic papillary balloon dilatation (CRE esophageal/pyloric or colonic; Boston Scientific) or endoscopic sphincterotomy was performed using a Billroth-II papillotome (MTW Endoskopie Manufaktur) to achieve effective ampullary intervention. To remove bile duct stones, basket catheter, retrieval balloon catheter, and/or mechanical lithotripter were used. A plastic stent (5 to 7 F) was deployed into the bile duct whenever further biliary drainage was needed. If SBE-ERCP failed, percutaneous transhepatic biliary drainage or surgical treatment was performed.

3. Definitions

Intubation success was defined as success in reaching AOV or bilioenteric anastomosis. Cannulation success was defined as successful cannulation into the bile duct to obtain a cholangiogram. Therapeutic success was defined

Fig. 3. Modification of overtube. An aperture was made on the overtube at a point 100 cm from its tip to enable the insertion of a conventional gastroscope.

as the ability to provide successful intervention including removal of bile duct stones and effective biliary drainage.

Intubation time was measured from the time of inserting the SBE through the mouth to the time of reaching AOV or bilioenteric anastomosis. Scope exchange time was measured from the time of withdrawing the SBE to inserting the gastroscope through the overtube to reach AOV or bilioenteric anastomosis. Intervention time was

measured from the time of attempting to perform cannulation at the AOV or bilioenteric anastomosis to the end of the therapeutic procedure. Total procedure time was measured from the time of inserting the SBE through the mouth to the time of completely removing the scope out of the mouth.

Adverse events related to SBE-ERCP included bleeding, perforation, pancreatitis, asymptomatic hyperamylasemia, cholangitis, and death. Severity of adverse events was evaluated in accordance with the American Society for Gastrointestinal Endoscopy severity grading system.⁵ Bleeding event was defined as bleeding that required intervention (endoscopic, angiographic, or surgical) or blood transfusion. Post-ERCP pancreatitis was defined as the presence of two of the following three criteria: (1) typical pancreatic pain persisting over 24 hours; (2) elevation of serum amylase exceeding three times the upper limit of normal within 24 hours after ERCP; and (3) evidence of pancreatitis in abdominal imaging studies. Asymptomatic hyperamylasemia was defined as elevation of serum amylase without abdominal pain and evidence of pancreatitis in abdominal imaging studies. Cholangitis was defined as right upper quadrant pain with fever $>38.5^{\circ}\text{C}$ and elevation of white blood cell count $>10 \times 10^9/\text{L}$ without other infection focus within 24 hours after ERCP.

4. Statistical analysis

Statistical analysis was performed using the chi-square test or the Fisher exact test to compare categorical variables. One-way analysis of variance was used to compare means of age, intubation time, scope exchange time, intervention time, and total procedure time. Univariate analysis followed by multivariate logistic regression analysis was used to identify potential factors for successful cannulation and therapy. A p -value <0.05 was regarded as statistically significant. All statistical analyses were performed using IBM-SPSS software version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS

1. Baseline characteristics

A total of 56 patients with SAA underwent SBE-ERCP procedures between February 2019 and October 2020. Surgical methods included 13 B-II with various reconstructions (11 REY anastomosis, one Braun anastomosis, and one intestinal adhesion), six PPPD, four REY HJ, and 33 TG REY (Fig. 4). A total of 152 patients with B-II underwent ERCP with conventional methods during the study period and 13 patients (8.6%) experienced intubation failure with a gastroscope or a pediatric colonoscope. Forty-four patients (78.6%) were males and 12 patients were females. The mean age of patients was 70.4 years (range, 46 to 88 years). Indications of SBE-ERCP included choledocholithiasis ($n=42$), papillary stenosis ($n=3$), anastomotic stricture ($n=8$), CBD cancer ($n=1$), recurrent cancer after PPPD ($n=1$), and bile leakage after cholecystectomy ($n=1$). Demographic characteristics of subjects are shown in Table 1.

2. Outcomes of ERCP

Results of SBE-ERCP procedures are summarized in Table 2. The overall success rate was 89.3% (50/56) for intubation, 62.5% (35/56) for scope exchange, 82.1% (46/56) for cannulation, and 82.1% (46/56) for therapeutic intervention. According to structural anatomy, intubation success rate was 100% (13/13) for B-II, 83.3% (5/6) for PPPD, 75% (3/4) for REY HJ, and 87.9% (29/33) for TG REY ($p=0.44$). Cannulation success rate was 92.3% (12/13) for B-II, 83.3% (5/6) for PPPD, 75% (3/4) for REY HJ, and 78.8% (26/33) for TG REY ($p=0.73$). Therapeutic success was achieved for all cases if cannulation was successful.

Failed intubation occurred in six patients. Reasons for failed intubation were severe adhesion ($n=4$), intestinal perforation ($n=1$), and paradoxical reaction to sedative agents ($n=1$). Therapeutic failure after successful intubation occurred in one case with B-II REY anastomosis and three

Fig. 4. Flowchart of our study.

ERCP, endoscopic retrograde cholangiopancreatography; STG, subtotal gastrectomy; B-II, Billroth II anastomosis; PPPD, pylorus-preserving pancreaticoduodenectomy; REY, Roux-en-Y; HJ, hepaticojejunostomy; TG, total gastrectomy.

cases with TG REY due to failure of bile duct cannulation.

Overall mean intubation time was 20.43 minutes (range, 2 to 109 minutes). The mean intubation time was the longest in patients with REY HJ, followed by TG REY and PPPD, and the shortest in B-II ($p=0.03$). The rate of successful scope exchange after successful intubation was 84.6% (11/13) for B-II, 0% (0/5) for PPPD, 0% (0/3) for REY HJ, and 82.8% (24/29) for TG REY ($p<0.001$). Successful scope exchange rate after successful intubation was significantly higher in native papilla (B-II and TG REY, 83.3%, 35/42) compared to bilioenteric anastomosis (PPPD and REY HJ, 0%, 0/8, $p<0.001$). The reason for failure of scope exchange was fixation with intestinal adhesion in 15 cases (one in B-II, one in B-II REY, five in PPPD, three in REY HJ, and five in TG REY). Overall mean scope exchange time was 6.29 minutes (range, 2 to 22 minutes). Overall mean intervention time was 22.27 minutes (range, 5 to 61 minutes). The mean scope exchange time and mean intervention time were not significantly different according to structural anatomies. Overall mean total procedural time was 45 minutes (range, 9 to 149 minutes). The mean total procedural time according to

structural anatomy was the longest for REY HJ, followed by PPPD, B-II, and TG REY ($p=0.02$).

Therapeutic interventions performed included precut ($n=7$), fistulotomy ($n=9$), endoscopic sphincterotomy ($n=2$), endoscopic papillary balloon dilatation ($n=28$), stone extraction ($n=35$), biliary stenting ($n=32$), pancreatic stenting ($n=12$), endoscopic nasobiliary drainage ($n=1$), and biopsy ($n=6$). Cannulation success rate after successful intubation was compared between native AOV and bilioenteric anastomosis. Successful intubation was achieved in 42 patients with native papilla and eight patients with bilioenteric anastomosis. Cannulation success rate was 82.6% (38/42) for native AOV compared to 100% (8/8) for bilioenteric anastomosis, showing no statistically significant difference between them ($p=0.36$). However, the rate of successful cannulation without precut access was significantly lower for native AOV than for bilioenteric anastomosis (57.9% vs 100%, $p=0.02$). Nevertheless, there was no significant difference in the intervention time or the complication rate between native AOV and bilioenteric anastomosis.

Table 1. Baseline Characteristics of the Enrolled Patients

Characteristics	STG B-II with variations	PPPD	REY HJ	TG REY	p-value
Procedures	13 (11 REY, 1 B-II Braun, 1 B-II with adhesion)	6	4	33	
Age, yr	73.5 (46–86)	71.0 (51–82)	66.8 (59–76)	69.6 (50–88)	0.68
Male sex	9 (69.2)	3 (50.0)	4 (100)	28 (63.6)	0.14
Indications					<0.001
Cholelithiasis	11	0	0	31	
Papillary stenosis	2	0	0	1	
Anastomotic stricture	0	6	2	0	
CBD cancer	0	0	1	0	
Recurrent cancer after PPPD	0	0	0	1	
Bile leakage after cholecystectomy	0	0	1	0	

Data are presented as mean (range) or number (%).

STG, subtotal gastrectomy; B-II, Billroth II anastomosis; PPPD, pylorus-preserving pancreatoduodenectomy; REY, Roux-en-Y; HJ, hepaticojejunostomy; TG, total gastrectomy; CBD, common bile duct.

Table 2. Outcomes of Enteroscopy-Assisted Endoscopic Retrograde Cholangiopancreatography

Variable	STG B-II with variations (n=13)	PPPD (n=6)	REY HJ (n=4)	TG REY (n=33)	p-value
Intubation success	13 (100)	5 (83.3)	3 (75.0)	29 (87.9)	0.44
Reasons for intubation failure	-	1 Adhesion	1 Adhesion	1 Perforation, 1 paradoxical reaction to sedatives, 2 adhesion	
Cannulation success	12 (92.3)	5 (83.3)	3 (75.0)	26 (78.8)	0.73
Therapeutic success	12 (92.3)	5 (83.3)	3 (75.0)	26 (78.8)	0.73
Intubation time, min	15.9 (2–27)	19.0 (11–32)	43.0 (15–109)	19.7 (7–62)	0.03
Scope exchange after successful intubation	11 (84.6)	0	0	24 (82.8)	<0.001
Scope exchange time, min	5.8 (3–13)	-	-	6.5 (2–22)	0.69
Intervention time, min	24.5 (12–61)	28.6 (21–37)	19.7 (12–24)	20.4 (5–33)	0.31
Total procedure time, min	45.2 (21–87)	47.6 (35–69)	81.3 (40–149)	41.2 (9–85)	0.02

Data are presented as number (%) or mean (range).

STG, subtotal gastrectomy; B-II, Billroth II anastomosis; PPPD, pylorus-preserving pancreatoduodenectomy; REY, Roux-en-Y; HJ, hepaticojejunostomy; TG, total gastrectomy.

Table 3. Univariate Analysis of Potential Factors for Successful Cannulation

Factor	Cannulation success (n=46)	Cannulation failure (n=4)	Univariate analysis p-value
Age, yr	69.9±11.7	77.3±9.2	0.23
Sex, M/F	35/11	3/1	0.96
Type of surgery, STG with B-II/PPPD/REY HJ/TG REY	12/5/3/26	1/0/0/3	0.82
Scope exchange, yes/no	34/12	1/3	0.04
Native AOV, yes/no	38/8	4/0	0.36

Data are presented as mean±SD or number.

M, male; F, female; STG, subtotal gastrectomy; B-II, Billroth II anastomosis; PPPD, pylorus-preserving pancreaticoduodenectomy; REY, Roux-en-Y; HJ, hepaticojejunostomy; TG, total gastrectomy; AOV, ampulla of Vater.

Table 4. Univariate Analysis of Potential Factors for Successful Therapy

Factor	Therapeutic success (n=46)	Therapeutic failure (n=10)	p-value
Age, yr	69.87±11.71	73.0±10.74	0.44
Sex, M/F	35/11	9/1	0.33
Type of surgery, STG with B-II/PPPD/REY HJ/TG REY	12/5/3/26	1/1/1/7	0.73
Intubation success, yes/no	46/0	6/4	<0.001
Scope exchanges, yes/no	34/12	1/9	<0.001
Cannulation success, yes/no	46/0	10/0	<0.001
Native AOV, yes/no	38/8	8/2	0.85

Data are presented as mean±SD or number.

M, male; F, female; STG, subtotal gastrectomy; B-II, Billroth II anastomosis; PPPD, pylorus-preserving pancreaticoduodenectomy; REY, Roux-en-Y; HJ, hepaticojejunostomy; TG, total gastrectomy; AOV, ampulla of Vater.

Because successful cannulation is a prerequisite to therapeutic success, factors affecting cannulation success were evaluated (Table 3). In the univariate analysis, age, gender, type of surgery, and native AOV failed to show significant relationship with procedural success. However, scope exchange was significantly associated with cannulation success ($p=0.02$). Potential factors for successful therapy were evaluated (Table 4). In the univariate analysis, age, sex, type of surgery, and native AOV failed to show significant association with therapeutic success. However, intubation success, scope exchange, and cannulation success were significantly related to therapeutic success ($p<0.001$).

3. Adverse events of SBE-ERCP

Adverse events occurred in six of 56 patients (10.7%). One case of perforation occurred in TG REY that required surgical repair of intestinal perforation and biliary stone removal. Asymptomatic hyperamylasemia occurred in five cases (two in B-II, three in TG REY). There were no other complications including bleeding, post-ERCP pancreatitis, or procedure-related deaths.

DISCUSSION

Recently, endoscopic ultrasound-guided interventions, rendezvous technique for percutaneous transhepatic biliary drainage, and laparoscopy-assisted ERCP have shown promising results for patients with SSA. However, enteros-

copy-assisted ERCP remains the first treatment modality for these patients because it is considered as less invasive to these procedures.

In our study, we evaluated the feasibility and safety of scope exchange during SBE-ERCP in patients with SAA. A total of 56 patients undergoing SBE-ERCP procedures were included. The overall success rate was 89.3% for intubation, 82.1% for cannulation, and 82.1% for therapeutic intervention. One meta-analysis of SBE-ERCP including 461 patients reported an intubation success rate of 80.9%, a cannulation success rate of 69.4%, and a therapeutic success rate of 61.7%.⁶ The relatively high success rates in our study may be attributable to the use of a transparent cap in all procedures. Trindade *et al.*⁷ reported high rates of cannulation and therapeutic success for SBE-ERCP using a cap (intubation success rate, 87.5%; cannulation success rate, 78.6%; and therapeutic success rate, 71.4%). In other studies without using a cap for SBE-ERCP in 211 patients, overall cannulation success and therapeutic success rates were lower (56% and 55%, respectively).⁸⁻¹²

There are three major hurdles to complete enteroscopy-assisted ERCP: (1) reaching AOV or bilioenteric anastomosis through a long afferent limb with or without angulation and adhesion; (2) biliary cannulation through an intact inverted AOV; and (3) effective ampullary intervention. A transparent cap is useful both for overcoming a long and tortuous afferent limb and for reaching AOV or bilioenteric anastomosis by allowing a suitable visual area, keeping distance from intestinal mucosa, and retracting

mucosal folds. In patients with B-II or TG REY, it is very difficult to achieve successful biliary cannulation because of several reasons, including the position of AOV that may vary widely in the field of view, bile duct that courses in the inverted direction, and periampullary diverticula that distort the location and course of AOV. Lack of an elevator on the enteroscope is another limitation. A transparent cap is useful for fixing the ampulla and aligning the axis of the cannula with that of the bile duct, thus enabling easier cannulation.^{7,13}

With regard to structural anatomy, no significant difference was observed in the therapeutic success rate among different types of surgery (B-II, 92.3%; PPPD, 83.3%; REY HJ, 75%; and TG REY, 78.8%; $p=0.73$). In a systematic review by Skinner *et al.*,² therapeutic success rates were 90% (45/50) in B-II, 76% (184/242) in PPPD or REY HJ, and 70% (187/266) in REY gastric bypass. Although statistical significance was not found, there was a trend of higher therapeutic success rate in B-II in our study. Statistical significance may not have been found in our study because of the small number of patients included.

Previously, native AOV was considered as one of major obstacles in enteroscopy-assisted ERCP.^{10,11} In our study, there was no significant difference in the cannulation success rate between native AOV and bilioenteric anastomosis (82.6% vs 100%, $p=0.36$). Results from a systematic evaluation of cannulation attempts for 274 patients with a native AOV and 270 with anastomoses also showed similar cannulation success rates (88% vs 92%).² However, cannulation rates without precut access differed significantly between native AOV and bilioenteric anastomosis, with native AOV needing precut access with or without pancreatic stenting more frequently (42.1% vs 0%, $p=0.02$). Although there was no difference in adverse events in relation to these procedures or in intervention time between native AOV and bilioenteric anastomosis, non-standard cannulations were considered more stressful than standard cannulation in our experience, especially with the lack of an elevator and the bile duct in the inverted direction.

Itoi *et al.*⁴ have reported that the endoscopic exchange technique can achieve good results in patients with B-II or REY anastomosis, with intubation success rate of 92.3% (12/13) and therapeutic success rate of 76.9% (10/13). As long length ERCP accessories are not commercially available in Korea, we tried to use this technique first when AOV or bilioenteric anastomosis was found. However, endoscopic exchange was not feasible in PPPD or REY HJ compared to possible scope exchange rate of 84.6% in B-II and 72.7% in TG REY ($p<0.001$). Reasons for endoscopic exchange impossibility were mostly intestinal adhesion and fixation.

Notably, cannulation success was directly related to therapeutic success (i.e., cannulation success led to 100% therapeutic success). Therefore, we evaluated factors for successful cannulation. In univariate analyses, scope exchange was the only factor associated with successful cannulation. This finding was not surprising because when endoscopic exchange was not feasible, we had to use self-assembled accessories or those for colonoscopic usage instead of dedicated ERCP accessories.

Currently, there are several types of DAEs, including SBE, double balloon enteroscopy (DBE), and spiral enteroscopy. Until now, there appears to be no difference in the success rate of ERCP across the three enteroscopy methods.^{2,11} DBE-ERCP has been studied most extensively since it is the first available DAE. However, these studies mainly involved retrospective analyses. Success rates of long and short DBE systems have been reported to be similar: 74% to 100% for intubation, 85% to 100% for cannulation, and 81% to 100% for therapeutic intervention.¹³⁻¹⁷ SBE-ERCP has been reported to have similar intubation success rates of 75% to 100% as DBE-ERCP and similar cannulation and therapeutic success rates (76% to 100%, and 60% to 100%, respectively) as other types of enteroscope.^{10,18-21} However, data on SBE-ERCP are less robust, with intubation success rate of 72%, cannulation success rate of 90%, and overall therapeutic success rate of 65% in a previous study.¹¹ DBE and SBE have similar adverse event rates,² although SBE is considered less technically demanding than DBE. Also, total procedure time for SBE-ERCP ranged from 15 to 212 minutes compared to 30 to 240 minutes for DBE-ERCP.²² Therefore, SBE has the potential to become the standard of procedure for patients with SAA.

In our study, adverse events occurred in 10.7% (6/56) of procedures. Most of these adverse events were mild. However, one case (1.8%) of perforation occurred in TG REY. It required surgical treatment. Previous studies demonstrated that the overall rate of adverse events ranged from 0% to 19.5% in enteroscopy-assisted ERCP cases.²³ In a systematic review of ERCP with the overtube-assisted enteroscopy technique, major complication rate was 3.4% and perforation was the most common.² Perforations might occur at different levels during the insertion or the shortening of loops, leading to intraperitoneal or retroperitoneal free air. Sharply angulated anastomoses or postoperative adhesion might cause perforation of the intestine. Perforation might also occur while manipulating devices at the AOV because of the inverted biliary direction at the AOV and an unstable position with a forward-viewing endoscope. In our study, perforation occurred while shortening of the loop. The patient complained of sudden abdominal pain. Perforation was noted in the view field. Fortunately, the patient

recovered well after surgical treatment. However, endoscopists should always bear in mind that perforation is one of the most common adverse events during enteroscopy-assisted ERCP. Thus, extra attention is needed to avoid this potentially lethal adverse event.

Limitations of this study include its retrospective design, limited number of patients, heterogeneity of patients included in this study, and the analysis of data from only a single medical center. However, to the best of our knowledge, this was the largest study that evaluated roles of SBE-ERCP and endoscopic exchange technique in various SAAs.

In conclusion, SBE-ERCP is a safe and effective endoscopic method to treat biliary problems in patients with SAA. Scope exchange technique appears to be feasible and effective in patients with B-II and TG REY, but not in PPPD or REY HJ. Possible scope exchange is a key factor for successful cannulation and subsequent therapeutic success. Further studies comparing the short enteroscopic system with the endoscopic exchange technique in patients with B-II and TG REY are warranted. In addition, prospective or larger multicenter studies comparing the therapeutic success rate of the short enteroscopic system with the long enteroscopic system in patients with PPPD and REY HJ procedures are needed.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

AUTHOR CONTRIBUTIONS

Conceptualization: C.H.P. Data curation: E.C., Y.K., S.Y.C. Formal analysis: E.C. Writing - original draft: E.C. Writing - review & editing: C.H.P. Approval of final manuscript: all authors.

ORCID

Eunae Cho <https://orcid.org/0000-0001-5931-4643>
Chang Hwan Park <https://orcid.org/0000-0002-2995-8779>
Youngjung Kim <https://orcid.org/0000-0003-4571-6021>
Seo Yeon Cho <https://orcid.org/0000-0003-0779-394X>

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