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Assessment of triple-phase CT findings for the differentiation of fat-deficient hepatic angiomyolipoma from hepatocellular carcinoma in non-cirrhotic liver

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ABSTRACT

Background: To evaluate the triple-phase CT findings for the differentiation of fat-deficient angiomyolipoma from hepatocellular carcinoma in non-cirrhotic liver.
Methods: We retrospectively reviewed contrast-enhanced triple-phase CT images of 10 patients with fat-deficient hepatic angiomyolipoma and 28 patients with 29 hepatocellular carcinomas in non-cirrhotic liver proved on histologic examination. The CT findings for the two types of tumors were compared using Fisher's exact test.
Results: Early draining vein depicted on arterial or portal phases was seen in eight (80%) angiomyolipomas and two hepatocellular carcinomas (7%) ($p < 0.001$), in which the early draining vein was connected with tumoral vessels. The tumoral vessels in the angiomyolipoma were more prominent and ectatic, were distributed both centrally and peripherally, and were seen in smaller tumors than in the hepatocellular carcinoma. Tumor capsule enhancement was absent in all angiomyolipomas as compared with two (7%) hepatocellular carcinomas with no tumor capsule ($p < 0.001$). The other CT findings were not significantly different for the two different types of tumors.
Conclusions: The presence of early draining vein connecting with prominent tumoral vessels and absent tumor capsule were useful CT findings for the differentiation of fat-deficient angiomyolipoma from hepatocellular carcinoma in non-cirrhotic liver.

1. Introduction

Angiomyolipoma (AML) is a benign mesenchymal neoplasm that is characterized by a heterogenous mixture of smooth muscle cells, thick-walled blood vessels, and mature adipose tissue, with occasional foci of extramedullary hematopoiesis [1–3].

Several reports have described that the characteristic CT findings of hepatic AML [4–9] were marked inhomogenous early and prolonged enhancement, absence of tumor capsule, prominent central vessels and especially the presence of fatty component [4–9]. However, hepatic AML has usually been misdiagnosed as hepatocellular carcinoma (HCC) with a frequency of more than 50% due to a significant overlap of the imaging features [4,10–12]. In most studies emphasis has focused on the differentiation of hepatic AML and fat-containing HCC that usually arise from the cirrhotic liver [4,6]. However, unlike renal AML, 50% of hepatic AMLs lack a considerable fat content and usually occur as a solitary tumor in the non-cirrhotic liver [4,13].

To the best of our knowledge, there has been no report comparing triple-phase CT findings of fat-deficient hepatic AML and HCC originating from the non-cirrhotic liver. Therefore, we have attempted to assess the CT findings that can clarify the differentiation of fat-deficient hepatic AML from HCC in non-cirrhotic liver, using contrast-enhanced triple-phase dynamic CT.

2. Materials and methods

2.1. Patient selection

The institutional review board waived the requirement for approval of this retrospective study. Patient informed consent was not required. By use of a computerized search of the radiological and pathological information systems of our hospitals for the 9-year period from January 2000 to October 2008, we retrospectively identified 17 patients with a diagnosis of hepatic AML. Among these patients, 7 were excluded from the study for two reasons: a preoperative contrast-enhanced triple-phase CT examination had not been performed ($n = 3$), or discrete fatty component within the mass had been found ($n = 4$). The remaining 10 patients (4 men, 6 women; mean age, 54.8 years; range, 38–76 years), who had both a pathological diagnosis of hepatic AML and had undergone

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a contrast-enhanced triple-phase CT examination were enrolled in the study. The tumors ranged from 1.2 to 12.7 cm in diameter (mean diameter, 4.1 cm). The diagnosis of AML was made at pathological examination after sonography-guided percutaneous biopsy ($n = 3$), or partial hepatectomy ($n = 7$). The underlying liver had non-specific or mild fatty change in 9 patients and only 1 patient had chronic hepatitis related with positive hepatitis B surface antigen. Two of 10 patients had concurrent renal AML and tuberous sclerosis. The patients had normal serum α-fetoprotein level.

For a comparison, 37 consecutive patients who had a pathological diagnosis of HCC after surgical resection between January 2005 and October 2008 were enrolled in the study. All of these patients were found to have no evidence of cirrhosis. Among them, 9 patients were excluded from the study, as seven had not undertaken preoperative contrast-enhanced triple-phase CT examination and two had hypovascular tumors as depicted on arterial and portal phases. Considering the hypervascularity of hepatic AML, poorly enhancing HCCs were considered insufficient as a control group. Ultimately, 28 patients (20 men, 8 women; mean age, 62.8 years; age range, 39–82 years) who had 29 HCCs and had underwent contrast-enhanced triple-phase CT examinations were enrolled in the study as a control group. Although the sampling period between fat-deficient AMLs and HCCs in non-cirrhotic liver was different, the number of HCCs in non-cirrhotic liver was considered to be enough for a comparison with fat-deficient AML without significant bias affecting the results. The tumors ranged from 1.5 to 17.3 cm in diameter (mean, 6.8 cm). All patients underwent partial hepatectomy. None of the patients had hepatitis B or C viral infection or chronic hepatitis. In 15 patients (54%), the serum α-fetoprotein level was abnormally increased.

2.2. CT imaging

In all patients, triple-phase dynamic CT examination was performed using a single detector (HiSpeed Advantage; GE Medical Systems, Milwaukee, Wis) ($n = 4$) or MDCT scanners (LightSpeed QX/I, LightSpeed Ultra8, LightSpeed 16; GE Medical Systems) ($n = 34$). The scanning parameters were 120 kVp, 175–184 mA s, 5-mm section collimation and 5-mm/s table speed for the single detector CT scanner; 5-mm slice thickness, table speed of 15.0–18.75 mm/s (pitch of 0.75–0.938) for the multidetector CT scanner; and a single breath hold helical acquisition of 25–30 s for the single detector and 8–10 s for the multidetector scanners (depending on liver size). The images were obtained in the craniocaudal direction and were reconstructed every 5 mm to provide contiguous sections.

All patients underwent a contrast-enhanced triple-phase helical CT examination that included arterial, portal and equilibrium phases. Contrast material was injected at a rate of 3–4 mL/s with an automatic power injector. According to our standard protocol for dynamic CT, the arterial phase was obtained 30 s after the injection of 120 mL of a nonionic iodinated contrast material (iopamidol, Iopamiro 300; Bracco, Milan, Italy) in a single detector at a rate of 3–4 mL/s. By the use of a bolus-triggered technique in the multidetector scanner, the arterial phase began 20–35 s after the injection of 120 mL of the nonionic iodinated contrast material at a rate of 3–4 mL/s. The portal and equilibrium phases began 70 and 180 s after initiation of the contrast injection, respectively.

2.3. Image analysis

The CT scans acquired were reviewed retrospectively in consensus by two abdominal radiologists with a 12-year and 19-year experience. Although the reviewers knew that all of the patients had a confirmed liver tumor, they were unaware of the histopathological diagnoses and clinical findings. All image data were directly interfaced with the Picture Archiving and Communication System (PACS) (Pathspeed, GE Medical Systems Integrated Imaging Solutions, MT. Prospect, IL USA), which displayed all image data on monitors (four monitors, 1536×2048 image matrices, 8-bit viewable gray scale, and 60-ft-Lambert luminescence), with an adjustment of the optimal window setting for each case. The following findings were evaluated: tumor size and location, tumor margin, the pattern of contrast enhancement, the presence of an early draining vein on arterial or portal phase, the presence of tumoral vessels with punctural or curved appearance connecting with the early draining vein, the area of prolonged and delayed enhancement, the washout area, and tumor capsule enhancement. In addition, upstream bile duct dilatation to the tumor, portal or hepatic vein thrombosis or invasion, necrosis (which was defined as non-enhanced area during all three phases) and liver surface retraction in the tumor attached to the liver capsule were evaluated.

A well-defined tumor margin was defined as a clear demarcation of the entire tumor on the CT images obtained on the portal and equilibrium phases. The pattern of contrast enhancement of the tumor was evaluated on arterial, portal and equilibrium phases. On arterial phase, contrast enhancement was defined as homogeneous, heterogeneous (mixed irregular areas of tumor enhancement) or peripheral rim-like (contrast enhancement at the periphery of the tumor). On arterial or portal phase, early draining vein was considered positive finding when conspicuous dilated or non-dilated vessel originating from tumor with draining to the portal vein, hepatic vein or inferior vena cava was seen. The area of prolonged and delayed tumor enhancement was defined when the solid part of the tumor except for the tumor capsule and septa showed higher attenuation than the surrounding hepatic parenchyma on equilibrium phase, irrespective of the level of contrast enhancement on arterial or portal phase [14]. The wash out area was defined as the area of tumor enhancement on arterial phase, followed by hypoattenuation relative to the surrounding hepatic parenchyma on portal or equilibrium phase.

Table 1
CT characteristics of fat-deficient hepatic angiomyolipoma (AML) and hepatocellular carcinoma (HCC) in non-cirrhotic liver.

Finding	AML ($n = 10$)	HCC ($n = 29$)	p
Mean tumor size ± S.D. (cm)	4.1 ± 3.3	6.8 ± 4.0	NS[a]
Location			NS
Right	6 (60)	20 (69)	
Left	4 (40)	9 (31)	
Margin			NS
Well-defined	8 (80)	27 (93)	
Ill-defined	2 (20)	2 (7)	
Tumor enhancement on arterial phase			
Homogeneous	6 (60)	5 (17)	NS
Heterogeneous	4 (40)	21 (72)	NS
Peripheral rim-like	0	3 (10)	NS
Early draining vein on arterial or portal phase	8 (80)	2 (7)	<0.001
Presence of tortuous tumoral vessels connecting with early draining vein	8 (80)	2 (7)	<0.001
Presence of prolonged and delayed enhancement on equilibrium phase	1 (10)	3 (10)	NS
Presence of washout area on portal or equilibrium phase	9 (90)	26 (90)	NS
Tumor capsule enhancement	0	27 (93)	<0.001
Upstream bile duct dilatation	0	1 (3)	NS
Portal or hepatic vein involvement	0	2 (7)	NS
Necrosis	0	8 (28)	NS
Liver surface retraction in tumor attached to the liver capsule[b]	0/5 (0)	6/26 (23)	NS

Note: Numbers in parentheses are percentages.

[a] Not significant.

[b] The number of tumors attached to the liver capsule in the AMLs and HCCs are 5 and 26, respectively.