Sonographic Appearances of Renal Cell Carcinoma: a review of 78 patients

Ching-Yih Yang1,2,4, Chui-Mei Tiu2,4, Yi-Hong Chou2,4, Hsin-Kai Wang2,4, Hong-Jen Chiou2,4, Jia-Hwia Wang2,4, See-Ying Chou2,4, Ming-Huei Sheu7,4, Cheng-Yen Chang2,4, Kuang-Kuo Chen1,4, Chu Yu2,4

Department of Radiology1, Keelung Hospital, Department of Health, Executive Yuan
Department of Radiology2, Department of Surgery3, Taipei Veterans General Hospital
School of Medicine4, National Yang-Ming University

Renal cell carcinoma (RCC) is the most common malignant renal tumor in adults. The kidney can usually be adequately imaged with real-time ultrasound (US) scanners. To summarize the ultrasonographic manifestations of RCC, we reviewed 78 patients with pathologically proved RCC.

Within a period of 5 years, seventy-eight patients were found to have renal masses by ultrasonography (US) study of upper abdomen, and subsequently underwent surgical treatment and/or biopsy. Histopathological study confirmed the diagnosis of RCC in all patients. Thirty-five of them were asymptomatic and were found to have renal tumor incidentally at US examination. The US studies were reviewed to clarify the relationship between echopatterns and sizes of RCC. The echogenicity of the lesions was graded from I through V as compared to the echogenicity of renal medulla, renal cortex, liver/spleen and renal sinus.

Most RCCs were presented as solid masses (n= 33; 42%) or complex masses (n= 42; 54%). Only 3 patients were presented with cystic masses (4%). Grade I echogenicity (not higher than renal medulla) was noted in only 5% of renal tumors; grade II (higher than medulla but not higher than renal cortex) in 35%; grade III (higher than cortex but not higher than liver/spleen) in 50%; and grade IV (not higher than renal sinus) in 10%. Small RCCs (≤ 3cm) tended to be relatively homogeneous in echogenicity and ranged from grade II to III echogenicity. RCCs with a size between 3cm and 5 cm were relatively heterogeneous in echogenicity and had grade II to IV echogenicity. RCCs sized between 5cm and 7cm were frequently complex masses. RCCs with grade IV echogenicity were rare (10%), and cystic RCCs were noted in 4% of the patients.

US is a cost-effective, easily available, portable, and non-radiating examination for kidneys. It can be used as a screening modality for renal cancer. In patients with inconclusive US imaging finding or clinically high suspicion of focal renal tumor, CT, MRI, or even angiography should be utilized as complementary diagnostic modalities.

Renal cell carcinoma (RCC) or renal adenocarcinoma represents the third most common genitourinary neoplasm in adults. Although the ultrasonographic appearances of RCC were frequently reported before 1990 [1], there have been limited reports regarding the high-resolution sonographic findings of RCC in recent 10 years. More and more small-sized renal neoplasms were detected incidentally during routine upper abdomen ultrasonography (US). The relationship between tumor size and US presentation among patients with RCC still needs to be elucidated. The aim of this study was to analyze the link between echopatterns and tumor size of RCCs.

MATERIALS AND METHODS

In 5-year period, a total of 78 patients found to have renal masses by US study and pathologically
proved to be RCCs were included in this retrospective study. They included 68 men and 10 women ranging with age from 30 to 87 years (mean 67.3 years). Some of them (35/78, 45%) were incidentally discovered to have RCC during US study for health check-up (n= 30) or survey for abnormal liver function (n= 5). All 78 patients subsequently underwent surgical treatment (n= 66) and/or biopsy (n= 12) after receiving other imaging studies including computed tomography (CT) (n= 77) and angiography (n= 1). We reviewed the US studies to clarify the relationship between the echopatterns and tumor sizes of RCC. The echogenicity of the tumors was graded from I through V as compared to the echogenicity of the renal medulla, renal cortex, liver/spleen and renal sinus (Table 1).

**Table 1. Grading of tumor echogenicity among 78 patients with renal cell carcinoma**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description of echogenicity</th>
<th>No.</th>
<th>(%)</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>( \leq ) renal medulla</td>
<td>4</td>
<td>5%</td>
</tr>
<tr>
<td>II</td>
<td>( \leq ) renal cortex and &gt; medulla</td>
<td>27</td>
<td>35%</td>
</tr>
<tr>
<td>III</td>
<td>( \leq ) liver / spleen and &gt; cortex</td>
<td>39</td>
<td>50%</td>
</tr>
<tr>
<td>IV</td>
<td>( \leq ) renal sinus and &gt; liver/spleen</td>
<td>8</td>
<td>10%</td>
</tr>
<tr>
<td>V</td>
<td>&gt; renal sinus</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

**RESULTS**

Most RCCs were presented as solid masses (n= 33, 42%) or complex masses (n= 42, 54%). Only 3 patients were presented with cystic masses (4%). Grade I echogenicity (not higher than renal medulla) was noted in only 5% of renal tumors, grade II (higher than medulla but not higher than renal cortex) in 35%, grade III (higher than cortex but not...
higher than liver/spleen) in 50%, and grade IV (not higher than renal sinus) in 10%. None had an echogenicity greater than renal sinus (Grade V) (Table 1).

Tumors less than 5 cm in size were commonly round and ovoid in shape (24/29, 83%) (Fig. 1, 2). However, when the tumor size was greater than 5 cm, the tumors were most commonly irregular in shape (40/49, 82%) (Fig. 3~5). Tumors less than 5 cm in size were most commonly homogeneous in echopattern, while tumors larger than 5 cm were frequently heterogeneous in echopattern (Fig. 6, 7). Most of the tumors in this study were of Grade III echogenicity (n= 39, 50%). In tumors larger than 5 cm, calcifications might be detected in US study (Fig. 6, 7). However, the correlation between the echogenicity grading and the tumor size was not statistically significant (P> 0.05) (Table 2).

**DISCUSSION**

The typical clinical manifestations of RCC include hematuria, palpable renal mass, and flank pain. However, in our study, 45% (35/78) of the RCCs were incidental findings. It was consistent with the previous study, which revealed that 15-48% of patients with RCC presented with no clinical symptoms or signs [2]. Since the development of the gray-scale real time US and CT, evaluations of focal renal pathology have been shifted to these cross-sectional tomographic techniques from the previously widely used intravenous urography. US is a well-accepted imaging modality in the evaluation of intra-abdominal organs. The advantages of US study include real-time imaging, noninvasiveness, no ionizing radiation, high portability, and relatively low

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**Table 2. Sonographic manifestations of 78 patients with renal cell carcinoma**

<table>
<thead>
<tr>
<th>Tumor Size (cm)</th>
<th>Echogenicity</th>
<th>Homogeneity</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 ~ 3.0</td>
<td>II ~ III</td>
<td>100%</td>
<td>Round</td>
</tr>
<tr>
<td>3.1 ~ 4.0</td>
<td>II ~ III</td>
<td>60%</td>
<td>Round</td>
</tr>
<tr>
<td>4.1 ~ 5.0</td>
<td>II ~ IV</td>
<td>60%</td>
<td>Round</td>
</tr>
<tr>
<td>5.1 ~ 6.0</td>
<td>I ~ III</td>
<td>43%</td>
<td>Round</td>
</tr>
<tr>
<td>6.1 ~ 7.0</td>
<td>I ~ IV</td>
<td>42%</td>
<td>Round</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>I ~ IV</td>
<td>13%</td>
<td>Ovoid</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>42%</td>
<td>Irregular</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td>Irregular</td>
</tr>
</tbody>
</table>

**Figure 2.** An 80-year-old male: a. A round mass, 3-4 cm in size, was detected (arrow) with presence of complex heterogeneous echogenicity at lower pole of right kidney. b. Color Doppler sonography revealed the presence of marginal color flow signals (arrows).
Figure 3. A 42-year-old female: US revealed a round mass, 4-5 cm in size, with complex heterogeneous echogenicity at upper pole of left kidney (arrow) with hypoechoic rim and a central hypoechoic area, representing central necrosis or hemorrhage.

Figure 4. A 74-year-old male: A mass with irregular border, 5-7 cm in size, was evident with complex heterogeneous echogenicity with a mural nodule (arrow).

Figure 5. A 50-year-old male: a. A solid mass with irregular border, 5-7 cm in size, was noted with heterogeneous echogenicity in left kidney (large arrow) with renal vein thrombosis (small arrow). b. Contrast-enhanced CT further revealed contrast enhancement of tumor (large arrow) with left renal vein thrombosis (small arrow).

Figure 6. A 57-year-old male: A mass with irregular border, 7 cm in size, was depicted on US (large arrows). The lesion was associated with complex heterogeneous echogenicity and some calcifications (small arrows).

Figure 7. A 42-year-old male: US revealed a renal mass with irregular border, 7 cm in size, associated with complex heterogeneous echogenicity and ring-like calcification (arrows).
cost. Although patients referred for abdominal US study usually have certain clinical symptoms, more and more patients received upper abdominal US study as a routine health check up in recent years in Taiwan [3]. The high prevalence of RCC as an incidental finding of US examinations thus prove the excellent utility of US in screening for RCC.

The characteristic sonographic findings of a RCC are a solid, well-defined mass with various echogenicity patterns. The echo texture can be heterogeneous, especially when necrosis or bleeding occurs. In about 20% of the cases, the masses are highly reflective and thus difficult to be differentiated from angiomyolipoma [4]. In children, the RCCs can appear as hypoechoic (35%), isoechoic (44%), or hyperechoic (21%) intrarenal masses [5-7]. The average diameter of the tumor at the time of diagnosis is 4 cm. The sensitivity of US in detecting a solid renal mass with diameter between 1 to 2 cm is approximately 65%, which increases to 85% in those between 2 to 3 cm [4]. Calcifications occur in about 10-25% of tumors, appearing as echogenic foci and usually located within the intrarenal mass. When tumor spreads into retroperitoneum and lymph nodes or invades the renal vein, sonography can be helpful to identify the extrarenal pathologies [8, 9]. Although US can detect RCC and venous invasion, it is not as sensitive as CT or MRI in assessing metastases from renal and urinary tract carcinomas [16]. Ultrasonography is particularly valuable in assessing masses that are indeterminate on CT when enhancement is equivocal or when intravenous contrast medium cannot be administered [17]. Duplex Doppler US may be as accurate as CT scanning in the staging of RCC [18]. Furthermore, in patients with renal vein or caval thrombi, color and duplex Doppler US is highly accurate (87%) in establishing the diagnosis and in determining the extent of the thrombosis [19].

Fine needle aspiration of focal renal pathology can also provide an accurate diagnosis in most renal tumors; however, aspiration cytology of the kidney has limitations and pitfalls. Low grade RCC has to be differentiated from oncocytoma, angiomylipoma, renal infarct and related conditions. Nevertheless, renal fine needle aspiration has a high negative predictive value, which is useful in reassuring patient with radiologically and cytologically benign lesions. Negative fine needle aspiration does not exclude malignancy in the presence of a suspicious image finding [20].

The majority of RCCs are tumors of clear cell or granular cell type. They are characterized by prominent neovascularity and have the tendency to invade renal veins, inferior vena cava, and the right atrium with a frequency of 20%, 10%, and 2%, respectively. The presence and location of venous tumor thrombus are of great importance in surgical decision-making [21]. Ultrasonographic evaluation of renal veins and inferior vena cava in the presence of focal renal mass should be done as a routine procedure [10, 19].

Although US study is an effective screening tool for the detection of renal tumors, especially cystic lesions and grade V masses, it is noteworthy that CT remains the most widely available and most effective modality for tumor staging. Other more advanced and/or invasive diagnostic modalities, such as MRI, angiography, and biopsy may also be required to rule out renal pseudotumors (e.g. column
of Bertin hypertrophy, fetal lobation).

In conclusion, small RCCs (≤ 3cm) tended to be relatively homogeneous in US imaging with the echogenicity ranging from grade II to III. Renal cell carcinomas with a size between 3cm and 5cm were relatively heterogeneous with grade II to IV echogenicity, whereas RCCs sized between 5cm and 7 cm were frequently complex masses. Grade IV RCCs were rare (10%), and cystic RCCs were noted in 4% of the patients.

Ultrasonography is a cost-effective, easily available, portable and non-radiating tool that can be used as an effective screening modality. In patients with inconclusive US imaging findings or clinically high suspicion of focal renal tumor, CT, MRI, or even angiography should be utilized as complementary diagnostic modalities.

REFERENCES

腎細胞癌在超音波的表現：78名案例之回顧

楊境亦1,2,4  刁翠美2,4  周宜宏2,4  王信凱2,4  邱宏仁2,4  王家槐2,4  許思穎2,4
許明輝2,4  張政彥2,4  陳光國3,4  于俊2,4

行政院衛生署基隆醫院 放射線科
台北榮民總醫院 放射線部2 外科部3
國立陽明大學 醫學院4

腎細胞癌是成人最常見的腎臟惡性腫塊。絕大多數的腎臟，皆可利用即時性高解像力超音波作檢查。為歸納腎細胞癌超音波表現的徵象，我們回顧78例曾接受超音波檢查，並經病理證實為腎細胞癌的患者。

在5年中，總共收集了78例經上腹部超音波檢查發現腎臟腫塊，隨後並接受手術或切片檢查的病患。組織病理學步驗證實這些病患皆有腎細胞癌。其中35名病患屬於無臨床症狀，但於例行超音波檢查中意外發現有腎臟腫瘤者。我們回顧相關超音波檢查結果，分析超音波型態與腫瘤大小的關係。病灶的回音強度在與腎臟細質、腎臟皮質、肝臟或脾臟、和腎盂比較後，依序分為一至五級。

大多數腎細胞癌呈現實質性腫塊(33例，42%)或複合性腫塊(42例，54%)；僅有3例呈現囊性腫塊(4%)。第一級回音強度(不透過腎臟細質)在所有腫瘤中佔5%；第二級回音強度(高於腎臟細質，但不透過腎臟皮質)佔35%；第三級回音強度(高於腎臟皮質，但不透過肝臟或脾臟)佔35%；第四級回音強度(高於肝臟或脾臟，但不透過腎竇)佔10%。較小(小於或等於3公分)的腎細胞癌相對而言多呈現同質性(homogeneous)，且回音強度範圍多在第二至第三級之間。3-5公分的腎細胞癌呈現相對的異質性(heterogeneous)，且回音強度多在第二至第四級之間。至於5-7公分的腎細胞癌，則經常表現為複合性腫塊。第四級回音強度的腎細胞癌甚見(佔10%)，囊性腎細胞癌則僅僅佔4%。

超音波檢查係具經濟效益、容易取得、可攜帶、且沒有游離輻射，並可作為篩檢腎臟癌症的檢查方式。對於超音波檢查後沒有定論的患者，或是臨床上高度懷疑局部腎臟腫瘤者，電腦斷層掃描、磁振造影檢查，或是甚至血管攝影檢查，則可用來作為補足的診斷檢查。