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Portal flow into the liver through veins at the site of biliary-enteric anastomosis

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Abstract The aim of this study was to establish the role played by jejunal veins in hepatopetal flow after biliary-enteric anastomosis and to evaluate the helical CT features of hepatopetal flow through the anastomosis. We retrospectively analyzed helical CT images of the liver in 31 patients with biliary-enteric anastomosis who underwent hepatic angiography with ($n=13$) or without ($n=18$) CT arterial portography within 2 weeks of the CT examination during the last 4 years. Arterial portography showed hepatopetal flow through small vessels located (communicating veins) between the elevated jejunal veins and the intrahepatic portal branches in two (9%) of 22 patients with a normal portal system. Helical CT showed focal parenchymal enhancement around the anastomosis in these two

patients. All nine patients with extrahepatic portal vein occlusion (100%) had hepatopetal flow through the anastomosis, and four of the nine had decreased portal flow. CT revealed small communicating veins in two of these four patients. In five patients with normal portal perfusion despite extrahepatic portal vein occlusion, CT detected dilated communicating veins and elevated jejunal veins. The presence of communicating veins and/or focal parenchymal enhancement around the anastomosis indicates hepatopetal flow through the elevated jejunal veins.

Keywords Portal vein · CT · Biliary-enteric anastomosis

Introduction

Although periampullary neoplasms are frequent causes of portal vein occlusion, adhesion due to inflammation, trauma, or surgical intervention can cause extrahepatic portal obstruction [1, 2]. The parabiliary venous system, which can function as a collateral pathway in cases of portal vein obstruction [3], is surgically interrupted by choledocho- or hepaticojejunostomy (biliary-enteric anastomosis) [4, 5].

There are many reports of blood supply into the liver through small veins outside the portal vein [6–12]; however, the role of the jejunal veins at the site of biliary-enteric anastomosis (elevated jejunal veins) has not been well investigated. We conducted a retrospective study to evaluate the role played by jejunal veins in hepatopetal

flow after such anastomosis and the helical computed tomography (CT) features of hepatopetal flow through the anastomosis.

Materials and methods

The ethics committee at our institution approved this study. Informed consent was not required as patient's privacy was maintained. We performed helical CT of the liver in 67 patients (21 women and 46 men, aged 39–79 years, mean 64 years) with biliary-enteric anastomosis between April 1999 and December 2002. All CT scans were obtained during the course of routine care, and no CT scans were obtained for the purpose of this study. Sixty-

Table 1 Summary of helical CT findings ($n=31$). *Communicating vein* vessels located between jejunal veins at the site of anastomosis and intrahepatic portal branches around hepatic hilum

Extrahepatic portal vein	Hepatopetal flow through biliary-enteric anastomosis	Helical CT	
		Focal parenchymal enhancement around the anastomosis	Communicating vein (small) Communicating vein (dilated)
Normal ($n=22$)	2	2	
Occlusion ($n=9$)	4 (decreased portal perfusion ^a)		2
	5 (normal portal perfusion ^a)		5

^aPortal perfusion into the entire liver on CTAP and/or arterial portography

one of the 67 patients had malignant disease. Sixty-five patients underwent pancreaticoduodenectomy with/without hepatic resection followed by creation of a gastrojejunostomy, choledochojejunostomy or hepaticojejunostomy, and pancreaticojejunostomy, and two underwent extrahepatic bile duct resection with partial hepatic resection followed by creation of a choledochojejunostomy or hepaticojejunostomy. Of these 67 patients, 31 underwent hepatic angiography with ($n=13$) or without ($n=18$) CT arterial portography (CTAP) within 2 weeks of the helical CT examination. Indications for hepatic angiography included hepatic artery infusion chemotherapy ($n=22$), intestinal hemorrhage ($n=2$), and suspected portal vein occlusion ($n=7$). We reviewed the CT findings in the 31 cases and compared the helical CT images with the angiograms ($n=31$) and CTAP images ($n=13$). None of the 31 patients had chronic hepatic disease. Pancreaticoduodenectomy had been performed in 29 patients. Two patients had undergone biliary-enteric anastomosis and partial hepatic resection around the hepatic hilum.

The time interval between surgery and our evaluation of the CT scans ranged from 3–86 months (mean 17 months). Helical CT scans were obtained with a Siemens Plus-4

scanner (Siemens Medical Systems, Erlangen, Germany). Patients were given 100 cm³ of contrast medium (300 mg I/ml) by power injection at 2 ml/s. Dual-phase helical scanning (arterial-dominant and portal-venous-dominant phases) was performed in all cases. Patients were instructed to hold their breath during the helical CT examination to avoid creation of motion artifacts. Arterial-phase imaging was begun 30 s after the start of contrast injection. Patients were allowed to breathe during a 20-s interphase delay after which portal phase imaging began (around 70 s after the start of contrast injection). Each series of scans was obtained with 7 mm/s cephalocaudal table movement and 5-mm collimation, with image reconstruction every 5 mm.

Hepatic angiography included selective celiac and superior mesenteric angiography with the use of prostaglandin E1 (Prostandin; Ono, Tokyo, Japan) to optimize visualization of the portal vein (arterial portography). Images were obtained by the digital subtraction angiography method. CTAP was performed in 13 of 31 patients by injection of 80–100 ml of contrast material (140–160 mg I/ml) with use of prostaglandin E1 at 3 ml/s. CTAP was performed immediately after hepatic angiography. Twenty

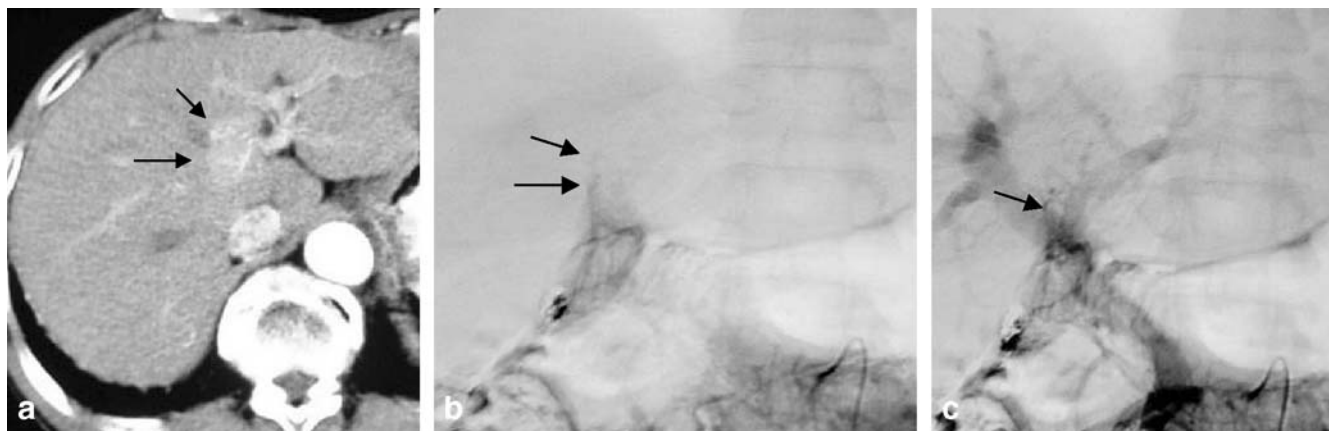


Fig. 1 Images obtained from a 72-year-old man 3 years after pancreaticoduodenectomy. **a** CT scan in the arterial-dominant phase shows focal parenchymal enhancement at the hepatic hilum (arrows). **b** Superior mesenteric arteriogram in the capillary phase shows a

small communicating vein at the hepaticojejunostomy site (arrows). **c** Arterial portography shows a patent portal system. The communicating vein anastomoses with the intrahepatic portal system around the hepatic hilum (arrow).



Fig. 2 Images obtained from a 53-year-old woman with liver dysfunction and portal vein occlusion. Images were obtained 5 months after pancreaticoduodenectomy. *Large white arrow*=spleen. **a** CT scan in the arterial-dominant phase shows communicating veins (*arrows*). *White arrows*=hepatic artery. Note that hepatic parenchymal enhancement caused by impaired portal perfusion. **b** CTAP image shows parenchymal enhancement predominantly in the

hilar region and hepatopetal flow into the liver through the communicating veins (*arrows*). Most of the liver shows hypoperfusion. The caval vein is enhanced by hepatofugal flow of the portal venous system via the veins of Retzius [23]. Note the catheter in the abdominal aorta and reflux of the contrast medium into the abdominal aorta.

seconds after the start of contrast injection, 5 mm of contiguous axial helical scans were obtained through the entire liver.

All images were reviewed by two independent radiologists who performed hepatic angiography and CTAP, and any differences in opinion were resolved by consensus. Depiction of focal parenchymal enhancement around the biliary-enteric anastomosis was assessed on helical CT (arterial-dominant phase) and on CTAP images, and the presence of vessels located between the intrahepatic portal

branches and elevated jejunal veins (communicating veins) was assessed on angiography, helical CT, and CTAP images.

Results

Arterial portography showed a patent portal system in 22 patients (Table 1) and hepatopetal flow through small communicating veins in two (9%) of the 22 patients. These small veins were not detected on helical CT images. Helical CT in the arterial-dominant phase showed focal

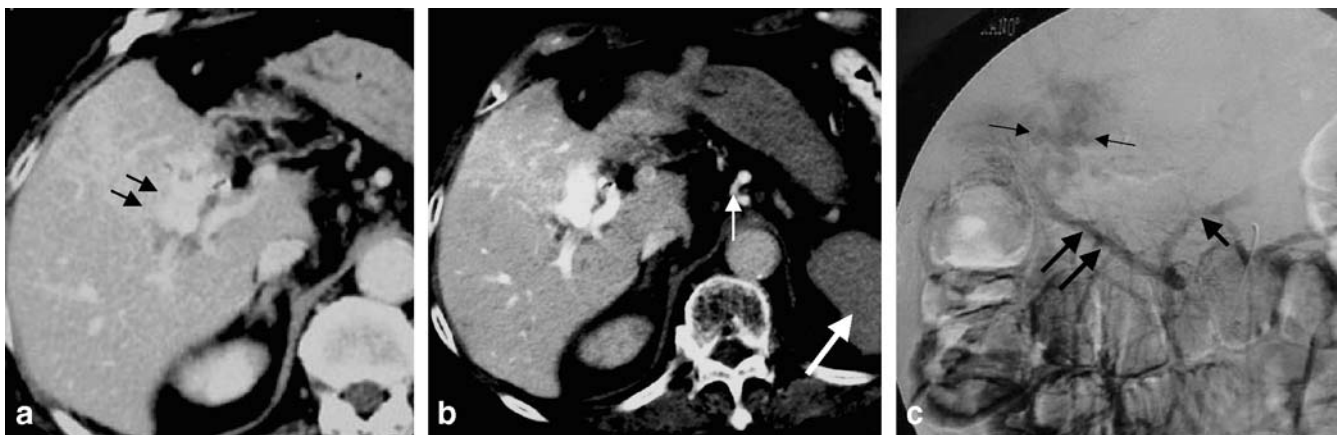


Fig. 3 Images obtained from a 75-year-old woman with tarry stools and portal vein occlusion. Images were obtained 7 years after surgery. **a** CT scan in the portal-dominant phase shows dilated communicating veins at the site of choledochojejunostomy (*arrows*). **b** CTAP image shows adequate portal perfusion through these veins.

White arrow=left gastric vein. *Large white arrow*=spleen. **c** Arterial portography image shows direct communication through dilated communicating veins (*small arrows*) between the intrahepatic portal vein and elevated dilated jejunal veins (*double large arrows*). *Large arrow*=splenic vein.

parenchymal enhancement around the anastomosis in these two patients (Fig. 1). The time intervals between surgery and CT scanning for these two patients were 20 and 27 months. Hepatopetal flow through the elevated jejunal veins was not present on angiograms or CTAP images ($n=5$) in the remaining 20 patients nor were there any abnormal helical CT findings. The mean interval between surgery and CT scanning for these patients was approximately 15 months (range 3–84 months).

Arterial portography revealed extrahepatic portal vein occlusion in nine patients; CTAP showed severely decreased portal perfusion throughout the liver in four of these nine patients (Fig. 2). Arterial portography did not show hepatopetal flow through the elevated jejunal veins in these four patients; however, CTAP revealed dense focal blood supply into the hepatic hilum adjacent to the anastomosis and opacification of the portal system around the hepatic hilum. Small communicating veins were seen on both CTAP and helical CT images in two of these four patients. All four had increased levels of indicators of liver function such as transaminase and bilirubin. Focal enhancement was not seen on helical CT images in any of the four patients. The mean interval between surgery and CT scanning was approximately 7 (range 4–11) months.

Arterial portography showed hepatopetal flow through dilated elevated jejunal veins and communicating veins in five of the nine patients with extrahepatic portal vein occlusion (Fig. 3). Direct communications through the dilated communicating veins were seen between the elevated jejunal veins and intrahepatic portal branches. Portography and/or CTAP ($n=4$) showed normal portal perfusion into the entire liver through these dilated veins. These veins were also visible on helical CT images at a mean interval of approximately 36 (range 14–86) months after surgery.

Discussion

Arterial portography revealed hepatopetal flow through dilated communicating veins in five patients with extrahepatic portal vein occlusion and normal portal perfusion and through small communicating veins in two patients with a normal portal system. Portography showed direct communication between the elevated jejunal veins and intrahepatic portal branches around the anastomosis through the communicating veins. Portal flow through the dilated communicating veins was adequate to perfuse the entire liver. Thus, the presence of communicating veins indicates hepatopetal flow through elevated jejunal veins in patients with biliary-enteric anastomosis. Communicating veins can develop into adequate hepatopetal collaterals to perfuse the entire liver.

The communicating veins were seen in 9% of our patients with a radiographically normal portal vein. This finding will likely be much rarer in the clinical setting. Helical CT cannot detect communicating veins in all cases,

especially when the caliber is small. The presence of communicating veins is not critical in patients with normal portal flow. Communicating veins may be newly developed vessels caused by postoperative adhesions [1, 2]. However, because of their location, we speculate that most of the communicating veins consisted of parabiliary veins [3].

Focal parenchymal enhancement around the biliary-enteric anastomosis on helical CT images was caused by hepatopetal blood flow through small communicating veins. This was confirmed by arterial portography in two patients with a patent portal system. In the four patients with extrahepatic portal vein occlusion and impaired portal flow, CTAP showed dense parenchymal enhancement around the anastomosis and opacification of the portal system in the hilar region. These findings indicate that parenchymal enhancement around the anastomosis is due to the presence of a small amount of portal flow through the anastomosis. Small communicating veins were seen in two of the four patients on both CT and CTAP images. These findings suggested that part of the hepatopetal flow through the anastomosis occurred through communicating veins. Helical CT did not show focal parenchymal enhancement in any of the four patients. All four patients showed extensive parenchymal enhancement on the arterial-dominant-phase CT images, which was caused by occlusion of the portal flow [13–15]. Hence, focal parenchymal enhancement caused by a small amount of hepatopetal flow through the anastomosis becomes obscure on helical CT images in patients with portal vein occlusion.

We found that helical CT can depict hepatopetal flow through the biliary-enteric anastomosis as either focal parenchymal enhancement around the anastomosis or as the presence of communicating veins. When the amount of hepatopetal flow through the anastomosis is small, focal parenchymal enhancement or small communicating veins are the predominant findings. In patients with decreased portal flow into the liver, however, parenchymal enhancement due to low portal flow through the anastomosis may not be clearly visible on helical CT images. When portal flow through the anastomosis is well developed, the dilated communicating veins and elevated jejunal veins are visible on helical CT images.

Four patients with extrahepatic portal vein occlusion and small communicating veins had impaired liver function. Portal occlusion occurred approximately 7 months after surgery, and portal flow into the entire liver was diminished in these four patients. Decreased portal flow can cause liver dysfunction, especially after hepatopancreatobiliary surgery. Hence, it is conceivable that the jejunal veins at the anastomotic site could serve as critically needed hepatopetal collaterals when portal flow from the mesentery is severely interrupted in cases of biliary-enteric anastomosis.

Hemorrhage after pancreaticoduodenectomy is one of the major complications of the procedure, with a mortality rate up to 50% [16]. Transarterial embolization or surgical ligation of the hepatic artery distal to the celiac artery is one

choice to control the bleeding [17]. Several reports have described that partial portal vein arterialization should be considered as an option in cases of total hepatic artery occlusion with impairment of portal flow [18, 19]. We think it is important to know whether hepatopetal flow through communicating veins is present in patients with portal flow disturbance, especially patients who are scheduled to undergo ligation or transarterial embolization of hepatic artery for hemorrhage after pancreaticoduodenectomy. It may be possible to achieve an adequate hepatic perfusion through communicating veins with portal vein arterialization.

There are potential limitations to our study. First, the retrospective review of CT findings has innate limitations. Second, we could not perform CTAP in all patients. Also, helical CT is not the best image acquisition technique for the identification of veins [20, 21]. Images were obtained with 7 mm/s cephalocaudal table movement and 5-mm collimation. Exact assessment of the presence of the veins and

parenchymal enhancement might not be possible with these parameters. Furthermore, multislice CT may provide more precise information about vascular state after pancreaticoduodenectomy such as the presence of pseudoaneurysm, portal vein occlusion, or portal flow via communicating veins [22]. However, we made some interesting observations. The communicating veins and elevated jejunal veins may play important roles in the formation of hepatopetal collaterals when flow through the portal vein is disturbed. Dilatation of these veins at the anastomotic site may prevent liver dysfunction caused by diminished portal flow.

In conclusion, the presence of communicating veins and/or focal parenchymal enhancement around the anastomosis on helical CT images indicates hepatopetal flow through the elevated jejunal veins. Jejunal veins at the site of biliary-enteric anastomosis can develop into an extensive system of hepatopetal collaterals when flow through the portal vein is disturbed.

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