



# A left-sided approach for wide mobilization of the pancreas with complete dissection of the Treitz ligament (with video)

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## Abstract

**Background** In recent years, the number of minimally invasive pancreatoduodenectomy (MIPD) has been increasing; however, the procedure has not been widely accepted due to its complexity and difficulty. We have developed a technique to mobilize the pancreas head using a left-sided approach with a focus on the complete dissection of the Treitz ligament.

**Methods** This technique focuses on the secure mobilization of the pancreas head using a left-sided approach. First, the transverse mesocolon is flipped upward and the anterior side of the mesojejunum is excised to expose the first jejunal artery (1st JA) from the distal side to its origin. During the procedure, the left sides of the SMA and Treitz ligament are exposed. The Treitz ligament is retracted to the left side and dissected anteriorly. Thereafter, the jejunum is flipped to the right side and the retroperitoneum around the origin of the jejunum and duodenum is dissected to identify the inferior vena cava (IVC). The rest of the Treitz ligament is dissected posteriorly and complete resection of the Treitz ligament releases the limitation of duodenal immobility. Thereafter, dissection proceeds along the anterior wall of the IVC, and mobilization of the pancreas head is completed from the left side.

**Results** A total of 75 consecutive patients underwent MIPD from April 2016 to July 2022. The median operation times of laparoscopic and robotic procedures were 528 min (356–757 min) and 739 min (492–998 min), respectively. The volume of blood loss during laparoscopic and robotic procedures was 415 g (60–4360 g) and 211 g (17–1950 g), respectively. There was no mortality in any of the cases.

**Conclusion** Mobilization of the pancreas head and left-sided approach using a caudal view will be a safe and useful technique for MIPD.

**Keywords** robotic surgery · pancreatoduodenectomy · left approach · Treitz ligament

The number of minimally invasive pancreatoduodenectomy (MIPD) procedures, including laparoscopic pancreatoduodenectomy (LPD) and robotic pancreatoduodenectomy (RPD), has been increasing due to reports showing the procedure's feasibility [1–6]. However, the procedure has not been widely accepted as a standard procedure due to its difficulty. A major contributor to the procedure's difficulty is the anatomical complexity surrounding the pancreas, which may cause unexpected trouble, such as bleeding or organ injury, during surgery. Therefore, sufficient knowledge of surgical

anatomy is essential for safe and widespread adaptation of MIPD procedures.

The caudal view is an advantage in minimally invasive surgery (MIS), and there have been several reports in which MIPD procedures were completed by taking advantage of this view [7, 8]. Mobilization of the pancreas head, generally called Kocher's maneuver, has been performed as a gold standard procedure in both open pancreatoduodenectomy (OPD) and MIPD. Therefore, there seem to be no reports focused on the mobilization of the pancreas head. Cho et al. [8] reported dissecting the anterior surface of the inferior vena cava (IVC) during their approach to the superior mesenteric artery (SMA) in an LPD case; however, they did not sufficiently detail the mobilization of the pancreas head.

One of the most important and challenging portions of MIPD is dissection around the SMA; various approaches

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have been reported, such as anterior, posterior, right, and left approaches. Nagakawa et al. [9] reported, in a systematic review of the SMA approach, that the right approach was the most frequently reported and seemed to be the most popular approach for a MIPD. On the other hand, there have been few reports regarding other types of approaches. Although Cho et al. [8] previously reported a left approach to the SMA during an LPD, there have been no reports regarding a left-sided approach during an RPD.

In this study, we focused on the mobilization of the pancreas head from the left side, based on our anatomical understanding of the Treitz ligament. We also showed a left-sided SMA approach for MIPD procedures, including both LPD and RPD.

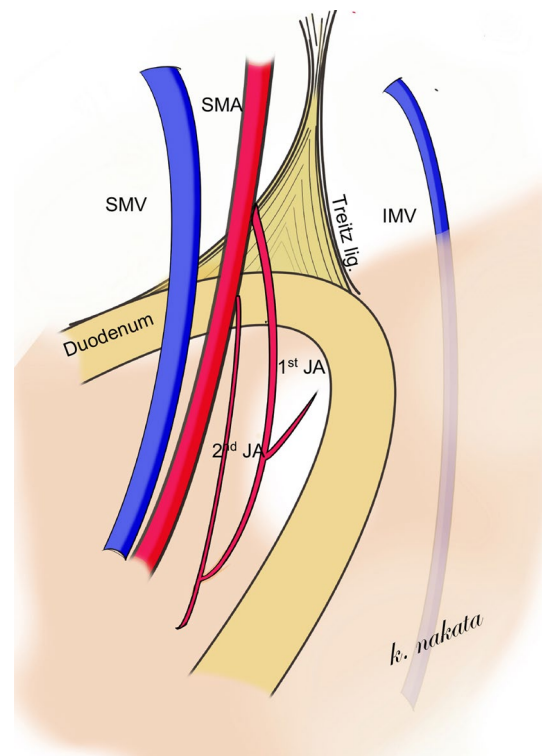
## Methods

### The anatomical significance of the Treitz ligament during MIPD

The ligament of Treitz, also known as the suspensory ligament of the duodenum, was first reported in 1853. The duodenum is fixed in place by the Treitz ligament; therefore, complete dissection of the ligament is essential for mobilization of the duodenum. The Treitz ligament is not attached only to the duodenojejunal junction. Nassar et al. [10] reported the ligament was widely attached from the 3rd and 4th portion of the duodenum to the duodenojejunal junction in 40–60% of patients (Fig. 1). Therefore, complete resection of the ligament only from the anterior side is difficult despite retraction to the left side since a part of the ligament is attached to the duodenum through the posterior side of the SMA (Fig. 1).

### Left-sided approach; Treitz ligament dissection, SMA approach, and mobilization of the duodenum from the left side (supplemental videos 1; robotic procedure and 2; laparoscopic procedure)

The patient is placed in a supine position with legs apart. The port is placed as in Fig. 2a. First, the gastrocolic ligament is dissected and entered the lesser sac. The transverse colon and mesocolon are taken down to the caudal side of the pancreas and mesenteric vessels to prevent obstruction of the view of the surgical field by the transverse colon and mesocolon (Fig. 2b, c). Thereafter, the left-sided approach is applied. The left-sided approach consists of three parts, Treitz ligament dissection, SMA approach including exposure of jejunal artery and vein, and mobilization of the duodenum. The transverse mesocolon is flipped upward. The transverse colon and transverse mesocolon are then fixed by either a liver retractor or forceps. The mesojejunum is

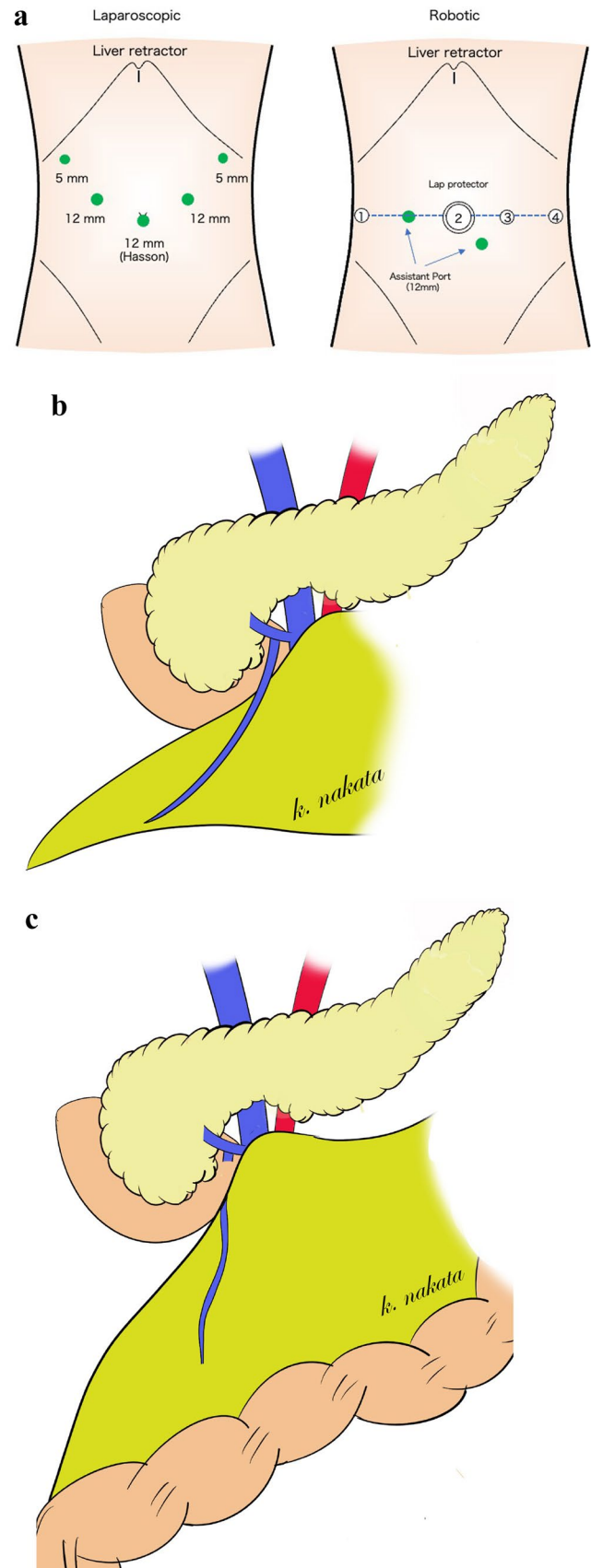


**Fig. 1** The Treitz ligament is widely attached from the 3rd and 4th portion of the duodenum to the duodenojejunal junction in 40–60% of patients. A part of the ligament is attached to the duodenum through the posterior side of the superior mesenteric artery

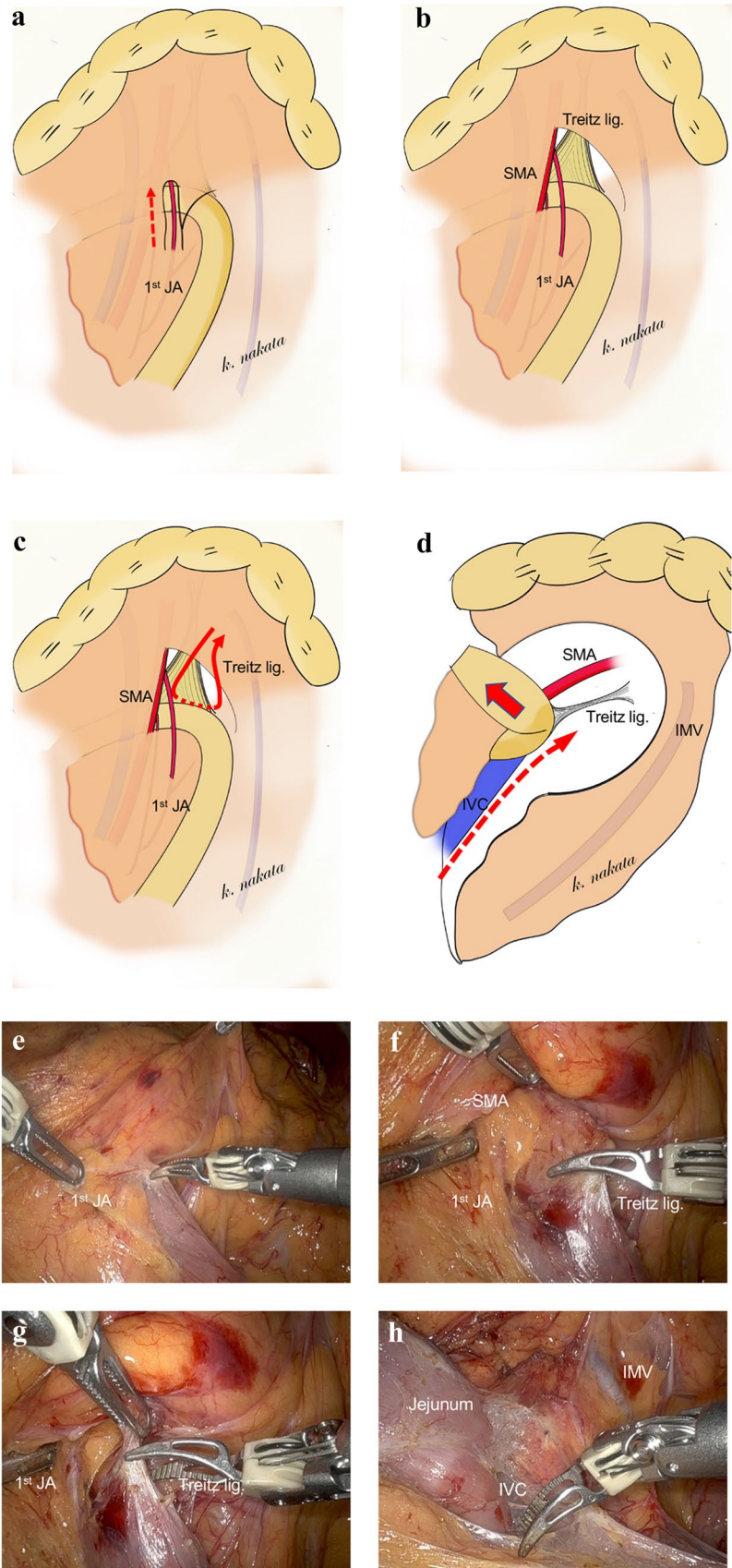
widely retracted and the anterior side of the mesojejunum is excised to expose the first jejunal artery (1st JA). The anterior side of the 1st JA is dissected from the distal side to its origin (Fig. 3a, e). The root of the 1st JA, the left side of the SMA, and part of the Treitz ligament can be clearly identified (Fig. 3b, f). The 1st JA is usually preserved in cases with benign to low malignant diseases, whereas it is dissected at the origin of the artery in cases with pancreatic cancer. The Treitz ligament is not only attached to the origin of the jejunum, but it is also widely attached to the duodenum in around 40–60% of patients (Fig. 1). Therefore, the Treitz ligament should be retracted to the left side as much as possible and dissected anteriorly (Fig. 3c, g).

Next, the origin of the jejunum is flipped to the right side and the retroperitoneum around the origin of the jejunum is dissected. Dissection begins between the left side of the jejunum and the inferior mesenteric vein (Fig. 3d, h). Since the duodenum is fixed by the retroperitoneum, dissection of the retroperitoneum allows for increased duodenal mobility such that the 3rd and 4th portions of the duodenum may be easily retracted and identified from the left side. The more the retroperitoneum around the duodenum is dissected, the more the duodenum may be retracted. At this stage in the procedure, the IVC can be identified from the left side.

**Fig. 2** **a** Port placement of laparoscopic (left) and robotic (right) procedure. **b** The transverse colon and mesocolon are completely mobilized to the caudal side to prevent obstruction of the surgical view by the transverse colon and mesocolon. **c** The transverse colon and transverse mesocolon are held away from the duodenum after complete mobilization. *SMA* superior mesenteric artery; *SMV* superior mesenteric vein; *IMV* inferior mesenteric vein; *JA* jejunal artery; *Treitz lig.* Treitz ligament



**Fig. 3** **a, b, e, and f** The jejunum and mesojejunum are widely retracted, and the anterior side of the mesojejunum is excised to expose the first jejunal artery (1st JA). **c, g** The Treitz ligament is retracted to the left side and dissected from anteriorly. **d, h** Retroperitoneum between the left side of the jejunum and the inferior mesenteric vein is dissected. The duodenum is pulled toward the left side, exposing the anterior surface of the inferior vena cava. *JA* jejunal artery; *SMA* superior mesenteric artery; *Treitz lig.* Treitz ligament; *IMV* inferior mesenteric vein; *IVC* inferior vena cava



Thereafter, the remainder of the Treitz ligament is dissected. The ligament is identified from the posterior side if the ligament is widely attached to the duodenum (Fig. 3d). After complete dissection of both the Treitz ligament and retroperitoneum, the duodenum is completely mobile. The anterior side of the IVC is dissected; dissection continues until the right side of the duodenum can be identified posteriorly (Fig. 4a, b). In this procedure, most of the mobilization of the pancreas head is completed from the left side. The remainder of the peritoneum is dissected from the right side to complete the mobilization of the pancreas head. Thereafter, the other part of the procedure is continued, which consists of transection of the stomach, isolation of the common hepatic artery (CHA), gastroduodenal artery (GDA), and proper hepatic artery (PHA), followed by isolation of the common bile duct. After dissection of the GDA, the

portal vein was exposed at the superior side of the pancreas, thereafter pancreas was isolated at the ventral side of the SMV. Thereafter, the proximal jejunum is pulled out to the right side of the SMA and transected at 10–15-cm distal side of the origin of the jejunum. The mesojejunum is also dissected toward the transection of the jejunum. The pancreatic parenchyma is transected; thereafter, tissues between the pancreatic head and right side of SMA were divided and the specimen was removed.

## Patients

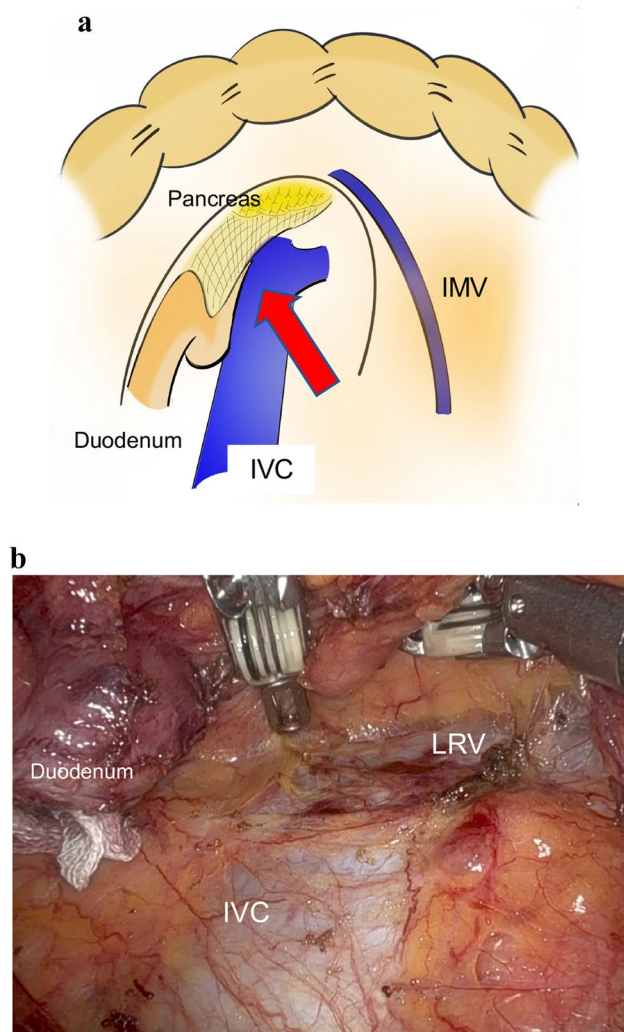
Between April 2016 and July 2022, a total of 75 consecutive patients underwent MIPD at the Department of Surgery and Oncology, Kyushu University Hospital (Fukuoka, Japan). RPD was introduced in 2018 through a clinical trial and was accepted for health insurance coverage in 2020. The indication of MIPD procedures in our institute was gradually expanded alongside the increase in surgical experience. MIPD procedures were initially only performed for patients with benign or low malignancies. However, the procedure is now performed for patients with malignant diseases, including pancreatic ductal adenocarcinoma (PDAC), except for cases with tumors exposed to the superior mesenteric vein. The Institutional Review Board of Kyushu University Hospital approved the study protocol (approval number 2022-104). The requirement for informed consent was waived by our review board.

## Statistical Analysis

All continuous data are expressed as median and range. Statistical analysis was performed using the Mann–Whitney test. A  $p$ -value of  $< 0.05$  was considered statistically significant. All statistical analyses were performed using JMP Pro 14.1.0 (SAS Institute, Cary, NC, USA).

## Results

A total of 75 consecutive MIPD case were completed between April 2016 and July 2022. Of these cases, 28 cases were completed laparoscopically, 43 cases were completed robotically, and 4 cases were completed using a hybrid method (laparoscopic resection with robotic reconstruction). The postoperative outcomes of our overall series are shown in Tables 1 and 2. The median operation times for laparoscopic, robotic, and hybrid procedures were 528 min (356–757 min), 739 min (492–998 min), and 697 min (542–764 min), respectively. The volume of blood loss was 415 ml (60–4360 ml), 211 ml (17–1950 ml), and 324 ml (247–720 ml) for laparoscopic, robotic, and hybrid procedures, respectively. Compared with LPD, operation time was longer in RPD. This could be



**Fig. 4** a, b The anterior side of the inferior vena cava is dissected from the left side and the pancreas head is mobilized. IVC inferior vena cava; IMV inferior mesenteric vein; LRV left renal vein

**Table 1** Patient characteristics and perioperative outcomes in LPD

Laparoscopic group	Total (n=28)	Early (n=20)	Late (n=8)	p value
Sex (male/female)		11/9	1/7	
Age		59 (40–82)	62 (40–75)	
Pathological diagnosis				
PDAC	3	2	1	
IPMN	7	6	1	
p-NEN	7	5	2	
Bile duct ca	0	0	0	
Vater Ca	4	3	1	
SPN	2	1	1	
Others	5	3	2	
Operation time (min)	528 (356–757)	540 (356–757)	472 (368–670)	0.1148
Blood loss (g)	415 (60–4360)	448 (92–4360)	202 (60–630)	0.037
Mortality	0	0	0	

ASA-PS American Society of Anesthesiologists physical status; LPD laparoscopic pancreaticoduodenectomy; IPMN intraductal papillary mucinous neoplasm; PDAC pancreatic ductal adenocarcinoma; p-NEN pancreatic neuroendocrine neoplasm; SPN solid pseudopapillary neoplasm

**Table 2** Patient characteristics and perioperative outcomes in RPD

Robotic group	Total (n=43)	Early (n=30)	Late (n=13)	p value
Sex (male/female)		13/17	6/7	
Age		67 (22–78)	67 (15–85)	
Pathological diagnosis				
PDAC	13	10	3	
IPMN	8	7	1	
p-NEN	6	5	1	
Bile duct ca	3	2	1	
Vater Ca	6	2	4	
SPN	3	1	2	
Others	4	3	1	
Operation time (min)	739 (492–998)	771 (588–998)	587 (492–855)	0.0036
Blood loss (g)	211 (17–1950)	252 (17–1950)	200 (57–600)	0.3973
Mortality	0	0	0	

ASA-PS American Society of Anesthesiologists physical status; IPMN intraductal papillary mucinous neoplasm; PDAC pancreatic ductal adenocarcinoma; p-NEN pancreatic neuroendocrine neoplasm; RPD robotic pancreaticoduodenectomy; SPN solid pseudopapillary neoplasm

because the variety of instruments required for the robotic procedure is still less than that for the laparoscopic procedure. We also divided laparoscopic and robotic procedures into an early period (cases 1–20 for LPD and cases 1–30 for RPD) and a late period (cases 21 and up for LPD and cases 31 and up for RPD). We found that the operation time during the late period for both LPD and RPD was shorter than that of the early period (540 min vs 471 min,  $p=0.115$ ; LPD, and 771 min vs 587 min,  $p=0.0036$ ; RPD) (Tables 1, 2). There was no mortality in any of the cases.

## Discussion

In this study, a left-sided approach, consisting of Treitz ligament dissection, SMA approach including exposure of jejunal artery and vein, and mobilization of the duodenum, was reported. Of these procedures, Treitz ligament dissection has been performed from the left side since the introductory period of MIPD, because identification of the ligament is clearer from the left side than from the right side.

Kocher's maneuver, a conventional method for mobilizing the duodenum from the right side, was previously performed during MIPD procedures at our institution during the

introductory period. However, considering taking advantage of the caudal view during MIS, once we found the proper dissection layer of the anterior IVC surface, it was easy to keep the layer and dissect the posterior layer of the pancreas head without holding the duodenum. To date, there have been few reports focusing on mobilizing the pancreas head since Kocher's maneuver is the standard procedure for both open and MIS procedures. Mobilization of the duodenum from the left side has advantages considering the benefits of the caudal view. Moreover, the procedure is also effective in OPD, especially if the tumor has invaded the duodenum such that dissection from the right side is difficult.

We also showed a left-sided approach to the SMA. As previously mentioned, a systematic review reported by Nagakawa et al. suggested that the right-sided approach was the most popular approach for dissection around the SMA based on its reported frequency [9]. In a 2021 consensus meeting held in Tokyo, 88% of the experts strongly recommended that surgical trainees should understand the "right approach" to the SMA when attempting an MIPD, which suggests that the right approach is a "basic" approach to the SMA [11]. During the introductory period, we applied the right-sided approach to the SMA because most of the cases were lean and had benign to low malignant tumors without pancreatitis. Mesojejunum will be clearly identified even from the right side in these patients. However, with expanding the indication for MIPD, such as cases with PDAC and obesity, it is difficult to complete an MIPD using only a right-sided approach. It is difficult to identify the mesojejunum from the right side in these patients because of concomitant pancreatitis around the pancreas or thick mesojejunum. An advantage of the left-sided approach includes a clear view of mesenteric arteries, such as the 1st JA and 2nd JA. If we expand the mesojejunum, we can clearly identify these arteries. The severity of the pancreatitis is usually less on the left side of SMA. If the left-sided approach was applied, the root of the 1st JA and 2nd JA will be more easily identified from the left side than from the right side. The procedure has been frequently applied during OPD, and it is also useful during MIPD procedures. Therefore, in addition to the right-sided approach, we also combined the left-sided approach for dissection around the SMA in several cases, especially in PDAC cases. There were few reports regarding the left-sided approach during MIPD procedures [7, 8, 12]. The approach is also useful in RPD procedures.

In this report, we introduced mobilization of the duodenum, complete dissection of the Treitz ligament, and SMA approach from the left side. We consider our technique to be a safe and useful option during MIPD procedures. While there are several approaches to the SMA and each surgeon and institute may have their favorite approach, no approach is universal for all cases and surgeons do not need to commit to one approach. In the consensus meeting, the experts

mentioned that they choose each approach on a case-by-case basis [11]. Surgeons should well understand various approaches and combine approaches for each case to complete MIPD procedures safely, as they may encounter some trouble if they are only familiar with one approach. Since we started MIPD, we performed MIPD safely. One of the important points to consider is to establish a clear operation view using the best approach.

In conclusion, the left-sided approach can be safely performed and has the potential to be one of the standardized approaches for completing MIPD procedures.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s00464-023-10065-2>.

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## Declarations

**Disclosures** Drs. Kohei Nakata, Toshiya Abe, Noboru Ideno, So Nakamura, Naoki Ikenaga, Kinuko Nagayoshi, Yusuke Mizuuchi, Taiki Moriyama, Kenoki Ohuchida, and Masafumi Nakamura have no conflicts of interest or financial ties to disclose.

## References

1. Palanivelu C, Senthilnathan P, Sabnis SC, Babu NS, Srivatsan Gurumurthy S, Anand Vijai N, Nalankilli VP, Praveen Raj P, Parthasarathy R, Rajapandian S (2017) Randomized clinical trial of laparoscopic versus open pancreatoduodenectomy for periampullary tumours. *Br J Surg* 104(11):1443–1450
2. Poves I, Burdio F, Morato O, Iglesias M, Radosevic A, Ilzarbe L, Visa L, Grande L (2018) Comparison of perioperative outcomes between laparoscopic and open approach for pancreatoduodenectomy: the PADULAP Randomized Controlled Trial. *Ann Surg* 268(5):731–739
3. Wang M, Li D, Chen R, Huang X, Li J, Liu Y, Liu J, Cheng W, Chen X, Zhao W, Li J, Tan Z, Huang H, Li D, Zhu F, Qin T, Ma J, Yu G, Zhou B, Zheng S, Tang Y, Han W, Meng L, Ke J, Feng F, Chen B, Yin X, Chen W, Ma H, Xu J, Liu Y, Lin R, Dong Y, Yu Y, Liu J, Zhang H, Qin R (2021) Laparoscopic versus open pancreatoduodenectomy for pancreatic or periampullary tumours: a multicentre, open-label, randomised controlled trial. *Lancet Gastroenterol Hepatol* 6(6):438–447
4. Nickel F, Haney CM, Kowalewski KF, Probst P, Limen EF, Kalkum E, Diener MK, Strobel O, Muller-Stich BP, Hackert T (2020) Laparoscopic versus open pancreaticoduodenectomy: a systematic review and meta-analysis of randomized controlled trials. *Ann Surg* 271(1):54–66
5. Liu Q, Zhao Z, Zhang X, Wang W, Han B, Chen X, Tan X, Xu S, Zhao G, Gao Y, Gan Q, Yuan J, Ma Y, Dong Y, Liu Z, Wang H, Fan F, Liu J, Lau WY, Liu R (2021) Perioperative and oncological outcomes of robotic versus open pancreaticoduodenectomy in low-risk surgical candidates: a multicenter propensity score-matched study. *Ann Surg*. <https://doi.org/10.1097/SLA.00000000000005160>
6. Shiroshita H, Inomata M, Akira S, Kanayama H, Yamaguchi S, Eguchi S, Wada N, Kurokawa Y, Uchida H, Seki Y, Ieiri S, Iwazaki M, Sato Y, Kitamura K, Tabata M, Mimata H, Takahashi H, Uemura T, Akagi T, Taniguchi F, Miyajima A, Hashizume M,

- Matsumoto S, Kitano S, Watanabe M, Sakai Y (2022) Current status of endoscopic surgery in Japan: the 15th National Survey of Endoscopic Surgery by the Japan Society for Endoscopic Surgery. *Asian J Endosc Surg*. <https://doi.org/10.1111/ases.13012>
7. Honda G, Kurata M, Okuda Y, Kobayashi S, Sakamoto K, Takahashi K (2013) Laparoscopic pancreaticoduodenectomy: taking advantage of the unique view from the caudal side. *J Am Coll Surg* 217(6):e45–e49
  8. Cho A, Yamamoto H, Kainuma O (2014) Tips of laparoscopic pancreaticoduodenectomy: superior mesenteric artery first approach (with video). *J Hepatobiliary Pancreat Sci* 21(3):E19–E21
  9. Nagakawa Y, Watanabe Y, Kozono S, Boggi U, Palanivelu C, Liu R, Wang S, He J, Nishino H, Ohtsuka T, Ban D, Nakata K, Endo I, Tsuchida A, Nakamura M (2022) Surgical approaches to the superior mesenteric artery during minimally invasive pancreaticoduodenectomy: a systematic review. *J Hepatobiliary Pancreat Sci* 29(1):114–123
  10. Nassar S, Menias CO, Palmquist S, Nada A, Pickhardt PJ, Shaaban AM, Gaballah AH, Elsayes KM (2021) Ligament of treitz: anatomy, relevance of radiologic findings, and radiologic-pathologic correlation. *Am J Roentgenol* 216(4):927–934
  11. Nagakawa Y, Nakata K, Nishino H, Ohtsuka T, Ban D, Asbun HJ, Boggi U, He J, Kendrick ML, Palanivelu C, Liu R, Wang S, Tang C-N, Takaori K, Hilal MA, Goh BKP, Honda G, Jang J-Y, Kang CM, Kooby DA, Nakamura Y, Shrikhande SV, Wolfgang CL, Yiengpruksawan A, Yoon Y-S, Watanabe Y, Kozono S, Ciria R, Berardi G, Garbarino GM, Higuchi R, Ikenaga N, Ishikawa Y, Maekawa A, Murase Y, Zimmitti G, Kunzler F, Wang Z-Z, Sakuma L, Takishita C, Osakabe H, Endo I, Tanaka M, Yamaue H, Tanabe M, Wakabayashi G, Tsuchida A, Nakamura M (2022) International expert consensus on precision anatomy for minimally invasive pancreaticoduodenectomy: PAM-HBP surgery project. *J Hepatobiliary Pancreat Sci* 29(1):124–135
  12. Inoue Y, Sato T, Kato T, Oba A, Ono Y, Ito H, Makuuchi R, Takahashi Y (2022) How can we optimize surgical view during robotic-assisted pancreaticoduodenectomy? Feasibility of multiple scope transition method. *J Am Coll Surg* 235(4):e1–e7

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