Nonhepatic Arteries Originating from the Hepatic Arteries: Angiographic Analysis in 250 Patients

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PURPOSE: To investigate the prevalence and patterns of origin of nonhepatic arteries originating from the proper hepatic artery (PHA) or its distal branches and to assess their relation to anatomic variations.

MATERIALS AND METHODS: Digital subtraction celiac arteriography and selective left hepatic arteriography was performed in 250 patients with hepatocellular carcinoma. Three interventional radiologists interpreted the angiograms on the monitor by consensus. If necessary, further superselective arteriography was performed. The prevalence of nonhepatic arteries, their sites of origin, and the influence of underlying anatomic variants were analyzed.

RESULTS: Nonhepatic arteries were found in 205 patients. The most common nonhepatic artery was the right gastric artery (RGA; n = 196), followed by the hepatic falciform artery (HFA; n = 129), accessory left gastric artery (LGA; n = 43), posterior superior pancreaticoduodenal artery (PSPDA; n = 18), and left inferior phrenic artery (LIPA; n = 5). The left hepatic artery (LHA) was the most frequent origin of nonhepatic arteries (170 of 250). Regardless of anatomic variation, the most common origins of the RGA and HFA were the PHA and the segment IV hepatic artery, respectively. In patients with an aberrant LHA from the LGA, no accessory LGAs or LIPAs were found. PSPDAs preferentially arose from variant hepatic arteries arising from the gastroduodenal artery.

CONCLUSIONS: Nonhepatic arteries commonly arise from the hepatic arteries, especially the LHA and PHA. Moreover, variants of the celiac and hepatic arteries influence the prevalence and sites of origin of nonhepatic arteries.

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Abbreviations: CHA = common hepatic artery, GDA = gastroduodenal artery, HCC = hepatocellular carcinoma, HFA = hepatic falciform artery, LGA = left gastric artery, LHA = left hepatic artery, LIPA = left inferior phrenic artery, PHA = proper hepatic artery, PSPDA = posterior superior pancreaticoduodenal artery, RGA = right gastric artery, RHA = right hepatic artery, TACE = transcatheter arterial chemoembolization

TRANSCATHETER arterial chemoembolization (TACE) has been widely used for the palliative treatment of hepatic tumors including hepatocellular carcinoma (HCC) and metastatic disease to the liver (1–3). Chemoembolic agents can induce tumor necrosis but also may cause diverse complications of hepatic parenchymal injury, gallbladder infarction, splenic infarction, bile duct necrosis, supraumbilical skin rash, and gastroduodenal mucosal lesion or ulceration (4–12). Inadvertent embolization of nontarget organs is an important cause of complications after TACE. Gastroduodenal mucosal lesions may result from accidental infusion of chemoembolic agents into gastric or duodenal arteries originating from the hepatic arteries. The right gastric artery (RGA) and the accessory left gastric artery (LGA) frequently arise from the hepatic arteries (13–15). Moreover, the hepatic falciform artery (HFA) has been reported to originate from the hepatic artery, and influx of chemoembolic agents into the HFA can cause supraumbilical skin rash (10,16,17).

Recently, intraarterial brachytherapy of the liver has been introduced as another effective interventional treatment for primary or metastatic hepatic tumors (18,19). With intraarterial brachytherapy, similar or even more serious complications of nontarget embolization may be possible. Therefore, the preprocedural identification of nonhepatic arteries arising from the hepatic arteries is important to reduce complications related to various liver-directed therapies such as TACE, hepatic infusional pump therapy, and brachytherapy (20).

The purpose of this study was to investigate the prevalence and patterns of origin of nonhepatic arteries arising from the proper hepatic artery (PHA) or its distal branches in detail and to assess their relation to anatomic

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Table 1
Summary of the Terminology Used in this Study

Term	Definition
Normal celiac axis	An arterial trunk originating from the aorta, which contains the left gastric, common hepatic, and splenic arteries
Normal hepatic artery	An arterial trunk containing all segmental hepatic arteries (the PHA), which arises from the CHA
CHA	An arterial trunk containing at least one segmental hepatic artery and the GDA
PHA	An arterial trunk containing all segmental hepatic arteries regardless of its origin site
PHA equivalent	The first arterial trunk arising from the CHA when the PHA is not present (aberrant origin of hepatic arteries, including the origin of two separate hepatic arterial trunks from the CHA)
Nonhepatic artery	An artery that arises from the PHA or its distal branches and supplies organs and areas other than hepatic parenchyma
S234	An arterial trunk supplying hepatic segments II, III, and IV
S23	An arterial trunk supplying hepatic segments II and III
S24	An arterial trunk supplying hepatic segments II and IV
S34	An arterial trunk supplying hepatic segments III and IV
S*n*	A segmental hepatic artery supplying hepatic segment *n*

variations of the celiac axis and hepatic arteries based on superselective angiography.

MATERIALS AND METHODS

Study Sample

During the study period, 464 patients were referred to our radiology department for TACE of hepatic tumors. Among them, 250 patients with suspected or proven HCC were included in this prospective study. These patients comprised 195 men and 55 women with ages from 23 to 87 years (mean, 58.4 y). The remaining 214 patients, who were excluded from the study, had advanced HCC (n = 118), history of gelatin sponge embolization of a hepatic artery (n = 55), history of upper abdominal surgery (n = 36), or celiac axis stenosis (n = 5). Reasons for exclusion were difficulty in evaluating small nonhepatic arteries behind prominent tumor vascularity and stain, possible occlusion of nonhepatic arteries, and possible nonvisualization of nonhepatic arteries as a result of reversed flow in the presence of collateral circulation. Because angiographic evaluation of the celiac axis and/or hepatic artery is performed as a part of interventional therapy for HCC, we did not require institutional review board approval for the study.

Angiographic Techniques and Image Interpretation

All patients underwent celiac axis arteriography and selective left hepatic arteriography with a digital subtraction angiography unit (Angiostar; Siemens, Erlangen, Germany; or V-3000; Philips Medical Systems, Einthoven, The Netherlands). Celiac axis arteriography was performed with selective catheterization of the celiac axis with use of a 6.5-F or 5-F Rösch hepatic catheter (Cook, Bloomington, IN). Selective left hepatic arteriography was performed with use of a 3-F microcatheter (Microferret; Cook).

A nonionic contrast medium (iopromide; Ultravist 370; Schering, Berlin, Germany) was used for angiography. The injection rate and total volume of contrast medium used were 6–7 mL/sec and 42–49 mL, respectively, for celiac arteriography and 1.5–2.0 mL/sec and 10–14 mL, respectively, for selective left hepatic arteriography.

Three interventional radiologists (J.W.C., S.Y.S., H.G.L.) interpreted the angiograms on a digital subtraction angiography unit monitor by consensus with respect to celiac axis and hepatic artery anatomy and for the presence or absence of nonhepatic arteries.

On arteriograms, the identification of nonhepatic arteries was based on their characteristic appearances. The RGA first runs caudally and then runs along the lesser curvature of the stomach. Sometimes its anastomosis with the LGA can be demonstrated. The HFA runs along the falciform ligament of the liver and shows a short proximal rim that meanders inferolaterally obliquely and a relatively long lower rim that courses inferomedially (10). The accessory LGA arises from the hepatic artery proximal to the umbilical point of the left hepatic artery (LHA) and then runs directly leftward apart from the lesser curvature of the stomach and supplies the cardia and fundus of the stomach with distal tortuosity (15). The posterior superior pancreaticoduodenal artery (PSPDA) runs caudally to form the posterior pancreaticoduodenal arcade with the inferior pancreaticoduodenal artery from the superior mesenteric artery. The left inferior phrenic artery (LIPA) runs leftward and upward along the left hemidiaphragm and shows an upward convexity.

When a nonhepatic artery was identified, we tried to determine its origin. When opinions conflicted, additional superselective arteriography with use of a microcatheter was performed.

Terminology Used in this Study

To describe the anatomy of the celiac axis and hepatic arteries and the origins of nonhepatic arteries, we first define the terminology used (**Table 1**).

A nonhepatic artery is defined as an artery that arises from the PHA or its distal branches and supplies organs and areas other than hepatic parenchyma. We did not include the cystic artery as a nonhepatic artery in this study because it almost always arises from the PHA or its distal branches and can supply hepatic parenchyma adjacent to the gallbladder bed.

We adopted the term "PHA equivalent" in this study. For example, an LHA arising from the PHA differs from one arising directly from the common hepatic artery (CHA) when the right hepatic artery (RHA) aberrantly originates from the superior mesenteric artery, celiac axis, or aorta. We assumed that when the PHA was absent as a result of an aberrant hepatic artery origin (or when two separate hepatic arterial trunks arose from the CHA), the first arterial trunk arising from the CHA is equivalent to the PHA found in patients with a conventional celiac and hepatic artery anatomy from the developmental point of view.