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● *Original Contribution*

COMPARATIVE DIAGNOSTIC PERFORMANCE OF CONTRAST-ENHANCED ULTRASOUND VERSUS BASELINE ULTRASOUND FOR RENAL PELVIS LESIONS

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Abstract—The aim of this study was to assess the relative efficacy of contrast-enhanced ultrasound (CEUS) and baseline ultrasound (B-US) in diagnosing renal pelvic lesions. B-US findings on 58 suspected renal pelvis lesions were examined. The B-US and CEUS results were classified into five grades. Receiver operating characteristic curve analysis was used to compare the diagnostic efficacy of the two imaging modalities. CEUS characteristics of renal pelvis malignancies at different tumor stages and pathologic grades were examined. In the final diagnosis, 29 patients had malignant lesions (27 transitional cell carcinomas, 1 squamous cell carcinoma and 1 renal cell carcinoma) and 29 had benign lesions. On B-US, echogenicity and renal pelvis separation pattern in patients with malignant renal lesions overlapped those of patients with benign lesions. CEUS significantly increased the diagnostic grade of malignant lesions and decreased the grade of benign lesions ($p = 0.000$). The area under the receiver operating characteristic curve of CEUS was larger than that of B-US ($p = 0.030$). Enhancement shape and intensity in the wash-in phase markedly differed in lesions of higher tumor stage and higher pathologic grade, compared with lesions of lower stage and grade. In this study, compared with B-US, CEUS had significantly higher diagnostic efficacy in patients with renal pelvis lesions. (E-mail: lianfang_du@126.com) **© 2015 World Federation for Ultrasound in Medicine & Biology.**

Key Words: **Contrast-enhanced ultrasound, Baseline ultrasound, Urothelial carcinoma, Transitional cell, Neoplasm staging.**

INTRODUCTION

Renal pelvis malignancy accounts for approximately 10% of all renal tumors, of which 90%–95% are transitional cell carcinomas and 3%–7% are squamous cell carcinomas (Dasanu et al. 2012). Renal pelvis malignancies are generally associated with poor prognoses; thus, early and accurate diagnosis is a priority in these patients (Akita et al. 2011). The clinical picture is often nonspecific, with intermittent hematuria being a common mode of presentation. Baseline ultrasound (B-US) is usually the investigation of first choice in these patients in China. However, studies have reported a limited role for B-US modalities, including gray-scale ultrasound and color Doppler ultrasound, in identifying and characterizing renal pelvis malignancy (Päivänsalo et al. 1990).

Contrast-enhanced ultrasound (CEUS) is a promising diagnostic modality for identification and characterization of neoplasms (Claudon et al. 2013). The second-generation ultrasound contrast agents (UCAs) are gas-filled lipid microspheres, 2–5 μm in diameter, that circulate in the vascular system in a stable form without diffusing into tissue spaces. Under low-energy ultrasound, UCAs resonate linearly and produce stronger acoustic signals than body tissues, allowing dynamic real-time visualization of tumor microvasculature and enhanced delineation of its characteristics. Given that the second-generation UCAs are not known to cause nephrotoxicity or nephrogenic systemic fibrosis in patients with renal dysfunction, CEUS is now recommended as an alternative investigation in cases in which contrast-enhanced computed tomography (CE-CT) or magnetic resonance imaging (CE-MRI) examination is contraindicated (Cosgrove 2004; Piscaglia et al. 2006; Torzilli 2005).

A previous study found that the diagnostic efficacy of CEUS in patients with liver tumors was vastly improved compared with that of B-US (Friedrich-Rust et al. 2013). For solid and cystic renal parenchymal tumors, CEUS allows a more definitive diagnosis through delineation of the microvasculature (Ignee et al. 2010; Quaia et al. 2003; Xu et al. 2010). In earlier studies, we reported that CEUS was more efficient than B-US in diagnosing small solid renal cell carcinomas (Cai et al. 2014; Fan et al. 2008).

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Xue et al. (2013) and Drudi et al. (2013) earlier described the characteristic enhancement seen in renal pelvis malignancies with CEUS. However, the overall diagnostic efficacy of CEUS in renal pelvis lesions has not been investigated. In this study, we conducted a retrospective evaluation of the comparative efficacy of B-US and CEUS in diagnosing renal pelvis lesions, using the second-generation UCA SonoVue and contrast pulse sequence (CPS) mode.

METHODS

Patients

Between December 2005 and March 2013, 75 patients had undergone CEUS examinations in our department (Department of Medical Ultrasound, Shanghai General Hospital). These patients were found to possibly have renal pelvis lesions after convention ultrasound examinations. Seventeen patients were removed from the final analysis because of incomplete information such as pathologic reports, radiologic examination and follow-up study results. Fifty-eight patients (31 male and 27 female, age range: 26–89 y) were finally enrolled in this study. The CEUS study was conducted after obtaining written consent from each patient. The study was approved by the institutional ethics committee of Shanghai General Hospital. All patients with contraindications to SonoVue, as per the black box warning issued by the U.S. Food and Drug Administration, were excluded from the study.

Baseline US and CEUS

The Sequoia 512 (Siemens, Berlin, Germany) and Acuson S2000 (Siemens) ultrasound machines were used for B-US and CEUS examinations. A convex array transducer (4 C1-S, frequency range: 1–4 MHz) was employed. In B-US examinations, the echogenicity, size and vascular pattern of the lesion and the renal pelvis separation pattern were documented. After the B-US examination, the same operator performed the CEUS examination using CPS (Siemens Acuson, New York, NY, USA) mode and a mechanical index (MI) of 0.21. The dose range for SonoVue (Bracco, Milan, Italy) was 1.2–2.0 mL, and it was administered as a bolus through the antecubital vein. Perfusion of the lesion was evaluated in real time by pressing the time marker. Four to five seconds after SonoVue injection, patients were asked to hold their breath for about 30 s to allow quantitative analysis of the image. The observation period lasted 2–3 min, during which the "live-dual" display modality, which simultaneously displays CEUS and gray-scale images on the screen, was used. For more clear delineation of the microcirculation, we used CPS Capture modality (Siemens Acuson), which allows cine collection of contrast-enhanced imaging and provides detailed images of micro- and macrovasculature, thus enhancing characterization of the lesion. The examination results were stored on a magneto-optical (MO) disk or DVD.

B-US image analysis

Baseline US images were reviewed by two specialist observers (with 10 and 15 y of specialized ultrasonography experience) blinded to CT, MRI and pathology results. Four parameters were analyzed to arrive at a final diagnostic grade. Differences, if any, were resolved by consensus:

1. Lesion echogenicity: Lesion echogenicity was categorized as hyper-echoic, iso-echoic or hypo-echoic, relative to the adjacent renal parenchyma.
2. Lesion margin and size: The lateral and/or posterior margin of the lesion was observed, and the average of two cross-sectional diameter readings and one vertical section diameter reading was used.
3. Lesion vascularity: On the basis of an earlier study and our own experience, vessel pattern was classified into three types—intra-tumoral vessel pattern, vessel displacement by space-occupying lesion and penetrating vessels (Seong et al. 2002).
4. Separation pattern of renal pelvis: This feature was classified into three types: irregular centrifugal type, eccentric type and lentil-like or infundibuliform type. In irregular centrifugal type lesions, the dilation of renal pelvis was moderate to severe, and the pelvis was centered and expansile, with an irregular boundary. In eccentric lesions, the upper or lower major renal calyx was mildly or moderately dilated. In lentil-like or infundibuliform lesions, the pelvis or extra-renal pelvis was dilated mildly, with or without upper ureter dilation.

CEUS image analysis

Another set of two observers (4 and 8 y of specialized CEUS experience), also blinded to the related results, reviewed the CEUS images. Differences if any were resolved by consensus. Three parameters were analyzed:

1. Enhancement shape: Enhancement shape was categorized as cauliflower type (defined as a sessile intraluminal mass involving the renal pelvis) or infiltrating type (defined as tumor occupying the renal pelvis with simultaneous partial enhancement of renal parenchyma, amputation of calyces, diseased parenchyma lacking a pseudo-capsule-like boundary separating it from adjacent normal parenchyma).
2. Enhancement intensity: Enhancement intensity was classified into hyper-, iso- and hypo-enhancement,