# Systematic review and meta-analysis of single-balloon enteroscopy–assisted ERCP in patients with surgically altered GI anatomy

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**Background:** Surgically altered pancreaticobiliary anatomy increases the difficulty of performing ERCP. Single-balloon enteroscopy (SBE) is a relatively new technique that can be used for ERCP in patients with surgically altered anatomy.

**Objective:** To evaluate the therapeutic and diagnostic success of SBE-ERCP among patients with surgically altered anatomy.

**Design/Setting:** Systematic review and meta-analysis of studies involving SBE-ERCP in patients with Roux-en-Y gastric bypass, hepaticojejunostomy, or Whipple procedure. Enteroscopy success was defined as success in reaching the papilla and/or biliary anastomosis by using SBE. Diagnostic success was defined as obtaining a cholangiogram. Procedural success was defined as the ability to provide successful intervention, if appropriate. A random-effects model was used.

**Results:** A total of 461 patients underwent SBE-ERCP from 15 trials. The pooled enteroscopy, diagnostic, and procedural success rates were 80.9% (95% confidence interval [CI], 75.3%-86.4%), 69.4% (95% CI, 61.0%-77.9%), and 61.7% (95% CI, 52.9%-70.5%), respectively. There was statistical large heterogeneity for enteroscopy, diagnostic, and therapeutic success ($P < .001$ for all). Adverse events occurred in 6.5% (95% CI, 4.7%-9.1%) of patients. There was no evidence of publication bias in this meta-analysis.

**Limitations:** Our findings and interpretations are limited by the quantity and heterogeneity of the studies included in the analysis.

**Conclusion:** SBE-ERCP has high diagnostic and procedural success rates in this challenging patient population. It should be considered a first-line intervention when biliary access is required after Roux-en-Y gastric bypass, hepaticojejunostomy, or Whipple procedure. (Gastrointest Endosc 2015;82:9-19.)

The obesity epidemic has many potential consequences for modern health care. The incidence of diabetes, cardiovascular disease, hypertension, increased risk of cancer, osteoarthritis, and the social and psychological consequences have all been well documented. Efforts to address this burgeoning issue have accelerated, not least of which is the increasing popularity of bariatric surgery. Although bariatric surgery is an effective option in the fight against obesity, it has also led to the development of unique problems for endoscopists, specifically to an increasing prevalence of patients with surgically altered gastroduodenal anatomy.[1] This is further compounded by the formation of cholesterol gallstones in about one-third of these patients after significant rapid weight loss after bariatric surgery. This leads to an increase in the risk of common bile duct stones and subsequent need for biliary intervention.[2]

Similarly, the increasing numbers of patients undergoing liver transplantation has further contributed to the difficulty for endoscopists. Roux-en-Y reconstructive surgery (either for patients with a diseased bile duct or as a consequence of postoperative adverse events) has led to an increased number of patients with surgically altered anatomy who are at risk of the development of biliary adverse events, potentially necessitating further endoscopic interventions.

The complicated GI anatomy seen in patients with Roux-en-Y gastric bypass, Whipple procedure, or

*Abbreviations: CI, confidence interval; DBE, double-balloon enteroscopy; SBE, single-balloon enteroscopy.*

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hepaticojejunostomy makes ERCP challenging, especially with the presence of a long afferent limb or an acute angle at the jejunojejunostomy.[3-8] Studies in the past have reported reaching the ampulla by using a duodenoscope in only 33% of patients with Roux-en-Y reconstructions.[9]

Before the advent of device-assisted enteroscopy, push enteroscopy techniques were used with a standard enteroscope or pediatric colonoscope. The reported success rates were less than ideal. In a case series by Wright et al,[10] biliary access was achieved in only 13%. Similarly, in a study by Raithel et al,[11] the papilla or the enteroanastomoses was reached in only 16% of cases.[11] In recent years, effective intubation of the afferent limb has been achieved by device-assisted enteroscopy.

Double-balloon enteroscopy (DBE) has been successfully used for ERCP in patients with different types of Roux-en-Y reconstructions with bilioenteric anastomosis.[11-15] However, DBE requires specialized equipment and expertise that are not widely available. Spiral enteroscopy is another such technique whose role is still evolving.

Single-balloon enteroscopy (SBE) is a relatively new technique that uses a single-balloon splinting overtube to sequentially reduce and pleat the small bowel over an enteroscope.[16,17] It is less technically demanding than DBE and thus has a potential for widespread use. The pleating of the small bowel helps negotiating the acute angulations seen at gastroenteric and enteroenteric anastomoses.[12,17] DBE and SBE have similar adverse event rates,[16,18-20] but the procedure time for SBE-ERCP is relatively shorter (72-78 minutes)[19,21] compared with DBE-ERCP (93-128 minutes).[11,20]

Given the ease of use and shorter duration of SBE-ERCP, it has the potential to become the standard of care for therapy in biliary adverse events in long limb altered surgical anatomy. To date, there have been no systematic review and meta-analysis evaluating the success rates of only SBE-ERCP. Our primary study aim was to systematically review and estimate the procedural and diagnostic success of SBE-ERCP in patients with surgically altered anatomy. Secondary aims included evaluating SBE-ERCP safety, indications, and use in native papilla versus a bilioenteric anastomosis. We did not include studies with DBE. SBE is less technically demanding than DBE, and, if as successful as DBE per this review, has the potential to be in widespread use given its ease of use.

## METHODS

### Literature search

MEDLINE, Embase, CINAHL, the Cochrane Central Register of Controlled Trials, the Cochrane Database of Systematic Reviews and the Cochrane Controlled Trials Register were queried for articles published from January 2000 to June 2014. We did not search medical literature before 2000 because balloon enteroscopy was first developed in 2001. The terms used for the search strategy were "balloon enteroscopy," "single balloon enteroscopy," "endoscopic retrograde cholangiopancreatography," "ERCP," "balloon-assisted ERCP," and "altered anatomy" as keywords or MeSH terms. Boolean operators (not, and, or) were used in succession to narrow and widen the search. The "explode" and "related article" function in Ovid search were implemented to increase the breadth of the articles collected. In addition, we reviewed the reference lists of retrieved full-text papers to evaluate for other medical literature that may have been missed during the search of the databases. We also reviewed abstracts from major conferences for studies not available as published articles.

### Inclusion and exclusion criteria

We used the Patients, Intervention, Comparator, Outcomes, Study design (PICOS) criteria for inclusion and exclusion of studies in the meta-analysis.

Studies were included in the systematic review and meta-analysis if (1) the patients had a surgically altered gastroduodenal anatomy, Roux-en-Y gastric bypass, hepaticojejunostomy, or Whipple procedure (Patients); (2) they were randomized, controlled trials, case control studies, cohort studies, or case series (Study design); (3) the patients underwent SBE-ERCP (Intervention); (4) the diagnostic and procedural success was assessed in the studies (Outcomes).

We excluded the studies that (1) contained 10 or fewer patients who underwent standard SBE-ERCP (in an effort to exclude inexperienced user bias); (2) were review articles, case reports, editorials, and letters to the editor; (3) had SBE-ERCP performed with Billroth 2 anatomy; (4) and animal studies. We excluded patients with Billroth 2 anatomy because these patients usually have short afferent limbs and have higher success rates of ERCP.

### Definitions

We aimed to use similar definitions of success as already described in the medical literature.[19-21] Enteroscopy success was defined as success in reaching the papilla and/or biliary anastomosis by using SBE. ERCP diagnostic success was defined as obtaining a cholangiogram. ERCP procedural success was defined as the ability to provide successful intervention (eg, stone extraction, stent placement) if appropriate. We defined a native papilla as an intact papilla with no previous manipulations performed. Therefore, a papilla that previously underwent sphincteroplasty with no other manipulation was not a native papilla per our definition.

### Data collection

Two independent investigators (S.I. and A.T.) identified the articles that met the predetermined inclusion and exclusion criteria as stated previously. There were a total of 254 article related to SBE that were identified,