Arterioportal Shunt: Prevalence in Small Hemangiomas versus That in Hepatocellular Carcinomas 3 cm or Smaller at Two-Phase Helical CT1

PURPOSE: To compare the prevalence of arterioportal (AP) shunting associated with (a) small (≤3 cm) hemangiomas and (b) hepatocellular carcinomas (HCCs) (≤3 cm) at two-phase helical computed tomography (CT).

MATERIALS AND METHODS: Two-phase helical liver CT was performed in 107 patients (61 men, 46 women; age range, 25–73 years; mean, 48.6 years) with 169 small hemangiomas and in 384 patients (292 men, 92 women; age range, 18–82 years; mean, 58.3 years) with 598 HCCs 3 cm or smaller. Diagnosis of HCC was verified with histologic findings (n = 30) or typical imaging and clinical findings (n = 568); that of all hemangiomas was verified with typical imaging and clinical findings. Three radiologists retrospectively reviewed all CT images in consensus. Contrast material–enhanced CT scans were obtained during the hepatic arterial and portal venous phases. AP shunt was considered to be present when wedge-shaped or irregularly shaped homogeneous enhancement peripheral to tumor appeared at hepatic arterial phase CT and isoattenuation or slight hyperattenuation in that area appeared at portal phase CT. The prevalence of AP shunting associated with hemangiomas and that associated with HCCs were compared with multivariate model testing. Speed of lesion enhancement (rapid enhancement, when extent of intratumoral enhancement at hepatic arterial phase CT was ≥50%; slow enhancement, when extent of intratumoral enhancement was <50%) and presence of AP shunt were correlated with 2 or Fisher exact testing.

RESULTS: AP shunts were more frequently found in hemangiomas (36 lesions [21.3%]) than in HCCs (25 lesions [4.2%]) (P < .001). Twenty-four (38%) of the 64 hemangiomas with rapid enhancement had AP shunts, whereas only 12 (11.4%) of the 105 hemangiomas with slow enhancement had AP shunts (P < .001). There was no significant difference between prevalence of AP shunt in the 573 HCCs with rapid enhancement (24 lesions, 4.2%) and that in the 25 HCCs with slow enhancement (one lesion, 4.0%).

CONCLUSION: AP shunts were more frequently seen at two-phase helical CT in small hepatic hemangiomas than in HCCs and thus represent a suggestive but not specific finding of hemangioma. Small hemangiomas with AP shunts tend to show rapid rather than slow enhancement.

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Hepatic hemangioma is the most common benign tumor of the liver and is found incidentally at many radiologic examinations, including computed tomography (CT) (1).
Hepatocellular carcinoma (HCC) is the most common primary malignancy of the liver; in most patients, it develops in the setting of underlying liver cirrhosis or chronic hepatitis (2). Differential diagnosis of these two tumors is important for determining patient care. Fortunately, differential diagnosis with imaging studies such as CT is possible in most cases owing to improvement in the characterization of focal hepatic lesions and the widespread use of two-phase (hepatic arterial phase [HAP] and portal venous phase [PVP]) helical CT. However, when a hemangioma has atypical findings at CT, differentiating it from HCC is sometimes difficult, especially in a cirrhotic liver. Hemangiomas with atypical CT findings tend to be small (3,4).

An arterioporal (AP) shunt associated with a hepatic tumor has been reported to be an important sign that the tumor is malignant (5–7), but AP shunts have been believed to be rare in hemangiomas (5,8–10). However, results of more recent studies have shown that AP shunts are not uncommonly seen in hepatic hemangiomas. Several authors have reported that a high percentage of hemangiomas (19%–26%) are accompanied by an AP shunt (3,11,12). In contrast, most HCCs accompanied by AP shunts tend to be advanced tumors with portal vein thrombosis. To our knowledge, a comparison of the prevalence of AP shunts associated with small hemangiomas and HCCs has not been performed by using two-phase helical CT except in one study (5,8–10). However, when two-phase helical CT was performed at 4-week intervals for one patient (n = 88), 21 had positive results at scintigraphy performed with 99mTc-labeled red blood cells, and 13 had consistent findings on dynamic MR images (n = 8), angiograms (n = 3), or both (n = 2). The remaining 13 hemangiomas were diagnosed on the basis of typical two-phase CT findings and no interval change in size at follow-up imaging (range of follow-up, 30–36 months; mean follow-up, 32 months).

Diagnosis of HCC was established as follows: (a) by histologic diagnosis (with cellular differentiation) of specimens obtained either at percutaneous biopsy after CT scanning (six lesions in six patients), lobectomy or segmentectomy (13 lesions in 12 patients), or liver transplantation (11 lesions in seven patients); (b) by consistent findings at two-phase helical CT and increase in the size of the mass at follow-up CT (two lesions in two patients); (c) by consistent findings at two-phase helical CT and a high level of serum a-fetoprotein (>300 μg/L) (140 lesions in 83 patients, including more than one lesion in 43 patients); or (d) by consistent findings at two-phase helical CT and lipiodized oil (Lipiodol; André Guerbet, Aulnay-sous-Bois, France) uptake at one or more follow-up CT examinations performed at 4-week intervals after transcatheter arterial chemoembolization (TACE) (426 lesions in 274 patients).

**MATERIALS AND METHODS**

**Patients**

For a 12-month period between July 2000 and June 2001, we reviewed, by examining computerized medical records, all radiology reports (n = 5,895) of hepatic helical CT examinations performed with a two-phase (HAP and PVP) protocol at our institution. We identified 540 patients for whom the differential diagnoses (according to the CT reports) included hemangioma or HCC 3 cm or smaller in greatest diameter. Two radiologists (J.H.B., C.W.L., who had 7 and 3 years of experience, respectively) reviewed the radiologic, clinical, and histopathologic data in consensus to decide whether a lesion fulfilled the criteria (described below) for a small hemangioma or an HCC.

Forty-five patients were excluded because they did not undergo follow-up CT examination or additional diagnostic radiologic investigation and did not have histologic proof of the diagnosis. In addition, we excluded all subjects (n = 4) who had undergone biopsy before CT scanning because of the possibility that an iatrogenic AP shunt had been created.

Thus, 169 small hemangiomas in 107 patients (61 men and 46 women; age range, 25–73 years; mean age, 48.6 years) and 598 HCCs in 384 patients (292 men and 92 women; age range, 18–82 years; mean age, 58.3 years) met the diagnostic criteria and were included in this study. The patients with HCCs were significantly older than those with hemangiomas (P < .001, Student t test). There were more male patients in the HCC group than in the hemangioma group (P < .001, x^2 test). Three patients had both small hemangiomas and HCCs. Our institutional review board approved our study and did not require patient informed consent for this type of retrospective review.

Diagnosis of hemangioma was established by means of (a) consistent findings at two-phase helical CT and positive results at both scintigraphy performed with technetium 99m (99mTc)-labeled red blood cells and single photon emission CT (for 21 lesions in 11 patients); (b) consistent findings at two-phase helical CT with no interval change in size for at least 6 months at follow-up radiologic examinations (range of follow-up, 6–18 months; mean follow-up, 13 months) (for 135 lesions in 84 patients); or (c) consistent findings at two-phase helical CT with consistent findings on dynamic magnetic resonance (MR) images (for eight lesions in eight patients), angiograms (for three lesions in three patients), or both (for two lesions in one patient).

The most common indication for performing CT in the patients with hemangiomas was further evaluation of a focal lesion in the liver that was observed at previous ultrasonography. At two-phase helical CT, a lesion was considered to be a hemangioma if it showed the following findings: (a) early peripheral nodular noncontinuous contrast enhancement, isodensity relative to the aorta during the HAP, and centripetal fill-in enhancement during the PVP (134 lesions); (b) early homogeneous enhancement during the HAP, persistent enhancement during the PVP, and isodensity relative to enhancing intrahepatic vessels (32 lesions); or (c) tiny enhancing dots (the “bright dot sign” [14]) during hypoattenuation in the HAP and PVP, as well as isodensity relative to enhancing intrahepatic vessels (three lesions).

At dynamic MR imaging, a lesion was considered to be a hemangioma if it showed high signal intensity similar to that of cerebrospinal fluid on T2-weighted images (repetition time msec/echo time msec, 4.4/134; flip angle, 150°) and globular enhancement that progressed centripetally on dynamic contrast material–enhanced images.

Angiographic findings were considered to be diagnostic for hemangioma when a lesion was seen as a round vascular mass associated with pooling of contrast material. Thirty-six patients with 47 hemangiomas had preexisting liver cirrhosis (n = 11) or chronic hepatitis caused by hepatitis B virus (n = 24) or hepatitis C virus (n = 1). Of these 47 hemangiomas, 21 had positive results at scintigraphy performed with 99mTc-labeled red blood cells, and 13 had consistent findings on dynamic MR images (n = 8), angiograms (n = 3), or both (n = 2). The remaining 13 hemangiomas were diagnosed on the basis of typical two-phase CT findings and no interval change in size at follow-up imaging (range of follow-up, 30–36 months; mean follow-up, 32 months).

In our study, the prevalence of AP shunts associated with small hemangiomas and HCCs (19%–26%) was similar to that of previous studies (3,11,12). In contrast, most HCCs (18%–26%) are accompanied by an AP shunt.
All 384 patients with HCC had preexisting liver cirrhosis (n = 165) or chronic hepatitis caused by hepatitis B virus (n = 120), hepatitis C virus (n = 40), or chronic alcoholism (n = 40) or with a cryptogenic origin (n = 19). TACE was performed before CT examination in 211 patients with 353 HCCs. At two-phase helical CT, a lesion was considered to be an HCC if it showed contrast enhancement during the HAP and contrast agent washout (ie, it was isosattenuating or hypoattenuating relative to liver parenchyma) during the PVP (n = 582). The remaining 16 HCCs showed contrast enhancement at two-phase helical CT during the HAP and were slightly hyperattenuating relative to liver parenchyma during the PVP, and all of them showed nodular lipiodized oil uptake at follow-up CT. If patients had undergone two or more CT examinations during the study period, only the scans obtained at the first examination were used.

CT Examinations

CT scanning was performed by using a helical CT scanner (HiSpeed Advantage; GE Medical Systems, Milwaukee, Wis) in 44 patients with 67 hemangiomas and 175 patients with 268 HCCs and a multi-detector row CT scanner (LightSpeed QX/i; GE Medical Systems) in 63 patients with 102 hemangiomas and 209 patients with 330 HCCs. CT scans were obtained during the HAP (by using a bolus tracking technique or 36-second delay) and the PVP (by using a 72-second delay) after intravenous injection of 150 mL of iopromide (Ultravist 370; Schering, Berlin, Germany) with a power injector (LF CT 9000; Liebel-Flarsheim, Cincinnati, Ohio) at a rate of 3 mL/sec through an 18-gauge angiographic catheter inserted into an antecubital vein. During the HAP and PVP, the helical CT images were obtained with 7–8-mm collimation, a pitch of 1.4, and 7–8-mm reconstruction intervals, while the multi-detector row CT images were obtained with 5-mm section thickness, a pitch of 3:1 (high-quality mode), and 5-mm reconstruction intervals. The images were obtained in a craniocaudal direction through the entire liver from the top of the diaphragm to the lower pole of the kidney during a single breath hold.

Image Analysis

Three radiologists (T.K.K., J.K.L., A.Y.K., with 13, 7, and 12 years of experience, respectively) retrospectively evaluated all CT images by means of consensus. They reviewed the images in chronological order by examination date. They were experienced abdominal radiologists and were aware of the purpose of this study but were blinded to the diagnosis of the lesion, any patient information, and results of any correlative imaging studies. For each lesion, they evaluated the size, the presence or absence of an associated AP shunt, and the rapidity of lesion enhancement.

AP shunts were diagnosed when HAP CT scans showed wedge-shaped or irregularly shaped homogeneous enhancement in the liver parenchyma adjacent to the tumor, when PVP CT scans showed isosattenuation or slight hyperattenuation relative to adjacent normal liver, and when there was no other demonstrable cause for these attenuation differences such as portal vein obstruction resulting in transient hepatic attenuation differences (THADs) (15,16). The size of each hemangima and HCC was measured as the greatest diameter on the PVP images.

The rapidity of lesion enhancement was characterized according to findings on HAP images; enhancement was considered rapid when the extent of intratumoral enhancement was more than 50% of the lesion and slow when the extent of intratumoral enhancement was equal to or less than 50%. All images were reviewed by using a local picture archiving and communication system, or PACS, monitor (IF210SA; WIDE, Cheongwon, Korea) and digital imaging and communications in medicine, or DICOM, image viewing software (PetaVision version 2.0; Asan Medical Center, Seoul, Korea).

Statistical Analysis

We statistically evaluated the difference between the mean size of the hemangiomas and that of the HCCs by using the Student t test. We evaluated the difference between the prevalence of AP shunts associated with hemangiomas and that associated with HCCs—after making adjustments for variations due to age and sex—by using a generalized estimating equation, or GEE, method to consider the correlation within subjects. Because there was often more than one lesion per patient, we also evaluated the issues of dependency and clustering by using a GEE, as implemented in the Genmod procedure in SAS for Windows version 8.01 (SAS Institute, Cary, NC), and a generalized linear mixed model, or GLMM, as implemented in the NImixed procedure in the SAS software. Statistical analysis of the relationship between the prevalence of AP shunts and the rapidity of intratumoral enhancement in hemangiomas and HCCs was performed by using the chi-square test or the Fisher exact test. We statistically evaluated the relationship between the presence of an AP shunt and the performance of TACE before CT examination by using the chi-square test. A P value of less than .05 was considered to indicate a statistically significant difference. All statistical analyses were performed by using SAS for Windows version 8.01 or SPSS for Windows version 9.0 (SPSS, Chicago, Ill).

RESULTS

The mean size of the 169 hemangiomas was 1.6 cm (range, 0.5–3.0 cm), and that of the 598 HCCs was 1.5 cm (range, 0.5–3.0 cm). There was no significant difference between the mean size of the hemangiomas and that of the HCCs (P = .155).

An AP shunt was found in 36 (21.3%) of the 169 hemangiomas (Fig 1) and in 25 (4.2%) of the 598 HCCs (Fig 2) at two-phase helical CT. Hemangiomas had a significantly higher prevalence of AP shunt than did HCCs (P < .001) when patient age and sex were considered. Hemangiomas had a significantly higher prevalence of AP shunt than did HCCs (P < .001) when dependency and clustering were considered. There was no significant difference between the size of hemangiomas with AP shunts (mean, 1.7 cm ± 0.7; range, 0.6–2.9 cm) and that of HCCs with AP shunts (mean, 1.9 cm ± 0.6; range, 0.8–3.0 cm) (P = .326).

Enhancement was rapid in 64 (37.9%) hemangiomas and in 573 (95.8%) HCCs. There was rapid enhancement in 24 (67%) of the 36 hemangiomas with AP shunts (Fig 1). In contrast, there was rapid enhancement in 40 (30.1%) of the 133 hemangiomas without an AP shunt. AP shunts were more frequently found in hemangiomas with rapid enhancement than in those with slow enhancement: Twenty-four (38%) of the 64 hemangiomas with rapid enhancement had AP shunts, whereas only 12 (11.4%) of the 105 hemangiomas with slow enhancement had AP shunts (P < .001). There was rapid enhancement in 24 (96%) of the 25 HCCs with AP shunts. In contrast, there was rapid enhancement in 549 (95.8%) of the 573 HCCs without an AP shunt. There was no significant difference between the prevalence of AP shunts in the 573 HCCs with rapid enhancement and that of AP shunts in the hemangiomas.
enhancement (24 lesions, 4.2%) and that in the 25 HCCs with slow enhancement (one lesion, 4.0%) ($P = .963$).

In 12 (3.4%) of 353 HCCs treated with TACE before CT examination, an AP shunt was detected. There was no significant difference between the prevalence of AP shunt in HCCs previously treated with TACE and that in HCCs not previously treated with TACE (13 [5.3%] of 245 lesions) ($P = .300$). The cellular differentiation of 30 HCCs proven at histologic diagnosis was Edmonson-Steiner (17) grade I in four HCCs, grade II in nine HCCs, grade III in seven HCCs, and grade IV in 10 HCCs. Two of 30 HCCs proven at histologic diagnosis had an AP shunt; their histologic grades were Edmonson-Steiner grades II and III.

**DISCUSSION**

One of the most common and important problems for radiologists is differentiating hepatic hemangiomas from malignant hepatic tumors with cross-sectional imaging examinations. The typical CT findings of hemangioma and HCC are well known, and the differential diagnosis of these two lesions is usually not difficult to determine. However, when the hemangioma is small, the CT findings are often atypical (4,14,18,19), and differentiating hemangioma from HCC can then be difficult, especially in a cirrhotic liver. The atypical CT appearances of small hemangiomas are that of a small hypotenuating lesion with slow enhancement, a lesion with early homogeneous enhancement in the arterial phase, and a lesion with an AP shunt (4,14,18,19).

The AP shunt is an organic or functional communication between a hepatic arterial branch and the portal venous system that results in a redistribution of arterial flow into a focal region of portal venous flow. A tumor-related AP shunt
can occur through several different routes (3,10,20–23): (a) a transvasal route (through a tumor thrombus with the thread-and-streaks sign); (b) a transtumoral route (through a draining vein from a hypervascular tumor such as a hemangioma or an HCC); (c) a transplexal route (between microscopic hepatic arterioles and portal venules peripheral to a site of portal venous obstruction caused by tumor emboli); or (d) an arterioporal fistula (through a macroscopic fistula that is usually of iatrogenic origin, such as a fistula caused by percutaneous biopsy).

HCC is the most common primary hepatic tumor associated with AP shunts, which can be caused by a variety of the previously described mechanisms. Okuda et al (24) noted that AP shunts occurred in 63% of cases of HCC. Oliver and Baron (7) reported that the presence of an AP shunt in a hepatic lesion makes the diagnosis of HCC highly likely and the diagnosis of other lesions considerably less likely. However, other and more recent reports (3,11,12) indicate that hemangiomas with AP shunts are not uncommon. Kim et al (11) found that the identification of an associated AP shunt on a HAP CT scan does not necessarily imply that the underlying tumor is malignant. To our knowledge, comparison of the prevalence of AP shunt associated with small hemangiomas and that associated with HCCs 3 cm in diameter or smaller at two-

Figure 2. Transverse CT scans in 28-year-old man who had undergone left lateral segmentectomy for HCC 18 months previously and was found to have a recurrent HCC accompanied by AP shunt at follow-up CT. (a, b) Consecutive HAP CT scans show small hyperattenuating tumor (solid arrows) in anterior segment of right lobe and peripheral wedge-shaped homogeneously hyperattenuating area (a THAD) (open arrows) adjacent to the tumor. (c, d) Consecutive PVP CT scans show heterogeneously hypoattenuating tumor (white arrows) and the peripheral wedge-shaped slightly hyperattenuating area (black arrows) adjacent to the tumor.
phase helical CT has not previously been performed except in one study (13), the results of which revealed that differential diagnosis between early and homogeneously enhancing HCC and hemangioma at two-phase CT was possible.

In our study, small (≤3 cm) hemangiomas had a significantly higher prevalence of AP shunt than did HCCs 3 cm in diameter or smaller (P < .001). Several authors (3,11,12) have reported that AP shunts are frequently (19%-26%) seen in hemangiomas. Kim et al (11) showed that AP shunts were more frequently found in hemangiomas with rapid enhancement. Yu et al (25) recently reported that on dynamic MR images, the incidence of transient peritumoral parenchymal enhancement in smaller (<2 cm) hemangiomas is significantly higher than it is in HCCs of the same size (11.3% vs 3.5%). Although their study involved use of a different radiologic examination from the one used in our study—that is, dynamic MR imaging versus two-phase helical CT—their results were similar to ours. Hanafusa et al (13) noted that at two-phase CT, early and homogeneously enhancing hemangiomas (size range, 5–29 mm) frequently (32%) had AP shunts, whereas early and homogeneously enhancing HCCs (size range, 8–40 mm) had no AP shunts. Although their study included only early and homogeneously enhancing hemangiomas and HCCs, their results were similar to ours.

Ueda et al (26), with confirmation from results at both single-level dynamic CT during hepatic arteriography and histologic analysis, reported that the main drainage vessels of encapsulated HCCs are the portal venules. Okuda et al (24) showed that the transit of blood from the tumor to the portal venules occurs around a tumor and that such microscopic AP shunts are almost always present in typical HCCs. Therefore, AP shunts associated with HCCs without portal vein invasion may depend on blood outflow from the HCCs, which may in turn depend on the arterial inflow per tumor volume as well as on the histologic structure of the HCC.

Regarding the mechanism of the AP shunt associated with hemangiomas, Jeong et al (12) reported that the hyperdynamic status of the hemangioma, consisting of large arterial inflow, rapid tumoral enhancement, and consequent larger and rapid outflow, correlated well with temporal peritumoral enhancement on dynamic MR images. Kim et al (11) assumed that high flow in the smaller intravascular spaces of the hemangioma is more likely to produce shunting in the potential communication between the hepatic artery and the portal vein. Therefore, the AP shunts associated with hemangiomas may also depend on blood outflow from the hemangioma, which may also depend on the arterial inflow per tumor volume and the histologic structure of the hemangioma.

The contrast enhancement of hemangiomas during the HAP represents the diluted contrast medium accumulated in the numerous tiny vascular spaces within the lesions (13). On the other hand, the contrast enhancement of HCCs during the HAP is produced by an increase in tumor vessels and diffusion of contrast medium into the extracellular interstitial spaces within the tumors (27). Therefore, it may be reasonable to assume that the outflow from a hemangioma is more rapid and larger than that from an HCC with similar small volume, and, therefore, that the incidence of the AP shunt associated with hemangiomas is higher than that of the AP shunt associated with HCCs. Improvements in CT technology (ie, faster scanners, thinner image thicknesses, and better delivery of contrast material) may contribute to the increased detection of AP shunts associated with benign and malignant liver lesions.

In our study, AP shunts were more frequently found in hemangiomas with rapid enhancement (38%) than in those with slow enhancement (11.4%) (P < .001). This result correlates well with the results of many other studies (3,11,12,25). Yamashita et al (28), after correlating pathologic findings with CT findings, found that hemangiomas with slow fill-in have relatively large vascular spaces, while those with rapid enhancement have small vascular spaces and a large interstitium. As mentioned above, it is reasonable to assume that a transmural AP shunt in a hemangioma is produced by rapid and larger inflow and outflow in the smaller intratumoral vascular spaces.

In our study, there was no statistically significant difference between the prevalence of AP shunts in HCCs with rapid enhancement (4.2%) and the prevalence of AP shunts in HCCs with slow enhancement (4.0%) (P = .963). Yu et al (25) reported that there is a low probability of displaying peritumoral enhancement in small HCCs with relatively well-differentiated or moderately differentiated histologic features because well-differentiated HCCs tend to be relatively hypovascular compared with poorly differentiated HCCs. In our study, two of 30 HCCs proved with histologic diagnosis had an AP shunt, and their histologic grades were Edmondson-Steiner grades II and III (17). None of 10 Edmondson-Steiner grade IV HCCs had an AP shunt. Therefore, we do not believe that the histologic differentiation of HCCs is one of the major factors affecting the presence of AP shunts in these tumors.

There were several limitations to our study. First, pathologic diagnosis was available for none (0%) of the hemangiomas and for only some (ie, 30 [5%] of 598) of the HCCs, although there was convincing evidence of the diagnoses of the hemangiomas and HCCs on the basis of follow-up imaging and clinical findings. Hemangiomas very infrequently show changes in size over a long period of time, and malignant lesions may show no enlargement for more than 6 months (29). However, a number of previous groups (4,11–14,25) have used lack of enlargement of the lesion as one of the criteria for the diagnosis of hemangioma. This was one of the limitations of this study and is a limitation of any study of hepatic hemangioma. In the present study, the diagnosis of 140 HCCs in 83 patients was established on the basis of consistent findings at CT and an elevated α-fetoprotein level. Among these 83 patients, 43 had more than one HCC. If there are multiple liver lesions, there is a possibility that one lesion is an HCC and the other lesion is a hemangioma, although this is very unusual. Second, AP shunts associated with hemangiomas and with HCCs were not confirmed with conventional angiography, and the radiologic diagnosis of AP shunts traditionally has been based on conventional angiographic findings. However, in our study, AP shunts were confirmed with conventional angiography in 11 of 25 HCCs presumed to have AP shunts, as well as in two of five hemangiomas presumed to have AP shunts for which conventional angiograms were available. Therefore, some of the AP shunts might have been THADs caused by portal vein obstruction. But there was no evidence of thrombosis or obstruction of small branches of the portal vein adjacent to the lesion at imaging in any of our patients.

Third, three reviewers evaluated the two-phase helical CT scans in consensus rather than individually. Independent reading by three reviewers could have produced more valuable results. However, it was practically difficult to analyze such a large number of lesions with inde-
The authors thank but not a specific CT. Therefore, a small hyperattenuating (21.3%) than in HCCs 3 cm in diameter frequently seen in small hemangiomas enhancement and AP shunting, further relationships between the rapidity of enhancement and the prevalence of AP shunt in HCC. A report (25) supports the idea that well-differentiated HCCs tend to be relatively hypovascular compared with poorly differentiated HCCs. However, the results of our study support the reverse hypothesis. To disclose the relationship between the rapidity of enhancement and AP shunting, further study would be needed.

In conclusion, AP shunts were more frequently seen in small hemangiomas (21.3%) than in HCCs 3 cm in diameter or smaller (4.2%) at two-phase helical CT. Therefore, a small hyperattenuating lesion associated with an AP shunt at two-phase helical CT may be a suggestive but not a specific finding of hemangioma. Small hemangiomas with AP shunts tend to show rapid enhancement.

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