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## Retrospective Cohort Study

Risk factors for perforation during endoscopic retrograde  
cholangiopancreatography in post-reconstruction intestinal tract

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## Abstract

## BACKGROUND

Endoscopic retrograde cholangiopancreatography (ERCP) in patients with surgically altered anatomy has been a major challenge to gastrointestinal endoscopists with low success rates for reaching the target site as well as high complication rates. The knowledge of ERCP-related risk factors is important for reducing unexpected complications.

## AIM

To identify ERCP-related risk factors for perforation in patients with surgically altered anatomy.

## METHODS

The medical records of 187 patients with surgically altered anatomy who underwent ERCP at our institution between April 2009 and December 2017 were retrospectively reviewed. An analysis of patient data, including age, sex, type of reconstruction, cause of surgery, aim of ERCP, success rate of reaching target site, success rate of procedure, adverse events, type of scope, time to reach the target site, and duration of procedure, was performed. In patients with Billroth-II reconstruction, additional potential risk factors were the shape of the inserted scope and whether the anastomosis was antecolic or retrocolic.

## RESULTS

All patients ( $n = 187$ ) had surgical anatomy, such as Billroth-I ( $n = 22$ ), Billroth-II ( $n = 33$ ), Roux-en-Y ( $n = 54$ ), Child, or Whipple reconstruction ( $n = 75$ ). ERCP was

welfare, and rights.

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performed for biliary drainage in 43 cases (23%), stone removal in 29 cases (16%), and stricture dilation of anastomosis in 59 cases (32%). The scope was unable to reach the target site in 17 cases (9%), and an aimed procedure could not be accomplished in 54 cases (29%). Adverse events were pancreatitis (3%), hyperamylasemia (10%), cholangitis (6%), cholestasis (4%), excessive sedation (1%), perforation (2%), and others (3%). Perforation occurred in three cases, all of which were in patients with Billroth-II reconstruction; in these patients, further analysis revealed loop-shaped insertion of the scope to be a significant risk for perforation ( $P = 0.01$ ).

## CONCLUSION

Risk factors for perforation during ERCP in patients with surgically altered anatomy were Billroth-II reconstruction and looping of the scope during Billroth-II procedure.

**Key words:** Surgically altered anatomy; Billroth-II; Endoscopic retrograde cholangiopancreatography; Perforation

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**Core tip:** Endoscopic retrograde cholangiopancreatography (ERCP) for patients with surgically altered anatomy accompanies a high risk of perforation. This study identified that Billroth-II reconstruction was associated with high risk of perforation during ERCP procedure. Moreover, a looping shape of a scope during insertion in patients with Billroth-II reconstruction proved to be a more specific risk factor of perforation in ERCP.

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## INTRODUCTION

Performing endoscopic retrograde cholangiopancreatography (ERCP) in patients with surgically altered anatomy has been a major challenge to gastrointestinal endoscopists; success rates for reaching the target site are 71%-92% and 33% in Billroth-II and Roux-en-Y reconstructions, respectively<sup>[1,2]</sup>. The development of deep enteroscopies, such as double-balloon enteroscopy (DBE) and single-balloon enteroscopy, increased those success rates to 95%-100% and 75%-100% in patients with Billroth-II<sup>[3-5]</sup> and Roux-en-Y<sup>[3,4,6-12]</sup> reconstructions, respectively. However, complication rates associated with ERCP in patients with surgically altered anatomy reportedly 10%-13%, are still high. Complications can include pancreatitis, cholangitis, aspiration pneumonia, biliary damage, and perforation<sup>[3,13]</sup>. Perforation<sup>[2]</sup> and embolic stroke<sup>[13]</sup> related deaths have been reported rarely, and although perforations associated with sphincterotomy can be treated conservatively, those not associated with sphincterotomy often require emergency surgical treatment<sup>[3,14]</sup>. Some reports show a high incidence of perforation, at rates of 2.0%-11.1%<sup>[3,8,12]</sup> and 5.6%-7.7%<sup>[2-5]</sup> in Roux-en-Y and Billroth-II reconstructions, respectively, though the overall rate of perforation in ERCP has been reported to be as low as 0.35%<sup>[15]</sup>.

Surgically altered anatomy is a risk factor for perforations, not only in ERCP-related procedures, but also in DBE-related procedures<sup>[16]</sup>. The perforation rates of DBE-related procedures are reported to be 0.2% and 3% in patients without and with surgically altered anatomy, respectively, with statistical significance. Moreover, the reported incidence of perforation seems to be higher in patients with Billroth-II reconstruction<sup>[3,8,12]</sup> than in those with Roux-en-Y reconstruction<sup>[2-5]</sup>, and another report showed that Billroth-II is a significant risk factor for adverse events, including perforations, in ERCP procedure with DBE<sup>[3]</sup>. However, no report has elucidated the risk factors for perforation by type of surgical anatomy and detailed operative



information.

In this study, we identified risk factors for perforation in ERCP-related procedures in patients with surgically altered anatomy. We identified the type of reconstruction carrying a high risk of perforation, and we further analyzed detailed information of operative methods to identify the risks for perforation before or during DBE.

## MATERIALS AND METHODS

### *Patients and data acquisition*

We retrospectively reviewed the medical records of 187 patients who had surgically altered anatomy and underwent ERCP-related procedures between April 2009 and December 2017 at our institution. Patient data collected were age, sex, type of reconstruction, indication for surgery, aim of ERCP, success at reaching target site, success of procedure, adverse events, type of scope, time to reach the target site, and duration of procedure.

### *Additional procedure-associated factors in cases of Billroth-II reconstruction*

In addition to data from medical records, we extracted two other factors in cases of Billroth-II reconstruction. The first was whether reconstruction was antecolic or retrocolic. Afferent loops pass through the anterior space of transverse colon in the antecolic reconstruction, but through posterior colonic mesentery in retrocolic reconstruction. The second risk factor was the shape of inserted scope when the target site was reached. There were two scope shapes upon reaching the target site: the simple J shape (Figure 1A, 1B) and the looped, L-shaped scope (Figure 1C, 1D).

### *Statistical analysis*

Continuous data were expressed as medians and ranges and categorical data were expressed as numbers and percentages. Two-group comparisons were conducted by  $\chi^2$  test, and differences with *P* values of  $< 0.05$  were considered statistically significant.

## RESULTS

### *Patient characteristics and procedures*

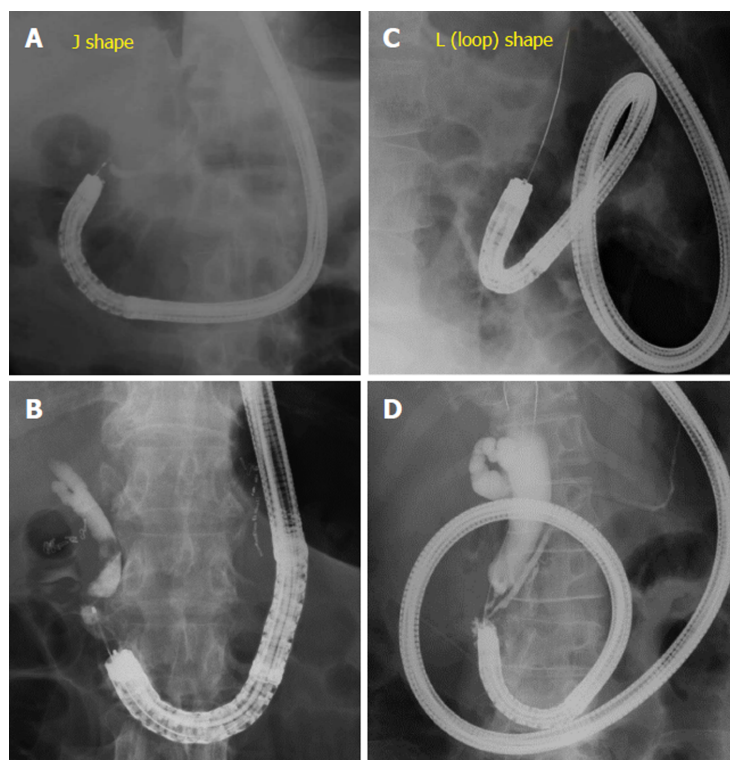
Characteristics of patients included in this retrospective study are shown in Table 1. All patients ( $n = 187$ ) had surgical anatomy such as Billroth-I, Billroth-II, Roux-en-Y, Child, or Whipple reconstruction. More than half of patients underwent operation for malignant tumor, the others for benign diseases such as gastric or duodenal ulcer. ERCP was performed for biliary drainage in 43 cases (23%), stone removal in 29 cases (16%), stricture dilation of anastomosis in 59 cases (32%) (Table 2). The scope was unable to reach the target site in 17 cases (9%), and an aimed procedure could not be accomplished in 54 cases (29%).

### *Adverse events in all cases and risk factors for gastrointestinal perforation*

The incidences of adverse events are shown in Table 3. Adverse events include pancreatitis ( $n = 5$ ), hyperamylasemia ( $n = 19$ ), cholangitis ( $n = 12$ ), cholestasis ( $n = 7$ ), excessive sedation ( $n = 1$ ), perforation ( $n = 3$ ), and other ( $n = 5$ ). The overall rate of adverse events, without overlapping, was 25% ( $n = 47$ ). We next evaluated risk factors for perforation in all cases (Table 4). Among factors of age, sex, type of scope, indication for surgery, and type of surgical anatomy, only Billroth-II reconstruction was significantly associated with perforation ( $P = 0.003$ ).

### *Risk factors for gastrointestinal perforation in cases with Billroth-II reconstruction*

That Billroth-II reconstruction is the risk factor for perforation in patients with surgically altered anatomy could easily have been predicted by previous reports, as described in the introduction section of this report. In addition, we noticed that some cases of ERCP procedure with Billroth-II reconstruction were easy, and some difficult, to perform. Therefore, we further pursued risk factors for perforation in patients with Billroth-II reconstruction, for which we extracted two more factors associated with operative methods. The two factors were whether the reconstruction was antecolic or retrocolic, and whether the shape of inserted scope was J type or L type upon reaching the target site (Figure 1). Among 33 patients with Billroth-II reconstruction, 14 cases had retrocolic reconstruction, with eight of those with the scope in an L shape when it reached the target site (Table 5). Statistical analysis revealed that only L shape; that is, loop-shaped insertion, of the scope was associated with perforation in patients with Billroth-II reconstruction.



**Figure 1 Shape of scope in Billroth-II reconstruction.** A, B: J-shaped scope inserted to the papilla; C, D: L-shaped, or looped, scope inserted to the papilla. The scope cannot be advanced to the papilla without looping the scope. Cases wherein looping is required during insertion, and releasing the loop during or after reaching the papilla, are included in this category.

Intraoperative imaging of an 82-year-old female with perforation is shown in **Figure 2**. The patient had antecolic Billroth-II reconstruction and underwent ERCP with DBE to remove common bile duct stones. The scope was inserted in a loop shape and could not be advanced further than the third portion of the duodenum retrograde; perforation (arrows) occurred while pushing the scope (**Figure 2B**). Review of the video indicates that the reduced mobility of the scope around the perforated space, suggesting that the perforation occurred in an area of thick adhesion. Clinical characteristics of all cases with perforation are shown in **Table 6** and all these cases were adequately managed by conservative therapy or operation.

## DISCUSSION

This study demonstrated that Billroth-II reconstruction was a risk factor for perforation in ERCP procedures in patients with surgically altered anatomy. We further identified that looping of the scope in Billroth-II reconstruction was a risk factor for perforation in ERCP.

Surgically altered anatomy is a risk factor for perforation in both ERCP procedures and DBE examinations. No report has compared the rate of perforation in ERCP between with and without surgical altered anatomy. The overall rate of perforation in ERCP has been reported to be 0.35%<sup>[15]</sup>, whereas that of patients with surgical anatomy has been reported to be 2.0%-11.1%<sup>[3,8,12]</sup> and 5.6%-7.7%<sup>[2-5]</sup> in Roux-en-Y and Billroth-II reconstruction, respectively, although there are some reports describing no incidence of perforation. Therefore, surgically altered anatomy appears to be a risk factor for perforation in ERCP. However, one report that analyzed the risk factors for complications during DBE, including perforation, suggested that the perforation rate was significantly elevated in patients with surgically altered anatomy<sup>[16]</sup>. Therefore, risk factors for perforation in patients with surgically altered anatomy should be investigated further.

Billroth-II reconstruction is a significant risk factor for perforation in ERCP procedures. The perforation rates of ERCP in patients with Roux-en-Y reconstruction are reported to be  $2.1 \pm 3.9\%$ , with a median and range of 0% and 0%-11.1%, whereas those with Billroth-II reconstruction are reported to be  $6.3 \pm 1.1\%$ , with a median and range of 6.7% and 5.6%-7.7% ( $P = 0.035$ ). A report of a multicenter prospective study



**Table 1 Patient characteristics *n* (%)**

Parameters	Value ( <i>n</i> = 187)
Age, median (range)	72 (31-90)
Female sex,	49 (26)
Surgical anatomy	
Billroth-I	22 (12)
Billroth-II	33 (18)
Roux-en-Y	54 (29)
Child or Whipple	75 (40)
Others	3 (2)
Cause of surgery	
GU or DU	30 (16)
Benign disease	14 (7)
Benign tumor	29 (16)
Malignant tumor	107 (57)
N/A	7 (4)

DU: Duodenal ulcer; GU: Gastric ulcer; N/A: Not available.

of ERCP with altered gastrointestinal anatomy demonstrated that there was an obvious perforation only in patients with Billroth-II anatomy<sup>[3]</sup>. These reports are consistent with our result that the perforation occurred only in patients with Billroth-II reconstruction.

Looping the scope during insertion proved to be a risk factor for perforation in patients with Billroth-II reconstruction. There were shown to be two types of scope insertion in patients with Billroth-II reconstruction: J type and L type. J type is a simple scope configuration that often makes it easy to reach a target site, whereas in L type, the scope forms a loop during scope insertion and sometimes makes it difficult to reach the target site. In all three patients with perforation, the scope was in an L type configuration upon reaching the target site. Review of the videos of the procedures led us to consider another possible cause of perforation in Billroth-II anatomy: the appearance of stiff adhesions at the perforation sites. We therefore added a potential risk factor, reconstruction technique in Billroth-II, for stiff adhesions after surgery. The reconstruction techniques are employed in Billroth-II and appear to be divided into two categories: whether the afferent loop passes antecolic or retrocolic. Although we did not identify a direct relationship between these reconstruction techniques and perforation, we speculate that an old surgical method may be associated with stiff adhesions, which could lead to perforation.

An intestinal tract with stiff adhesions is presumed to be easy to perforate during scope insertion of a scope, although this was not demonstrated directly in our study. Upon reviewing the videos of procedures, we noted that the intestinal tracts wherein perforation occurred did not seem flexible, suggesting those areas had stiff adhesions and were easy to perforate. One way to avoid perforation might be to insert the overtube used in deep enteroscopy beyond the adhesion site to distribute the scope's load on the intestinal tract. Another possibility may be to have the courage to withdraw when there is little chance to achieve success.

In conclusion, the present study shows surgically altered anatomy, especially in Billroth-II reconstruction to be ERCP-related risk factors for perforation. Our findings suggest that, in patients with Billroth-II reconstruction, reaching the target site with the scope in a loop configuration carried a risk of perforation and should be performed carefully.

**Table 2 Success rates for procedures *n* (%)**

Parameters	Value ( <i>n</i> = 187)
Failure in reaching target site	17 (9)
Failed procedure	54 (29)
Procedure	
ERCP	23 (12)
Drainage	43 (23)
Stone treatment	29 (16)
Stricture dilation	59 (32)
N/A	33 (18)

ERCP: Endoscopic retrograde cholangiopancreatography; N/A: Not available.

**Table 3 Incidence of adverse events *n* (%)**

Parameters	Incidence ( <i>n</i> = 187)
Pancreatitis	5 (3)
Hyperamylasemia	19 (10)
Cholangitis	12 (6)
Cholestasis	7 (4)
Excessive sedation	1 (1)
Perforation	3 (2)
Others	5 (3)
Total (no overlap)	47 (25)

**Table 4 Risk factors for perforation in all cases *n* (%)**

Parameters	<i>n</i>	Perforation	<i>P</i> value
Age (yr) ≥ 75	68	2 (2.9)	0.621
Female sex	49	2 (4.1)	0.345
Scope			
DBE	108	1 (0.9)	0.784
Other scope	49	2 (4.1)	0.345
Cause of surgery			
malignancy	107	1 (0.9)	1
Type of surgical anatomy			
B-II	33	3 (9.1)	0.003
R-Y	54	0 (0.0)	0.638

B-II: Billroth-II reconstruction; DBE: Double-balloon endoscope; R-Y: Roux-en-Y reconstruction.

**Table 5 Risk factors for perforation in cases with Billroth-II reconstruction**

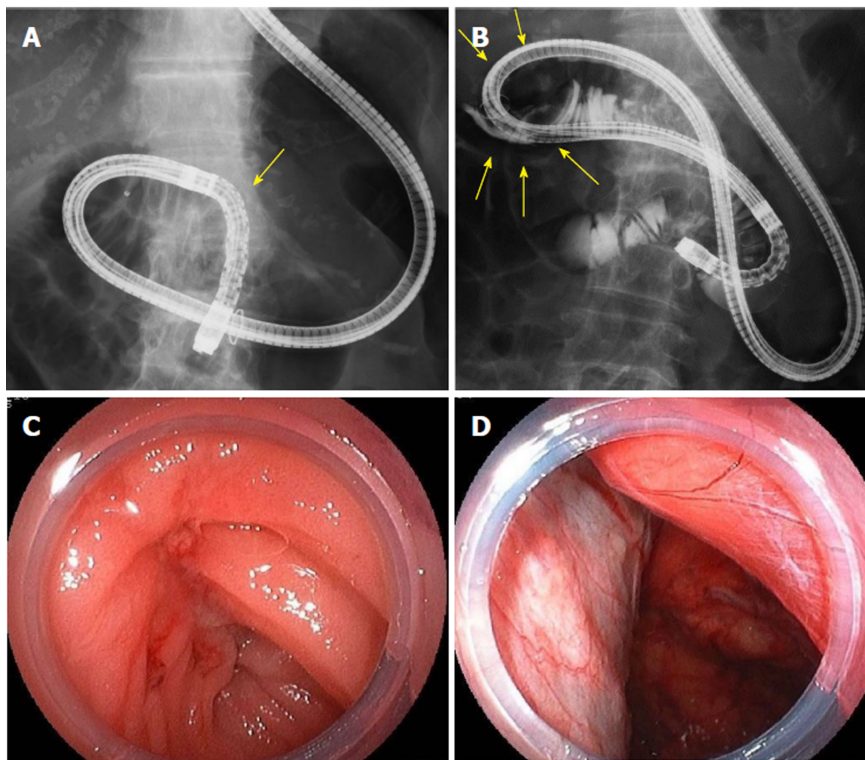
	<i>n</i>	Perforation	<i>P</i> value
Age (yr) ≥ 75	25	2 (8)	1
Female sex	8	2 (25)	0.14
L shape	8	3 (37.5)	0.01
Retrocolic reconstruction	14	2 (14.3)	0.56
Surgery by malignancy	10	1 (10)	0.34
Time to papilla (> 15 min.)	14	3 (21.4)	0.07

L shape: Looped scope insertion.

**Table 6** Clinical characteristics of three perforated Billroth-II cases

Case	Age	Sex	Diagnosis	Indication for an endoscopy	Reaching the target site	Cause of surgery	Therapy of perforation
1	67	F	Pancreatic cancer	Drainage	Success	Gastric cancer	Conservative
2	83	M	Biliary tract cancer	Drainage	Failure	Duodenal ulcer	Operation
3	82	F	Cholelithiasis	Stone treatment	Failure	N/A	Operation

N/A: Not available.



**Figure 2** A case of gastrointestinal perforation during scope insertion after Billroth-II reconstruction. A: Scope is being inserted retroflexed in the intestinal tract of Billroth-II anatomy. Arrow indicates the ligament of Treitz; B: Perforation of gastrointestinal tract occurred in an area showing air within retroperitoneal cavity (arrows); C: The area of perforation in gastrointestinal tract lumen; D: The retroperitoneal cavity seen from the area of perforation.

## ARTICLE HIGHLIGHTS

### Research background

The development of deep enteroscopies, such as double-balloon enteroscopy (DBE) and single-balloon enteroscopy has enabled performing endoscopic retrograde cholangiopancreatography (ERCP) in patients with surgically altered anatomy, such as Billroth-II and Roux-en-Y reconstructions.

### Research motivation

Surgically altered anatomy is a risk factor for perforations, not only in ERCP-related procedures, but also in DBE-related procedures. However, no report has elucidated the risk factors for perforation by type of surgical anatomy and detailed operative information.

### Research objectives

The main objective of this study is to identify ERCP-related risk factors for perforation in patients with surgically altered anatomy.

### Research methods

Medical records of 187 patients with surgically altered anatomy who underwent ERCP at our institution between April 2009 and December 2017 were retrospectively reviewed and analyzed to identify risk factors for perforation.

### Research results

All patients who had undergone perforation were with Billroth-II reconstruction; further

analysis in these patients revealed loop-shaped insertion of the scope to be a significant risk for perforation.

### Research conclusions

The new findings of this study are that risk factors for perforation during ERCP in patients with surgically altered anatomy were Billroth-II reconstruction and looping of the scope during Billroth-II procedure.

### Research perspectives

Our findings suggest that, in patients with Billroth-II reconstruction, reaching the target site with the scope in a loop configuration carried a risk of perforation; therefore, it should be performed carefully.

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