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Original Paper

Gastric vein preservation to minimize gastric venous congestion following total pancreatectomy

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Abstract

Brittle diabetes, malabsorption, and liver steatosis are the most common adverse consequences of total pancreatectomy (TP). While some authors have described gastric venous congestion and bleeding, details of gastric venous drainage following TP remain incompletely known. We examined the effectiveness of our methods for avoiding gastric venous congestion in five patients who recently underwent TP. During TP, our standard practice is preservation of at least one vein providing gastric drainage. When no pancreatic vein draining the stomach can be preserved, a relatively extensive gastrectomy is added. Among five patients who underwent TP, preservation of the left gastric vein was possible in three patients, whereas the posterior and short gastric veins and the splenic vein were preserved in one patient. These four patients underwent subtotal stomach-preserving TP or TP with distal gastrectomy in two patients each. One patient requiring sacrifice of all gastric drainage veins additionally underwent TP with subtotal gastrectomy. No patient developed gastric venous congestion or bleeding; patency of drainage veins in four patients was confirmed by postoperative three-dimensional computed tomography. Postoperative body weight decreased compared with preoperative weight in three patients; however, nutritional parameters on postoperative blood tests did not significantly change compared with preoperative values. The favorable outcomes of our strategy for gastric vein preservation in TP should encourage more frequent use of TP when required.

Key words: total pancreatectomy, gastric venous congestion, 3D-CT, gastric venous drainage

Introduction

Total pancreatectomy (TP) is performed for the treatment of extensive intraductal papillary mucinous neoplasms and pancreatic cancers. Unfortunately, gastric venous congestion and bleeding can result because of sacrifice of veins draining the stomach. Although TP with gastric preservation has been recently reported[1,2], TP is more frequently combined with distal gastrectomy to reduce gastric venous congestion[3]. However, details of gastric venous drainage following TP remain incompletely understood. At our institution, we seek to preserve a gastric drainage vein during TP whenever possible. When preservation of gastric venous drainage is problematic, gastrectomies of varying extent are added to reduce gastric venous congestion.

In this study, we comprehensively reviewed our recent patients who underwent TP to assess our strategy for avoiding gastric venous congestion.

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Abbreviations: CT, computed tomography; Hb, hemoglobin; HU, Hounsfield units; RAMP, radical antegrade modular pancreatosplenectomy; SSPTP, subtotal stomach-preserving total pancreatectomy; TP, total pancreatectomy; TPDG, total pancreatectomy with distal gastrectomy; TPSTG, total pancreatectomy with subtotal gastrectomy.

Patients and methods

Patients

Between 2019 and 2021, five patients underwent TP at our institution (four males and one female; median age, 65 years; age range, 60-77 years; Table 1). Of the five patients, three, one, and one had pancreatic adenocarcinoma, pancreatic adenocarcinoma including duodenal ampullary adenocarcinoma, and intrapapillary mucinous neoplasm, respectively. Among the three resections for pancreatic adenocarcinoma, two involved residual pancreatic adenocarcinoma following a previous pancreatoduodenectomy.

This study was approved by the Institutional Ethics Committee of Showa University (notice of approval number, 21-184-A). Written informed consents were obtained from the patients included in this study.

Pancreatectomy procedure

As previously mentioned, we aimed to preserve at least one gastric drainage vein during TP. When this is impossible, gastrectomy of appropriate extent is added. All patients in this report underwent TP-associated splenectomy. The following types of TP were classified according to the type of associated gastrectomy (Figure 1): subtotal stomach-preserving TP (SSPTP), two patients; TP with distal gastrectomy (TPDG), two patients; and TP with subtotal gastrectomy (TPSTG), one patient. Although distal gastrectomy for treating gastric cancer generally means two-third of the distal side of the stomach is resected, approximately one-third of distal gastrectomy is the standard in this study. SSPTP or TPDG was selected according to the surgeon's decision during surgery regarding the extent of the disease progression, edema of the gastric wall, and ease of anastomosis during reconstruction when at least one drainage vein could

Table 1. Patient background and operative procedures

Patient	Age (years)	Gender	Disease	Procedure	Gastric inflow vessel	Gastric drainage vein	Operative duration (min)	Intraoperative blood loss (ml)	Postoperative hospital stay (day)
1	73	Male	PDAC (Residual pancreas)	SSPTP	LGA	LGV	360	295	18
2	60	Female	PDAC (Residual pancreas)	TPDG	LGA	LGV	647	382	33
3	77	Male	PDAC Ampulla of Vater carcinoma	TPDG	LGA	LGV	652	1,395	25
4	65	Male	IPMN	SSPTP	LGA	SGV, PGV, SPV	821	85	58
5	64	Male	PDAC	TPSTG	LGA	Esophageal venous plexus	816	385	26

PDAC, pancreatic duct adenocarcinoma; IPMN, intraductal papillary mucinous neoplasm; SSPTP, subtotal stomach-preserving total pancreatectomy; TPDG, total pancreatectomy with distal gastrectomy; TPSTG, total pancreatectomy with subtotal gastrectomy; LGA, left gastric artery; LGV, left gastric vein; SGV, short gastric vein; PGV, posterior gastric vein; SPV, splenic vein.

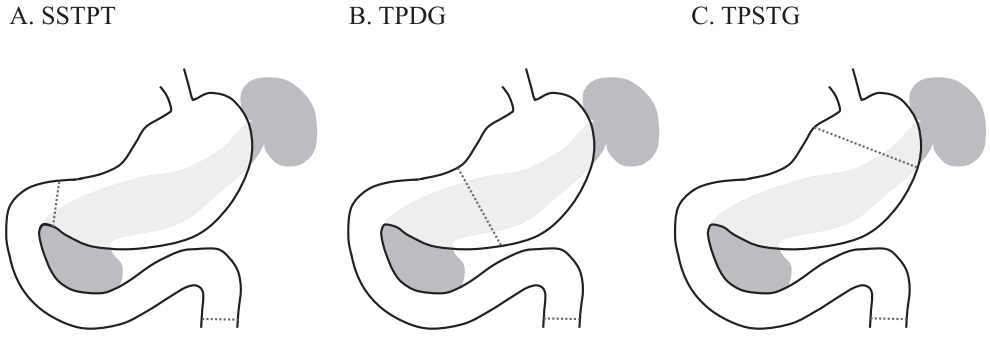

Fig. 1. Types of total pancreatectomy (TP) classified by type of gastrectomy. The gray shading indicates the pancreas and spleen. The blue dotted lines show possible oral and anal cut ends of the stomach and duodenum. a, Subtotal stomach-preserving total pancreatectomy (SSPTP) ; b, total pancreatectomy with distal gastrectomy (TPDG) ; c, total pancreatectomy with subtotal gastrectomy (TPSTG).

be preserved. The left gastric artery was preserved as the blood supply in all five patients (Table 1).

Preoperative and 6-month postoperative assessments of nutritional status

As nutritional parameters and indicators of malabsorption, body weight, serum albumin concentration, hemoglobin (Hb) concentration, and computed tomography (CT) values in Hounsfield units (HU) were compared between preoperative and 6-month postoperative assessments. These CT values were obtained for three regions in the liver and three in the spleen using transverse abdominal CT. In each instance, mean values for the three regions were used for each calculation. While the liver was evaluated preoperatively and at 6 months postoperatively, the spleen was evaluated only preoperatively. Accordingly, preoperative and postoperative calculations for the liver relative to the spleen used the preoperative value for the spleen as the divisor for calculating relative values at both time points. A value for the liver below 40 HU[4] or a liver value relative to the spleen below 1.0 was considered to indicate hepatic steatosis[5]. Glycemic control was evaluated in terms of change in glycosylated Hb (HbA1c) values over 6 months.

Results

Clinical characteristics and operative procedures

Details of treatment for each patient are shown in Table 1. Patients 1 and 2 underwent surgery for residual adenocarcinoma of the pancreatic body that became evident after an initial pancreatoduodenectomy. The previous operative procedure for both patients was subtotal gastric-preserving pancreatoduodenectomy. In patient 1, radical antegrade modular pancreatosplenectomy (RAMP) was subsequently performed, with left gastric vein preservation as drainage for the stomach. In patient 2, RAMP, including en bloc resection of the distal residual stomach, transverse colon, and left adrenal, was subsequently performed with left gastric vein preservation. In patient 3, TP for left-sided pancreatic adenocarcinoma and carcinoma of the ampulla of Vater was performed, with left gastric vein preservation. In patient 4, pancreatoduodenectomy and distal pancreatosplecentomy, sparing the middle segment of the pancreas and the short and posterior gastric veins and the splenic vein, were performed. A fistula subsequently formed from the residual middle pancreatic segment; the segment was resected on postoperative day 1. RAMP was initially performed for patient 5, who had adenocarcinoma located mainly in the left side of the pancreas. Intraoperative pathologic examination revealed malignancy at the cut end of the pancreatic duct. To obtain a surgical margin negative for cancer spread, we extended pancreatic parenchymal resection toward the right; however, we encountered difficulties that required pancreatoduodenectomy. In addition to the left gastroepiploic vein, the left gastric vein was sacrificed during lymphadenectomy during the RAMP procedure; therefore, subtotal gastrectomy was added.

For the five patients, the median operative duration was 652 (range, 360-821) min. The median estimated intraoperative blood loss was 382 (range, 85-1,395) ml. The median postoperative hospital stay was 26 (range, 18-58) days. The following postoperative complications occurred in two patients: Clavien-Dindo class Ⅱ enterocolitis in patient 5 and class Ⅲa wound infection treated with negative-pressure wound therapy in patient 2. No postoperative mortality occurred.

Gastric vein drainage evaluation using three-dimensional computed tomography (3D-CT)

The left gastric vein remained patent according to postoperative 3D-CT (Figure 2) in all three patients with its preservation (1, 2, and 3). Drainage via the posterior and short gastric veins to the splenic vein remained patent in patient 4 (Figure 3A). Patient 5, with no remaining gastric drainage vein, required the addition of subtotal gastrectomy. The esophageal venous plexus was confirmed to provide gastric venous drainage by 3D-CT (Figure 3B). Routes of gastric venous drainage for each patient are summarized in Table 1.

Nutritional outcome

Over 6 months, postoperative body weight decreased compared with preoperative weight in three patients; however, nutritional parameters, including serum albumin and Hb, did not significantly change compared with preoperative values. Preoperative body mass indices of the three patients who showed body weight loss postoperatively were 27.3, 25.4, and 22.0 kg/m^2, indicating grade I obesity preoperatively in the first two instances according to the criteria of the Japan Society for the Study of Obesity[6]. All patients tolerated insulin therapy, with HbA1c values essentially similar pre- and postoperatively.

According to CT, no patient showed a hepatic HU value of <40 postoperatively; however, one patient had a value of <40 HU preoperatively. This patient

showed grade I obesity (preoperative body mass index, 27.3 kg/m^2). The liver/spleen ratio was <1.0 preoperatively in four patients, whereas only two of them showed a ratio below 1.0 postoperatively (Table 2).

Discussion

In terms of perioperative complications, TP has generally been considered a safer procedure than pancreatoduodenectomy because pancreatojejunostomy is not required. However, published data have not supported this notion. Reported mortality among patients undergoing TP has ranged from 1.6% to 12.5%. An additional report has included a 3% occurrence of late mortality related to hypoglycemic episodes[7]. It can be inferred that the patient's burden is heavy owing to the lifetime requirement of

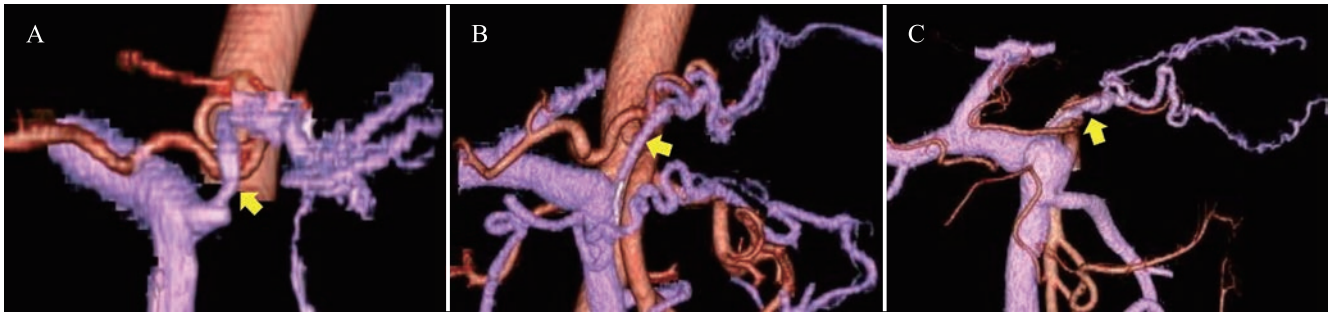

Fig. 2. Gastric drainage veins following TP depicted by three-dimensional computed tomography (3D-CT). Panels a, b, and c show venous drainage (left gastric vein, yellow arrow) in patients 1, 2, and 3, respectively.

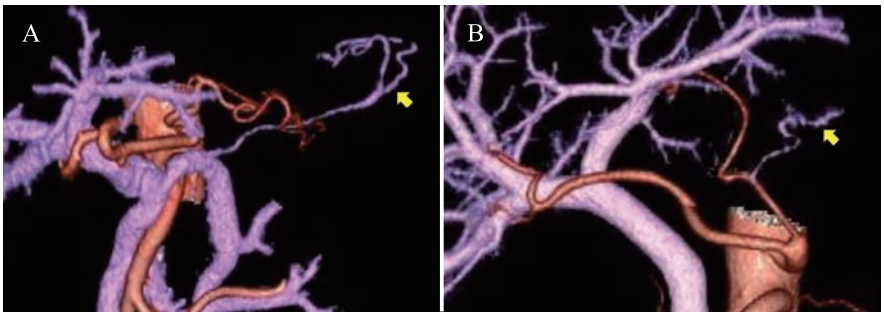

Fig. 3. Gastric drainage veins following TP depicted by 3D-CT. Panel a shows the posterior and short gastric veins and the splenic vein as gastric drainage veins (yellow arrow) in patient 4. Panel b shows esophageal venous plexus enlargement to provide gastric drainage in patient 5.

Table 2. Short-term follow-up results of nutritional status following surgery

	BW (kg)		BMI (kg/m^2)		Albumin (g/dl)		Hb (g/dl)		HbA1c (%)		CT (HU)				
											Liver		Spleen	Liver/Spleen	
Patient	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Pre	Post
1	56.5	56.5	19.5	19.5	4.5	4.4	12.6	11.3	7.6	7.6	67.7 ± 11.4	63.0 ± 11.5	54.3 ± 8.5	1.24	1.16
2	49.5	53.5	19.7	21.3	4.1	4.2	12.1	11.8	10.8	10.3	48.7 ± 5.0	43.3 ± 12.0	49.0 ± 6.2	0.99	0.88
3	70.0	58.0	25.4	21.0	3.9	3.7	15.0	13.0	6.1	7.4	49.3 ± 16.5	54.3 ± 23.0	53.3 ± 2.5	0.92	1.02
4	59.2	49.0	22.0	18.2	4.5	4.1	13.9	10.8	5.5	6.9	58.0 ± 3.5	52.7 ± 11.0	60.3 ± 2.1	0.96	0.87
5	79.8	55.0	27.3	18.9	4.2	3.4	15.6	12.9	7.1	7.6	26.3 ± 8.0	47.3 ± 8.1	43.0 ± 11.3	0.61	1.10

BW, body weight; BMI, body mass index; CT, computed tomography; Hb, hemoglobin; HU, Hounsfield unit; pre-, preoperative; post-, postoperative.

medication following TP.

The apancreatic state following TP has several metabolic consequences. The most commonly known and investigated sequel is diabetes. Glycemic control may be labile in this type of diabetes, not only owing to lost insulin secretion but particularly owing to lost glucagon secretion[8]. Significant late mortality following TP (3%) owing to hypoglycemic episodes has been reported, as previously mentioned[7]. Exocrine pancreatic insufficiency is yet another consequence of TP. Even with high-dose pancreatic enzyme replacement therapy, a significant fraction of patients who have undergone TP still exhibit malabsorption-associated steatorrhea. Hepatic steatosis is yet another TP-associated complication[9].

Gastric bleeding following TP is infrequent. Brittle diabetes[8] and malabsorption have been the main complications described, with less mention of gastric congestion. In early reports[10], various degrees of gastrectomy accompanied TP in all patients, whereas necrosis of the gastric remnant, gastric ulcers with perforation, and bleeding from the gastrojejunal anastomosis were reported. Some of these complications may arise from gastric venous congestion. To reduce the gastric congestion arising from the inability to preserve sufficient gastric venous drainage, TP is typically combined with distal gastrectomy[11]. Recently, complete or partial gastric preservation during TP has been advocated. When Takami *et al*.[4] compared patients who underwent TP with and without pyloric resection, pyloric ring preservation contributed little or no benefit regarding the short-term outcome or long-term nutritional status[1]. However, gastric bleeding or congestion was not reported, and details of gastric venous drainage in their patients were unclear. In a report concerning pylorus-and spleen-preserving total pancreatoduodenectomy[2], CT performed on postoperative day 7 revealed gastric congestion in two of five patients who underwent the procedure. A minimal to moderate degree of perigastric fundal varix was observed in three patients, although none of them experienced gastrointestinal bleeding. Nakao *et al*.[3] reported the occurrence of gastric bleeding in 2 of 38 patients who underwent TP. In these two patients, TP was combined with pylorus-preserving or subtotal gastric-preserving pancreatoduodenectomy. In their study, the 38 patients underwent various types of gastric resection and degrees of gastric venous drainage preservation. Those who experienced bleeding had total or subtotal gastric preservation without gastric drainage vein preservation. Considering these procedures and outcomes, preservation of at least one gastric drainage vein or a fairly extensive gastric resection was needed to avoid gastric congestion and bleeding.

To avoid malabsorption and maintain good nutritional status following TP, less extent of gastrectomy is significant, and adequate gastric venous drainage is mandatory while preserving the stomach as possible. In our study, owing to either drainage vein preservation or an appropriate extent of gastrectomy, none of the patients experienced gastric bleeding. Particularly in patients with SSPTP and TPDG, drainage vein preservation may contribute more because the extent of gastric resection was small in both procedures. Furthermore, owing to adequate insulin and pancreatic enzyme replacement following surgery, our patients did not develop severe diabetes, malabsorption, or steatosis.

Preservation of the LGV is not frequently possible, depending on the confluent pattern of the LGV to the portal venous system. In our two patients without LGV preservation, the splenic vein that joined the LGV was resected during RAMP, followed by pancreatoduodenectomy (patient 5). Therefore, LGV preservation was impossible. Radical lymphadenectomy surrounding the celiac and common hepatic artery made LGV preservation in the other patient impossible (patient 4); however, the venous drainage route from the PGV or SGV to SPV could be preserved.

Recent expansion of the indication of pancreatic surgery suggests that TP must be occasionally indicated. TP greatly affects the postoperative nutritional status of patients; however, it may be important to maintain an adequate extent of the stomach while preserving adequate venous drainage. When a patient requires TP, gastric vein preservation, partial gastrectomy as needed, and perioperative metabolic support can make this treatment successful and lifesaving.

Comparing the postoperative nutritional status among the three procedures to identify the effectiveness of our strategy may also be necessary. Therefore, further investigation with more patients is mandatory.

Conflict of interest

The authors have no conflicts of interest to declare.

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