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Observational study (retrospective cohort study)

Short- and long-term outcomes of laparoscopic endoscopic cooperative surgery for duodenal neoplasms: a retrospective single-center study

Short- and long-term outcomes of D-LECS

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Abstract

Background

Non-ampullary duodenal tumors are relatively rare; however, advancements in esophagogastroduodenoscopy have improved their detection. Endoscopic resection is effective for treating adenomas and early-stage cancers without lymph node involvement. However, challenges include assessing tumor invasion depth, achieving complete resection, and managing postoperative complications such as delayed perforation. Consequently, laparoscopic endoscopic cooperative surgery (D-LECS) was introduced, but data on its long-term outcomes remain limited.

Methods

This retrospective study reviewed 18 cases of D-LECS performed between June 2016 and October 2024 at Tonan Hospital. Included patients had non-ampullary duodenal tumors—adenoma, mucosal adenocarcinoma, or neuroendocrine neoplasms—without lymph node involvement. Surgical outcomes, complications, and follow-up data were analyzed.

Results

The median patient age was 65.5 years, and 14 patients were male. Tumors were located in the first (4 cases), second (11 cases), and third (3 cases) portions of the duodenum. The median operative time was 233 min, longer in the reinforcement after endoscopic submucosal dissection group than in the full-thickness resection group (289 vs. 221 min, $P = 0.37$). A Clavien–Dindo grade ≥3a complication occurred only in the first case, involving delayed perforation. The median hospital stay was 12 days. En-bloc and R0 resection rates were 83.3% and 92.9%, respectively. No long-term complications, including stricture or recurrence, were observed over a median follow-up of 37 months.

Conclusions

D-LECS demonstrated favorable short- and long-term outcomes for non-ampullary duodenal tumors, with high en-bloc and R0 resection rates. These findings suggest that D-LECS is a viable treatment option for selected duodenal tumors.

Keywords: Laparoscopic Endoscopic Cooperative Surgery; D-LECS; non-ampullary duodenal tumors; endoscopic submucosal dissection

Introduction

Non-ampullary duodenal tumors are relatively rare, with a reported detection rate of 0.03–0.4% during esophagogastroduodenoscopy (EGD) [1,2]. However, advancements in EGD have increased their detection. Recently, endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD) have emerged as effective techniques for achieving en-bloc resection of adenomas, early-stage cancers, and neuroendocrine neoplasms (NENs), not requiring lymph node dissection [3–5]. Regardless, endoscopic resection of duodenal tumors presents several challenges, including difficulty in accurate assessment of tumor invasion depth, the technical complexity of endoscopic manipulation affecting R0 resection rates, and the risk of delayed perforation, which can lead to life-threatening peritonitis. Consequently, laparoscopic endoscopic cooperative surgery for duodenal neoplasms (D-LECS) was developed to mitigate these risks and improve curative outcomes, adapting techniques originally designed for gastric tumors [6,7]. Initial reports have demonstrated the surgical technique and the feasibility of D-LECS based on short-term outcomes [6, 8–10]. However, few studies have evaluated its long-term results. Therefore, this study aimed to evaluate both the short- and long-term outcomes of patients who underwent D-LECS at our institution.

Materials and Methods

Patients

This retrospective cohort study reviewed patients who underwent initial D-LECS between June 2016 and October 2024 at the Tonan Hospital. The surgical indications for D-LECS included patients with non-ampullary duodenal tumors, such as adenoma, mucosal adenocarcinoma, and NEN, that did not require lymphadenectomy. Exclusion criteria included invasive carcinomas, lesions with resection margins extending to the pancreas, and dorsal lesions that are difficult to suture laparoscopically. Clinicopathological data of patients, including age, sex, operative procedure (reinforcement after ESD/EMR, full-thickness resection [FTR], and marking only), operative time, estimated laparoscopic blood loss, conversion to laparotomy, and postoperative complications classified using the Clavien–Dindo system, were collected. Additional data included time to resumption of oral intake, length of hospitalization, and histopathological diagnosis. Long-term outcomes, including EGD findings, time since surgery, follow-up duration, recurrence, and survival, were reviewed through medical records or patient follow-up calls.

Written informed consent was obtained from all patients prior to D-LECS. This retrospective cohort study was approved by the Tonan Hospital Ethics Committee

(approval no. 246).

Surgical procedure

The patient was placed in the lithotomy position with reverse Trendelenburg. Four trocars were inserted based on the suture site location, and a fifth was added if needed. Pneumoperitoneum was maintained at 10 mmHg. The hepatic flexure of the colon was mobilized, and the accessory right colic vein was dissected if necessary to prevent bleeding. A bowel clip was placed near the ligament of Treitz to prevent insufflation into the distal intestine (Fig. 1a). The tumor location was confirmed both endoscopically and laparoscopically (Fig. 1b), followed by either EMR/ESD or FTR (Fig. 1c). Kocher mobilization was performed after endoscopic manipulation, as early mobilization could hinder the endoscopic procedure (Fig. 1d). For tumors at the inferior duodenal angle, an infracolic approach was used for duodenal mobilization and separation from the pancreas. After ESD, anchoring sutures were placed at both edges of the defect, and the resected bed was closed with a running suture using 4-0 V-Loc^{TM} 90 (Medtronic). In FTR cases, the mucosa was first circumferentially incised endoscopically, creating a full-thickness perforation at a single site. Laparoscopic intervention then facilitated a circumferential full-thickness incision (Fig. 1e), and the specimen was retrieved in a specimen bag. Anchoring sutures were placed at both ends of the defect, followed by mucosal closure with a running suture using 4-0 V-Loc^{TM} 90, reinforced with a seromuscular layer closure utilizing 3-0 PROLENE^{TM} (ETHICON) (Fig. 1f). Bleeding and stricture were confirmed endoscopically, whereas a negative air leak test was verified laparoscopically. A decompression tube was placed in the stomach, and a drainage catheter was positioned near the suture site, with the closure covered by the omentum.

Data collection and statistical analysis

Data were collected from medical records and telephone follow-ups. For patients with duodenal cancer and NENs, follow-up included blood tests every 6 months and annual computed tomography (CT) and EGD. For patients with duodenal adenomas, follow-up was completed with an EGD 1 year postoperatively, after which their status was assessed through telephone inquiries. All continuous variables are expressed as medians with interquartile ranges (IQR). Operative times between the two groups (reinforcement after ESD/EMR vs. full-thickness resection) were compared using the Mann–Whitney U test due to the small sample sizes and non-normal distribution of the data. Two-sided $P < 0.05$ was considered statistically significant. Statistical analyses were performed using JMP Pro 17 (SAS Institute, Cary, NC, USA). No operative time data were missing. Blood loss

included only that associated with the laparoscopic procedure, and minimal blood loss that could not be directly measured was estimated as 5 g. This manuscript followed the STROBE reporting guidelines.

Results

From June 2016 to October 2024, laparoscopic and endoscopic cooperative surgery was performed for duodenal neoplasms in 23 cases. Five cases were converted to laparotomy as planned after laparoscopic exploration, leaving 18 cases included in this study. Table 1 summarizes patient and tumor characteristics. The median patient age was 65.5 years, with 14 male and 4 female. Tumors were located in the first (4 cases), second (11 cases), and third (3 cases) portions of the duodenum, with the second portion being the most common site. Postoperative pathological diagnoses included 10 adenomas, 6 mucosal carcinomas, and 2 neuroendocrine grade 1 tumors (NET G1).

Table 2 presents the surgical outcomes. The procedures included reinforcement after endoscopic treatment (nine cases), full-thickness resection with suture closure (seven cases), and marking only (two cases); both marking cases were converted to open surgery. In one patient with a 34 mm tumor in the third portion of the duodenum, a full-thickness endoscopic resection resulted in a large defect, necessitating conversion to open surgery with duodenojejunal side-to-side anastomosis. The median operative time was 233 min. Although the reinforcement after EMR/ESD group had a longer operative time than the FTR or marking group owing to the prolonged endoscopic procedure, the difference was not statistically significant (289 vs. 221 min, $P = 0.37$). The median intraoperative laparoscopic blood loss was 5 g. Conversion to laparotomy occurred in four cases (22.2%), including one with a dorsally located lesion that made suturing technically difficult, two with lesions in the third portion of the duodenum near the superior mesenteric vein, and one with prior abdominal surgery, which hindered localization despite the combined use of endoscopy and laparoscopy. Postoperatively, the median time to oral fluid intake and meal initiation was 3.5 and 6.5 days, respectively. Patients were discharged after a median of 12 days. A Clavien–Dindo grade ≥3a complication occurred only in the first case, involving delayed perforation. This patient developed a fever on postoperative day (POD) 5, and CT revealed fluid collection on the right side of the duodenum (Fig. 2a). Endoscopic nasobiliary and nasopancreatic drainage were performed on the same day (Fig. 2b). On POD 8, residual fluid was drained percutaneously (Fig. 2c), leading to improvement without re-operation, and the patient was discharged on POD 23. Pathologically, the median tumor size was 17 mm, with a median resection diameter of 28.5 mm. En-bloc resection was achieved in 83.3% of cases.

After excluding four cases where assessment was impossible owing to thermal damage, R0 resections were achieved in 13 of the 14 cases (92.9%).

Postoperative EGD was performed in 13 of the 18 cases, with no observed abnormalities such as stricture or bleeding at the resection site. The median follow-up period was 37 months, during which no stenosis-related symptoms or recurrences were reported.

Discussion

In this study, D-LECS was performed in 18 cases involving duodenal adenomas, early carcinomas, and neuroendocrine tumors without lymph node involvement. The key advantages of D-LECS include reducing severe complications such as delayed perforation and improving tumor resection curability. Our institution introduced D-LECS relatively early, and a unique feature of this study is its median follow-up period exceeding 3 years, with five patients followed for more than 5 years—making it one of the longest follow-up reports, comparable to that of Kanaji et al. [11]. Moreover, the standardized surgical technique at our institution allowed non-expert surgeons with 10–12 years of postgraduate experience to perform the procedure in 13 of the 18 cases, yielding stable outcomes.

Previous studies have established the safety and efficacy of D-LECS. Nunobe et al. reported en-bloc and R0 resection rates of 96.1% and 95.1%, respectively, with delayed perforation in only four of 206 cases [12]. However, direct comparisons between D-LECS and ESD are essential to assess its benefits fully. Although no randomized controlled trials exist, Ojima et al. found that D-LECS had a lower complication rate (0% vs. 28%) and a higher R0 resection rate (100% vs. 52%) than ESD [13]. In our study, the serious complication rate was 5.6%, lower than reported for ESD [14–16]. The only major complication, a delayed perforation, was successfully managed with endoscopic nasobiliary/nasopancreatic and percutaneous drainage. Our R0 resection rate was 92.9% after excluding cases with difficult pathological evaluation, consistent with previous studies. Meanwhile, in the four excluded cases, the goal of achieving minimal local resection hindered pathological assessment due to thermal tissue damage—a limitation requiring improvement. To ensure oncological curability and facilitate reliable pathological evaluation in future cases, a surgical margin of several millimeters from the tumor should be maintained when determining the resection line. Furthermore, no stenosis-related symptoms or recurrences were observed during long-term follow-up, reflecting both long-term safety and curability of D-LECS.

Initially, tumors on the pancreatic or dorsal side of the duodenum, where suturing

is difficult, were considered indications for open surgery. Since delayed perforation in the duodenum can cause severe complications owing to bile or pancreatic juice leakage, expanding D-LECS indications must be carefully considered. The delayed perforation we encountered may have resulted from insufficient suturing of the dorsal edge owing to limited surgical field exposure during laparoscopic reinforcement after ESD. Given this technical difficulty, conversion to laparotomy should be considered for dorsal lesions. We successfully performed D-LECS in two cases involving duodenal dissection from the pancreatic head for ESD, followed by closure in the latter half of our study, indicating the potential for expanding D-LECS indications for pancreatic-side tumors. Although ampullary tumors remain contraindications, preoperative ampullary stenting may be beneficial in certain cases to secure sufficient suturing margins [11]. Given our study's favorable short- and long-term outcomes, our current selection criteria for D-LECS appear reasonable.

This study included both reinforcement after ESD and FTR. Although not statistically significant, reinforcement after ESD tended to have longer operative times (289 vs. 221 min, $P = 0.37$). Reinforcement after ESD is generally preferred for epithelial lesions to prevent intraperitoneal dissemination of tumor cells [11, 17, 18]. Furthermore, although non-exposure techniques such as non-exposed endoscopic wall-inversion surgery (NEWS) and a combination of laparoscopic and endoscopic approaches to neoplasia with a non-exposure technique (CLEAN-NET) have been developed for gastric tumors, applying similar procedures in D-LECS is challenging due to the narrow lumen and difficulty in accurately localizing small lesions [19]. Meanwhile, previous studies involving D-LECS have included classical FTR for epithelial lesions [3, 12, 13]. Our study included FTR in four adenoma cases and one adenocarcinoma case adopted due to technical difficulty with ESD, and no recurrences were observed in these patients. In contrast, reinforcement after ESD exhibits the risk of inadequate suturing, as evidenced by our delayed perforation case. Considering these factors, FTR—being a technically simpler procedure—could be a viable alternative for epithelial lesions if appropriate measures to prevent intraperitoneal dissemination—such as adequate lifting of the duodenal wall, aspiration of luminal contents, and peritoneal lavage after sutured closure—are implemented. Nevertheless, further evaluation of long-term outcomes is warranted.

We primarily used the supracolic approach for tumor resection and suturing, but the infracolic approach may be advantageous for tumors on the anal side of the inferior duodenal angle. Particularly, for ventral tumors in the third portion of the duodenum, the infracolic approach minimizes mobilization [20]. A comparison of short-term outcomes

between supracolic and infracolic approaches (which the authors refer to as antecolic and retrocolic approaches) showed no significant differences. The infracolic approach has also been suggested to involve placing the port 2 cm caudally [18]. Accurately determining the tumor location using preoperative EGD alone can be challenging, particularly when the relationship with the papilla of Vater is unclear within the same field of view. Therefore, a flexible surgical strategy, incorporating intraoperative confirmation via laparoscopy in conjunction with EGD, is needed to optimize approach selection and port placement.

We performed the Kocher maneuver after endoscopic treatment because performing it beforehand could result in a loss of fixation, making endoscopic manipulation more challenging. However, some reports suggest that performing the maneuver before endoscopic treatment can facilitate manipulation after mobilization [21], indicating that the timing may depend on the endoscopist's preference.

This study also has some limitations. First, as a single-center retrospective study, its findings may not be fully generalizable. In our clinical practice, endoscopic follow-up for duodenal adenomas is generally concluded after 1 year if no recurrence or stricture is observed on EGD, assuming that the risk of these events becomes negligible beyond that point. Nonetheless, in the present study, we reviewed available medical records from other departments and conducted telephone interviews when possible to evaluate longer-term outcomes. Second, although CT follow-up is effective in prospective studies for detecting short-term complications such as anastomotic leakage and long-term distant metastases, it was not routinely performed for all cases in this retrospective analysis. Notably, in patients without postoperative symptoms such as fever, abdominal pain, or poor oral intake, the necessity for routine CT may be limited, and symptom-based follow-up remains one of the most practical and meaningful indicators of safety. To overcome these limitations, a prospective randomized controlled trial comparing D-LECS with ESD is warranted to further validate its efficacy and safety with a multimodality approach including CT imaging for a longer follow-up period. Third, duodenal ESD requires a high level of technical expertise, and outcomes may vary depending on the endoscopist's skills. Moreover, as demonstrated in the present study where a duodenojejunostomy was required for a 34 mm tumor, high surgical skill is required to ensure adequate resection margins and secure suture closure in cases involving tumors larger than 30 mm. As tumor size criteria for D-LECS indications vary across reports, further reports are necessary to define appropriate and safe indications. Finally, although D-LECS enables safe resection of duodenal adenomas, whether all adenomas require resection remains uncertain. High-grade dysplasia and tumor size >20 mm have been identified as risk factors for malignant

transformation [22]. Future research is necessary to investigate the malignant potential of duodenal adenomas and the risk of lymph node metastases in early duodenal carcinoma.

In conclusion, D-LECS demonstrated favorable short- and long-term outcomes for non-ampullary duodenal tumors, with high en-bloc and R0 resection rates. It is a promising option for certain duodenal tumors, offering improved safety and curability. Although its indications may expand, careful patient selection remains essential to minimize the risk of serious complications.

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Disclosures

Drs. Sekiya, Kushibiki, Okawa, Miyasaka, Saikawa, Teramura, Hayashi, Suzuki, Kawada, Kawarada, Sumiyoshi, Kitashiro, Kaga, Okushiba, and Hirano declare no conflict of interest.

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Figure legends

Figure 1. Procedure of D-LECS.

A bowel clip is placed near the ligament of Treitz on the jejunum to prevent insufflation into the distal intestine (a). The tumor location is confirmed both endoscopically and laparoscopically (b), followed by endoscopic treatment (c). Kocher mobilization is performed after endoscopic manipulation (d). Next, laparoscopy is employed to achieve a circumferential full-thickness incision (e). Finally, the endoscopically resected bed or full-thickness defect is reinforced with a seromuscular layer closure (f).

Figure 2. Image findings of the postoperative leakage.

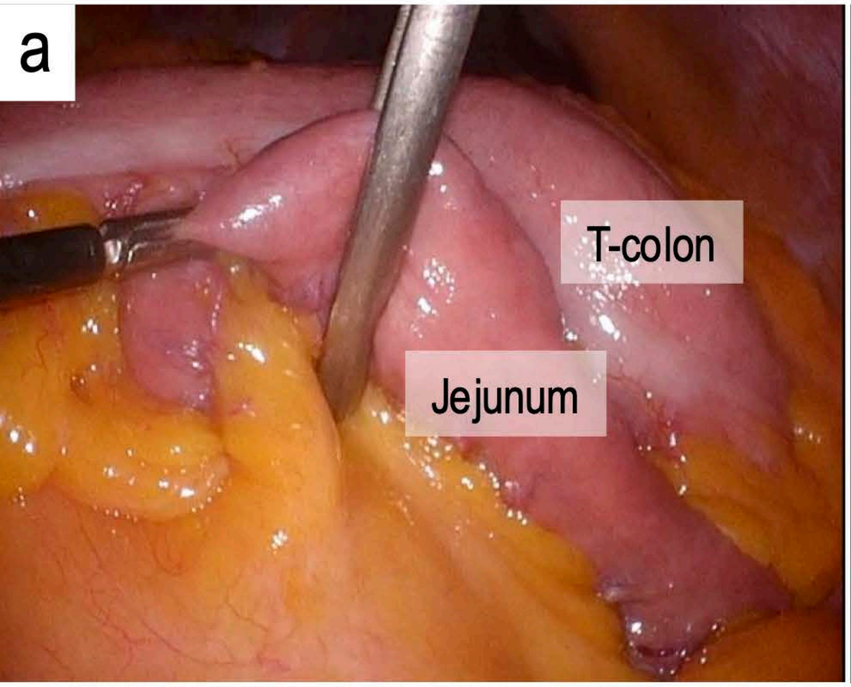
CT scan revealing a fluid collection on the right side of the duodenum (a). Endoscopic nasobiliary drainage (ENBD) and endoscopic nasopancreatic drainage (ENPD) were performed (b) on postoperative day (POD) 5. Residual fluid collection was drained percutaneously on POD 8 (c).

Table 1. Clinical characteristics of the study population and tumors.

Data are presented as numbers (%) or medians [IQR]. IQR, Interquartile range; NET, neuroendocrine tumors.

Table 2. Short- and long-term outcomes of the study population.

Data are presented as numbers (%) or medians [IQR]. *Operative blood loss is from laparoscopic procedure, not including that from endoscopic procedure. IQR, interquartile range; ESD, endoscopic submucosal dissection; EMR, endoscopic mucosal resection; FTR, full-thickness resection; POD, postoperative day; CD III, Clavien-Dindo grade 3; EGD, esophagogastroduodenoscopy.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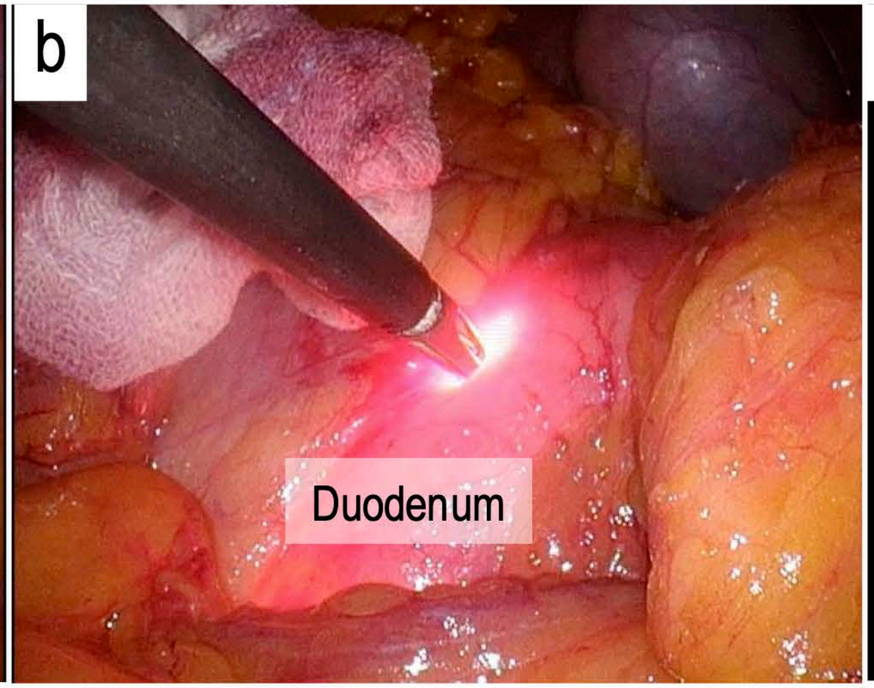
Jejunum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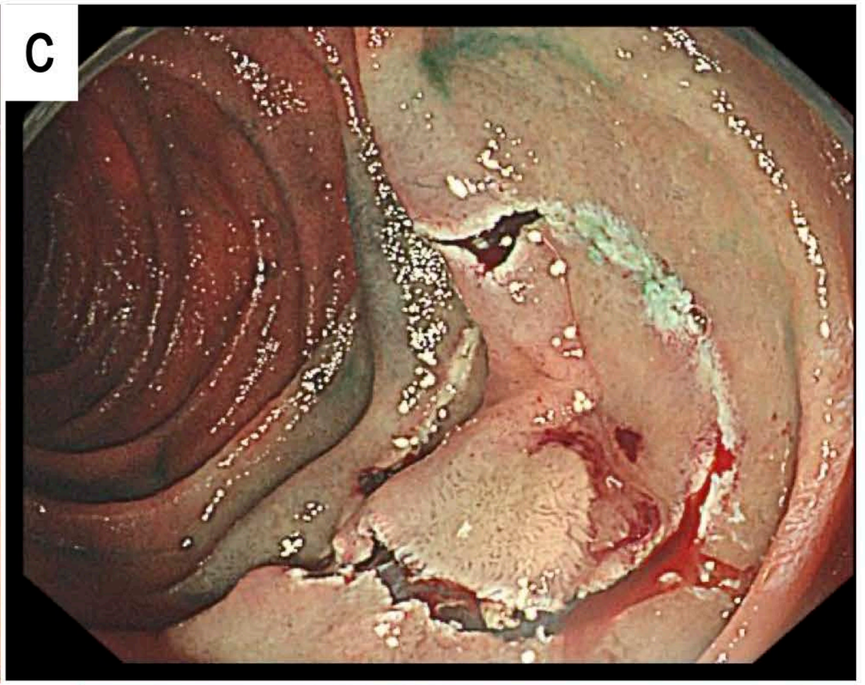
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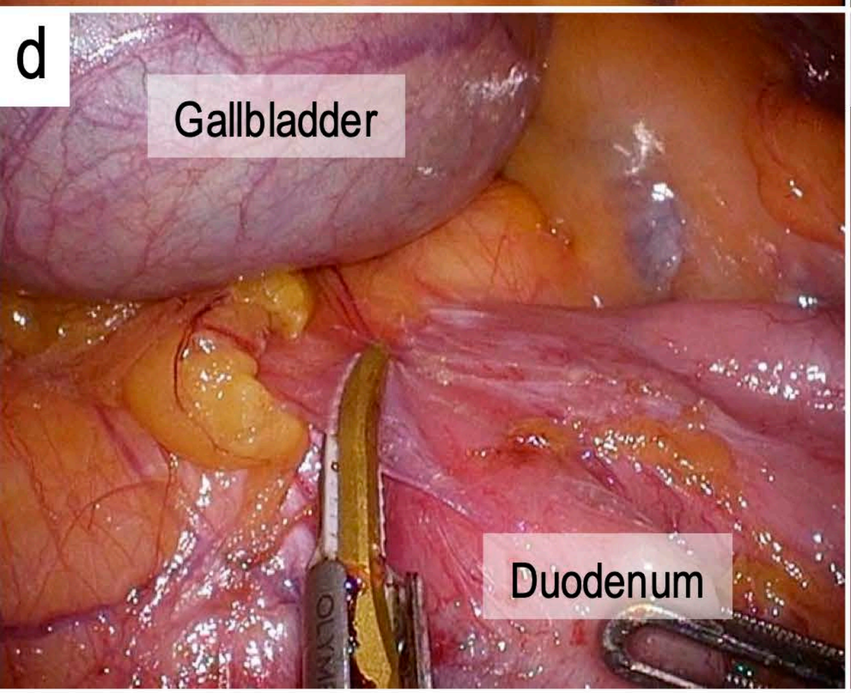
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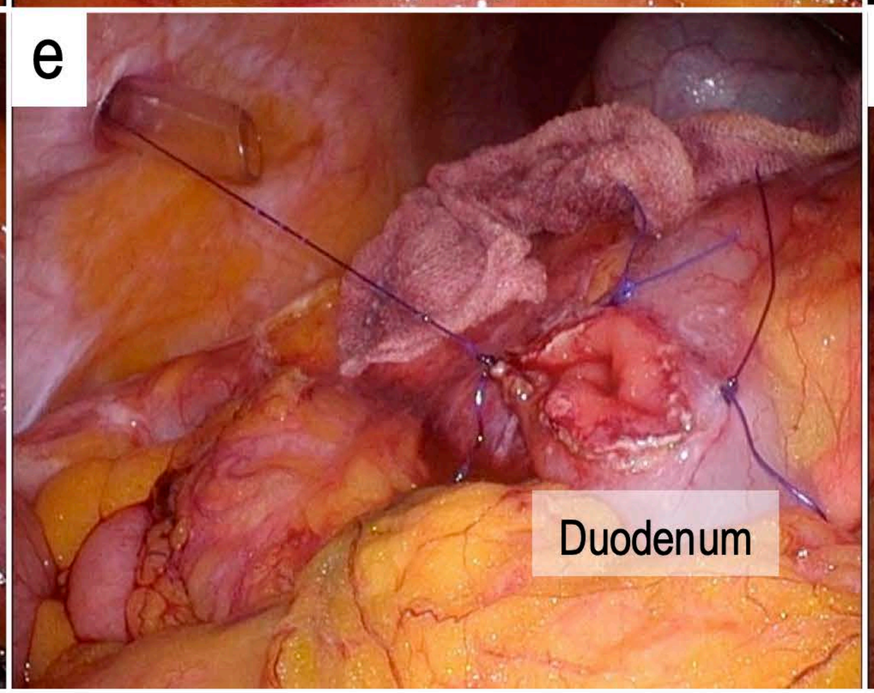
Duodenum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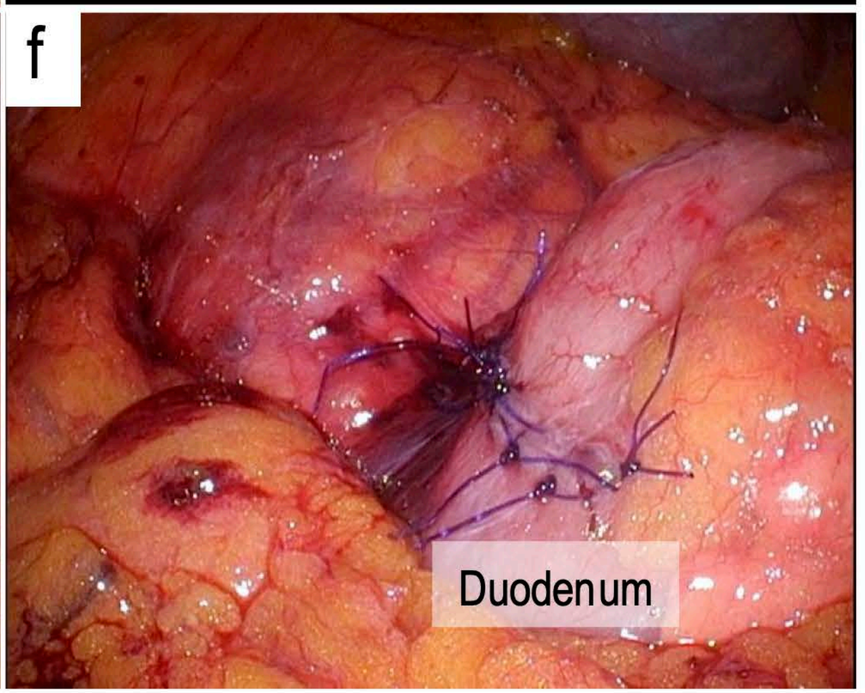
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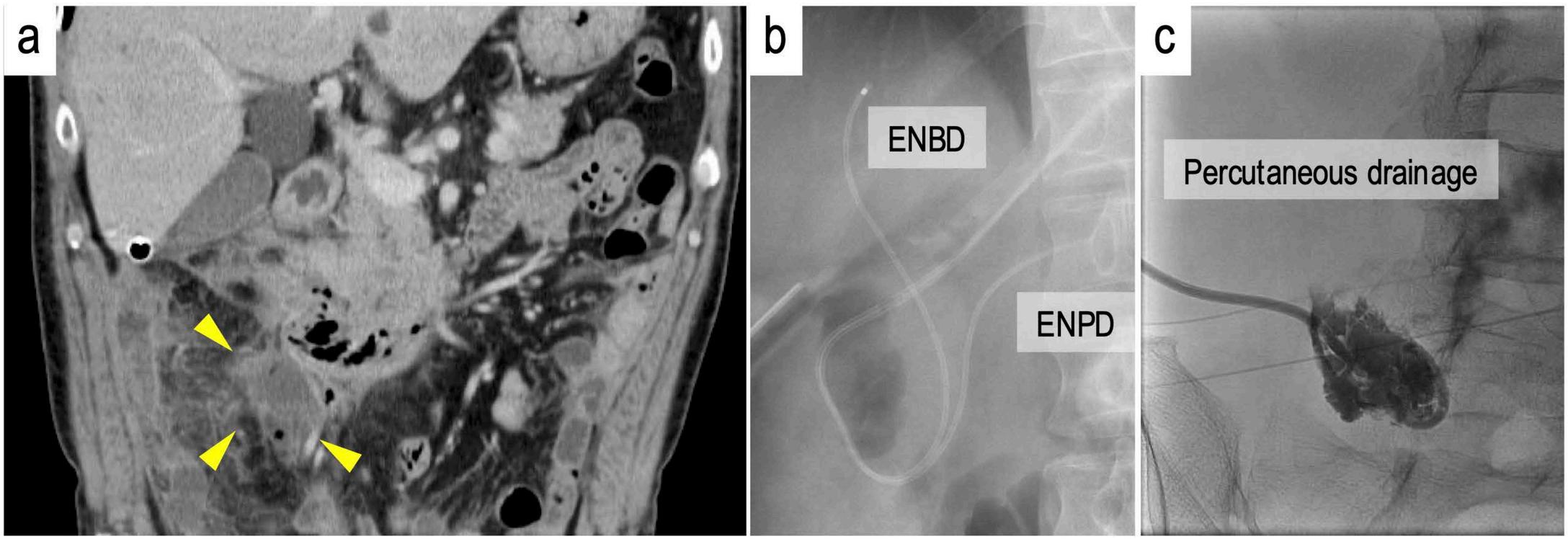
a
b
ENBD
ENPD
c
Percutaneous drainage

	n = 18
Patient characteristics	
Age	65.5 [56.5-74.5]
Sex	
Male	14 (77.8%)
Female	4 (22.2%)
Tumor characteristics	
Location	
First portion	4 (22.2%)
Second portion	11 (61.1%)
Third portion	3 (16.7%)
Histologic type	
Adenoma	10 (55.6%)
Adenocarcinoma (intramucosal)	6 (33.3%)
NET G1	2 (11.1%)

	n = 18
Short-term outcomes	
Procedure	
reinforcement after ESD/EMR	9 (50%)
full-thickness resection	7 (38.9%)
marking	2 (11.1%)
Operative time (min)	233 [182.5-324.5]
EMR/ESD	289 [173.5-381]
FTR/marking	221 [179-249.5]
Operative blood loss (g)*	5 [5-40.5]
Conversion to laparotomy	4 (22.2%)
Drinking (POD)	3.5 [3-5]
Eating (POD)	6.5 [6-7]
Hospitalization (day)	12 [10.5-14]
Postoperative complication (≧CD III)	1 (5.6%)
Size of resected lesion (mm)	28.5 [20.5-45]
Size of tumor (mm)	17 [11.5-29]
En-bloc resection	15 (83.3%)
R0 resection	13/14 (92.9%)
Long-term outcomes	
EGD after operation	13 (72.2%)
EGD interval after operation (months)	36 [27.5-46.5]
Abnormality with EGD	0 (0%)
Follow-up period (months)	37 [32.5-65.5]
Recurrence	0 (0%)
Death	0 (0%)