

# Endoscopic retrograde cholangiopancreatography with double balloon enteroscope in patients with altered gastrointestinal anatomy: A meta-analysis

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## Abstract

**Background/Aims:** The aim of this study was to evaluate the effectiveness and safety of endoscopic retrograde cholangiopancreatography with double balloon enteroscope (DBE-ERCP) in patients with altered gastrointestinal anatomy in a meta-analysis.

**Materials and Methods:** A comprehensive literature search was conducted on PubMed, EMBASE, and Cochrane library covering the period from January 2001 to December 2015. Data were selected and abstracted from eligible studies and were pooled using a random-effects model. Heterogeneity was assessed using the  $I^2$  test.

**Results:** Ten studies involving a total of 301 patients were included in the analysis. The pooled enteroscopy, diagnostic, and therapeutic success rates were 89.75% [95% confidence interval (CI): 79.65–94.30%], 79.92% (95% CI: 68.06–89.59%), and 63.55% (95% CI: 53.70–72.86%), respectively. DBE-ERCP-related complications occurred in 18 patients including perforation (5), pancreatitis (3), cholangitis (9), and bleeding (1). The incidence of DBE-ERCP-related complication was 6.27% (95% CI: 2.61–11.38%).

**Conclusion:** Diagnostic and therapeutic DBE-ERCPs are feasible in patients with altered gastrointestinal anatomy. DBE-ERCP may be considered when pancreaticobiliary diseases occur in patients undergoing Roux-en-Y reconstruction or pancreaticoduodenectomy.

**Keywords:** Double balloon enteroscope, endoscopic retrograde cholangiopancreatography, gastrointestinal reconstruction, pancreaticobiliary disease

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## INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP) is an important procedure in the management of pancreaticobiliary disorders. This procedure is widely used for treating pancreaticobiliary disorders with a success rate of approximately 90–95% in patients with normal gastric and pancreaticoduodenal anatomy. In

many medical units, ERCP is commonly performed as an initial attempt to manage postoperative disorders prior to percutaneous drainage and reoperation. More patients with surgically altered bowel anatomy are being referred for ERCP owing to a rise in application of bariatric surgery, surgical interventions of pancreaticobiliary lesions, and liver transplantation. However, in patients with altered

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anatomy due to previous abdominal surgery, ERCPs are technically difficult and often unsuccessful. Patients with Billroth II reconstruction may undergo successful ERCP with standard duodenoscope or gastroscope, however, patients with Roux-en-Y reconstruction or pancreaticoduodenectomy (PD) tend to have longer afferent limb and have failed ERCP with conventional endoscopes. Patients with surgically altered anatomy have lower ERCP success rates compared with patients with normal anatomy.<sup>[1,2]</sup> ERCP success rates are as low as 51% in patients with prior PD.<sup>[3]</sup> After an extensive resective surgery involving hepatobiliary or gastroduodenal segments, a Roux-en-Y anastomosis is usually established. It is a challenge to get access to bile or pancreatic duct in patients with Roux-en-Y anastomosis and pancreaticobiliary diseases because of the altered anatomy. Initially, side-viewing duodenoscopes, forward-viewing push enteroscopes, and colonoscopies were used to perform ERCP in patients with long limb surgical bypass. Success rate is low because of the inability to reach the papilla or anastomosis through the long limb after digestive tract reconstruction.<sup>[4-8]</sup> Conventional endoscopic access to the afferent limb and papilla or bilioenteric/pancreaticoenteric anastomoses is extremely difficult because of various lengths of bowel, angulation of jejunal loops, and postoperative strictures. Reported success rates of ERCPs in Roux-en-Y gastrojejunostomies ranged from 33% to 67% accompanied by high complication rates.<sup>[1,2,9]</sup>

In the past, postoperative problems occurring at bilioenteric/pancreaticoenteric anastomosis or other excluded segments were often dealt with percutaneously or surgically. Reported success rates of treatment for postoperative bile duct stenosis by percutaneous transhepatic cholangiography (PTC) were 55–95%.<sup>[10-12]</sup> The long-term effect of percutaneous treatment of hepaticojejunostomy (HJ) anastomotic stenosis does not seem to be satisfactory because the recurrence rate was 27% over 30 months of follow-up.<sup>[13]</sup> Percutaneous transhepatic biliary drainage has a high complication rate of 4–9%.<sup>[14,15]</sup> In reports on PTC for postoperative bile duct stenosis, the complication rates were as high as 11–35%.<sup>[16-20]</sup> PTC may be impossible due to the absence of dilated intrahepatic ducts. In addition, this procedure is contraindicated in patients with ascites or compromised coagulation and does not allow access to the pancreatic duct system.<sup>[21]</sup> ERCP via gastrostomy is more invasive than other purely endoscopic approaches and is associated with risks related to anesthesia and surgery.<sup>[22]</sup> This procedure is not suitable in acute settings because of the need for a matured gastrostomy tract to perform ERCP. ERCP performed with laparoscopic transgastric and intraoperative transjejunal approaches was

reported.<sup>[23,24]</sup> Overall, the laparoscopy-assisted route carries a higher technical success rate (94–100%), however, it also carries morbidity related to the surgical component and a higher cost.<sup>[25]</sup> Surgical re-anastomosis can treat patients with postoperative bile duct stenosis with a success rate of 71–91%.<sup>[26]</sup> However, reoperations are often technically difficult and mean prolonged hospitalizations. Surgery may lead to more relapse in new anastomosis compared with previous HJ anastomosis.<sup>[27]</sup> Open surgery brings about greater morbidity, longer hospitalization, and increased costs compared with other less invasive methods. In reports on surgical treatment for postoperative stenotic choledochojejunal anastomosis, complication rates were 20–33%.<sup>[28,29]</sup>

Double balloon enteroscopy (DBE) is an effective modality to achieve deep intubation in small intestine. Since its introduction in 2001, DBE has rapidly evolved to achieve complete visualization of the small bowel. DBE is mainly used to diagnose or treat small intestine lesions such as bleeding, tumor, and stricture. Now with the development of devices and the improvement of technique, DBE is used to perform some interventions including polypectomy, dilation, argon plasma coagulation, and stenting. The first DBE-ERCP was reported in 2005 by Haruta who performed ERCP and treated anastomotic stricture in a patient with Roux-en-Y anastomosis.<sup>[30]</sup> Subsequent reports suggested that DBE was useful in ERCP in patients with altered gastrointestinal anatomy.<sup>[31-37]</sup> Most of the studies on the effectiveness of DBE-ERCP have been limited to a small number of patients. These studies showed the feasibility of the procedure, however, data on the overall success and complication rate of DBE-ERCP are scarce. The outcome of DBE-ERCP may be associated with enteroscopes used, previous operation, intact papilla or bilioenteric anastomosis, and the intervention attempted. Long type DBE can reach papilla or anastomosis with higher success rate, but precludes the use of many standard ERCP devices. DBE-ERCP requires high expertise and is not a routine procedure now. Further improvement of outcome and development of accessory devices are needed. The purpose of this study was to evaluate the effectiveness and safety of DBE-ERCP in patients with altered gastrointestinal anatomy by pooling all available evidence with a meta-analysis.

## MATERIALS AND METHODS

### Literature search

A comprehensive literature search was conducted using PubMed, EMBASE, and Cochrane Library for the period from January 2001 to December 2015. The search

terms included, in different combinations “endoscopic retrograde cholangiopancreatography,” “double balloon enteroscopy,” “endoscopic retrograde cholangiography,” “balloon-assisted enteroscope,” and “endoscopic retrograde pancreatography.” The search was limited to studies in humans published in English. References of eligible articles and review articles were manually searched.

### Selection of articles

The selection criteria were studies in (1) patients with surgically long afferent limb including Roux-en-Y reconstruction and PD with Child or Whipple procedure; (2) patients undergoing DBE-ERCP due to pancreaticobiliary problems; and (3) series that included at least 10 patients. Case reports or series with fewer than 10 patients were excluded. Studies involving DBE-ERCP performed in patients with Billroth II anatomy were excluded because these patients have a relatively high success rate of ERCP with conventional endoscopes. After excluding duplicate articles, article titles and abstracts were screened by a reviewer (SXD). Each eligible article was reviewed in full text.

### Data extraction

Data was extracted by the same reviewer and entered into an Excel spreadsheet (Microsoft Corp, Redmond, Washington). The following information was extracted from each study: author, country, publication year, publication type, study design, participants, indication of ERCP, and outcome of interest (success rate of enteroscopy, success rate of diagnostic ERCP, success rate of therapeutic ERCP, duration of procedure, and procedure-related complications).

### Definitions

*Success of enteroscopy:* The afferent limb and papilla or bilioenteric/pancreaticoenteric anastomoses were successfully reached by using DBE.

*Success of diagnostic ERCP:* Selected cannulation into bile duct or pancreatic duct was achieved and cholangiogram or pancreatogram was clearly presented resulting in a diagnosis.

*Success of therapeutic ERCP:* Intended endoscopic interventions were successfully performed by using DBE-ERCP including stent insertion/removal, stone extraction, pancreaticobiliary duct dilation, sphincterotomy, and anastomosis stricturoplasty.

*DBE-ERCP-related complications:* DBE-ERCP-related complications include cholangitis, pancreatitis, bleeding, and perforation, which need further specific treatment.

### Statistical analysis

Data from eligible studies were pooled using a random-effects model with StatsDirect statistical software Version 2.7.8 (StatsDirect Ltd, Sale, Cheshire, UK). Outcomes are expressed as proportions (percentages) with 95% confidence intervals (CIs). The pooled analyses are presented as forest plots. Statistical heterogeneity between studies was assessed using the Cochran Q test and the  $I^2$  statistic. An  $I^2$  value of greater than 50% or a  $P$  value of less than 0.05 for the Q statistic was taken to indicate significant heterogeneity.

## RESULTS

### Literature search results

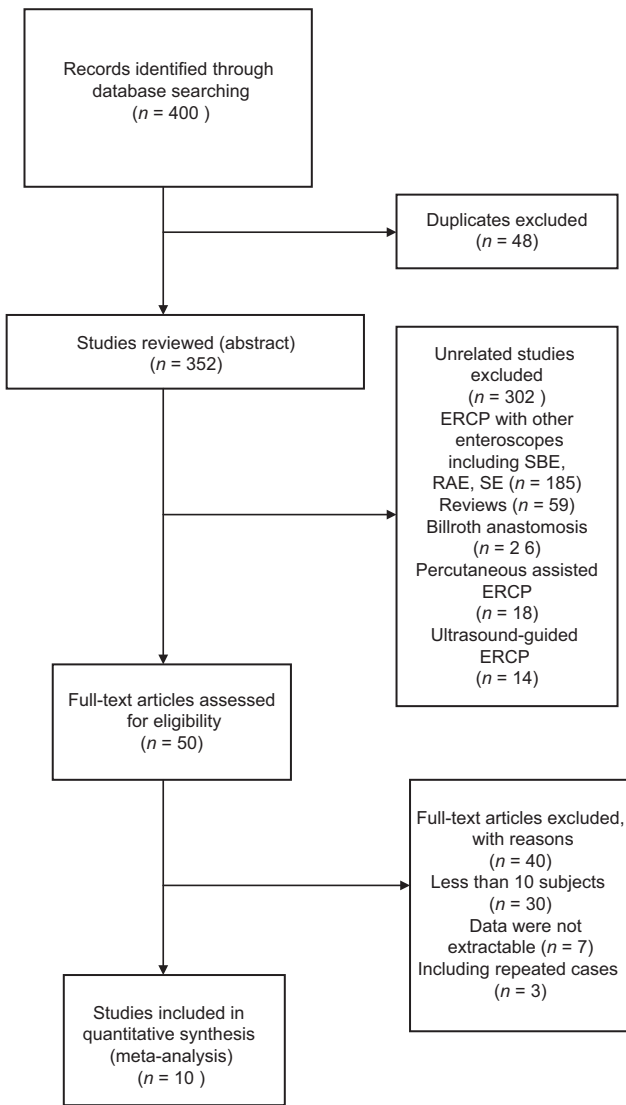
Ten studies involving a total of 301 patients were included in the analysis. Thirty studies were excluded because each had a small number of study subjects (less than 10). Figure 1 summarizes the results of the literature search. Table 1 summarizes the characteristics of the 10 eligible studies.

### Characteristics of study

In the 10 studies, a total of 301 patients underwent DBE-ERCP. All studies were conducted between 2007 and 2015. Half of the studies were performed in Europe (5/10), followed by Japan (3/10) and the United States (2/10). The surgical procedures that the patients underwent included Roux-en-Y reconstruction (for orthotopic liver transplantation, gastric bypass, and HJ) and PD with Whipple or Child resection. The most common indications for DBE-ERCP included stricture of biliary/pancreatic duct or bilioenteric/pancreaticoenteric anastomosis, cholelithiasis, cholangitis, pancreaticobiliary pain, and abnormal liver function tests (LFTs). Table 2 shows the results of the various outcomes of the individual studies.

### Success of enteroscopy

The enteroscopy success rates among the studies ranged from 69% to 100%. The pooled success rate of enteroscopy was 89.75% (95% CI: 79.65–94.30%) [Figure 2]. Heterogeneity was significant among the studies ( $I^2 = 73\%$ ;  $P = 0.0001$ ). In the study by Aabakken *et al.* in which the enteroscopy success rate was 100%, most of the patients (10/13) had Roux-en-Y anatomy due to liver transplantation and were treated with long type DBE. In the study by Choi *et al.* with an enteroscopy success rate of 75%, all patients had bariatric Roux-en-Y gastric bypass (RYGB) surgery and underwent ERCP with short type DBE. The causes of failed enteroscopy included (1) strong postsurgical adhesions; (2) scope malfunction; (3) lots of food in gastrointestinal tract; (4) acute angulation of anastomosis; and (5) malignant intestinal obstruction.



**Figure 1:** Study selection flow chart. Of a total of 400 studies only 10 studies met selection criteria. SBE: Single balloon enteroscope; RAE: Rotational overtube-assisted enteroscope; SE: Spiral enteroscope

### Success of diagnostic endoscopic retrograde cholangiopancreatography

As shown in Table 2, the success rate of diagnostic ERCP ranged from 57% to 99%. The pooled success rate of diagnostic ERCP was 79.92% (95% CI: 68.06–89.59%) [Figure 3]. Heterogeneity was significant among the studies ( $I^2 = 81.5\%$ ;  $P < 0.0001$ ). All patients in the study with the highest success rate of diagnostic ERCP had bilioenteric anastomosis without intact papilla. In contrast, the study with the lowest success rate of diagnostic ERCP involved a total of 28 patients who had bariatric RYGB surgery and intact papilla. Diagnostic DBE-ERCP failed because (1) bilioenteric anastomoses or papilla were at inaccessible angles; (2) it was impossible to advance the wire into the common bile duct (CBD) (impacted stone or severe stenosis); (3) papilla or anastomoses were infiltrated

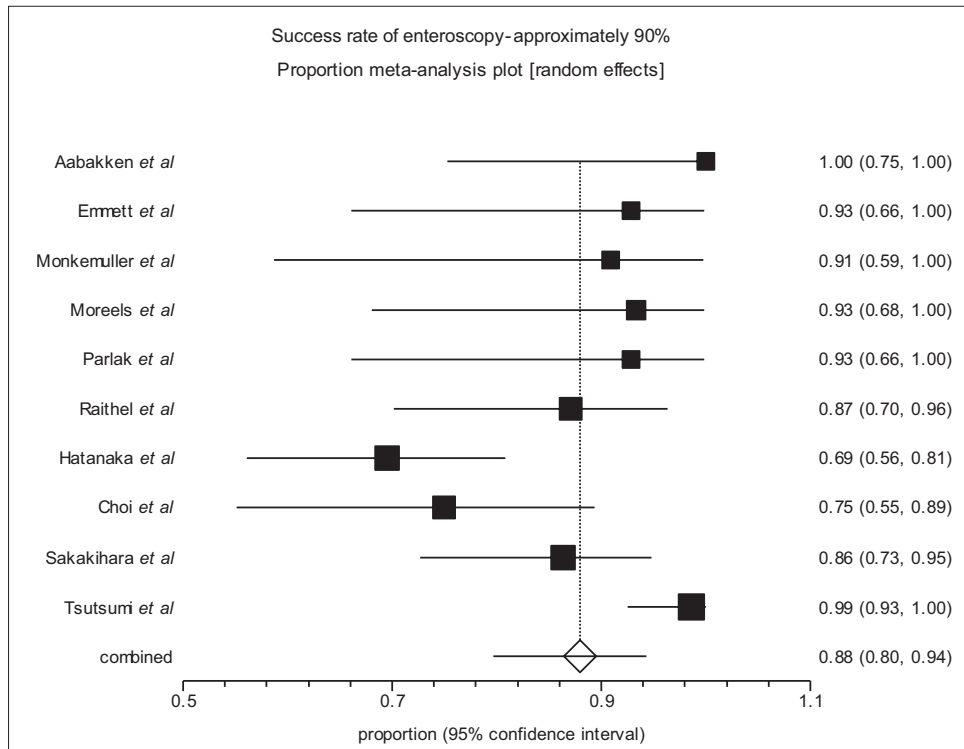
**Table 1: Study characteristics**

Author	Country	Publication year	Publication type	Study design	No. case	Gender (M/F)	Age (years)	Cholangitis	Abnormal LFTs	Pancreatitis	Bile duct stones	Stricture	Bile leak	Pancreaticobiliary pain	Stent/catheter extraction	Itching
Aabakken <i>et al.</i>	Norway	2007	Full text	Retrospective	13	9/4	Median: 53 (2-81)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Emmett <i>et al.</i>	USA	2007	Full text	Retrospective	14	7/7	Mean: 47 (27-73)	2	4	3	0	0	0	5	0	0
Mönkemüller <i>et al.</i>	Germany	2009	Full text	Prospective	11	10/1	Mean: 59.7 (36-77)	2	5	0	1	1	0	1	1	0
Moreels <i>et al.</i>	Belgium	2009	Full text	Retrospective	15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Parlak <i>et al.</i>	Turkey	2010	Full text	Retrospective	14	6/8	Mean: 42 (28-61)	9	2	0	0	1	0	0	1	1
Raihel <i>et al.</i>	Germany	2011	Full text	Retrospective	31	16/15	Mean: 63 (38-84)	7	0	4	5	13	0	2	0	0
Hatanaka <i>et al.</i>	Japan	2012	Abstract	Retrospective	59	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Choi <i>et al.</i>	USA	2013	Full text	Retrospective	28	2/26	Mean: 56.1 (NA)	0	0	0	16	4	2	6	0	0
Sakahihara <i>et al.</i>	Japan	2015	Full text	Retrospective	44	26/18	Mean: 63.5±14.0	0	0	0	0	44	0	0	0	0
Tsutsumi <i>et al.</i>	Japan	2015	Full text	Retrospective	72	44/28	Median: 69 (37-83)	NA	NA	NA	NA	NA	NA	NA	NA	NA

LFTs: Liver function tests

**Table 2: Outcomes of ERCP with DBE**

Author	DBE type	No. case	Anastomosis/intact papilla	Endoscopy success	Diagnostic success	Therapeutic success	Duration of procedure	Complicaiton
Aabakken <i>et al.</i>	Long	13	12/1	13 (100%)	11 (84.62%)	6 (46.15%)	40 min (5-120 min)	0 (0%)
Emmett <i>et al.</i>	Long	14	NA	13 (92.86%)	12 (85.71%)	6 (42.86%)	99±48 min	0 (0%)
Mönkemüller <i>et al.</i>	Long	11	NA	10 (90.91%)	9 (81.82%)	8 (72.73%)	70 min (35-240 min)	1 (9.09%)
Moreels <i>et al.</i>	Long	15	10/5	14 (93.33%)	12 (80.00%)	9 (60.00%)	NA	1 (6.67%)
Parlak <i>et al.</i>	Long	14	13/0	13 (92.86%)	13 (92.86%)	8 (57.14%)	75±62 min	1 (7.14%)
Raithel <i>et al.</i>	Long	31	18/13	27 (87.10%)	23 (74.19%)	21 (67.74%)	111±54 min	5 (16.13%)
Hatanaka <i>et al.</i>	NA	59	NA	41 (69.49%)	37 (62.71%)	34 (57.62%)	NA	0 (0%)
Choi <i>et al.</i>	Short	28	0/28	21 (75.00%)	16 (57.14%)	14 (50.00%)	101.2±36.8 min	1 (3.57%)
Sakakihara <i>et al.</i>	Short	44	44/0	38 (86.36%)	36 (81.82%)	36 (81.82%)	NA	7 (15.90%)
Tsutsumi <i>et al.</i>	Short	72	72/0	71 (98.61%)	71 (98.61%)	59 (81.94%)	50 min (9-167 min)	2 (2.78%)



**Figure 2:** Access to the papilla or bilioenteric/pancreaticoenteric anastomosis in patients with altered anatomy. The DBE successfully reached papilla or bilioenteric/pancreaticoenteric anastomosis in 89.75% (95% CI: 79.65–94.30%) of the 301 patients in the 10 studies. There was significant heterogeneity among the studies ( $P = 0.0001$ )

or covered by tumor; and (4) ostium of anastomosis was not found.

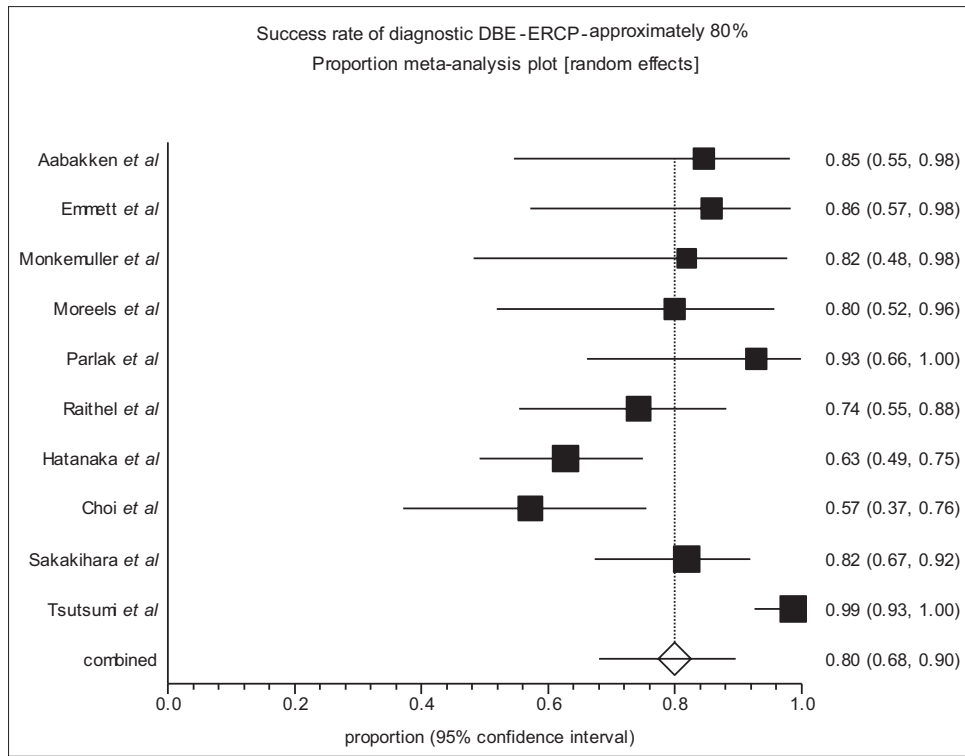
**Success of therapeutic endoscopic retrograde cholangiopancreatography**

The success rate of therapeutic ERCP was 63.55% (95% CI: 53.70–72.86%) [Figure 4]. Heterogeneity was significant among the studies ( $I^2 = 65.2%$ ;  $P = 0.0022$ ). Completed interventions with DBE-ERCP included stent insertion/removal, stone extraction, pancreaticobiliary duct dilation, sphincterotomy, and anastomosis stricturoplasty. The success rate of therapeutic ERCP was 55% in the studies conducted between 2007 and 2010 and 70% in the studies conducted between 2011 and 2015. The studies

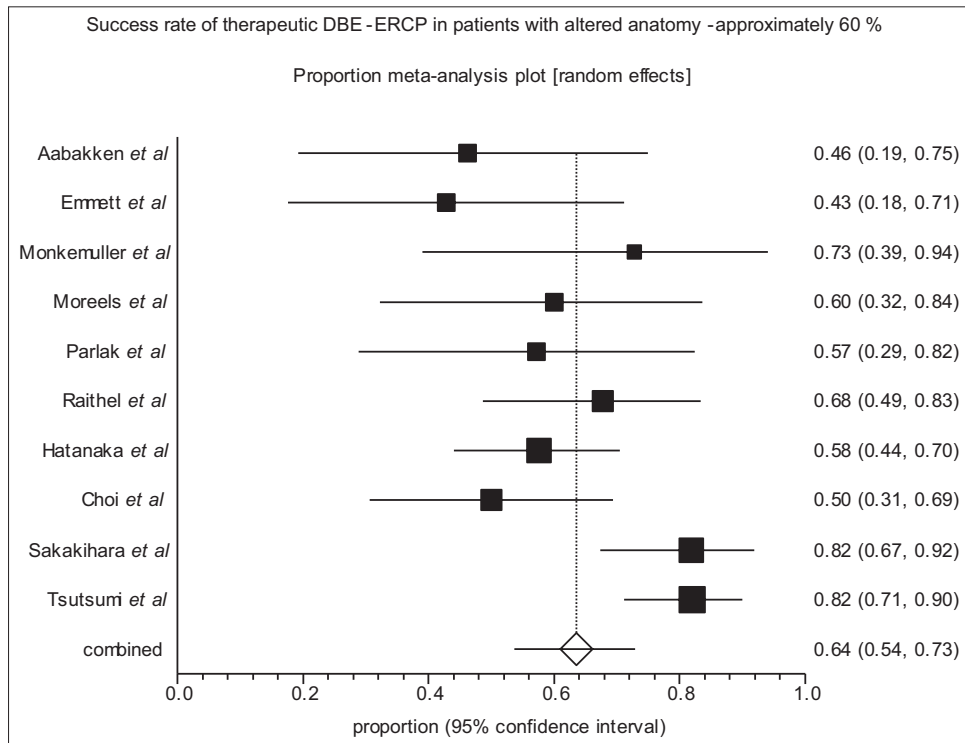
conducted between 2011 and 2015 contained a larger number of cases and started to use short type DBE.

**Double balloon enteroscope-endoscopic retrograde cholangiopancreatography-related complications**

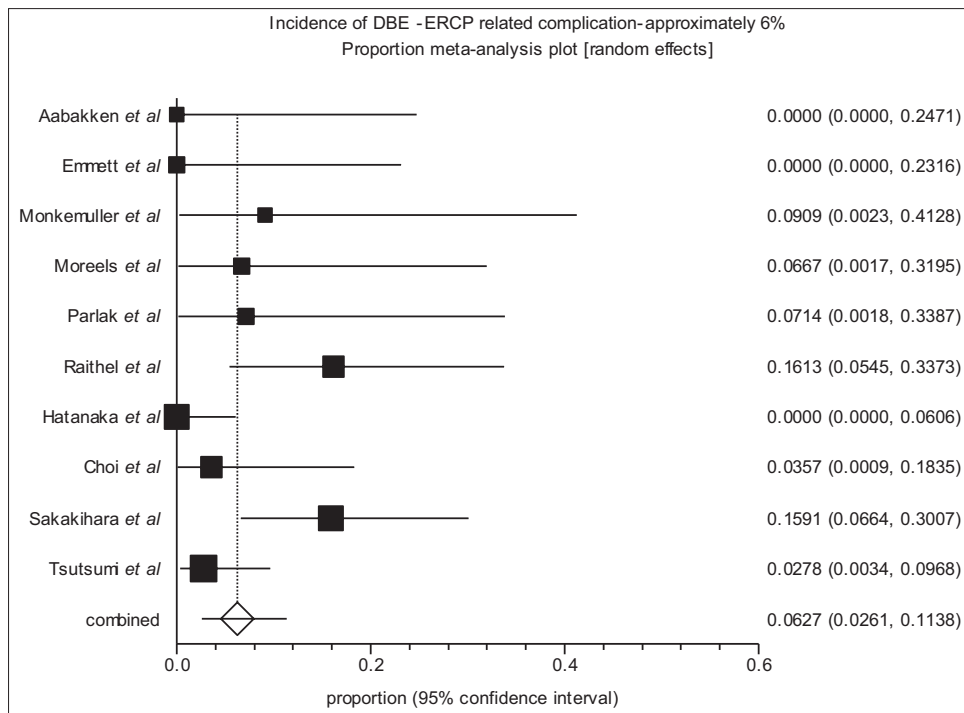
DBE-ERCP-related complications occurred in 18 patients including perforation (5), pancreatitis (3), cholangitis (9), and bleeding (1). The incidence of DBE-ERCP-related complications was 6.27% (95% CI: 2.61–11.38%) [Figure 5]. Heterogeneity was significant among the studies ( $I^2 = 57.6%$ ;  $P = 0.0116$ ). No complications were reported in two studies conducted in 2007, which presented the lowest therapeutic success rate (43% and 46%). There was no death reported in the 10 studies.



**Figure 3:** Diagnostic DBE-ERCP in patients with altered anatomy. Forest plot shows that 79.92% (95% CI: 68.06–89.59%) of the 301 patients in the 10 studies had a successful diagnostic ERCP with DBE. There was evidence of heterogeneity among the studies ( $P < 0.0001$ )



**Figure 4:** Therapeutic interventions completed in patients with altered anatomy with DBE-ERCP. Forest plot shows that 63.55% (95% CI: 53.70–72.86%) of the 301 patients in the 10 studies had successful therapeutic ERCP procedure. There was evidence of heterogeneity among studies ( $P = 0.0022$ )



**Figure 5:** Complication related to DBE-ERCP. Complication was noted in 6.27% (95% CI: 2.61–11.38%) of the 301 patients in the 10 studies. There was evidence of heterogeneity among the studies ( $P = 0.0116$ )

## DISCUSSION

The present pooled analysis shows that bilioenteric/pancreaticoenteric anastomosis or papilla after gastrointestinal reconstruction is accessible with a high success rate and that diagnostic and therapeutic DBE-ERCPs are possible in such cases. In approximately 90% of the cases, bilioenteric/pancreaticotenteric anastomosis or papilla could be reached, identified, and satisfactorily visualized by the use of DBE. Diagnostic DBE-ERCP could be successfully conducted in 80% of the cases, and interventions were successfully completed with DBE-ERCP in 60% of the patients. Complications occurred in 6% of the cases and no death was reported.

Several surgical procedures, including gastric bypass surgery, orthotopic liver transplantation (OLT), HJ with Roux-en-Y anastomosis, and PD with Whipple or Child resection, leave patients with long afferent limb that is excluded from conventional endoscopic access.<sup>[38,39]</sup> In these cases, papilla or bilioenteric/pancreaticoenteric anastomosis is out of the range of standard duodenoscopes. Roux-en-Y anastomosis of the small bowel was first introduced in the 19<sup>th</sup> century.<sup>[40]</sup> Now it is widely used to drain the biliopancreatic system via an afferent limb or to create malabsorption in case of bariatric surgery.<sup>[41]</sup> HJ with Roux-en-Y anastomosis is a method used to resolve surgical bile duct injuries as well as in the surgical treatment of bile duct tumors and in the biliary

anastomosis of OLT. Complications occur in 10–30% of post-OLT patients. The most common complication is biliary tract diseases, including biliary leaks, strictures, and stone diseases.<sup>[42-45]</sup> Some patients with post-OLT complications may need endoscopic interventions. The obesity epidemic and related comorbidities have become a world public health problem.<sup>[46]</sup> Surgery is the most effective method to sustain weight loss, and RYGB is considered the gold standard,<sup>[47]</sup> that is increasingly performed in developed countries.<sup>[48-50]</sup> RYGB surgery is the most commonly performed weight-loss surgery in the United States and accounts for more than 60% of bariatric procedures performed in the United States.<sup>[51]</sup> Patients undergoing bariatric surgery typically have a high prevalence of biliary diseases related to weight loss.<sup>[52]</sup> Thus, more patients may need ERCP via Roux-en-Y limb in future. Traditional ERCP is difficult to perform in these patients because of the altered anatomy. These problems are being addressed by DBE, single balloon enteroscopy (SBE), and spiral endoscope (SE).

DBE was first introduced by Yamamoto *et al.* in 2001,<sup>[53]</sup> and has improved our ability to diagnose and treat the disorders of small intestine.<sup>[54-58]</sup> It was designed for deep intubation of small bowel and difficult colonoscopy. The long type DBE is composed of a 200 cm endoscope with a 145 cm soft overtube. Latex balloons are attached to the end of the endoscope and to the end of the overtube.

Short type DBE is of similar construction and features of the long type DBE except a 150 cm endoscope. The introduction of DBE permits access to bilioenteric anastomosis or papilla through long limbs in patients with altered anatomy and may be used to perform ERCP in these patients. Once the papilla or anastomosis is reached with DBE, the completion of endoscopic interventions usually performed by conventional ERCP is possible, such as sphincterotomy, stones extraction, stent insertion, and dilation of anastomotic strictures. Compared with percutaneous route or surgical approach, DBE-ERCP may be less invasive with a lower morbidity. During DBE-ERCP, a number of biliary stents could be placed in a procedure providing a wider anastomotic opening.

In general, DBE-ERCP is a laborious and time-consuming procedure. In most cases, several balloon-assisted enteroscopic cycles may be needed to approach afferent limb and papilla or anastomosis. Application of X-rays or manual guidance of the enteroscope might be necessary in difficult cases. The mean duration of the procedure was from 40 min to 111 min in this analysis. The length of Roux limb varies depending on the indication for the Roux-en-Y reconstruction. The longest Roux limbs are encountered in patients who have undergone a standard RYGB for bariatric indications,<sup>[59]</sup> which are typically at least 100 cm, and total length from mouth to major papilla may exceed 300 cm.<sup>[60]</sup> The endoscope must pass through the esophagus, gastric pouch, Roux limb, and then return retrograde through the afferent limb to reach the papilla. Investigation of the factors contributing to the failure of treatment with DBE-ERCP procedures by multivariate analysis revealed that Roux-en-Y reconstruction was associated with DBE-ERCP failure. A study evaluating DBE-ERCP with short type DBE showed that the majority of ERCP failures occurred in patients with RYGB.<sup>[61]</sup> The success rate of insertion into the bilioenteric anastomotic site for patients after Roux-en-Y reconstruction was unsatisfactory compared with that for patients after PD with Child resection.<sup>[62]</sup> In our analysis a low enteroscopy success rate did occur in the patient group who had bariatric RYGB surgery undergoing ERCP with short type DBE. However, a large multicenter study showed that the success rates of ERCP with various enteroscopes appear to be similar between RYGB and non-RYGB surgical anatomy.<sup>[63]</sup> A recent study investigated the predictors of success for DBE-ERCP in patients with Roux-en-Y anastomosis. The study showed that DBE-ERCP was most successful in non-liver transplant adult surgery and post-transplant patients without a second operation. The procedure was least successful in patients with surgically corrected biliary atresia and post-transplant patients who

had a second operation.<sup>[64]</sup> The DBE is a forward-viewing endoscope without elevator such that cannulation with DBE into a native papilla is considered difficult. Placing papilla in an adequate position and maintaining it to be stable are challenging for endoscopists. Moreels *et al.* reported a DBE-ERCP success rate of 90% in bilioenteric anastomosis, but only 60% in intact papilla.<sup>[65]</sup> Their finding is similar to our results that revealed the lowest success rate (57%) of diagnostic DBE-ERCP in a patient group with intact papilla. The major reason for difficult cannulation is the difficulty in obtaining a favorable view of intact papilla.<sup>[66]</sup> An EMR cap may help bring to view or steady the native papilla for cannulation and patient position change may put papilla into an adequate angle. When the papilla is located in the diverticulum, it is often difficult to identify the papilla. In some cases, precut technique may be needed to achieve access into the desired duct, and a high success rate (86.7%) with precut was reported during DBE-ERCP.<sup>[66]</sup> Selective access is difficult in some cases due to the limited maneuverability of the tip of DBE, especially at looping and twisting the scope position. Cumulative resistance through the curves of the enteroscope makes delivering accessories more difficult and even impossible. The lack of an elevator and the absence of the side-viewing perspective make sphincterotomy more difficult compared with the standard ERCP. There are limited accessories specially designed to use with the long type DBE to perform diagnostic and therapeutic ERCP. Only 5–8 Fr stents could be inserted into the biliopancreatic duct through DBE limiting draining effect of the procedure. Fluoroscopy is often used to direct enteroscope to correct limb and X-ray exposure is increased. Some methods have been adopted to increase the success rate of DBE-ERCP including various rendezvous technique, intraluminal injection of indigo carmine, CO<sub>2</sub> inflation, overtube-assisted technique, and short type DBE.

Long type DBEs were used in 6 studies before 2012 in the analysis, and then short type DBEs were adopted in all 3 studies during the last 3 years. Long type DBE has the limitation of long working length and sometimes needs modified accessories. Short type DBE was introduced to overcome these problems. Theoretically, a shorter endoscope with a larger channel would have higher success rate of ERCP. Its short working length and availability of various accessory devices might make reaching the papilla/anastomosis and completing ERCP easier than long type DBE. It allows the endoscopists to apply pressure more effectively to the endoscope to increase intervention success rate. In the present analysis, the success rate of therapeutic ERCP was 55% in the studies conducted between 2007 and 2010 and 70% in the studies



conducted between 2011 and 2015. The studies conducted during the latter period contained more cases and started to use short type DBE. An increased success rate may be attributed to short type DBE, however, the improved skills of endoscopists over time should be considered. A study reported that short type DBE is equally effective in reaching the target limb as long type DBE and overcomes some limitations of long type DBE, resulting in higher success rate of ERCP. However, that study included patients with Billroth gastroenterostomy.<sup>[67]</sup> In a study evaluating ERCP with short type DBE, the initial insertion success rate in Whipple patients was significantly higher than that in HJ with Roux-en-Y patients.<sup>[68]</sup> The disadvantage of short type DBE in patients with too long afferent limb has been noted in several studies.<sup>[61]</sup> In these cases, long type DBE may be required to complete ERCP.

Before DBE was introduced, a higher incidence of complications was found in patients with bowel reconstruction who underwent ERCP.<sup>[69]</sup> The actual rates of complications associated with DBE-ERCP are unknown. Pancreatitis occurred in 1% of the patients in the present analysis. In some cases, such as OLT with Roux-en-Y anastomosis, cannulation into bile duct does not involve the orifice of pancreatic duct and the risk of post-ERCP pancreatitis is very low. Perforation was found in 5 patients that occurred in the small bowel or HJ. It was advised to place a stent into the CBD to enlarge the small HJ and during a second session to proceed with balloon dilation of the HJ.<sup>[70]</sup> Such sequent modalities may lower the risk of perforation in HJ. In a large study including 79 patients undergoing DBE-ERCP, all complications occurred in patients with RYGB highlighting the challenge and risk in this subset of patients.<sup>[61]</sup>

There are some limitations of our analysis. Most studies included in this analysis have been performed in a diverse cohort of patients who have had different forms of surgery. Hence, there is significant heterogeneity among studies in terms of procedural success rates. Most of the included studies (9/10) are retrospective studies with innate bias. Given the lack of long-term follow up in some patients, the definitive efficacy of therapeutic DBE-ERCP is unclear. Therefore, studies with more patients and longer follow-up are needed to further verify the effectiveness and safety of DBE-ERCP in patients with altered gastrointestinal anatomy.

In conclusion, diagnostic and therapeutic DBE-ERCPs are feasible in patients with altered gastrointestinal anatomy. DBE-ERCP may be considered when pancreaticobiliary diseases occur in patients undergoing Roux-en-Y

reconstruction or PD. The indication that Roux-en-Y anastomosis impacts the success rate of DBE-ERCP and Roux-en-Y reconstruction with longer afferent limb, and native papilla usually means difficult DBE-ERCP. Short type DBE may play a more important role in DBE-ERCP because it overcomes some limitations of conventional DBE.

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### REFERENCES

- Hintze RE, Adler A, Veltzke W, Abou-Rebyeh H. Endoscopic access to the papilla of Vater for endoscopic retrograde cholangiopancreatography in patients with billroth II or Roux-en-Y gastrojejunostomy. *Endoscopy* 1997;29:69-73.
- Wright BE, Cass OW, Freeman ML. ERCP in patients with long limb Roux-en-Y gastrojejunostomy and intact papilla. *Gastrointest Endosc* 2002;56:225-32.
- Chahal P, Baron TH, Topazian MD, Petersen BT, Levy MJ, Gostout CJ. Endoscopic retrograde cholangiopancreatography in post-Whipple patients. *Endoscopy* 2006;38:1241-5.
- Elton E, Hanson BL, Qaseem T, Howell DA. Diagnostic and therapeutic ERCP using an enteroscope and a pediatric colonoscope in long-limb surgical bypass patients. *Gastrointest Endosc* 1998;47:62-7.
- Haber GB. Double balloon endoscopy for pancreatic and biliary access in altered anatomy (with videos). *Gastrointest Endosc* 2007;66:S47-50.
- Chu YC, Su SJ, Yang CC, Yeh YH, Chen CH, Yueh SK. ERCP plus papillotomy by use of double-balloon enteroscopy after Billroth II gastrectomy. *Gastrointest Endosc* 2007;66:1234-6.
- Feitoza AB, Baron TH. Endoscopy and ERCP in the setting of previous upper GI tract surgery. Part II: Postsurgical anatomy with alteration of the pancreaticobiliary tree. *Gastrointest Endosc* 2002;55:75-9.
- Park JS, Kim MH, Lee SK, Seo DW, Lee SS, Han J, et al. Efficacy of endoscopic and percutaneous treatments for biliary complications after cadaveric and living donor liver transplantation. *Gastrointest Endosc* 2003;57:78-85.
- Faylona JM, Qadir A, Chan AC, Lau JY, Chung SC. Small bowel perforations related to endoscopic retrograde cholangiopancreatography (ERCP) in patients with Billroth II gastrectomy. *Endoscopy* 1999;31:546-9.
- Köcher M, Cerná M, Havlík R, Král V, Gryga A, Duda M. Percutaneous treatment of benign bile duct strictures. *Eur J Radiol* 2007;62:170-4.
- Schumacher B, Othman T, Jansen M, Preiss C, Neuhaus H. Long-term follow up of percutaneous transhepatic therapy (PTT) in patients with definite benign anastomotic stricture after hepaticojejunostomy. *Endoscopy* 2001;33:409-15.
- Fontein D, Gibson R, Collier N, Tse GT, Wang LL, Speer TG, et al. Two decades of percutaneous transjejunal biliary intervention for benign biliary disease: A review of the intervention nature and complications. *Insights Imaging* 2011;2:557-65.
- Vos PM, van Beek JR, Smits NJ. Percutaneous balloon dilatation for benign hepaticojejunostomy strictures. *Abdom Imaging* 2000;25:134-8.
- Weber A, Gaa J, Rosca B, Born P, Neu B, Schmid RM, et al. Complications of percutaneous transhepatic biliary drainage in patients with dilated and nondilated intrahepatic bile ducts. *Eur J Radiol* 2009;72:412-7.
- Kühn JP, Busemann A, Lerch MM, Heidecke CD, Hosten N, Puls R.

- Percutaneous biliary drainage in patients with nondilated intrahepatic bile ducts compared with patients with dilated intrahepatic bile ducts. *AJR Am J Roentgenol* 2010;195:851-7.
16. Weber A, Rosca B, Neu B, Rösch T, Frimberger E, Born P, et al. Long-term follow-up of percutaneous transhepatic biliary drainage (PTBD) in patients with benign bilioenterostomy stricture. *Endoscopy* 2009;41:323-8.
  17. Pellegrini CA, Thomas MJ, Way LW. Recurrent biliary stricture. Patterns of recurrence and outcome of surgical therapy. *Am J Surg* 1984;147:175-9.
  18. Lillemoie K, Melton G, Cameron J, Pitt HA, Campbell KA, Talamini MA, et al. Postoperative bile duct strictures: Management and outcome in the 1990s. *Ann Surg* 2000;232:430-41.
  19. Pitt H, Kaufman S, Coleman J, White R, Cameron J. Benign postoperative biliary strictures operate or dilate? *Ann Surg* 1989;210:417-25.
  20. Born P, Rösch T, Brühl K, Sandschin W, Allescher HD, Frimberger E, et al. Long-term results of endoscopic and percutaneous transhepatic treatment of benign biliary strictures. *Endoscopy* 1999;31:725-31.
  21. Teplick SK, Flick P, Brandon JC. Transhepatic cholangiography in patients with suspected biliary disease and nondilated intrahepatic bile ducts. *Gastrointest Radiol* 1991;16:193-7.
  22. Lopes TL, Wilcox CM. Endoscopic retrograde cholangiopancreatography in patients with Roux-en-Y anatomy. *Gastroenterol Clin North Am* 2010;39:99-107.
  23. Peters M, Pappasavvas PK, Caushaj PF, Kania RJ, Gagné DJ. Laparoscopic transgastric endoscopic retrograde cholangiopancreatography for benign common bile duct stricture after Roux-en-Y gastric bypass. *Surg Endosc* 2002;16:1106.
  24. Mergener K, Kozarek RA, Traverso LW. Intraoperative transjejunal ERCP: Case reports. *Gastrointest Endosc* 2003;58:461-3.
  25. Schreiner MA, Chang L, Gluck M, Irani S, Gan SI, Brandabur JJ, et al. Laparoscopy-assisted versus balloon enteroscopy-assisted ERCP in bariatric post-Roux-en-Y gastric bypass patients. *Gastrointest Endosc* 2012;75:748-56.
  26. Tocchi A, Costa G, Lepre L, Liotta G, Mazzoni G, Sita A. The long-term outcome of hepaticojejunostomy in the treatment of benign bile duct strictures. *Ann Surg* 1996;224:162-7.
  27. Chaudhary A, Chandra A, Negi SS. Reoperative surgery for postcholecystectomy bile duct injuries. *Dig Surg* 2002;19:22-7.
  28. Röhlin M, Löpfe M, Schilumpf R, Largiadèr F. Long-term results of hepaticojejunostomy for benign lesions of the bile ducts. *Am J Surg* 1998;175:22-6.
  29. Davids PH, Tanka AK, Rauws EA, van Gulik TM, van Leeuwen DJ, de Wit LT, et al. Benign biliary strictures. Surgery or endoscopy? *Ann Surg* 1993;217:237-43.
  30. Haruta H, Yamamoto H, Mizuta K, Kita Y, Uno T, Egami S, et al. A case of successful enteroscopic balloon dilation for late anastomotic stricture of choledochojejunostomy after living donor liver transplantation. *Liver Transpl* 2005;11:1608-10.
  31. Mehdizadeh S, Ross A, Gerson L, Leighton J, Chen A, Schembre D, et al. What is the learning curve associated with double-balloon enteroscopy? Technical details and early experience in 6 U.S. tertiary care centers. *Gastrointest Endosc* 2006;64:740-50.
  32. Sato H, Yamamoto H, Tamada K, Kita H, Wada S, Sunada K, et al. Application of double-balloon endoscopy for afferent limb lesions of Roux-en-Y surgical anastomoses. *Gastrointest Endosc* 2005;61:AB238.
  33. Moreels TG, Roth B, Vandervliet EJ, Parizel PM, Dutré J, Pelckmans PA. The use of the double-balloon enteroscope for endoscopic retrograde cholangiopancreatography and biliary stent placement after Roux-en-Y hepaticojejunostomy. *Endoscopy* 2007;39:E196-7.
  34. Emmet DS, Mallat DB. Double-balloon ERCP in patients who have undergone Roux-en-Y surgery: A case series. *Gastrointest Endosc* 2007;66:1038-41.
  35. Aabakken L, Bretthauer M, Line PD. Double-balloon enteroscopy for endoscopic retrograde cholangiography in patients with a Roux-en-Y anastomosis. *Endoscopy* 2007;39:1068-71.
  36. Mönkemüller K, Bellutti M, Neumann H, Malfertheimer P. Therapeutic ERCP with the double-balloon enteroscope in patients with Roux-en-Y anastomosis. *Gastrointest Endosc* 2008;67:992-6.
  37. Koornstra JJ. Double balloon enteroscopy for endoscopic cholangiopancreatography after Roux-en-Y reconstruction: Case series and review of the literature. *Neth J Med* 2008;66:275-9.
  38. Feitoza AB, Baron TH. Endoscopy and ERCP in the setting of previous upper GI tract surgery. Part I: Reconstruction without alteration of pancreaticobiliary anatomy. *Gastrointest Endosc* 2001;54:743-9.
  39. Baron TH, Vickers SM. Surgical gastrostomy placement as access for diagnostic and therapeutic ERCP. *Gastrointest Endosc* 1998;48:640-1.
  40. Haubrich WS. Roux of the Roux-en-Y anastomosis. *Gastroenterology* 2004;126:653.
  41. Deitel M. César Roux and his contribution. *Obes Surg* 2007;17:1277-8.
  42. Stratta RJ, Wood RP, Langnas AN, Hollins RR, Bruder KJ, Donovan JP, et al. Diagnosis and treatment of biliary tract complications after orthotopic liver transplantation. *Surgery* 1989;106:675-83.
  43. Tsujino T, Isayama H, Sugawara Y, Sasaki T, Kogure H, Nakai Y, et al. Endoscopic management of biliary complications after adult living donor liver transplantation. *Am J Gastroenterol* 2006;101:2230-6.
  44. Qin YS, Li ZS, Sun Z, Wu RP, Wang N, Yao YZ. Endoscopic management of biliary complications after orthotopic liver transplantation. *Hepatobiliary Pancreat Dis Int* 2006;5:39-42.
  45. Mata A, Bordas JM, Llach J. ERCP in orthotopic liver transplanted patients. *Hepatogastroenterology* 2004;51:1801-4.
  46. Nguyen DM, El-Serag HB. The big burden of obesity. *Gastrointest Endosc* 2009;70:752-7.
  47. Needleman BJ, Happel LC. Bariatric surgery: Choosing the optimal procedure. *Surg Clin North Am* 2008;88:991-1007.
  48. Berghöfer A, Pischon T, Reinhold T, Apovian CM, Sharma AM, Willich SN. Obesity prevalence from a European perspective: A systematic review. *BMC Public Health* 2008;8:200.
  49. Cummings S, Apovian CM, Khaodhlar L. Obesity surgery: Evidence for diabetes prevention/management. *J Am Diet Assoc* 2008;108:S40-4.
  50. Hubens G, Balliu L, Ruppert M, Gypen B, Van Tu T, Vaneerdeweg W. Roux-en-Y gastric bypass procedure performed with the da Vinci robot system: Is it worth it? *Surg Endosc* 2008;22:1690-6.
  51. Khashab MA, Okolo PI III. Accessing the pancreatobiliary limb and ERCP in the bariatric patient. *Gastrointest Endosc Clin N Am* 2011;21:305-13.
  52. Byrne TK. Complications of surgery for obesity. *Surg Clin North Am* 2001;81:1181-93.
  53. Yamamoto H, Sekine Y, Sato Y, Higashizawa T, Miyata T, Iino S, et al. Total enteroscopy with a nonsurgical steerable double-balloon method. *Gastrointest Endosc* 2001;53:216-20.
  54. May A, Nachbar L, Wardak A, Yamamoto H, Ell C. Double-balloon enteroscopy: Preliminary experience in patients with obscure gastrointestinal bleeding or chronic abdominal pain. *Endoscopy* 2003;35:985-991.
  55. Cazzato IA, Cammarota G, Nista EC, Cesaro P, Sparano L, Bonomo V, et al. Diagnostic and therapeutic impact of double-balloon enteroscopy (DBE) in a series of 100 patients with suspected small bowel diseases. *Dig Liver Dis* 2007;39:483-7.
  56. Heine GD, Hadithi M, Groenen MJ, Kuipers EJ, Jacobs MA, Mulder CJ. Double-balloon enteroscopy: Indications, diagnostic yield, and complications in a series of 275 patients with suspected small-bowel disease. *Endoscopy* 2006;38:42-8.
  57. Di Caro S, May A, Heine DG, Fini L, Landi B, Petruzzello L, et al. The European experience with double-balloon enteroscopy: Indications, methodology, safety, and clinical impact. *Gastrointest Endosc* 2005;62:545-50.
  58. Mönkemüller K, Weigt J, Treiber G, Ebert M, Fry L, Malfertheimer P. Diagnostic and therapeutic impact of double balloon enteroscopy. *Endoscopy* 2006;38:67-72.
  59. Ross AS. Endoscopic retrograde cholangiopancreatography in the

- surgically modified gastrointestinal tract. *Gastrointest Endosc Clin N Am* 2009;19:497-507.
60. Stellato TA, Crouse C, Hallowell PT. Bariatric surgery: Creating new challenges for the endoscopist. *Gastrointest Endosc* 2003;57:86-94.
  61. Siddiqui AA, Chaaya A, Shelton C, Marmion J, Kowalski TE, Loren DE, *et al.* Utility of the short double-balloon enteroscope to perform pancreaticobiliary interventions in patients with surgically altered anatomy in a US multicenter study. *Dig Dis Sci* 2013;58:858-64.
  62. Sakakihara I, Kato H, Muro S, Noma Y, Yamamoto N, Harada R, *et al.* Double-balloon enteroscopy for choledochojejunal anastomotic stenosis after hepato-biliary-pancreatic operation. *Dig Endosc* 2015;27:146-54.
  63. Shah RJ, Smolkin M, Yen R, Ross A, Kozarek RA, Howell DA, *et al.* A multicenter, U.S. experience of single-balloon, double-balloon, and rotational overtube-assisted enteroscopy ERCP in patients with surgically altered pancreaticobiliary anatomy (with video). *Gastrointest Endosc* 2013;77:593-600.
  64. Liu K, Joshi V, Saxena P, Kaffes AJ. Predictors of success for double balloon assisted endoscopic retrograde cholangiopancreatography in patients with Roux-en-Y anastomosis. *Dig Endosc* 2016 [Epub ahead of print].
  65. Moreels TG, Hubens GJ, Ysebaert DK, Op de Beeck B, Pelckmans PA. Diagnostic and therapeutic double-balloon enteroscopy after small bowel Roux-en-Y reconstructive surgery. *Digestion* 2009;80:141-7.
  66. Ishii K, Itoi T, Tono-zuka R, Itokawa F, Sofuni A, Tsuchiya T, *et al.* Balloon enteroscopy-assisted ERCP in patients with Roux-en-Y gastrectomy and intact papillae (with videos). *Gastrointest Endosc* 2016;83:377-86.
  67. Cho S, Kamalporn P, Kandel G, Kortan P, Marcon N, May G. 'Short' double-balloon enteroscope for endoscopic retrograde cholangiopancreatography in patients with a surgically altered upper gastrointestinal tract. *Can J Gastroenterol* 2011;25:615-9.
  68. Itokawa F, Itoi T, Ishii K, Sofuni A, Moriyasu F. Single- and double-balloon enteroscopy-assisted endoscopic retrograde cholangiopancreatography in patients with Roux-en-Y plus hepaticojejunostomy anastomosis and Whipple resection. *Dig Endosc* 2014;26(Suppl 2):136-43.
  69. Bagci S, Tuzun A, Ates Y, Gulsen M, Uygun A, Yesilova Z, *et al.* Efficacy and safety of endoscopic retrograde cholangiopancreatography in patients with Billroth II anastomosis. *Hepatogastroenterology* 2005;52:356-9.
  70. Mönkemüller K, Fry LC, Bellutti M, Neumann H, Malfertheiner P. ERCP with the double balloon enteroscope in patients with Roux-en-Y anastomosis. *Surg Endosc* 2009;23:1961-7.