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# A 47-Year-Old Man with Advanced Distal Pancreatic Carcinoma and an Initial Partial Response to Chemotherapy Requiring Celiac Axis Reconstruction of the Common Hepatic Artery and Left Gastric Artery

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Statistical Analysis C  
Data Interpretation D  
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**Patient:** Male, 47-year-old  
**Final Diagnosis:** Pancreatic adenocarcinoma  
**Symptoms:** Loss of appetite  
**Medication:** —  
**Clinical Procedure:** —  
**Specialty:** Surgery  
**Objective:** Unusual or unexpected effect of treatment  
**Background:** Distal pancreatectomy with en bloc celiac artery resection (DP-CAR) is a curative surgical method for locally advanced pancreatic body cancer; however, arterial reconstruction remains controversial in this procedure. This report presents the case of a 47-year-old man with advanced distal pancreatic carcinoma and initial partial response to chemotherapy who required celiac axis reconstruction of the common hepatic artery and left gastric artery.  
**Case Report:** A 47-year-old man had loss of appetite. He had a 40-mm hypovascular tumor extending from the pancreatic body to the tail, invading around the celiac artery, common hepatic artery, left gastric artery, and splenic artery. We initiated chemotherapy concurrent with chemo-radiotherapy with S-1 administration. After chemo-radiotherapy, computed tomography (CT) showed tumor shrinkage, indicating partial response, but soft tissue CT density surrounding the celiac axis arteries persisted. We conducted conversion surgery. When the common hepatic artery was clamped during surgery, the intrahepatic arterial blood flow reduced; thus, we reconstructed the middle hepatic artery to the common hepatic artery. The left gastric artery was also reconstructed using the second jejunal artery to prevent ischemic gastropathy. Histopathologic examination showed no tumor cells in the specimen; thus, R0 resection was achieved.  
**Conclusions:** Arterial reconstruction can be an option for R0 resection in DP-CAR when hepatic arterial blood flow is reduced due to an intraoperative common hepatic artery clamping test.  
**Keywords:** Anastomosis, Surgical • Radiotherapy • Pancreatectomy • Pancreatic Cancer, Adult • Chemotherapy, Adjuvant

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## Background

Pancreatic carcinoma is the seventh cause of cancer death in the world and continues to have a poor prognosis, even in the modern era [1]. Recent advances in multidisciplinary therapies have sometimes led to surgery as a treatment option after neoadjuvant therapy, chemotherapy, and radiotherapy for patients with unresectable locally advanced (UR-LA) pancreatic carcinoma [2,3]. This surgical strategy is called conversion surgery. Kimura et al [4] reported that a conversion ratio for UR-LA pancreatic carcinoma to surgery was approximately 20% to 30% in the most recent meta-analysis.

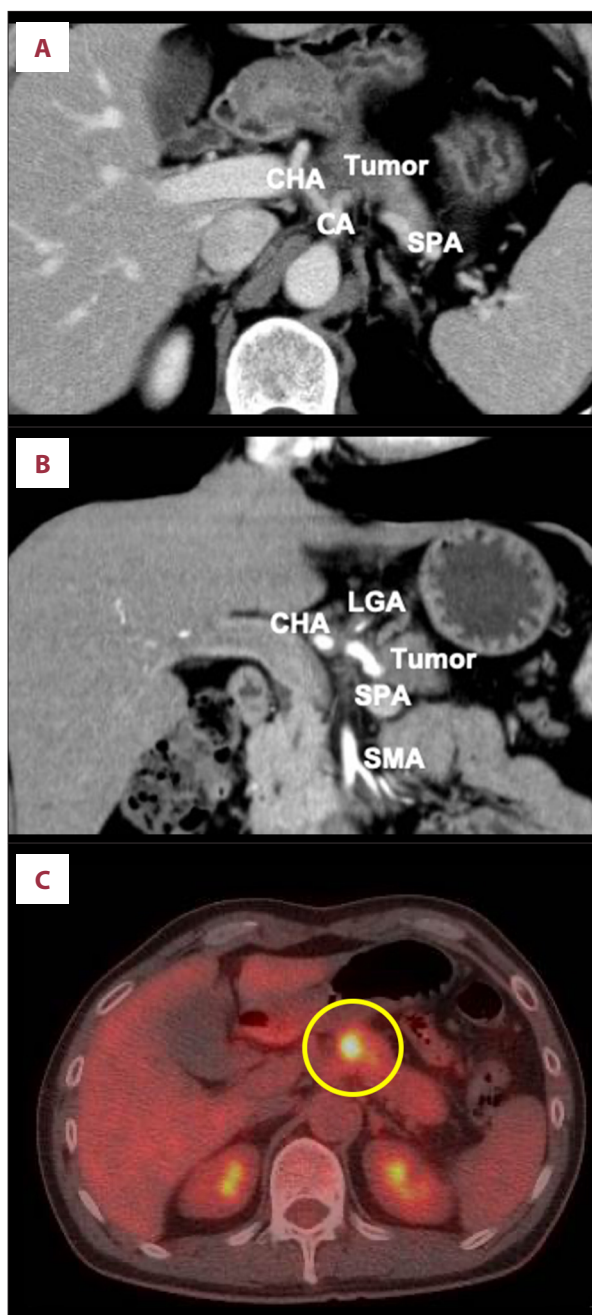
A distal pancreatectomy with en bloc celiac artery resection (DP-CAR) is an appropriate operative procedure for UR-LA pancreatic body carcinoma [5]. Meta-analyses comparing DP-CAR to conventional DP in patients with pancreatic carcinoma [6] reported that there was no significant difference in terms of mortality, and the involvement of the celiac trunk should no longer be considered a contraindication to surgery. In this operation, the pancreas is removed, containing the common hepatic artery (CHA) and celiac artery (CA), to achieve R0 resection status [7]. Consequently, CHA clamping during this procedure can result in decreased intrahepatic blood flow, indicating weak intrahepatic and gastric blood stream from the mesenteric artery through the pancreas, and can lead to organ damage due to postoperative ischemia.

Murase et al [8] reported a case in which R0 resection was possible after chemoradiotherapy for locally advanced pancreatic carcinoma. They performed DP-CAR with gastroduodenal artery resection and reconstruction with a saphenous vein graft. There have been cases reported of arterial reconstruction for tumor invasion as such [9,10]; however, to the best of our knowledge, this study is the first to present hepatic arterial reconstruction as a treatment option when hepatic blood flow is diminished by the clamping test. In such a case, surgical practitioners might consider the tumor inoperable or excise it using DP with forced preservation of the CHA.

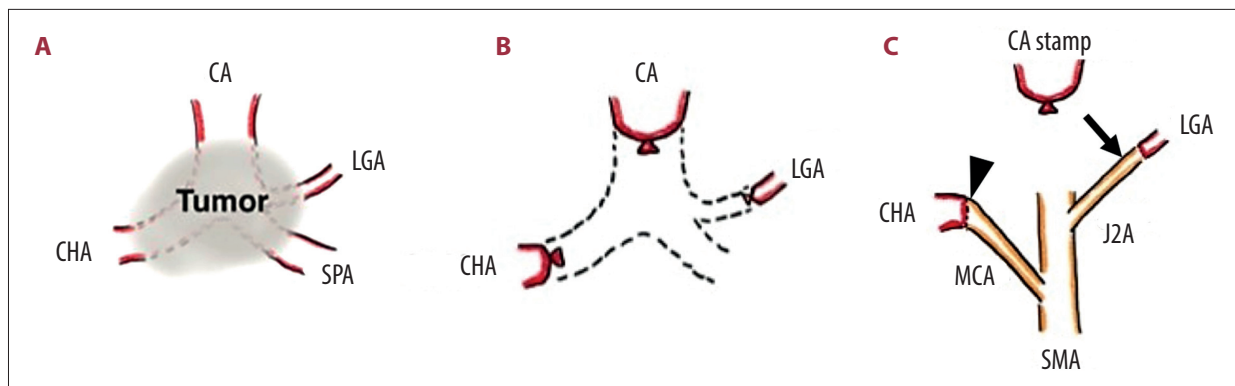
Our report describes the case of a 47-year-old man with advanced distal pancreatic carcinoma and initial partial response to chemotherapy who required celiac axis reconstruction of the left gastric artery (LGA) and CHA.

## Case Report

We present the case of a 47-year-old man who was referred to our institution with the symptom of loss of appetite. The patient had no relevant medical history and no smoking or drinking habits. He had no familial history of pancreatic cancer or any hereditary diseases. An earlier abdominal ultrasonography



**Figure 1.** (A) Abdominal computed tomography (CT) at diagnosis. Abdominal CT showed a 40-mm hypovascular tumor in the pancreatic body. The tumor is abutment with the celiac artery (CA), common hepatic artery (CHA), and splenic artery (SPA). (B) Abdominal CT at diagnosis. The tumor is in contact with the CA, CHA, LGA, and SPA. There is no tumor encasement in the superior mesenteric artery (SMA). (C) Positron emission tomography-computed tomography (PET-CT) at diagnosis. This revealed increased metabolic activity in the pancreatic tumor.



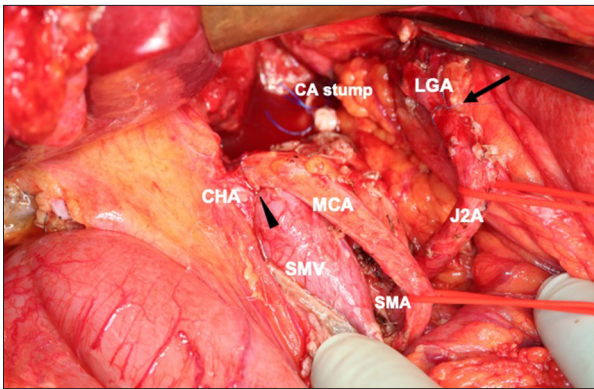
**Figure 2.** (A) Intraoperative findings before the tumor removal. The tumor had invaded the celiac artery (CA), common hepatic artery (CHA), left gastric artery (LGA), and splenic artery (SPA). (B) Intraoperative findings after the tumor removal and vascular dissection. (C) Intraoperative findings. We anastomosed the superior mesenteric artery (SMA) to the CHA using the middle colic artery (MCA) and anastomosed the second jejunal artery (J2A) to the LGA. The black arrowhead indicates CHA-MCA anastomosis, and the black arrow indicates LGA-J2A anastomosis.

showed a 40-mm pancreatic body tumor; consequently, he was admitted to our department for detailed assessment and therapy. Serum examinations revealed no elevation in tumor markers. Computed tomography (CT) indicated a 40-mm hypovascular tumor extending from the body to the tail of pancreas. There was a direct tumor invasion around the CA, CHA, and splenic artery (Figure 1A). The tumor was also in contact with the LGA. No tumor involvement of the superior mesenteric artery (SMA) was observed (Figure 1B). Liver metastasis was not detected on enhanced magnetic resonance imaging (MRI) with gadolinium-ethoxybenzyl-diethylenetriamine pentaacetic acid, commonly known as EOB-MRI, and on CT. 18F-Fluorodeoxyglucose (FDG)-positron emission tomography (PET)/CT showed increased metabolic activity, as defined by an abnormal uptake of 18F-FDG in the pancreatic tumor (maximum standardized uptake value was 9.3), whereas no abnormal uptake was observed in the other organs (Figure 1C).

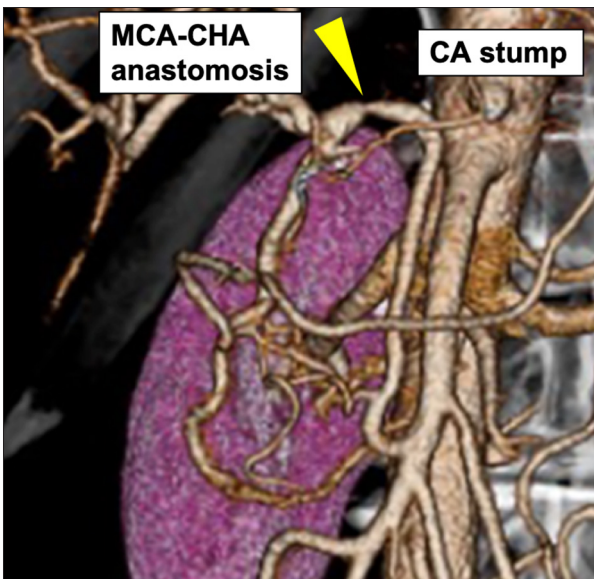
The patient was subsequently diagnosed as having cT4N0M0: cStage III (Union for International Cancer Control-tumor, nodes, and metastases classification) and UR-LA (National Comprehensive Cancer Network criteria) pancreatic cancer. We promptly began a multidisciplinary treatment approach to address the patient's cancer. First, we administered 3 courses of systemic chemotherapy consisting of gemcitabine (1000 mg/m<sup>2</sup>) and nab-paclitaxel (125 mg/m<sup>2</sup>) (GnP) on days 1, 8, and 15, every 4 weeks. After chemotherapy, CT revealed tumor shrinkage to 25 mm, indicating partial response by Response Evaluation Criteria in Solid Tumors criteria. FDG-PET/CT showed no significant 18F-FDG uptake. Subsequently, we administered concurrent chemo-radiotherapy with S-1 (oral fluoropyrimidine anticancer drug that contains tegafur, gimeracil, and oteracil); radiotherapy consisted of 50.4 Gy/28 fractions; S-1 dosage was 80 mg/m<sup>2</sup>/day for 28 consecutive days to ensure an antitumor effect and surgical margin negativity. After chemo-radiotherapy,

CT revealed further tumor shrinkage, but soft tissue CT density surrounding the CA, LGA, CHA, and splenic artery remained. We then arranged for conversion surgery. In the assessment, we believed R0 resection could be done by DP-CAR with LGA reconstruction. At our institution, the LGA is routinely reconstructed to prevent ischemic gastropathy. In our patient, surgery was carried out 7 months after the initial start of cancer therapy. Preoperative angiography was not performed.

The intraoperative appearance showed the tumor mainly existed in the pancreatic body, invading the main arteries, including the CA, LGA, CHA, and splenic artery (Figure 2A). These findings were comparable to those seen on the preoperative CT. Once the CHA was clamped, pulsation of the proper hepatic artery and intrahepatic arterial blood flow thoroughly weakened; hence, we assumed the tumor to be inoperable. However, we considered it would be possible to conduct R0 surgery by resecting the CHA and, thus, planned a strategy for simultaneous reconstruction of the CHA and LGA, as the patient was young and had good performance status. The schema after tumor resection is shown in Figure 2B. Consequently, we anastomosed the middle colic artery to the CHA, and the second jejunal artery to the LGA (Figures 2C, 3). These procedures were performed by expert plastic surgeons using a surgical microscope. After reconstruction, we confirmed the preservation of the intrahepatic and gastric blood flow using intraoperative ultrasonography and intraoperative indocyanine green (ICG) fluorescence imaging. We also evaluated the blood flow in the transverse colon using the ICG fluorescence method and confirmed that the blood flow was sufficient. The surgery time was 744 min, and bleeding amount was 770 mL. The patient experienced some postoperative complications, including grade IIIa chylorrhea, grade II delayed gastric emptying (based on the Clavien-Dindo classification), which was alleviated by postoperative fasting for 5 days. Other major



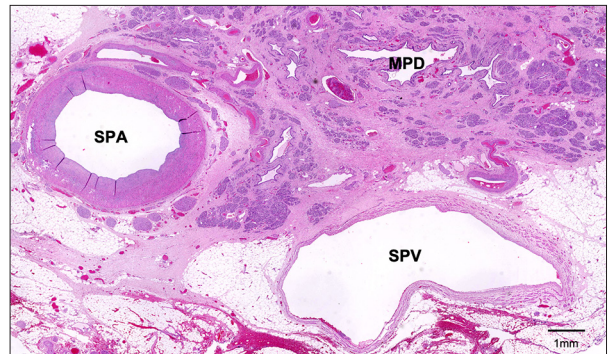
**Figure 3.** Image obtained after tumor resection and reconstruction of the common hepatic artery (CHA) and left gastric artery (LGA). The black arrowhead indicates CHA-middle colic artery (MCA) anastomosis, and the black arrow indicates LGA-second jejunal artery (J2A) anastomosis. CA – celiac artery; SMV – superior mesenteric vein.



**Figure 4.** Imaging of postoperative abdominal computed tomography. Yellow arrowhead indicates the middle colic artery-common hepatic artery (MCA-CHA) anastomosis. CA – celiac artery.

postoperative complications, such as postoperative pancreatic fistula, were absent. Postoperative CT revealed that the hepatic arterial blood flow and gastric blood flow were preserved (**Figure 4**). The patient was discharged on postoperative day 22.

Histopathological findings revealed no cancer cells in the specimen, defined using the Evans classification grade IV (**Figure 5**). Residual malignant cells were not detected at the surgical margin, signaling R0 resection. After surgery, the patient underwent 6 months of adjuvant chemotherapy with GnP on days 1, 8,



**Figure 5.** Histopathological findings. The acinar cells were atrophied, and the pancreatic parenchyma was fibrotic. No cancer cells were found in the specimen. SPA – splenic artery; SPV – splenic vein; MPD – main pancreatic duct.

and 15, and then every 28 days, and has been doing well without recurrence. Ten months after surgery, hepatic arterial patency was acceptable, without any apparent tumor recurrence.

## Discussion

Here, we report a case of a 47-year-old man with advanced distal pancreatic carcinoma and initial partial response to chemotherapy who underwent simultaneous reconstruction of the CHA and LGA to achieve radical resection.

About 30% to 40% of patients with pancreatic cancer are initially diagnosed with UR-LA pancreatic cancer [11]. Advances in multidisciplinary treatment modalities, such as chemotherapy and radiation therapy, in recent years have enabled conversion surgery as a treatment method for patients with UR-LA pancreatic carcinoma [4]. Patients who underwent conversion surgery had a better survival result than those who did not (44.1 vs 14.5 months,  $P < 0.0001$ ) [4]. In addition, recent studies have shown that surgical treatment of UR-LA pancreatic carcinoma after preoperative therapy has resulted in surgical rates of up to 51% to 60% [12,13]. In our case, the patient was initially diagnosed with UR-LA pancreatic cancer at the first consultation, but the tumor shrank following multidisciplinary treatment. DP-CAR with arterial reconstruction was performed, and relapse-free survival was achieved for >10 months after surgery.

DP-CAR is an appropriate surgical procedure in ensuring that margin-negative resections of the CA, proximal part of the CHA, and periarterial plexus can be achieved and, thus, in increasing the R0 ratio in patients with locally advanced pancreatic body carcinoma [14]. This procedure was devised in the 1990s as an Appleby operation for the resection of pancreatic cancer that had invaded the CA [15]. Recent studies showed

that DP-CAR contributes to the improved prognostic outcome of pancreatic cancer [16-19]. The main challenge of DP-CAR, however, is that resection of the CA and CHA results in a secondary decrease in the arterial flow to the liver and stomach. Regarding the blood flow to the stomach, arterial anastomosis with the middle colic artery has been analyzed to decrease the risk of ischemia [20,21]. In addition, preoperative coiling of the CHA has been reported to maintain the hepatic blood flow [22]. There are relatively few reports on the simultaneous reconstruction of the CHA and LGA. The problem of DP-CAR with arterial reconstruction is the risk of hemorrhage or disruption of the arterial anastomosis due to effects of a postoperative pancreatic fistula [23]. Del et al [23] reported that total pancreatectomy could be an option to avoid the risk of a pancreatic fistula; however, total pancreatectomy can lead to poor glycemic control and malnutrition and decrease the completion rate of postoperative adjuvant therapy [24]. Arterial reconstruction in pancreatic carcinoma with arterial invasion remains controversial [25].

In our case, CHA clamping showed a decrease in the hepatic arterial blood flow; therefore, we planned to perform hepatic artery reconstruction to achieve radical resection. Murase et al [8] have described the usefulness of arterial reconstruction due to cancer invasion in DP-CAR. However, to the best of our knowledge, there is no report on the indications for hepatic artery reconstruction based on the results of CHA clamping, and the present case is the first to be reported. Hepatic arterial blood flow can be intraoperatively assessed by palpation, Doppler ultrasonography, and ICG [26]. However, reports on the frequency of intrahepatic arterial blood flow loss due to intraoperative CHA clamping are practically nonexistent. The weakened hepatic arterial flow may have resulted from the non-development of pancreatic head arterial arcades, but we did not confirm this routinely through preoperative angiography.

The method of arterial reconstruction in pancreatic resection includes end-to-end arterial anastomosis or vein grafting using a great saphenous vein [8,25,27]. In the present case, we used the middle colic artery for the CHA reconstruction and the second jejunal artery for the LGA reconstruction. The reasons for middle colic artery and jejunal artery transpositioning are as follows. First, they are autologous arteries and easy to access. Second, interpositional grafting is unnecessary and only one arterial anastomosis is needed due to proximity. The risk of anastomotic bleeding is reduced with only one anastomosis. Third, the middle colic artery and jejunal artery can

be sacrificed. One of the problems with sacrificing the middle colic artery is the risk of colonic ischemia. The mesenteric approach has been reported by Nakao et al [28] as a surgical method for advanced pancreatic cancer, and the middle colic artery is resected at the beginning of the surgery in their technique. Even if the middle colic artery is sacrificed, blood stream to the colon is reportedly kept by the marginal artery, and similarly, blood flow to the small intestine is kept by the other jejunal arteries. These facts enabled safe CHA and LGA reconstruction. Murase et al [8] showed a case of DP-CAR with a Y-shaped anastomosis to the aorta with a saphenous venous graft and reconstruction of the PHA and LGA. Great saphenous venous grafts are sometimes used, but they pose problems of graft patency and varix formation caused by long-term elevated arterial blood pressure [8]. Ours is the first report of a combined resection of the CHA and LGA in DP-CAR, both of which were reconstructed with autologous arterial grafts.

In our patient, preoperative chemo-radiotherapy resulted in a pathologic complete response (pCR). The rate of pCR in patients administered with preoperative chemo-radiotherapy for pancreatic carcinoma has been reported to be 4% to 10% [29,30]. In addition, patients with pancreatic carcinoma who had a pCR after preoperative chemo-radiotherapy had a significantly prolonged survival compared with those who had near complete or limited pathologic responses [31,32]. In the present case, multidisciplinary treatment of UR-LA pancreatic cancer, including chemotherapy and radiation therapy, showed good histological outcomes and therapeutic effects.

## Conclusions

Arterial reconstruction can be an option for R0 resection in DP-CAR when hepatic arterial blood flow is reduced due to an intraoperative CHA clamping test.

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## Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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