# Hepatocellular Carcinoma: Detection of Blood Supply from the Right Inferior Phrenic Artery by the Use of Multi–Detector Row CT

**Hyo-Cheol Kim, MD, Jin Wook Chung, MD, Sangbu An, MD, Kyu Ri Son, MD, Hwan Jun Jae, MD, and Jae Hyung Park, MD**

**PURPOSE: To evaluate retrospectively the ability of multi–detector row computed tomography (CT) to detect blood supply from the right inferior phrenic artery (RIPA) in patients with hepatocellular carcinoma (HCC).**

**MATERIALS AND METHODS: Between July 2006 and June 2007, angiography of the RIPA was performed in 178 patients (151 men, 27 women; mean age, 59 years) with HCC who also had undergone multi–detector row CT. CT scans and digital subtraction angiograms of these patients were retrospectively reviewed by consensus by two investigators to evaluate tumor feeder vessels.**

**RESULTS: Tumor staining fed by the RIPA was noted on angiography in 113 patients (63%). Readers interpreted that the tumor feeder vessels were evident on CT images in 63 of these 113 patients (56%). Young age (odds ratio [OR], 0.934; $P < .0001$), exophytic growth pattern (OR, 2.702; $P = .009$), and presence of a visible feeder vessel on CT (OR, 6.933; $P < .0001$) were significant factors for predicting parasitic blood supply from the RIPA. In a subgroup of tumors smaller than 5 cm, multivariate analysis revealed that young age (OR, 0.94; $P = .03$) and repeated chemoembolization sessions (OR, 8.65; $P = .01$) were significant factors.**

**CONCLUSIONS: Visualization of a tumor feeding vessel from the RIPA on multi–detector row CT could be a clue of a parasitic supply of a large tumor. In patients who have received repeated chemoembolization, small tumors in the dorsal hepatic area can be supplied by the RIPA.**

**J Vasc Interv Radiol 2008;** 19:1551–1557

**Abbreviations:** HCC = hepatocellular carcinoma, RIPA = right inferior phrenic artery

CHEMOEMBOLIZATION has become a widely accepted treatment for patients with unresectable hepatocellular carcinoma (HCC) (1,2). In practice, we frequently encounter HCCs additionally supplied by extrahepatic collateral arteries, even when the hepatic artery is patent (3–7). The right inferior phrenic artery (RIPA) is the most common extrahepatic collateral vessel that supplies HCC. Therefore, chemoembolization performed via the RIPA is important to achieve effective control of a tumor.

The origins of the RIPAs are variable, and the proximal segment of the celiac axis, aorta around the celiac axis, and right renal artery are the common sites of origin (8). If the origin of the RIPA is not known, selective angiography of the RIPA may be time-consuming. Fortunately, the use of multi–detector row computed tomography (CT) can show the exact origin of the RIPA in most patients (9–11). In the case of significant celiac axis stenosis caused by median arcuate ligament compression and poststenotic dilation, it can be challenging to perform superselective catheterization of the RIPA originating from the ascending part of the dilated celiac axis in the posterosuperior direction (12). Therefore, if CT could select patients who required chemoembolization via the RIPA, the use of CT could save angiographic time, curtail the use of contrast media, and reduce exposure of the patient to radiation. Some investigators have insisted that asymmetric dilation of the RIPA and visualization of the distal portion of the RIPA on CT is a clue to indicate a parasitic supply from the RIPA (13,14). However, these studies included a small number of patients

From the Department of Radiology (H.C.K., J.W.C., S.A., H.J.J., J.H.P.), Seoul National University College of Medicine, Institute of Radiation Medicine, Seoul National University Medical Research Center, and Clinical Research Institute, Seoul National University Hospital; and Department of Radiology (K.R.S.), SMG-SNU Boramae Medical Center, Seoul, Republic of Korea. Received March 20, 2008; final revision received July 26, 2008; accepted August 5, 2008. **Address correspondence to** J.W.C., Department of Radiology, Seoul National University Hospital, 28 Yongon-dong, Chongno-gu, Seoul 110-744, Korea; E-mail: chungjw@snu.ac.kr

None of the authors have identified a conflict of interest.



**DOI: 10.1016/j.jvir.2008.08.005**

who were evaluated with single-detector CT. We therefore undertook this study to determine how to predict the presence of blood supply from the RIPA with use of multi–detector row CT.

## MATERIALS AND METHODS

### Patients

From July 2006 to June 2007, selective angiography of the RIPA was performed during a chemoembolization procedure in 220 patients with an HCC. We excluded 42 patients who (i) had CT scans performed at another institution ($n = 15$), (ii) had an ambiguous blood supply from the RIPA to the tumor ($n = 16$), and (iii) had a time interval between CT examination and chemoembolization longer than 30 days ($n = 11$). Therefore, 178 patients (151 men, 27 women; age range, 18–81 years; mean age, 58.6 y) were included in this study. Our institutional review board approved the study, and informed consent was waived as a result of the retrospective nature of the study.

A diagnosis of HCC was determined based on the results of a percutaneous needle biopsy ($n = 10$), surgical resection ($n = 22$), or clinical or laboratory testing (eg, increased serum α-fetoprotein levels and expression of viral markers) in combination with typical CT and angiographic appearances and disease progression as detected on follow-up images ($n = 146$).

### Multi–Detector Row CT

CT examinations were performed with various multi–detector row CT scanners, including a four–detector row scanner (MX 8000; Philips, Cleveland, Ohio; $n = 22$), an eight–detector row scanner (LightSpeed Ultra, GE Medical Systems, Milwaukee, Wisconsin; $n = 58$), a 16–detector row scanner (Sensation 16, Siemens, Erlangen, Germany; $n = 51$), and a 64–detector row CT scanner (Brilliance 64; Philips; $n = 47$). Time intervals between CT and chemoembolization ranged from 0 to 30 days (mean, 12 d), and all patients who received chemoembolization in our institution underwent CT before each chemoembolization session.

The respective scanning parameters used for the four-, eight-, 16-, and 64-detector row CT scanners were as follows: detector configurations, 4 × 2.5 mm, 8 × 1.25 mm, 16 × 0.75 mm, and 64 × 0.625 mm; slice thicknesses, 3.2 mm, 2.5 mm, 3 mm, and 3 mm; reconstruction intervals, 3 mm, 2.5 mm, 3 mm, and 2 mm; table speeds, 12.5 mm/rotation, 13.5 mm/rotation, 24 mm/rotation, and 46 mm/rotation; and effective mAs, 150, 200, 200, and 200. All scans were performed with a rotation time of 0.5 seconds at 120 kVp.

Unenhanced images were first obtained in a craniocaudal direction. The dynamic images consisted of three phases (ie, hepatic arterial, portal venous, and equilibrium phases). After acquiring unenhanced liver images, contrast medium (Iopromide; Ultravist 370; Schering, Berlin, Germany) was administered, followed by a 30-mL sterile saline solution flush with use of a power injector (Multilevel CT; Medrad, Pittsburgh, Pennsylvania). Contrast medium and saline solution were injected at 3 mL/sec through an 18-gauge plastic intravenous catheter placed in an antecubital vein. Contrast medium volumes (delivered at 2 mL/kg body weight) varied from 100 mL to 150 mL. Hepatic arterial-phase scan delays were 11–17 seconds after descending aorta enhancement to 100 HU, as measured with a bolus-tracking technique, and portal venous-phase interscan delays were 20–30 seconds. The equilibrium phase was acquired 180 seconds after completion of the administration of contrast medium.

### Methods of Chemoembolization

All angiographic examinations were performed by one of two interventional radiologists (J.W.C., with 16 years of experience; or J.H.P., with 27 years of experience). All patients were suspected of having blood supply from the RIPA for the following reasons: (i) an HCC was located in the dorsal hepatic area as depicted on a CT scan; (ii) iodized oil infused at a previous chemoembolization session had not accumulated in the dorsal portion of the tumor as seen on CT images; (iii) even though a viable tumor abutting the diaphragm was observed in the ventral hepatic portion on CT images, corresponding tumor staining was not found by hepatic, internal mammary, and intercostal angiography; or (iv) a large RIPA was noted on a CT scan.

When selective catheterization had been achieved by placing a microcatheter with a 2.4-F tip (Microferret; Cook, Bloomington, Indiana) or 2.0-F tip (Progreat; Terumo, Tokyo, Japan) as close as possible to a specific branch or branches supplying a tumor, iodized oil (Lipiodol; Andre Gurbet, Aulnay-sous-Bois, France) and doxorubicin hydrochloride (Adriamycin RDF; Ildong Pharmaceutical, Seoul, Korea) emulsion was infused until stasis was achieved. If initial blockade of the feeding artery was insufficient as a result of a large mass size or arterioportal shunting, embolization was performed with use of absorbable gelatin sponge particles (Gelfoam; Upjohn, Kalamazoo, Michigan) 1 mm in diameter soaked in a mixture of 2 mg of crystalline mitomycin (Mitomycin-10; Kyowa Hakko Kogyo, Tokyo, Japan) and 10 mL of nonionic contrast medium. We infused the chemotherapeutic agent (maximum of 12 mL of iodized oil and 60 mg of doxorubicin hydrochloride) through the hepatic artery and all extrahepatic collateral arteries in one session.

### Analysis

Data were recorded in an electronic database (Access; Microsoft, Redmond, Washington) immediately after angiography performed by two investigators (J.W.C. and J.H.P.). These data included the amounts of iodized oil and anticancer agents that had been infused into arteries, the presence of an extrahepatic collateral arterial supply, and anatomic descriptions of the hepatic and extrahepatic collateral arteries.

Tumor location, tumor growth pattern, tumor feeding vessel, and pulmonary shunt on CT and angiography were determined by consensus by the two interventional radiologists (J.W.C. and J.H.P) who performed all the chemoembolization procedures. Tumor size and RIPA size were measured by another reviewer (H.C.K.). If multiple tumors were present, readers evaluated the tumor supplied by the RIPA or suspected to be fed by the RIPA. Tumors were assigned to liver segments in accord with Couinaud classification (15). If a tumor occupied two or more segments, its location was assigned to the dominant segment. Tu-