Contrast-enhanced ultrasound in the characterization of renal lesions: our initial experience.

Poster No.: C-1838  
Congress: ECR 2014  
Type: Educational Exhibit  
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Keywords: Abdomen, Kidney, Contrast agents, Ultrasound, Ultrasound-Colour Doppler, Contrast agent-intravenous, Cancer  
DOI: 10.1594/ecr2014/C-1838

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Learning objectives

The aim of this educational exhibit is to expose the role of contrast-enhanced ultrasound (CEUS) in the characterization of solid and complex cystic renal lesions.
Background

Within increased use of diagnostic imaging, cystic renal lesions, which are very common among general population, are often detected incidentally. In a similar way, renal tumors are also found incidentally and within this context, lesion size is smaller at detection. The assessment of these lesions requires a comprehensive approach, considering besides imaging patterns, the age, comorbidity and clinical setting for each patient.

Among subtypes of renal cell carcinomas, most frequent cortical tumors are clear cell carcinomas (75%), which has an aggressive behavior and higher risk of metastases. Papillary (10%) has a variable behavior: nonaggressive for type 1 and aggressive for type 2. Other renal tumors have a lower significance due to its low prevalence or less aggressive pattern.

There is no noninvasive method for definitive determination of the nature of cortical neoplasms. However, imaging techniques represent a noninvasive method to characterize those lesions, grading its malignancy risk and suggesting a proper management. Size, gray-scale heterogeneity, vascularity and enhancement patterns differ among malignant and benign lesions.

Ultrasound contrast agents are composed of gas-filled lipid microspheres measuring approximately 3-5 µm, that are injected in intravenous bolus. When exposed to low-energy ultrasound, the microspheres resonate and produce an acoustic signal that allows dynamic real-time visualization of tumor vasculature and enhancement characteristics. These microbubbles agents do not diffuse into the interstitial space, remaining intravascular and allowing visualization of microvasculature. Ultrasound contrast, besides, carry no risk of nephrotoxicity in patients with renal dysfunction.
Findings and procedure details

We have studied 56 renal lesions on 52 patients (40 men and 12 women), detected by different imaging techniques, such as ultrasound (US), Computed Tomography (CT) or Magnetic Resonance Imaging (MRI). All of them were studied by contrast-enhanced ultrasound (SonoVue® bolus, 2.5 ml).

The 56 renal lesions were first classified into 15 solid lesions and 38 complex cystic ones.

- **When a solid lesion is evidenced:**

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Clear cell carcinoma has a variable pattern of enhancement, most frequently hyperattenuating, with a delayed washout compared to normal kidney. Oncocitoma, however, is a benign lesion that has also a similar pattern of enhancement, which difficulties its differentiation from a malignant tumor. Papillary renal cell carcinoma is more common to show a hillyovascular pattern, having a less avid enhancement of the kidney.

Among solid lesions, we obtained histological confirmation in 8 patients, all consistent with renal cell carcinoma.

In 4 cases the CEUS study did not confirmed its solid nature, corresponding to simple cysts (Bosniak I) or false images.

- **The complex renal cysts universe:**

The Bosniak criteria (see next table) were proposed to classify renal cystic lesions according to their CT features. Importance of this assessment was the need to grade the risk of those lesions and determine the therapeutic procedure depending on imaging patterns. In this way, the Bosniak classification is thought to be a proper method to assess treatment management.

<table>
<thead>
<tr>
<th>Category</th>
<th>Findings</th>
<th>Management</th>
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</thead>
<tbody>
<tr>
<td>Category I</td>
<td>Simplefluid-containing (water attenuation) cysts</td>
<td>Benign: No further imaging assessment or surgical procedure</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Action</td>
</tr>
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<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
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</table>
| Category II   | Cysts containing something smooth septa or minimal wall thickening or minimal calcification within it  
                | Also, high-attenuation, sharply marginated, completely intrarenal and nonenhancing cystic lesions #3 cm |
|               |                                                                             | Benign: No further imaging assessment or surgical procedure |
| Category III  | Thickened (>2 mm) thickened irregular septa or wall that clearly enhances | Uncertain: Surgery                          |
| Category IV   | Enhancing nodular soft tissue areas adjacent to or separate from the wall | Malign: Surgery                             |
| Category IIF  | Complex cystic lesions that cannot be classified as category II or that are not complex enough to be characterized as category III (increased number of septa, increased amount of calcifications in the walls or septa, which may be thicker and nodular)  
                | Also, high-attenuation, sharply marginated, completely intrarenal and nonenhancing cystic masses >3 cm | Uncertain: Follow up                        |

These same characteristics may also be used in other techniques such as MRI, US and CEUS.

Ultrasound has a higher resolution when depicting cystic content such as septations, wall characteristics and debris.

Contrast-enhanced ultrasound is appropriate in the Bosniak classification of renal cysts and was found to be superior to CT in detecting additional septa, thickening of the wall or septa, and solid components, indicating in these cases a higher Bosniak classification.
Regarding cystic lesions, our CEUS approach suggested a higher degree of Bosniak in 10 cases, a lower one in 17 and remained unchanged in 9 cases, compared to CT and US without contrast enhancement.
Images for this section:

**Fig. 1:** US and CEUS show a complex cyst containing some thin smooth septa.

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**Fig. 2:** Bosniak II. US and CEUS images show a cortical cyst 15mm containing thick pseudonodular septa that enhances at CEUS.

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**Fig. 3:** US and CEUS images depict a complex cyst containing thick septum showing a solid nodular area that clearly enhances at CEUS. Biopsy was consistent with clear cell carcinoma.

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Fig. 4: US image shows two ill-defined hypoechoic cystic lesions. At CEUS image both lesions show early and marked enhancement. These findings are suggestive of solid renal tumors.

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**Fig. 5:** CECT, US and CEUS images show a complex cystic lesion containing a solid nodular area. Biopsy confirmed a clear cell carcinoma.

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Fig. 6: After injection of ultrasound contrast there is no enhancement of cystic lesions or solid walls. The image shows an irregular area that corresponds to the imprint of the adjacent parenchyma.

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Fig. 7: Papillary renal cell carcinoma. CT images show a solid lesion. CEUS depicts a hippovascular pattern of enhancement.

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Fig. 8: CT and US images show a hyperattenuating and hypoechogenic lesion, respectively. CEUS image depicts the moderate enhancement of the hypoechoic nodular lesion. Biopsy was consistent with papillary renal cell carcinoma type 1.

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Fig. 9: Another example of a papillary renal cell carcinoma, showing a hippovascular pattern, having a less avid enhancement of the kidney.

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**Fig. 10:** CT image shows a complex cyst containing a solid pole. US and CEUS images revealed a thin septum without nodular areas.

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Fig. 11: CT images show a hyperattenuating cortical lesion. US reveals as a cystic lesion. There is no enhancement at CEUS, corresponding to Bosniak I category.

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Fig. 12: Another example of a hyperattenuating cortical lesion at CT images. US and CEUS images reveal as a simple cystic lesion, without any enhancement.

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Conclusion

The use of CEUS in selected patients provides a safe and useful tool in the characterization of renal lesions, approaching an accurate classification and playing an increasingly important role in patient management.

We need to continue developing the experience with this technique to gather sufficient data to compare the findings with other imaging techniques.
References