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Original Article

Pancreatoduodenectomy with colon-last approach for advanced pancreatic head cancer

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Purpose: Margin-negative surgery is very important in surgical oncology. Considering margin-negative pancreatectomy is known to be essential for cure of the pancreatic cancer, pancreatoduodenectomy with combined venous vascular or arterial resection can be a potential option for margin-negative resection, especially, in era of neoadjuvant treatment with potent systemic chemotherapy. To the contrary, special attention was not paid on combined colonic resection during PD. In this article, safe surgical technique for PD with combined colonic resection is introduced, under the name of PD with "colon-last" approach.
Methods: At Severance Hospital (Yonsei University College of Medicine, Seoul, Republic of Korea), between 2014 and 2021, a total of six patients underwent PD with "colon-last" approach. The surgical technique and surgical outcome are reviewed.
Results: All patients recovered without major complications (Clavien-Dindo classification grade ≥ III) after surgery, and most of them recovered after conservative treatment with postoperative pancreatic fistula biochemical leak. None of the patients were readmitted. Only the first and second cases represent cancer-related mortality, and the other patients are still alive and are being followed up.
Conclusion: It is hoped that the present technique, PD with colon-last approach, could be helpful enhance the procedural safety in treating advanced cancer requiring PD with combined colon resection. However, its technical safety and oncologic role should be validated by many pancreatic surgeons' collaborative studies in the near future.

Keywords: Pancreaticoduodenectomy, Pancreatic neoplasms, Neoadjuvant therapy, Colectomy

INTRODUCTION

Margin-negative surgery is very important in surgical oncology. Adjacent organs often need to be simultaneously removed due to anatomical intimacy with primary tumor. In spite of raising concerns about quality of life and patient' safety, combined multi-organ resection should be decided in well selected patients for radical surgery.

Pancreatoduodenectomy (PD) itself is thought be one of the surgical procedures composed of multiple organ resection (pancreatic head, distal bile duct, and duodenum, or even distal part of stomach) for complete removal of malignant disease in periampullary lesion. Considering margin-negative pancreatectomy is known to be essential for cure of the pancreatic cancer, PD with combined venous vascular or arterial resection can be a potential option for margin-negative resection [1-3], especially, in era of neoadjuvant treatment with potent systemic chemotherapy [3,4].

To the contrary, special attention was not paid on combined colonic resection during PD. Most literatures seemed that PD was the additional approach for treating advanced right colon cancer [5,6]. However, there is still controversy in the safety of combined colonic resection in PD [7-9]. Recent systemic review showed en bloc PD with right hemicolectomy is rarely performed, but it can be a potentially safe treatment option in patients with locally advanced right colon cancer [5]. However, Solaini et al. [10] concluded PD-colon for pancreatic ductal adenocarcinoma seems to be asso-

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ciated with an increased morbidity and mortality but with survival comparable with standard PD in selected patients.

In our early experiences, once, there was a patient with pancreatic cancer who should have received PD with combined colonic resection for margin-negative resection. At that time, surgical dissection of uncinated process from superior mesenteric artery (SMA) was the last step for en block resection as usual. However, the patient had to experience profound gram-negative sepsis during the whole surgical procedure because colonic segment resected with en block "PD-last" approach resulted in vascular compromising of resected colon, which was thought to be septic nidus (Fig. 1A). In addition, severe adhesion and inflammatory changes around the pancreas and bile duct led to prolonged operation time to complete surgical procedure.

In this article, safe surgical technique for PD with combined colonic resection is introduced, under the name of PD with "colon-last" approach. Personal experiences and potential advantages of this surgical technique are also discussed. This surgical procedure is rarely performed, but it is hoped that PD with colon-last approach could provide the patients with good quality of radical surgery, and patients' safety, as well.

METHODS

Surgical technique-video

The patient's condition before surgery needs to be reviewed from various angles. This surgery should exclude cases where distant metastasis is difficult to obtain the oncologic benefit of margin-negative resection. It is necessary to review the direction of tumor growth based on computed tomography (CT) taken before surgery. A "colon-last" approach can be considered if the vector from which the tumor grows is directed towards the antero-inferior (colon mesentery). Before surgery, it is necessary to check the patient's history of colon surgery. In patients who previously had inferior mesenteric artery high ligation through the anterior resection of colon, if the transverse colon is supplied with blood only through the middle colic artery, ischemic changes may occur in the remnant colon during this operation. To review this, it may be helpful to check the bloody supply of the colon by performing an abdomen angio-CT before surgery. Written informed consent was obtained from all patients.

Surgical approach

First, the patient is placed in supine position. Selective staging laparoscopy is performed during the same procedure, to rule out peritoneal seeding and occult metastasis. If no metastases are found, it is converted to open surgery. In this case, inverted L incision is preferred to ensure visibility. After confirming the location of the tumor, it is checked whether the vector in which the tumor grows is consistent with the preoperative imaging findings and whether segmental resection of the colon is absolutely necessary. In most cases, combined partial excision of colonic mesentery can preserve

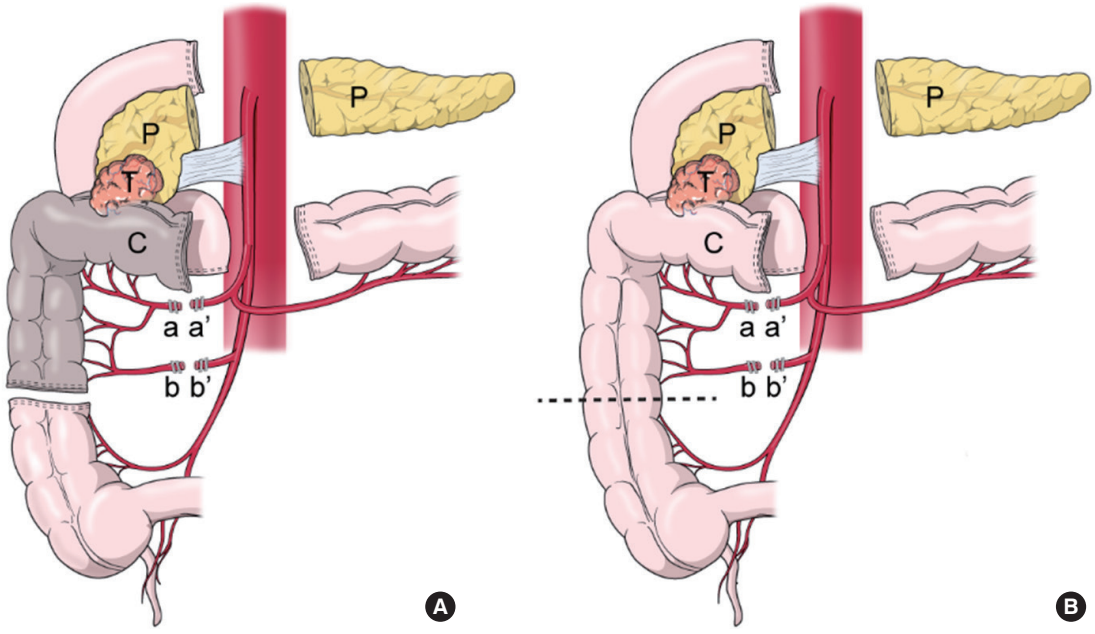

Fig. 1. (A) Pancreatoduodenectomy-last approach, resected colon with ischemic change. (B) Colon-last approach. P, pancreas; T, tumor; C, colon; a-a', middle colic artery; b-b', right colic artery.

Table 1. Perioperative characteristics of all patients

No.	Age (yr)/ Sex	Diagnosis	Neoadjuvant Tx	Operation date	Operation name	Venous resection	ICV-preserving	Operation time (min)	Intraoperative blood loss (mL)	Transfusion (mL)	Complication	Re-admission	Follow-up (mo), (status)
1	74/M	Pancreatic cancer	No	2014-11-25	PD with colon SR	No	Yes	508	400	0	POPF BL	No	30 (death)
2	58/M	Stomach cancer	No	2016-03-23	PD with colon SR	SMV/PV SR	Yes	719	1,300	537	POPF BL	No	38 (death)
3	58/F	Pancreatic cancer	Yes	2019-11-06	PD with colon SR	SMV SR	Yes	394	350	0	POPF BL	No	19 (alive)
4	72/M	Gallbladder cancer	No	2020-05-12	PD with RHC, HIPEC	No	No	666	1,100	300	POPF BL	No	12 (alive)
5	62/M	Colon cancer	Yes	2020-06-15	PD with RHC	No	No	670	1,400	500	DGE, ileus	No	11 (alive)
6	65/F	Pancreatic cancer	No	2021-01-26	PD with colon SR	SMV SR	Yes	536	400	0	No	No	4 (alive)

Tx, treatment; ICV, ileocolic vessel; PD, pancreatoduodenectomy; SR, segmental resection; POPF BL, postoperative pancreatic fistula biochemical leak; SMV, superior mesenteric vein; PV, portal vein; RHC, right hemi-colectomy; HIPEC, hyperthermic intraperitoneal chemotherapy; DGE, delayed gastric emptying.

colon (e.g., by mesenteric approach [11]), however, in certain cases where extent of tumor invasion approaches near the mesenteric border of the colon or even is directly into the colon, PD with "colon-last" approach could be considered.

Standard PD performed as usual. When combined colonic resection is decided to be performed, main trunk of middle colic artery is isolated and preserved. It can be ligated according to the extent of colonic resection, but mostly it can be preserved because tumor invading portion is not that extensive in resectable pancreatic cancer. But its branch to the resected portion of the colon need to be controlled and distal part of the colon is divided by GIA stapler. This procedure can facilitate subsequent surgical dissection of uncinated process from the SMA. Right colic artery is divided with ileocolic artery is preserved (this part can be also conserved according to extent of the tumor invasion), so that the remaining colon is supplied with blood by the ileocolic artery (Fig. 1B). As shown in Fig. 1B, a viable colon color can still be maintained by the ileocolic artery unit. After completely separating retroperitoneal margin from SMA, division of the pancreatic neck and bile duct, finally, the colon was cut by securing sufficient margin in the proximal portion of the colon invaded by the tumor.

In this fashion, the pancreatic head and tumor are excised with en bloc while attached to the colon. Colon reconstruction, PD, hepaticojejunostomy, duodenojejunostomy are performed as usual [12,13]. The abdomen is closed and a surgical drain is left around the reconstruction site.

RESULTS

At Severance Hospital (Yonsei University College of Medicine, Seoul, Republic of Korea), between 2014 and 2021, a total of six patients underwent PD with "colon-last" approach. Their average age was 64.83 years, and there were many relatively elderly patients. The male to female ratio was 2:1, twice as many men as women. Half of the patients underwent surgery for pancreatic cancer, and each had stomach cancer, gallbladder cancer, and colon cancer. One of them received neoadjuvant chemotherapy for pancreatic cancer, and one received neoadjuvant chemotherapy for colon cancer. Fifty percent of patients suspected superior mesenteric vein (SMV) invasion during surgery, and SMV segmental resection was performed. The average operation time was 582.17 minutes, and the amount of blood loss during surgery was 825 cc. Three patients with more than 1,000 cc of intraoperative bleeding received blood transfusions during surgery. All patients recovered without major complications (Clavien-Dindo classification grade ≥ III [14]) after surgery, and most of them recovered after conservative treatment with postoperative pancreatic fistula biochemical leak. None of the patients were readmitted. Only the first and second cases represent cancer-related mortality, and the other patients are still alive and are being followed up.

In case 4, the gallbladder was perforated due to gallbladder cancer. Curative intent surgery was performed because peritoneal seeding was thought to be localized, covered by omentum, colon, and duodenum according to both preoperative CT scan and intraoperative finding. Since the peritoneal seeding was limited around the tumor, we decided that en bloc resection by PD with colon-last approach would be helpful for the patient's prognosis. This patient underwent PD with colon-last approach (right hemicolectomy) followed by hyperthermic intraperitoneal chemotherapy. Currently, this patient has been alive for more than 1 year and is under follow-up (Table 1).

DISCUSSION

According to personal experiences, there are several advantages of PD with colon-last approach; First, by avoiding surgical separation between colonic mesentery and pancreatic head, intact margin-negative anterior aspect of the pancreatic head portion can be obtained. Second, as results, it also can reduce the chance of potential tumor spillage by omitting dissection colonic mesentery from pancreatic head portion. Third, by dividing transverse colon first, good surgical field can be obtained for appropriate dissection to-

ward SMV and SMA. In other words, mesenteric approach [11,15,16] and anterior approach [17] are thought to be much easier, resulting in facilitating safe combined venous vascular resection and clear SMA lateral margin as shown in the video (Supplementary Video 1). In addition, even combined en bloc venous vascular resection can be ensured. Fourth, colonic perfusion can be conserved to the end of the surgical procedure. In spite of long operation time for PD, well preserved ileocolic artery and responsible collaterals (in spite of controlling right colic artery) guarantee the good colonic perfusion to avoid unexpected intraoperative gram-negative septic event. Lastly, according to the condition of colon perfusion, ileocecal value can be also preserved for future quality of the patient's life.

Marsman et al. [18] recently performed a nationwide retrospective analysis on PD with colonic resection for cancer patients. From 2004 to 2014, 13 centers of the Dutch pancreatic cancer group reviewed the surgical outcome of PD with colonic resection for periampullary or colon cancer. Only 1.6% of the patients (50 out of 3,218 patients) underwent PD with colonic resection, and showed 90-day severe complication (Clavien-Dindo classification grade ≥ III) occurred in 60% of the patients with 6% surgery-related mortality. They concluded that PD with colonic resection was associated with considerable complications, but could ensure acceptable survival rates as long as tumor negative resection margin was achieved. However, as noted in previous meta-analysis [10], the study period is very old. Considering recent advance of surgical technique based on the accumulating experiences, concerns regarding the procedural safety is still open to be answered. Especially, in era of new potent chemotherapeutic agents, surgical safety should be mandatory for ensuring long-term survival of cancer patients.

It is hoped that the present technique, PD with colon-last approach, could be helpful enhance the procedural safety in treating advanced cancer requiring PD with combined colon resection. However, its technical safety and oncologic role should be validated by many pancreatic surgeons' collaborative studies in near future.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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SUPPLEMENTARY MATERIALS

Supplementary materials are available at the Korean Journal of Clinical Oncology website (http://www.kjco.org/).

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