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Minimally invasive radical antegrade modular pancreatosplenectomy: routine vs. modified

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Radical antegrade modular pancreatosplenectomy (RAMPS) was introduced in 2003 by Strasberg to improve survival outcomes in left-sided pancreatic ductal adenocarcinoma. Many investigators have shown the feasibility and safety of minimally invasive RAMPS (MI-RAMPS). However, the survival benefit of RAMPS is inconclusive, and possible risks following the procedure, such as exocrine and endocrine insufficiencies, cannot be ignored. Therefore, several modifications of RAMPS were designed. Modified RAMPS is not a specific technique but rather a reduced form of RAMPS that is undertaken without compromising oncologic principles. In this literature review, the surgical technique and strategies of MI-RAMPS were examined.

Keywords: Pancreatic neoplasms, Pancreatectomy, Minimally invasive surgical procedures

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INTRODUCTION

Pancreatic ductal adenocarcinoma is a malignant tumor that has one of the most dismal prognoses. In 2003, Strasberg et al. [1] introduced the concept of "radical antegrade modular pancreatosplenectomy (RAMPS)," which involves neck-level resection; complete N1 and N2 dissection, including gastroduodenal, infrapancreatic, splenic, gastrosplenic, celiac, and superior mesenteric artery (SMA) nodes; and *en bloc* resection of Gerota fascia, with or without left adrenalectomy in left-sided pancreatic ductal adenocarcinoma. The "antegrade modular" refers to a pancreatic neck-to-tail direction of *en bloc* resection. Pancreatic neck division facilitates the dissection of gastroduodenal, infrapancreatic, celiac, and SMA node. Thereafter, the posterior resection plane is chosen (anterior or posterior RAMPS). Therefore, RAMPS is a form of distal pancreatectomy (DP) with maximal extent of lymph node (LN) excision and posterior dissection that targets higher LN yield and a higher R0 resection rate. The ultimate goal is improvement of survival in patients with left-sided pancreatic ductal adenocarcinoma.

Despite its well-established feasibility and safety [2–4], minimally invasive RAMPS (MI-RAMPS) is more complex and technically challenging than open RAMPS. Notwithstanding the complexity and wide extent of dissection in the original RAMPS, the survival benefit remains inconclusive [5,6]. Therefore, several modified RAMPS procedures have been suggested. In this literature review, we examined the advantages and disadvantages of RAMPS and the indications for the original and modified RAMPS.

MAIN SUBJECTS

Advantages and disadvantages of the original radical antegrade modular pancreatosplenectomy

The total retrieved LN count and R0 resection rate are significantly higher in RAMPS than in conventional DP [5–11]. However, a higher LN yield and a higher R0 resection rate do not indicate better survival. Several meta-analyses have shown better 1-year survival with RAMPS [8,10], whereas other meta-analyses reported no differences in survival outcomes between RAMPS and conventional DP [5,6,9,11]. Therefore, despite the high number of LN harvested and the R0 resection rate, the survival benefit, which is the ultimate goal, is inconclusive.

Extensive resection of the pancreas can result in pancreatic exocrine and endocrine insufficiencies. The prevalence of new-onset diabetes mellitus (DM) is higher after DP than after pancreaticoduodenectomy (PD). In a study by Thomas et al. [12], the prevalence of new-onset DM was 38.59% and 28.69% after DP and PD, respectively. Shirakawa et al. [13] evaluated the risk factors for new-onset DM in patients who underwent DP. The resection of a pancreatic volume >44% was a significant independent risk factor. Using the three-dimensional (3D) slicer, an open-source 3D reconstruction program, the volume of the pancreatic head, body, and tail was measured on images obtained from computed tomography scans of 50 patients who underwent DP. The head and body were divided along the portal vein, and the body and tail were divided along the aortic left border, and the mean volumes were 47.10%, 14.16%, and 38.74% in the head, body, and tail, respectively (Fig. 1A). The sum of the volume of the body and tail was more than 44% (Fig. 1B), which was higher than the cutoff point for the resected volume as a significant risk factor for post-DP new-onset DM in 42 of the 50 patients (84.0%). There are few studies on the incidence of DM according to pancreatic resection volume in DP. However, the lower incidence of new-onset DM following central pancreatectomy compared with DP was well-elucidated in many studies [14–17]. Therefore, a large amount of pancreatic resection may be a risk factor for the development of DM after pancreatectomy, and the majority of patients who undergo RAMPS may be at risk of post-pancreatectomy DM. Similarly, the occurrence of pancreatic exocrine insufficiency after DP is higher than after central pancreatectomy [14–16]. Excessive pancreatectomy may also be a risk factor for postoperative pancreatic exocrine insufficiency. However, more investigations are needed for more clear evidence.

Reconsidering the extent of lymph node dissection

Extensive LN dissection is a time-consuming and complex procedure. Extended lymphadenectomy during PD does not ensure better survival in cancer of the head of the pancreas [18]. Furthermore, extensive LN dissection confers a potential risk of complications, such as vascular complications and chyle leak. Therefore, the extent of LN dissection should be selected according to the necessity. Imamura et al. [19] calculated the efficacy index of LN dissection based on the frequency of metastasis and 5-year survival. The efficacy index of celiac and common hepatic artery (CHA) node dissection was zero in pancreatic tail cancer.

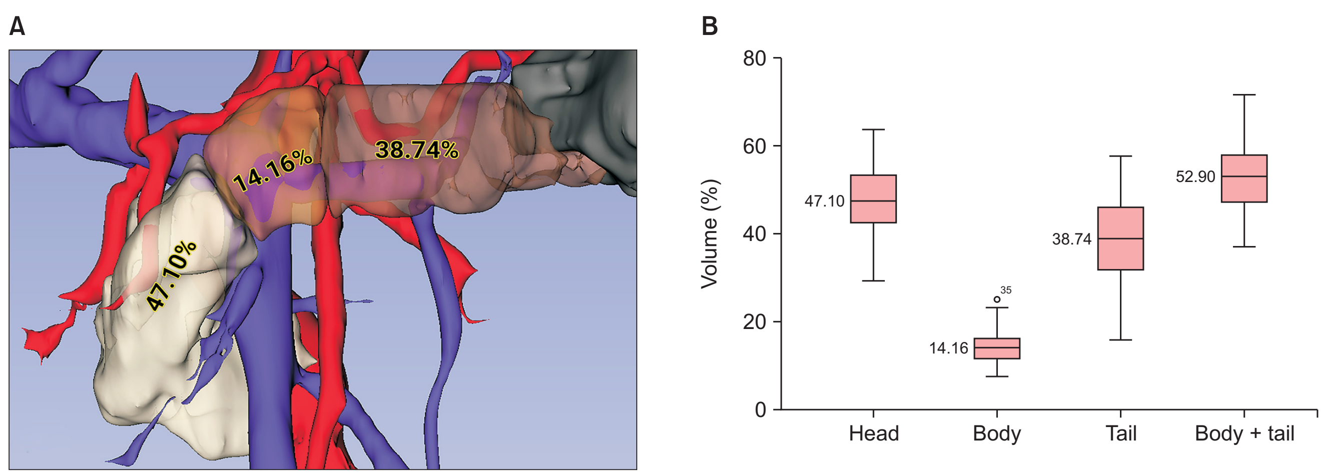

Fig. 1. (A) Measurement of volume percentage of the pancreatic head, body, and tail using the three-dimensional slicer (https://slicer.org). (B) Mean volume percentage of the pancreatic head, body, and tail was 47.10%, 14.16%, and 38.74%, respectively. The sum of the mean volume percentage of the pancreatic body and tail was 52.90%. It is greater than 44%, the cut-off for the significant risk factor of new-onset diabetes after distal pancreatectomy.

Moreover, the efficacy index of splenic hilar node dissection was zero in pancreatic body cancer. Ishida et al. [20] analyzed the frequency of LN metastasis according to the portal vein-to-tumor distance. The CHA, celiac, and SMA node metastases were observed only in cases wherein the tumor was located within 20 mm of the portal vein. Similarly, Tanaka et al. [21] reported that, when the tumor was confined to the tail of the pancreas, metastases to the CHA, celiac, and SMA nodes were nearly absent. Based on these results, it can be inferred that lymphadenectomy around the CHA, celiac axis, and SMA is not mandatory in cases where the tumor is confined to the pancreatic tail. Furthermore, splenic hilar node dissection and deep posterior dissection are not required in pancreatic body cancer.

Selection of the surgical extent in left-sided pancreatic cancer

The modified RAMPS is not a specific technique, but rather an optimization of the extent of LN dissection, pancreatic resection level, and posterior dissection plane from that of the RAMPS in accordance with the tumor location, without compromise of the oncologic principle. Therefore, the original RAMPS could be the optimal procedure for cancer extending from the body to the tail of the pancreas. However, if the tumor is only confined to the pancreatic tail, the pancreas might be divided at the left border of the aorta, and the LN dissection around the CHA, celiac axis, and SMA may be omitted [21]. If the tumor is confined to the right side of the left border of the aorta, deep posterior dissection and splenectomy could be omitted.

Techniques for minimally invasive radical antegrade modular pancreatosplenectomy

Modified RAMPS comprises a small modification of the original RAMPS and therefore, the modified MI-RAMPS is not a difficult procedure to master for surgeons who are familiar with the original MI-RAMPS, which provides the basic technique for the successfully modified MI-RAMPS. Our center usually makes use of four ports for laparoscopic original RAMPS as depicted in Fig. 2A. When the resection level is planned at the left aortic border, the locations of the ports are slightly shifted to left side (Fig. 2B).

Procedures at the right side of the left aortic border

The LN 8a can be easily found and dissected via the lesser omentum. The junction of the CHA and gastroduodenal artery (GDA) is usually located below LN 8a (Fig. 3A). The anterior surface of the portal vein is identified within a triangle, which is composed of the CHA, GDA, and the upper border of the pancreatic neck (Fig. 3B). After identifying the anterior surface of the superior mesenteric vein (SMV) at the inferior border of the pancreatic neck, the pancreatic neck is encircled and divided (Fig. 3C). The early division of the pancreatic neck facilitates LN dissection around the pancreatic neck, which is followed by the identification of the splenoportal junction and ligation and division of the splenic vein. The SMA lies below the root of the SMV. The gastroduodenal node and infrapancreatic node are located within a triangle composed of the portal vein, CHA, and SMA (Fig. 3D). In the lateral view, the gastroduodenal and infrapancreatic node dissection is not performed at a level that is deeper than the SMA (Fig. 3E). The dissection proceeds from the pancreatic neck-to-tail direction. When the root of the splenic artery is identified, it is ligated and divided. By dividing the splenic artery, celiac node dissection is facilitated (Fig. 3F).

Procedures at the left side of the left aortic border

After identifying the celiac axis and SMA, dissection proceeds

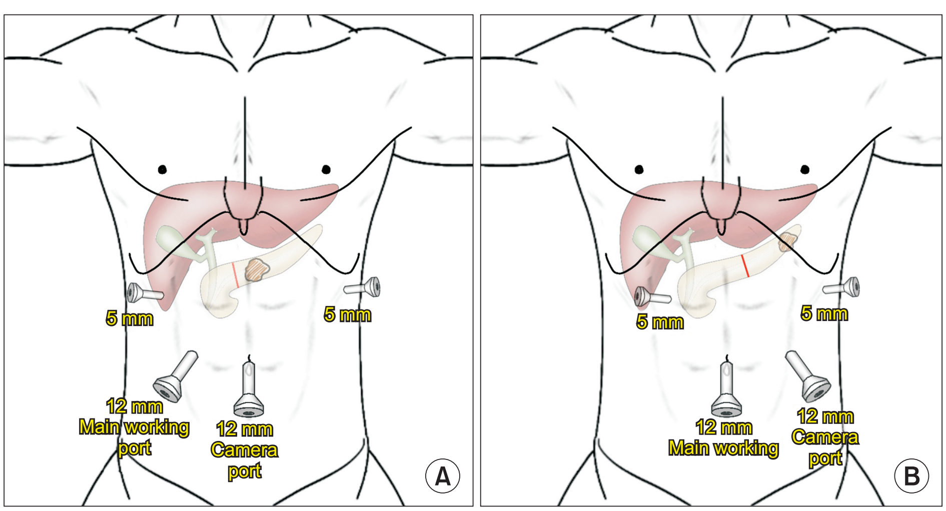

Fig. 2. (A) Port placement for laparoscopic original radical antegrade modular pancreatosplenectomy (RAMPS). (B) Left-shifted port placement for laparoscopic modified RAMPS. If the resection level is planned at the left aortic border, the locations of the operator's ports and camera port are shifted to left side.

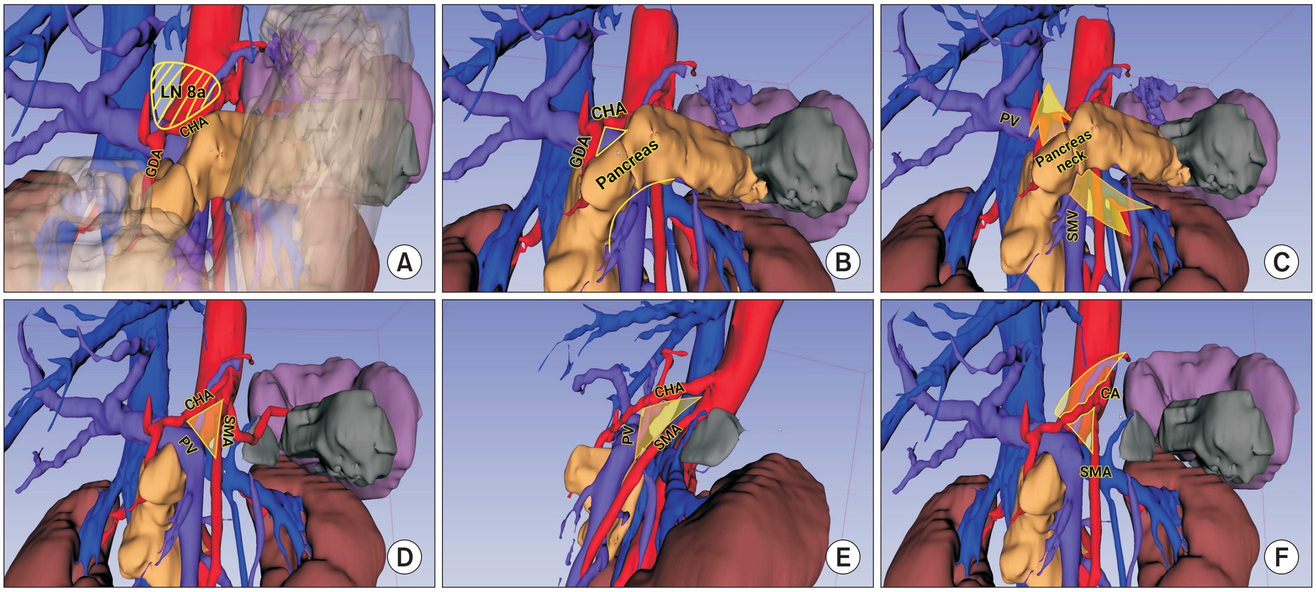

Fig. 3. Technical tip for the procedure at the right side than the left aortic border in radical antegrade modular pancreatosplenectomy. The three-dimensional (3D)-model was reconstructed using the 3D slicer (https://slicer.org). (A) The CHA, and GDA are found below the LN 8a. (B, C) A triangle composed of the CHA, GDA, and upper border of the pancreatic neck is an important landmark for pancreatic neck tunneling. (D) The gastroduodenal and infrapancreatic node is located within a triangle composed of the CHA, PV, and SMA. (E) A lateral view of the gastroduodenal and infrapancreatic node dissection area. (F) By division of the splenic artery, celiac node dissection is facilitated. CHA, common hepatic artery; GDA, gastroduodenal artery; LN, lymph node; PV, portal vein; SMV, superior mesenteric vein; SMA, superior mesenteric artery; CA, celiac axis.

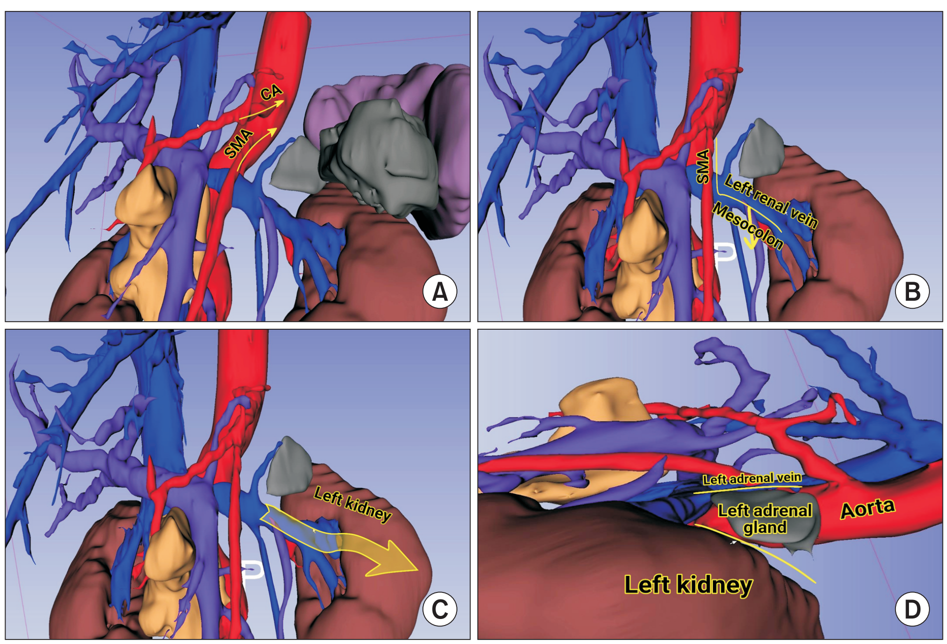

Fig. 4. Technical tip for the procedure at the left side than the left aortic border in radical antegrade modular pancreatosplenectomy. The three-dimensional (3D)-model is reconstructed using the 3D slicer (https://slicer.org). (A) Dissection along the CA and SMA reach the left side of the aorta. (B) The anterior surface of the left renal vein is usually found below the junction of the SMA and transverse mesocolon. (C) Posterior dissection proceeds along the left renal vein toward the left kidney. The inferior dissection border is the inferior border of the left renal vein. (D) The left adrenal vein, anterior surface of the left adrenal gland, and anterior wall of the aorta is usually present at the same level. CA, celiac axis; SMA, superior mesenteric artery.

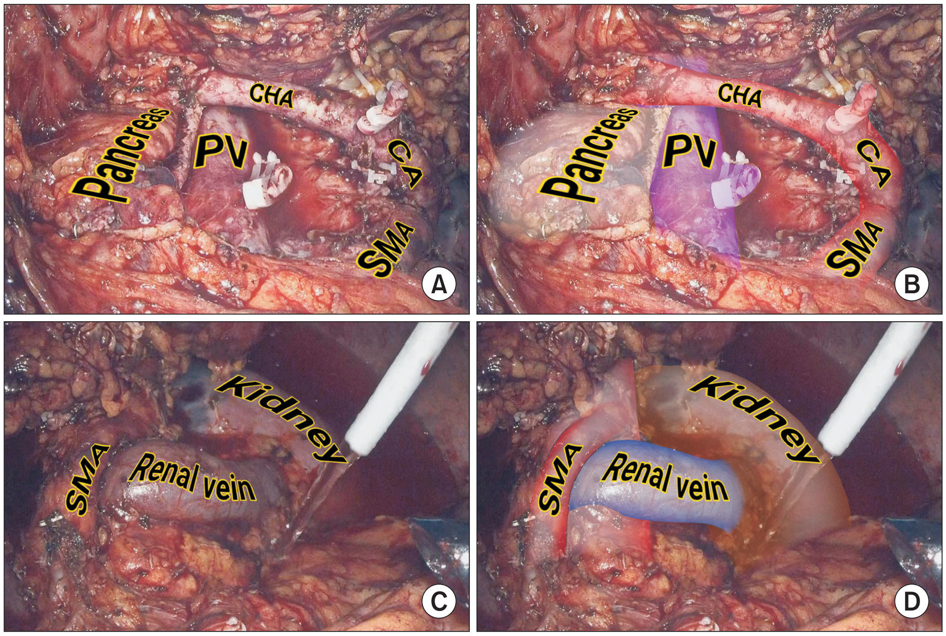

Fig. 5. The final operative field after completing the original radical antegrade modular pancreatosplenectomy. (A, B) The PV, CHA, CA, and SMA are exposed on the right side of the left aortic border. (C, D) The renal vein, and left kidney are exposed on the left side of the left aortic border. PV, portal vein; CHA, common hepatic artery; CA, celiac axis; SMA, superior mesenteric artery.

along the left side of the celiac axis and SMA. Then, the dissection plane reaches the left side of the aorta because the celiac axis and SMA usually originate from the left side rather than from the center of the aorta (Fig. 4A). The inferior mesenteric vein (IMV) is a helpful landmark to distinguish the mesocolon from Gerota fascia. After the division of the IMV, the mesocolon is pulled down to explore the anterior surface of the left renal vein below the junction of the SMA and mesocolon (Fig. 4B). The Gerota fascia is dissected along the inferior border of the left renal vein toward the left kidney (Fig. 4C). The left adrenal gland is located at the anterior aspect, rather than along the superior portion of the left kidney. The anterior surface of the left adrenal gland and left adrenal vein are usually found at the same level as the anterior surface of the aorta (Fig. 4D). After completion of the RAMPS, the CHA, celiac axis, SMA, renal vein, and left kidney are exposed (Fig. 5).

Identification of the left aortic border in pancreatic tail cancer

The left aortic border is difficult to identify in the view of a minimally invasive surgery. In addition, the aorta is often torturous. Therefore, the SMA is a more helpful landmark than the left aortic border in minimally invasive settings. Sometimes, the location of the coronary vein, splenic artery, and IMV constitute other helpful landmarks to identify the level of pancreatic resection at the left aortic border.

CONCLUSIONS

Routine extensive LN dissection and removal of a large amount of the pancreatic parenchyma in RAMPS does not improve survival outcomes in left-sided pancreatic cancer. The key principles of the RAMPS are "adequate LN dissection and margin-negative resection." Furthermore, the ultimate goal is to improve survival. The modified RAMPS can be defined as an optimized and reduced form of the RAMPS according to the tumor location without compromising oncologic principles. By optimal modification, unnecessary loss of the pancreatic parenchyma and unnecessary risk of complications may be avoided without disadvantage to the survival outcome. The surgeon should be familiar with the original MI-RAMPS for successfully performing the modified MI-RAMPS. To elucidate the efficacy of the modified RAMPS, a large-scale, well-designed study is needed.

NOTES

Conflict of interest

The author has no conflicts of interest to declare.

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REFERENCES

1. Strasberg SM, Drebin JA, Linehan D. Radical antegrade modular

pancreatosplenectomy. Surgery 2003;133:521-527.

2. Lee SH, Kang CM, Hwang HK, Choi SH, Lee WJ, Chi HS. Minimally invasive RAMPS in well-selected left-sided pancreatic cancer within Yonsei criteria: long-term (>median 3 years) oncologic outcomes. Surg Endosc 2014;28:2848-2855.
3. Kang CM, Kim DH, Lee WJ. Ten years of experience with resection of left-sided pancreatic ductal adenocarcinoma: evolution and initial experience to a laparoscopic approach. Surg Endosc 2010;24:1533-1541.
4. Wu EJ, Kabir T, Zhao JJ, Goh BK. Minimally invasive versus open radical antegrade modular pancreatosplenectomy: a meta-analysis. World J Surg 2022;46:235-245.
5. Cao F, Li J, Li A, Li F. Radical antegrade modular pancreatosplenectomy versus standard procedure in the treatment of left-sided pancreatic cancer: a systemic review and meta-analysis. BMC Surg 2017;17:67.
6. Chun YS. Role of radical antegrade modular pancreatosplenectomy (RAMPS) and pancreatic cancer. Ann Surg Oncol 2018;25:46-50.
7. Zhou Y, Shi B, Wu L, Si X. A systematic review of radical antegrade modular pancreatosplenectomy for adenocarcinoma of the body and tail of the pancreas. HPB (Oxford) 2017;19:10-15.
8. Dragomir M, Eftimie MA. Is radical antegrade modular pancreatosplenectomy the solution?: a systematic literature review and meta-analysis. Chirurgia (Bucur) 2017;112:653-663.
9. Huo Z, Zhai S, Wang Y, et al. Comparison of radical antegrade modular pancreatosplenectomy with standard retrograde pancreatosplenectomy for left-sided pancreatic cancer: a meta-analysis and experience of a single center. Med Sci Monit 2019;25:4590-4601.
10. Zhou Q, Fengwei-Gao, Gong J, et al. Assessement of postoperative long-term survival quality and complications associated with radical antegrade modular pancreatosplenectomy and distal pancreatectomy: a meta-analysis and systematic review. BMC Surg 2019;19:12.
11. Sutton TL, Potter KC, Mayo SC, Pommier R, Gilbert EW, Sheppard BC. Complications in distal pancreatectomy versus radical antegrade modular pancreatosplenectomy: a disease risk score analysis utilizing national surgical quality improvement project data. World J Surg 2022;46:1768-1775.
12. Thomas AS, Huang Y, Kwon W, et al. Prevalence and risk factors for pancreatic insufficiency after partial pancreatectomy. J Gastrointest Surg 2022;26:1425-1435.
13. Shirakawa S, Matsumoto I, Toyama H, et al. Pancreatic volumetric assessment as a predictor of new-onset diabetes following distal pancreatectomy. J Gastrointest Surg 2012;16:2212-2219.
14. Jung D, Bari H, Hwang HK, Lee WJ, Kang CM. Short and long-term outcomes of minimally invasive central pancreatectomy: Comparison with minimally invasive spleen-preserving subtotal distal pancreatectomy. Asian J Surg 2022 Sep 8 [Epub]. DOI: 10.1016/j.asjsur.2022.08.084
15. Iacono C, Verlato G, Ruzzenente A, et al. Systematic review of central pancreatectomy and meta-analysis of central versus distal pancreatectomy. Br J Surg 2013;100:873-885.
16. Xu SB, Zhu YP, Zhou W, Xie K, Mou YP. Patients get more long-term benefit from central pancreatectomy than distal resection: a meta-analysis. Eur J Surg Oncol 2013;39:567-574.
17. Asano Y, Kato H, Arakawa S, et al. Clinical outcomes of organ-preserving pancreatectomy for benign or low-grade malignant pancreatic tumors: a multicenter nationwide survey in Japan. J Hepatobiliary Pancreat Sci 2022;29:898-910.
18. Jang JY, Kang MJ, Heo JS, et al. A prospective randomized controlled study comparing outcomes of standard resection and extended resection, including dissection of the nerve plexus and various lymph nodes, in patients with pancreatic head cancer. Ann Surg 2014;259:656-664.
19. Imamura T, Yamamoto Y, Sugiura T, et al. Reconsidering the optimal regional lymph node station according to tumor location for pancreatic cancer. Ann Surg Oncol 2021;28:1602-1611.
20. Ishida H, Ogura T, Takahashi A, et al. Optimal region of lymph node dissection in distal pancreatectomy for left-sided pancreatic cancer based on tumor location. Ann Surg Oncol 2022;29:2414-2424.
21. Tanaka K, Nakamura T, Asano T, et al. Pancreatic body and tail cancer and favorable metastatic lymph node behavior on the left edge of the aorta. Pancreatology 2020;20:1451-1457.