Hypothesis: Blood supply to the peripancreatic region is derived from the celiac and superior mesenteric arteries, complementary to each other.

Design: Cohort analytic study.

Setting: Tertiary care public hospital.

Patients and Methods: Computed tomography (CT) during superior mesenteric artery arteriography (SMAA-CT) and during celiac artery arteriography (CEAA-CT), in which a catheter tip was inserted into the common hepatic or gastroduodenal artery, was performed in 25 patients.

Main Outcome Measure: Distribution and correlation of these areas of marked enhancement on SMAA-CT and CEAA-CT were analyzed.

Results: The right cephalic part of the pancreatic head that is derived from the dorsal bud was enhanced on CEAA-CT, and the left caudal part of the pancreatic head that is derived from the ventral bud was enhanced on SMAA-CT. Blood supply to the intrapancreatic bile duct, including the ampulla of Vater, is derived from the CEA. The boundary between the areas of the duodenum supplied from the CEA and SMA was in the second or third portion.

Conclusion: The pancreatic head can be separated into 2 segments by the arterial supply, and each segment may be removed separately.

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RESULTS

DISTRIBUTION OF THE HYPERATTENUATING AREAS IN THE PANCREATIC HEAD PARENCHYMA

On CEAA-CT, pancreatic parenchymal enhancement was present on the right cephalic side of the pancreatic head (Figure 1 and Figure 2). In contrast, the

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PATIENTS, MATERIALS, AND METHODS

From May 1, 1997, through April 30, 1998, 25 patients with suspected hepatopancreaticobiliary abnormalities were selected. Patients with deformity of the pancreas due to severe pancreatitis or advanced pancreatic carcinoma, obstructive jaundice, and portal hypertension were excluded. Patients underwent helical CT during visceral artery injection at the time of conventional preoperative angiography.

In the angiography suite, celiac artery (CEAA) and superior mesenteric artery arteriography (SMAA) was performed to visualize the peripancreatic arterial anatomy. After confirming the branching pattern of the CEAA and SMA, helical CT during the injection of the contrast medium into the visceral artery was performed to evaluate the perfusion areas of the pancreaticoduodenal region.

All studies were performed using a commercially available system (IVR-CT system; Toshiba Medical Systems, Tokyo, Japan), which consisted of a digital subtraction angiography system and a helical CT scanner. This equipment is capable of performing digital subtraction angiography and CT scanning with the patient in the same position. The helical CT was obtained on a 1:1 pitch, 5-mm collimation, 2- to 5-mm reconstruction, 120-kV peak, and 250 mA. Scanning was started 5 to 10 seconds after the commencement of injection of ioversol (350 mg/mL iodine) diluted with isotonic sodium chloride solution (1:2 ratio) at a rate of 1 to 3 mL/s for a total volume of 20 to 60 mL (40 mL in most cases) using a power injector. We confirmed the absence of reflux into the celiac axis or superior mesenteric axis of this condition on previous arteriograms and CT images. A vasodilator was not injected through the catheter.

All CT and angiographic images were analyzed by 2 experienced radiologists (H.F. and R.I.); discrepancies were resolved by consensus. The evaluation was focused on the following 3 points: (1) distribution and correlation of the hyperattenuating areas in the pancreas; (2) the degree of enhancement of the intrapancreatic bile duct by injection of contrast medium from the CEAA and SMA; and (3) distribution and correlation of the enhanced areas in the duodenum injected with contrast medium from the CEAA in which a catheter tip was inserted into the common hepatic artery or the gastroduodenal artery and from the SMA; (2) the degree of enhancement of the intrapancreatic bile duct by injection of contrast medium from the CEAA and SMA; and (3) distribution and correlation of the enhanced areas in the duodenum injected with contrast medium from the CEAA and SMA. The cephalic part of the duodenum was divided into the following 3 areas: the second portion, located on the right side of the inferior vena cava, including the ampulla of Vater; the third portion, located on the front of the inferior vena cava; and the fourth portion, located on the left side of the inferior vena cava and in front of the aorta.

COMMENT

The pancreas arises from 2 primordia during embryogenesis. Both primordia fuse at about the sixth to seventh fetal week.12 The smaller ventral bud forms the caudal part of the pancreatic head, which is equal to the uncinate process, whereas the cephalic part of the pancreatic head and the body and tail are derived from the larger dorsal bud. The dorsal pancreatic duct becomes the major pancreatic duct by fusing with the proximal portion of the ventral duct, draining the body and tail and a portion of the head of the organ and emptying into the duodenum through a common opening with the CBD at the ampulla of Vater.

In our series using CT during arteriography, the right cephalic part of the pancreatic head was enhanced on CEAA-CT, and the left caudal part of the pancreatic head was enhanced on SMAA-CT. This means the superior pancreaticoduodenal artery departing from the CEAA provides blood to the part of the pancreas derived from the dorsal bud, and the inferior pancreaticoduodenal artery departing from the SMA supplies that derived from the ventral bud. These findings were consistent with the development of the human pancreas. Thus, the pancreas can be separated clinically into dorsal and ventral segments by the arterial blood supply. If some sophisticated surgical technique is used to preserve the outlet for pancreatic juice, each segment can be removed separately.66

The CBD, including the ampulla of Vater, was enhanced on CEAA-CT in all cases. Even if the PIPD derived from the SMA was demonstrated along with the in-
trapancreatic bile duct on SMAA-CT, the bile duct was not enhanced. Using autopsy materials, Kimura and Nagai also reported that arterial branches to the bile duct and the ampulla of Vater were derived from the PSPD, which was located along the intrapancreatic bile duct and was communicating with the PIPD. Preservation of the PSPD during surgery may be important to preserve better blood supply to the bile duct.

Figure 1. Comparison of computed tomographic (CT) images obtained during celiac artery arteriography (CEAA-CT), in which a catheter tip was inserted into the common hepatic artery, and during superior mesenteric artery arteriography (SMAA-CT). A, The CEAA-CT at the level of the superior mesenteric artery (SMA) shows an area of marked enhancement in the right side of the pancreas and the second portion of the duodenum (D) in which the common bile duct (CBD) is depicted as a hypoattenuating area. B, The SMAA-CT at the same level shows an area of marked enhancement in the left side of the pancreatic head. The CBD and surrounding area are not enhanced. The main pancreatic duct (MPD) is demonstrated at the boundary of both areas of marked enhancement on A and B. C, The CEAA-CT at the level of the gastrocolic trunk (GCT) shows an area of marked enhancement in the right ventral side of the pancreas and the duodenum. D, The SMAA-CT at the same level shows an area of marked enhancement in the left dorsal side of the pancreas. The main pancreatic duct (MPD) is depicted at the boundary of both areas of marked enhancement on C and D.
Maintaining duodenal blood flow is an important aspect of duodenum-preserving pancreatic head resection. In most of our cases, preserving the duodenal branches from the SMA is necessary to maintain the blood supply to the anal side of the duodenum. Similarly, the duodenal branches from the CEA are important to maintain blood supply to the oral side of the duodenum, including the ampulla of Vater. Thus, duodenal branches...
derived from the CEA and SMA should be preserved to avoid ischemic change of the duodenum in duodenum-preserving surgery.

To our knowledge, this is the first study of the blood supply to the peripancreatic region using CT during arteriography. Although unusual opacification induced by high-pressure injection might be a potential pitfall, each artery was catheterized and injected without reflux, then helical CT was performed so that 3-dimensional evaluation of the anatomy of the enhanced area could be performed under quasiphysiologic conditions.

In conclusion, the pancreas can be separated into 2 segments by the arterial supply. Blood supply to the intrapancreatic bile duct, including the ampulla of Vater, is derived from the CEA. The boundary between the areas of the duodenum that are supplied blood from the CEA and SMA is in the second or third portion. These data will be useful for limited resection of the pancreatic head and their adnexa.

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REFERENCES


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Barrett’s Esophagus: Update on Screening, Surveillance, and Treatment

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The last 2 decades have seen dramatic advances in Barrett’s esophagus. The definition has evolved; the rising incidence of adenocarcinoma has been recognized; and effective therapy to control gastroesophageal reflux disease has been developed. Both proton pump inhibitor therapy and laparoscopic fundoplication represent major developments. Studies of patients with dysplasia have helped to clarify appropriate surveillance intervals and treatment strategies for these patients, although controversy still exists. The possibility of reversing Barrett’s esophagus in selected high-risk patients offers major hope for the future prevention of adenocarcinoma of the esophagus. (1999;159:1411-1416)