

World Journal of *Gastrointestinal Surgery*

World J Gastrointest Surg 2022 November 27; 14(11): 1179-1319



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ABOUT COVER

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AIMS AND SCOPE

The primary aim of *World Journal of Gastrointestinal Surgery* (*WJGS*, *World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, etc.

INDEXING/ABSTRACTING

The *WJGS* is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Current Contents/Clinical Medicine, Journal Citation Reports/Science Edition, PubMed, PubMed Central, Reference Citation Analysis, China National Knowledge Infrastructure, China Science and Technology Journal Database, and Superstar Journals Database. The 2022 Edition of Journal Citation Reports® cites the 2021 impact factor (IF) for *WJGS* as 2.505; IF without journal self cites: 2.473; 5-year IF: 3.099; Journal Citation Indicator: 0.49; Ranking: 104 among 211 journals in surgery; Quartile category: Q2; Ranking: 81 among 93 journals in gastroenterology and hepatology; and Quartile category: Q4.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: Rui-Rui Wu, Production Department Director: Xiang Li; Editorial Office Director: Jia-Ru Fan.

NAME OF JOURNAL

World Journal of Gastrointestinal Surgery

ISSN

ISSN 1948-9366 (online)

LAUNCH DATE

November 30, 2009

FREQUENCY

Monthly

EDITORS-IN-CHIEF

Peter Schemmer

EDITORIAL BOARD MEMBERS

<https://www.wjgnet.com/1948-9366/editorialboard.htm>

PUBLICATION DATE

November 27, 2022

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INSTRUCTIONS TO AUTHORS

<https://www.wjgnet.com/bpg/gerinfo/204>

GUIDELINES FOR ETHICS DOCUMENTS

<https://www.wjgnet.com/bpg/GerInfo/287>

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH

<https://www.wjgnet.com/bpg/gerinfo/240>

PUBLICATION ETHICS

<https://www.wjgnet.com/bpg/GerInfo/288>

PUBLICATION MISCONDUCT

<https://www.wjgnet.com/bpg/gerinfo/208>

ARTICLE PROCESSING CHARGE

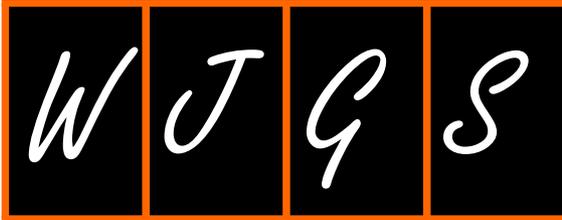
<https://www.wjgnet.com/bpg/gerinfo/242>

STEPS FOR SUBMITTING MANUSCRIPTS

<https://www.wjgnet.com/bpg/GerInfo/239>

ONLINE SUBMISSION

<https://www.f6publishing.com>



Preoperative blood circulation modification prior to pancreaticoduodenectomy in patients with celiac trunk occlusion: Two case reports

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Specialty type: Surgery

Provenance and peer review:

Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification

Grade A (Excellent): 0
Grade B (Very good): B
Grade C (Good): C
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Chiu CC, Taiwan;
Zhao K, China

Received: July 15, 2022

Peer-review started: July 15, 2022

First decision: September 12, 2022

Revised: September 24, 2022

Accepted: October 19, 2022

Article in press: October 19, 2022

Published online: November 27, 2022



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Abstract

BACKGROUND

Celiac trunk stenosis or occlusion is a common condition observed in patients undergoing pancreaticoduodenectomy (PD). The risk of upper abdominal organ ischemia or failure increases if the blood circulation in the celiac arterial system is not maintained after the surgery.

CASE SUMMARY

We present two cases of elderly patients with distal cholangiocarcinoma and celiac trunk occlusion who underwent PD. We performed blood circulation modification preoperatively with transcatheter coil embolization of the arterial arcades of the pancreatic head *via* the superior mesenteric artery to develop collateral communication between the superior mesenteric artery and the common hepatic or splenic arteries to ensure arterial blood flow to the upper abdominal organs. The postoperative course was marked by delayed gastric emptying, but no major surgical complications, such as biliary or pancreatic fistula, or clinical, biochemical, or radiological evidence of ischemic disease, was observed.

CONCLUSION

Preoperative blood circulation modification may be a valid alternative procedure for elderly patients with celiac trunk occlusion who are ineligible for interventional or surgical revascularization.

Key Words: Preoperative blood circulation modification; Cholangiocarcinoma; Pancreaticoduodenectomy; Whipple procedure; Celiac trunk occlusion; Atherosclerosis; Transcatheter coil embolization; Case report

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Core Tip: Celiac trunk stenosis or occlusion is a common condition observed in patients undergoing pancreaticoduodenectomy (PD). Celiac trunk occlusion may increase the risk of upper abdominal organ ischemia or failure. In this case report, we present two elderly patients who underwent PD for distal cholangiocarcinoma with celiac trunk occlusion. We performed blood circulation modification preoperatively with transcatheter coil embolization of the arterial arcades of the pancreatic head to develop collateral communication between the superior mesenteric and the common hepatic or splenic artery.

Citation: Colella M, Mishima K, Wakabayashi T, Fujiyama Y, Al-Omari MA, Wakabayashi G. Preoperative blood circulation modification prior to pancreaticoduodenectomy in patients with celiac trunk occlusion: Two case reports. *World J Gastrointest Surg* 2022; 14(11): 1310-1319

URL: <https://www.wjgnet.com/1948-9366/full/v14/i11/1310.htm>

DOI: <https://dx.doi.org/10.4240/wjgs.v14.i11.1310>

INTRODUCTION

Celiac trunk stenosis is a common condition observed in up to 10% of patients undergoing pancreaticoduodenectomy (PD)[1,2]. If undiagnosed, it can lead to fatal ischemia of the upper abdominal organs after the surgery because the blood supply *via* the pancreatic head arcades is sacrificed intraoperatively due to the ligation of the gastroduodenal artery (GDA)[1-4]. Herein we describe two elderly patients who underwent PD following a novel blood circulation modification with transcatheter coil embolization of the arterial arcades of the pancreatic head.

CASE PRESENTATION

Chief complaints

Case 1: In June 2019, an 83-year-old man with a history of hypertension, chronic kidney disease, and chronic obstructive pulmonary disease was referred to our hospital for liver dysfunction during a blood test, fever, and anorexia.

Case 2: An 84-year-old man with a history of cervical spondylosis, chronic obstructive pulmonary disease, and atrial fibrillation was admitted to our institution in August 2019 with a 1-mo history of epigastric pain, weight loss, and dyspepsia.

History of present illness

Case 1: A computed tomography (CT) scan revealed celiac artery (CeA) occlusion due to atherosclerosis, with thickening of the extrahepatic bile duct wall and luminal stenosis, resulting in mild upstream bile duct dilatation, and the possibility of cholangitis or distal cholangiocarcinoma was enlightened.

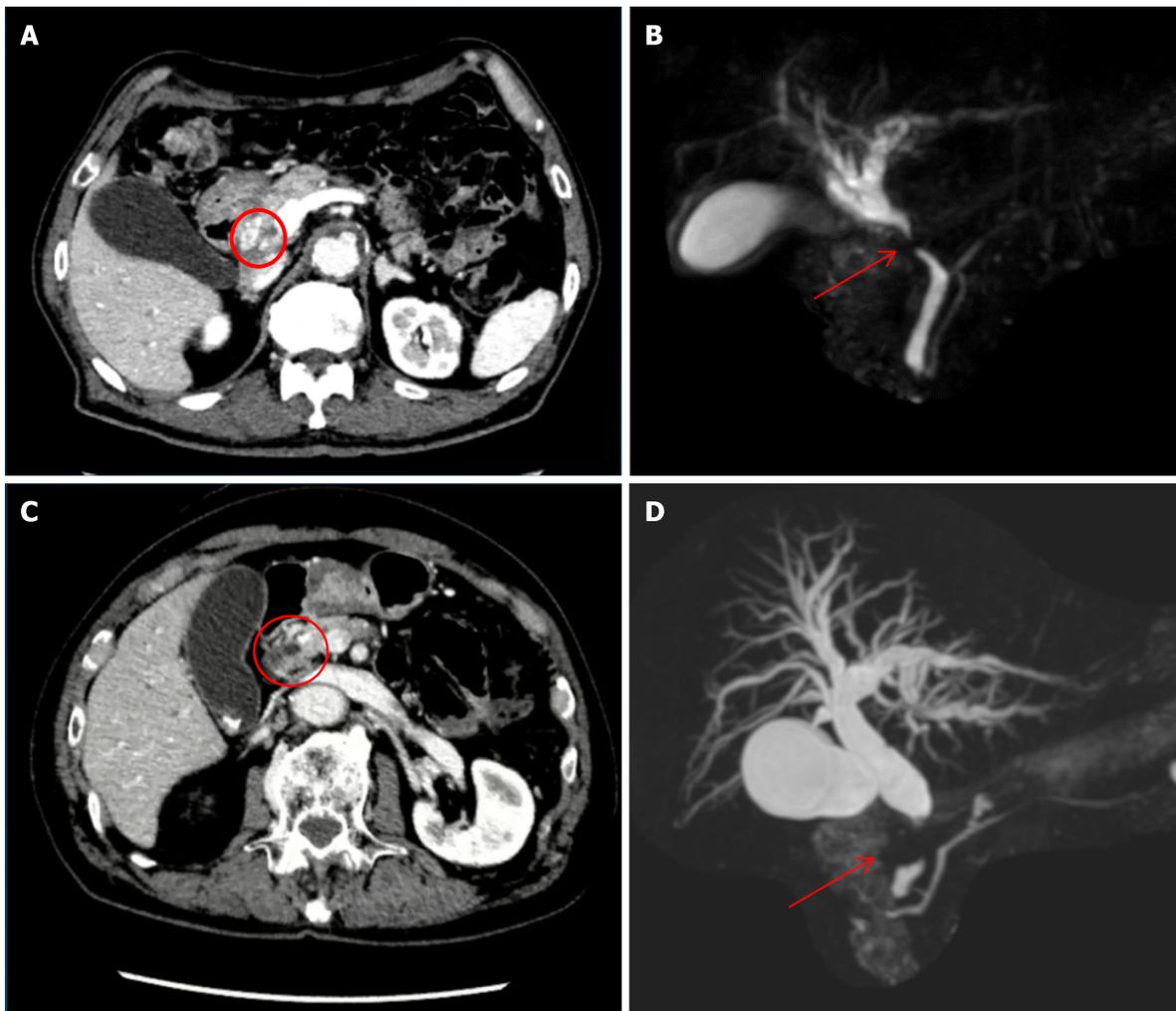
Distal cholangiocarcinoma was suspected following magnetic resonance cholangiopancreatography (MRCP), which revealed a stricture of the extrahepatic bile duct and mild dilatation of the intrahepatic bile duct (Figure 1A and B). An ERCP with brushing cytology was performed to confirm the diagnosis, and a plastic stent was placed.

Case 2: CT revealed dilatation of the entire bile duct system, with 15-mm tissue obstructing the wall and lumen of the pancreatic tract of the common bile duct without pancreatic duct dilatation. Additionally, a small lymph node was observed around the hepatic hilum and abdominal aorta (Figure 1C and D). Distal bile duct cancer was suspected, and the patient underwent MRCP and ERCP with brushing cytology, which confirmed the diagnosis.

Laboratory examinations

Case 1: Distal cholangiocarcinoma cT2N0M0 stage IIA was diagnosed according to the American Joint Committee on Cancer (AJCC) 8th classification, and PD was scheduled.

Case 2: According to the AJCC 8th edition classification, a diagnosis of distal cholangiocarcinoma cT2N1M0 stage IIB was made, and PD was scheduled. A plastic stent was placed in the common hepatic duct preoperatively.



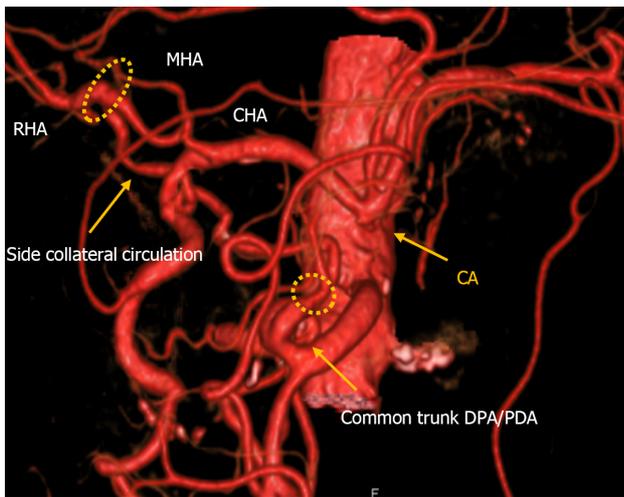
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Figure 1 Imaging examinations. A: Dynamic computed tomography (case 1) showing common bile duct wall thickening at the ductal confluence (circle) and mild dilatation of the intrahepatic bile duct; B: Magnetic resonance cholangiopancreatography showing stricture of common bile duct (arrow) and dilatation of the intrahepatic bile duct; C: Dynamic computed tomography (case 2) showing bile duct wall thickening at the upper pancreatic margin level (circle) with dilatation of the entire bile duct system without pancreatic duct dilatation; D: Magnetic resonance cholangiopancreatography showing stenosis of the distal common hepatic duct (arrow) and dilatation of the intrahepatic bile duct.

Imaging examinations

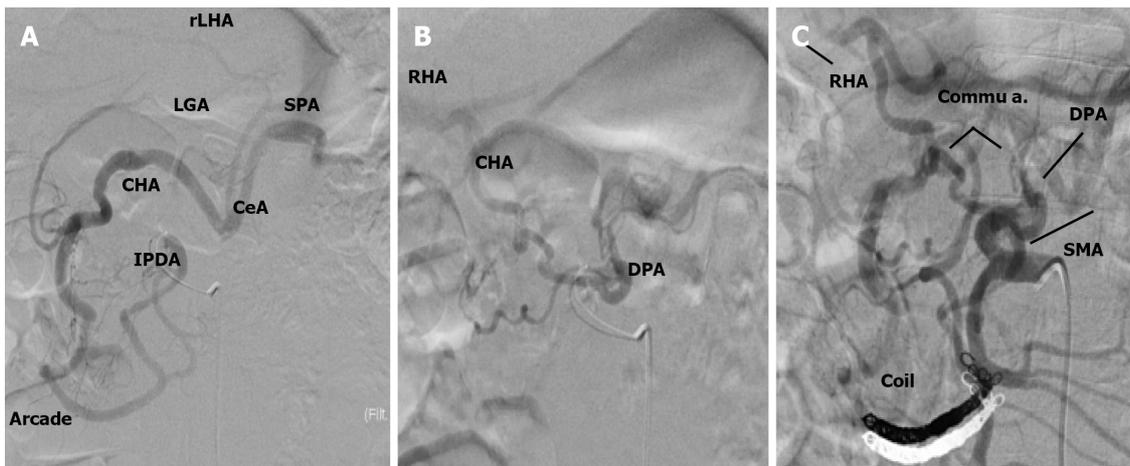
Case 1: An angiographic study and CT with 3D reconstruction were performed; complete occlusion of the CeA and complex anomalous arterial anatomy were observed (Figure 2). The inferior pancreaticoduodenal artery (IPDA), which branches from the superior mesenteric artery (SMA), supplied the celiac arterial system's primary blood supply, while the dorsal pancreatic artery (DPA) supplied the right hepatic arteries (RHA) and splenic arteries (SPA). Preoperatively, we embolized the arterial arcades of the pancreatic head using a coil to increase blood flow *via* the SMA to the RHA and SPA (Figure 3). Both post-procedural CT and angiography confirmed the development of blood flow sustained by the DPA, and no radiological signs of ischemic complications were observed.

Case 2: On preoperative CT, complete CeA obstruction due to atherosclerosis and a well-developed collateral pathway between the SMA and CeA were observed (Figure 4). Angiography revealed complete celiac trunk occlusion, maintenance of the major backflow to the celiac arterial system by two main pathways (the pancreatic head arcades), and linkage of the DPA to the common hepatic artery (CHA). We speculated that celiac arterial blood flow could be supplied *via* the DPA; however, ligating the GDA would cause blood flow reduction. Hence, there was a high risk of severe ischemia of the upper abdominal organs.



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Figure 2 Computed tomography with 3D reconstruction of the vascular anatomy in case 1. Computed tomography showed a right hepatic artery (RHA) and middle hepatic artery originating from the common hepatic artery, the usual pancreaticoduodenal arcade originating from the gastroduodenal artery, a common trunk between the dorsal pancreatic artery and pancreaticoduodenal artery originating from the superior mesenteric artery, an additional arcade originating from the common trunk and passing through the dorsal surface of the pancreatic head and linking directly to the RHA, and a replaced left hepatic artery originating from the left gastric artery. RHA: Right hepatic artery; MHA: Middle hepatic artery; CHA: Common hepatic artery; PDA: Pancreaticoduodenal artery; SMA: Superior mesenteric artery.



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Figure 3 Angiographic study. A: The inferior pancreaticoduodenal artery was responsible for the main back flow to the celiac artery; B: The dorsal pancreatic artery (DPA) was responsible for the blood flow of the right hepatic artery; C: Blood re-flow post embolization and the DPA was responsible for the main flow to the celiac artery. IPDA: Inferior pancreaticoduodenal artery; DPA: Dorsal pancreatic artery; SPA: Splenic arteries; RHA: Right hepatic artery; MHA: Middle hepatic artery; CHA: Common hepatic artery; GDA: Gastroduodenal artery; SMA: Superior mesenteric artery; LHA: Left hepatic artery; LGA: Left gastric artery; CeA: Celiac artery.

FINAL DIAGNOSIS

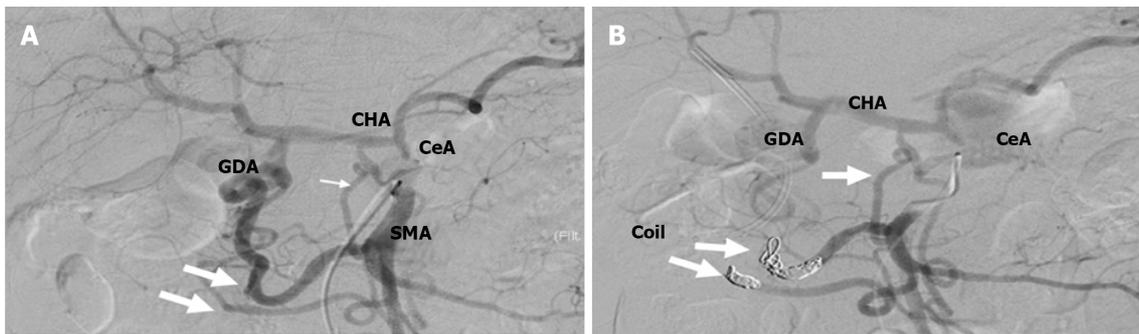
Case 1

Pathological diagnosis identified pT3apN1pM0, stage IIB, poorly differentiated biliary tract cancer. Of the 24 lymph nodes retrieved, only one was involved, and the lesion was completely included in the resection margin (R0 resection). The operative time was 7 h and 55 min, and the estimated blood loss was 700 mL.

Case 2

Pathological diagnosis identified pT2pN1pM0, stage IIB, intermediate-grade biliary tract cancer, which involved 3 of 20 lymph nodes retrieved.

The nodes and the lesion were completely included in the resection margin (R0 resection). The operation time was 6 h and 32 min, and the estimated blood loss was 200 mL.



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Figure 4 Angiographic study. A: Pre-embolization angiography showed that the main backflow to the celiac artery was granted from the GDA; B: Post embolization angiography showed that after blood flow modification, the main backflow was granted from the dorsal pancreatic artery (arrow). CHA: Common hepatic artery; GDA: Gastroduodenal artery; SMA: Superior mesenteric artery; CeA: Celiac artery.

TREATMENT

Case 1

An open-approach Whipple procedure with D2 lymphadenectomy was performed in August 2019 (10 d after the TAE). During lymph node dissection around the hepatoduodenal ligament, the collateral artery from the DPA to RHA was successfully preserved.

Case 2

To reduce this risk, we decided to embolize the arterial arcades of the pancreatic head using a coil to increase the blood flow from the DPA to the CHA preoperatively. After embolization, angiography and CT confirmed blood re-flow from the DPA through the entire celiac arterial system, and no radiological signs of parenchyma or bowel ischemia were found. A standard open-approach Whipple procedure with D2 Lymphadenectomy was performed in September 2019 (10 d after the TAE). During the operation, the DPA was identified and preserved (Figure 5).

OUTCOME AND FOLLOW-UP

Case 1

Postoperatively, the patient developed blue toe syndrome and delayed gastric emptying but did not show any major surgical complications, such as biliary or pancreatic fistula; additionally, there was no clinical, biochemical, or radiological evidence of ischemic disease. The patient was discharged on postoperative day (POD) 56. The patient was not followed up; hence, no evidence of recurrence or delayed complications was obtained on the scheduled 6-mo CT scan.

Case 2

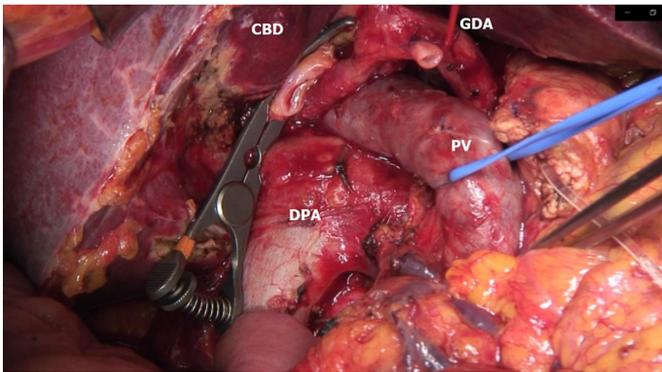
Postoperatively, the patient developed pneumonia, pulmonary embolism, and delayed gastric emptying but did not show any major surgical complications and was discharged on POD 41. No evidence of recurrence was observed at the 3-year follow-up.

DISCUSSION

Stenosis of the celiac trunk is a frequent occlusive vascular disease that can be observed in 2%-11% of patients who undergo PD[2-5]. Occlusion of the celiac axis is a rare situation encountered in 1%-3% of patients and is associated with a higher risk of ischemic consequences on the liver and both hepaticojejunal and pancreatico-jejunal anastomoses[6].

The main causes of stenosis or total occlusion of the celiac trunk are compression by the medial arcuate ligament (MAL) followed by atherosclerosis, which accounts for nearly 90% of the causes, including aortic dissection, congenital causes, inflammatory disease, invasion of malignancy, and iatrogenicity[7].

The typical symptoms of celiac trunk stenosis include postprandial abdominal pain, nausea, vomiting, and weight loss; nevertheless, clinically significant ischemic disease is rarely encountered owing to the development of rich collateral vessels from the SMA[8]. The diagnosis of CeA stenosis can be easily accessed through CT and arteriography, with a detection rate of 91.5%[4]; evaluation of all the



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Figure 5 Intraoperative image. The common bile duct was clipped with a bulldog, the gastroduodenal artery was ligated, and the portal vein was surrounded by a vessel loop at the bottom of the dorsal pancreatic artery hypertrophy. DPA: Dorsal pancreatic artery; CBD: Common bile duct; PV: Portal vein; GDA: Gastroduodenal artery.

collateral pathways is essential for any preoperative planning. When considering PD, any anatomical variant that may affect surgical planning should be evaluated using CT along with 3D reconstruction[9] and, in selective cases, angiographic studies. However, most surgeons do not routinely perform angiographic studies, and while preoperative imaging is often diagnostic, if an angiographic study is not performed in case of doubt, vascular sufficiency can be assessed intraoperatively.

Bull *et al*[3] endorsed a well-known maneuver that tested the pulsation of the hepatic artery before GDA ligation to ensure adequate patency of the collateral pathways. GDA ligation at its origin is an essential step during PD, and in the event of celiac trunk stenosis, the procedure can lead to ischemia of the liver, stomach, spleen, and residual pancreas, resulting in complications such as organ failure, abscess, and anastomotic leakage[4,5]. Berney *et al*[9] reported two cases of postoperative transient ischemic liver dysfunction and two cases of disruption of the pancreatic jejunal anastomosis in patients with CeA stenosis without preoperative or intraoperative revascularization procedures. Gaujoux *et al*[4] reported 545 patients who underwent PD and identified 23 CeA compressions by MAL, 2 CeA, and 2 SMA atherosclerotic stenoses. After PD, ischemic complications accounted for one-third of the 2.6% postoperative mortality, suggesting that ischemic complications account for significant morbidity and mortality after PD. Zhou *et al*[10] retrospectively analyzed the risk for biliary fistula in 508 patients who underwent PD, of which 84 had CeA stenosis due to atherosclerotic disease. The incidence of biliary fistulas was 2.1% in patients with mild CeA stenosis (1/47) and 27% in those with severe stenosis.

Different options have been proposed to treat CeA stenosis encountered during PD, majorly depending on the underlying disease. In cases of extrinsic compression caused by MAL, division of the median arcuate ligament can be performed intraoperatively[11]. In cases of atherosclerotic stenosis, percutaneous transcatheter angioplasty or stenting can be performed[12]. In cases of severe stenosis or complete occlusion, percutaneous revascularization with angioplasty or stenting of the CeA was not possible. Therefore, endovascular treatment *via* arcades of the pancreatic head[13] or surgical treatment with vascular reconstruction should be considered. Several surgical revascularization methods have been reported in the literature: Bypass grafting using autologous or prosthetics graft[14,15], end-to-end or end-to-side arterial anastomosis method[14-16] (Table 1), *etc.* Vascular reconstruction with PD increases the risk of thromboembolism and postoperative bleeding (caused by pancreatic fistula) and carries an intrinsic risk of thrombosis and leakage of the vascular anastomosis.

In our study, we treated two elderly patients with severe comorbidities and atherosclerotic diseases. In such cases, arterial bypass could be technically difficult because of diffuse atherosclerotic disease, and the risk of thrombosis and leakage of vascular anastomoses could be very high.

Considering the patients' advanced age and risk of comorbidities as well as to avoid the risk of fatal ischemic complications after PD, we decided to embolize the arterial arcades of the pancreatic head before the operation to increase the blood flow from the SMA to the celiac arterial system.

This expedient minimizes the risk of fatal ischemic complications after PD, ensuring that the entire collateral pathway and hypertrophy of the collateral vessels are preserved during the operation. We observed delayed gastric emptying, which was correlated with slight transient gastric ischemia. Repetitive postoperative CT showed strong hypertrophy of the collateral vessels, with good blood flow of the celiac arterial system and no vascular complications.

In elderly patients with severe stenosis or complete occlusion who are not eligible for interventional revascularization or surgical reconstruction, this technique is simple, feasible, repeatable in case of failure, and less prone to complications than any previous vascular reconstruction method. However, the use of CT and angiographic studies to evaluate vascular anatomy and eventually plan blood flow modification prior to the surgical procedure is crucial.

Table 1 Outcome of treatment in case of CA stenosis due to atherosclerosis

Ref.	Number of cases	Age, yr	Disease	Degree of CA stenosis	Treatment	Time between vascular reconstruction and surgery	Outcome	Discharged POD
Berney <i>et al</i> [9], 1999	13	69 median ages	Pancreatic adenocarcinoma	9 occlusion, 5 subtotal stenosis, 1 partial stenosis	2 GDA preservation	IO	Pancreatic fistula	N/A
			Pancreatic adenocarcinoma		1 aortohepatic bypass	IO	No complications	
			2 Pancreatic adenocarcinoma, 5 chronic pancreatitis, 1 ampullary cancer, 1 duodenal adenoma		9 no reconstruction	IO	2 liver ischemia3 pancreatic fistulas	
			Pancreatic adenocarcinoma		1 CeA reimplantation	IO	No complications	
Nara <i>et al</i> [2], 2005	2	57	Duodenal cancer	Occlusion	Middle colic right gastroepiploic anastomosis	IO	Transient liver ischemia	35 d
			Duodenal cancer		Preservation of replaced RHA	IO	Pancreatic fistula	128 d
Hayashibe <i>et al</i> [17], 2005	1	75	Duodenal cancer	Occlusion	Aorta-CHA venous bypass	IO	No complications	35 d
Halazun <i>et al</i> [16], 2006	1	65	CCA	50%	Preoperative stent	1 d	No complications	N/A
Soonawalla <i>et al</i> [5], 2007	1	60	Pancreatic adenocarcinoma	Occlusion	CeA reimplantation into aorta	IO	No complications	N/A
Smith <i>et al</i> [18], 2007	10	76 median ages (73-86)	Adenocarcinoma, ampullary tumor, islet cell tumor, papillary tumor	3 pt 30%; 1 pt 20%; 2 pt 50%; 1 pt 25%; 2 pt 60%; 1 pt occlusion	10 no reconstruction	IO	1 death for MOF, 1 GI bleeding	N/A
Gaujoux <i>et al</i> [4], 2009	3	72	Malignant ampulloma	N/A	Aortohepatic bypass	IO	Pancreatic fistula	N/A
			Pancreatic adenocarcinoma		Preoperative CeA stent	3 wk	Pancreatic fistula	N/A
			Malignant ampulloma		Postoperative CeA stent	0 POD	Pancreatic fistula	N/A
El-Ghazaly <i>et al</i> [19], 2009	1	70	Pancreatic adenocarcinoma	Occlusion	Anterior pancreaticoduodenal arcade resected and anastomosed end-to-end	IO	No complications	10 d
Berselli <i>et al</i> [20], 2010	1	72	Branch type IPMN	Occlusion	Side to side anastomosis SPPDA to the IPPDA	IO	Pancreatic fistula, GI bleeding, Splenic artery pseudoaneurysm	97 d
Yi <i>et al</i> [21], 2014	1	51	NET	N/A	Preoperative angioplasty and stent of CA	1 mo	No complications	7 d

Beane <i>et al</i> [22], 2017	1	69	Pancreatic cancer	Occlusion	SMA to HA venous bypass	IO	Pancreatic fistula, GI bleeding, pseudoaneurysm of graft; hepatic abscess (4 mo after discharge)	30 d
Zhou <i>et al</i> [10], 2018	84	73 median ages (61-88)	N/A	47 pt (mild 1%-49%); 37 pt (substantial 50%-99%)	No treatment	IO	2 deaths, 2 GI bleeding, 11 biliary fistulas, 8 pancreatic fistulas	21 d median (8-21 POD)
Tagkalos <i>et al</i> [23], 2018	1	64	Pancreatic adenocarcinoma	Occlusion (postoperative diagnosis)	Heparinization	3 POD	Transient liver ischemia	14 d
Oikawa <i>et al</i> [7], 2022	1	80	CCA	Occlusion	No reconstruction	IO	Pancreatic fistula	41 d

IO: Intraoperative; CCA: Cholangiocarcinoma; N/A: Not applicable; POD: Postoperative day.

CONCLUSION

In elderly patients with celiac trunk occlusion, PD can lead to a severe risk of postoperative complications, and preoperative blood circulation modification can reduce the risk of ischemic accidents. Precise preoperative anatomical studies of the vascular pathway and an optimal surgical or radiological technique must be chosen on a case-by-case basis to avoid unfavorable postoperative outcomes.

FOOTNOTES

Author contributions: Colella M and Mishima K wrote the manuscript; Mishima K treated the patients; Wakabayashi G, Wakabayashi T, Fujiyama Y, and Alomari M critically reviewed the manuscript; all authors read and approved the final manuscript.

Informed consent statement: Informed written consent was obtained from the patients for the publication of this report and any accompanying images.

Conflict-of-interest statement: The authors declare that they have no conflict of interest to disclose.

CARE Checklist (2016) statement: The authors have read the CARE Checklist (2016), and the manuscript was prepared and revised according to the CARE Checklist (2016).

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S-Editor: Chen YL

L-Editor: Wang TQ

P-Editor: Chen YL

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