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Clear cell renal cell carcinoma: Contrast-enhanced ultrasound features relation to tumor size

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ABSTRACT

Objectives: To analyze the contrast-enhanced ultrasound (CEUS) features of clear cell renal cell carcinoma (CCRCC) in relation to tumor size.
Materials and methods: The CEUS appearance of 92 CCRCCs confirmed pathologically were retrospectively analyzed. Tumor size was stratified into six groups with a 1 cm interval. For each lesion, the degree of enhancement, the homogeneity of enhancement and the presence of pseudocapsule sign were evaluated and compared with the pathologic findings.
Results: The tumors of groups I–VI were counted for 13, 26, 21, 11, 10 and 11, respectively. All the CCRCCs mainly showed a marked enhancement, and there was no statistically significance between the degree of enhancement and tumor size ($P > 0.05$). However, both homogeneity of enhancement and frequency of pseudocapsule correlated well with the tumor size ($P < 0.01$). Homogeneous enhancement was shown in 85%, 65%, 19%, 9%, 0% and 0% of the tumors in the six groups, respectively. In tumors $\leq$3 cm the frequency (72%) of homogeneity was significantly higher than in tumors >3 cm (9%; $P < 0.01$). The detection rate of pseudocapsule sign in the six group was 23%, 62%, 71%, 64%, 50% and 0%, respectively. The frequency of pseudocapsule sign was significantly higher in tumors 2.1–5 cm than <2 cm and >5 cm (66%, 23%, 24%, respectively; $P < 0.01$). On the pathologic examinations, the mean MVD was significantly higher in marked enhancement tumors than slight enhancement tumors (46.0 ± 15.9, 27.5 ± 8.3, respectively; $P < 0.01$). Any tumors with a heterogeneous enhancement pattern were accompanied by intratumoral necrosis or cysts on histologic specimen. A pseudocapsule was seen at pathology in all the 46 cases with perilesional enhancement and 4 of 46 tumors without perilesional enhancement at CEUS.
Conclusion: CEUS features of CCRCCs vary with the size of the tumor, especially in the homogeneity of enhancement and the presence of pseudocapsule sign. CEUS is effective in demonstrating the sonographic visualization of tumoral characteristics.

1. Introduction

Renal cell carcinoma is the most common primary malignancy of the kidney. This tumor accounts for 2% of all cancer diagnoses in humans [1]. Among the RCC histologic subtypes, the vast majority are classified as clear cell renal cell carcinoma (CCRCC) [2].

Although renal tumors are usually discovered during an ultrasonographic abdominal examination, one should not rely on US when differentiating between surgical and nonsurgical renal masses, and further examination with contrast-enhanced CT or MRI will be performed to confirm the diagnosis. This lack of diagnostic accuracy is mainly due to the absence of contrast material, considering that the vascular perfusion pattern of the lesion represents a crucial factor to characterize the mass.

Today, harmonic ultrasonography performed with second-generation contrast agents can also be used to examine the perfusion patterns of lesions and it has revealed promising perspectives in the diagnosis of renal tumors [3–8]. For example, Tranquart et al. [3] stated that real-time CEUS could improve detection and characterization of renal masses by marked improvement in tumor delineation or internal microvasculature. Wink et al. [4] concluded that the CEUS was a sensitive technique to determine perfusion patterns of renal masses and its characteristics corresponded to the

Abbreviations: CEUS, contrast-enhanced ultrasound; CCRCC, clear cell renal cell carcinoma.

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clinical diagnosis and histologic findings. Thorelius [5] stated that harmonic imaging CEUS was able to exclude the presence of blood supply, thus making distinction between benign cysts and possible malignant lesions. In addition, both Quaia et al. [6] and Siracusano et al. [7] stated that subjective as well as objective analysis of CEUS using harmonic imaging enables differentiation between solid RCC and typical angiomyolipoma. Each of these reports demonstrates the potential of CEUS; however, the relationship between CEUS features and tumor size has not yet been systematically described. Thus, the purpose of this study was to analyze the CEUS features of CCRCCs in relation to tumor size and correlate imaging features with pathologic findings.

2. Materials and methods

2.1. Patients

From January 2005 to September 2007, 89 patients with 92 renal masses were confirmed pathologically to be CCRCCs, and these patients were evaluated retrospectively for this study. Therefore, in our series, there were 73 men and 16 women aged 26–85 years (mean age, 56 years). Of these patients, 86 had a unilateral tumor and 3 had bilateral tumors. The maximum diameter of the tumors ranged from 1.1–10.3 cm (mean diameter, 3.9 cm). The study was approved by our local Ethics Committee, and written informed consent was obtained from all patients.

2.2. Contrast agent

All patients received injections of a sulfur hexafluoride ultrasound contrast agent (SonoVue; Bracco, Milan, Italy). The agent (25 mg) was shaken for about 20 s with 5 mL of 0.9% saline solution, and 1.2 mL of this suspension was injected as a bolus manually through an antecubital vein. Then 5 mL of a 0.9% saline flush was injected quickly.

2.3. Ultrasonographic examination

An Acuson Sequoia 512 ultrasonography system (Siemens Medical Solutions,Mountain View,CA) with a 4C1-S curvilinear array transducer was used for ultrasound examination, which was matched with contrast pulse sequencing (CPS) contrast-enhanced ultrasound imaging software. The renal tumors were scanned first by gray-scale ultrasongraphy and color Doppler ultrasonograhy to obtain the tumor size and the best imaging plane from which both the tumors and the normal adjacent renal parenchyma could be observed. Before injection of SonoVue, we optimized the contrast condition with the “iscan” key on the machine. Then the renal mass perfusion was evaluated in real time until 3–4 min after the beginning of the injection, with a low mechanical index of 0.11–0.18 and a transducer frequency of 1.5 MHz. A digital video clip of the entire examination was stored on the hardware of the ultrasonography machine in the DICOM format.

2.4. Image analysis

Tumor size as determined from ultrsonography was stratified into six subgroups with a 1-cm interval, i.e. group I included tumors 1–2 cm in diameter, group II included tumors 2.1–3 cm, group III included tumors 3.1–4 cm, group IV included tumors 4.1–5 cm, group V included tumors 5.1–6 cm and group VI included tumors >6 cm.

After CEUS, the dynamic images were reviewed for the degree of enhancement, the homogeneity of enhancement and the presence of pseudocapsule sign. The degree of enhancement was classified as marked enhancement and slight enhancement. If the tumor echogenicity is higher than or equal to that of the adjacent renal parenchyma after injection of contrast agent, it was defined as marked enhancement. If it was lower than that of the renal parenchyma, it was defined as slight enhancement. If various degree of enhancement were mixed in a lesion, the most predominant findings were used to classify the lesion. Homogeneous enhancement was identified as the appearance of a lesion occupied by a full enhancement after the injection of SonoVue (Fig. 1). On the contrary, the heterogeneous enhancement pattern was defined as the appearance of a lesion with areas without any enhancement, regardless of various enhancement echo level [4] (Fig. 2). On contrast-enhanced imaging, a rim of perilesional enhancement was considered to represent the presence of a pseudocapsule [8]

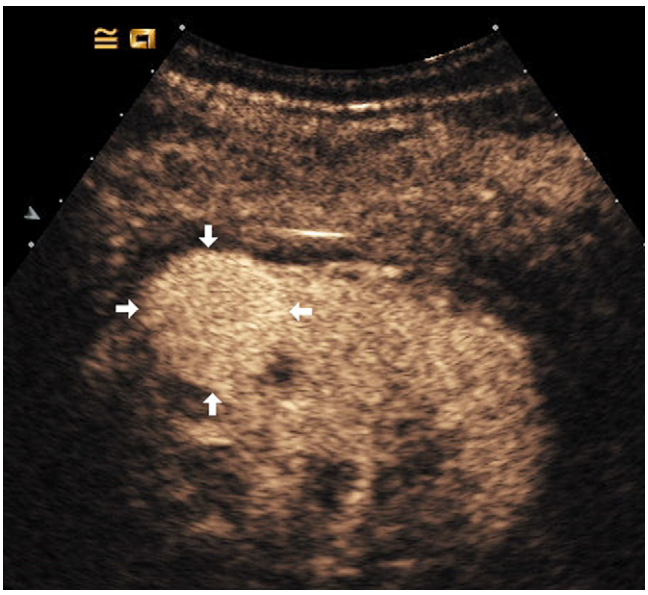

Fig. 1. Homogeneous enhancement The appearance of the renal tumor is occupied by a full enhancement after SonoVue injection (arrowhead).

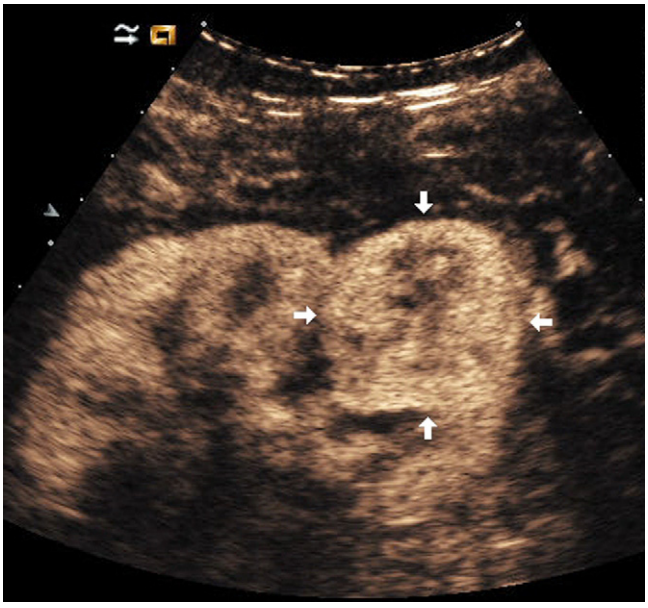

Fig. 2. Heterogeneous enhancement There are anechoic defects in the enhancing renal tumor after the injection of SonoVue (arrowhead).