Original article

**IMAGING FEATURES OF SOLID RENAL MASSES: IMPLICATION FOR OPTIMAL TREATMENT**

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**Abstract**

**Objective** To describe the imaging features of solid renal masses that possibly differentiate benign from malignant tumors.

**Materials and methods** We retrospectively analyzed CT images of 27 patients with solid renal masses from January 2002 to June 2005. Twenty patients were proven by surgery, three by laboratory results, and four by follow-up study. Each mass was evaluated by its largest diameter, presence of fat, calcifications, perinephric invasion, and hetero- or homogeneity. Associated thrombus in the inferior vena cava, retroperitoneal node enlargement, and renal stone were also recorded.

**Results:** Thirteen patients had malignant tumors and fourteen had benign lesions. Of the 13 malignant tumors, 10 were renal cell carcinoma and three urothelial carcinoma. There were 15 benign lesions in the 14 patients (angimyolipoma = 10, abscesses = 4, organized thrombus =1). The mean age of patients with malignant and benign tumors was 53.8 and 45.2 years, respectively \((p = 0.063)\). The mean diameter of malignant and benign tumors was 9.6 cm and 7.7 cm \((p = 0.2)\), respectively. None of the malignant tumors had fat density and 10 of the benign tumors had intratumoral fat \((p<0.05)\). Six malignant tumors and one benign one had intratumoral calcifications \((p<0.05)\). All malignant tumors were treated by nephrectomy, whereas only 1 organized thrombus and 1 angiomyolipoma underwent nephrectomy.

**Conclusion** The most common solid renal masses in our study were benign lesions. Tumor size was not helpful in differentiating between benign and malignant masses, but the presence of intratumoral fat and calcifications were the most reliable imaging features for this purpose. Hence, the proper management can be provided.

**Keywords:** kidney, tumor, computed tomography
Renal cell carcinoma (RCC) is the most common primary renal tumor, accounting for 2% of all malignancy.\(^{(1)}\) Although solid renal mass is primarily regarded malignant, the percentage of benign solid renal mass is increasing.\(^{(2)}\) The widespread use of computed tomography (CT) has led to an increased detection of solid renal tumors. The differential diagnoses of these solid tumors include RCC, renal adenoma, oncocytoma, angiomyolipoma (AML), transitional cell carcinoma (TCC), metastatic tumor, abscess, infarction, vascular malformation, and renal pseudotumor.\(^{(3)}\) The differentiation is important because the prognosis and treatment are different. Therefore, familiarity with the CT features of these benign and malignant solid renal tumors will help radiologists to provide accurate diagnosis leading to proper management. Hence, we studied the CT features of solid renal masses that may possibly differentiate between benign and malignant tumors.

**Materials and methods**

We retrospectively reviewed clinical data and CT features of 27 patients with solid renal masses at Maharaj Nakorn Chiang Mai Hospital from January 2002 to June 2005. Twenty patients were proven by surgery, three by laboratory results, and four by follow-up study. Because the study was retrospective, the CT was performed on a conventional system (Cytec 3000i, General Electric Medical Systems, Milwaukee, WI, USA) and 16-slice multidetector (Aquilion16, Toshiba, Tochigi-Ken, Japan) scanner, with various slice collimations. All examinations were performed both before and after intravenous contrast administration, with various types and amounts of contrast agent. Solid renal mass is defined as a mass that does not predominantly contain liquid, although necrosis or hemorrhage may occur. Cystic renal masses were excluded. Each mass was evaluated for its largest diameter, the presence of fat, calcifications, perinephric invasion, and hetero- or homogeneity. The associated thrombus in the inferior vena cava (IVC) and retroperitoneal node enlargement were also recorded. The Chi-square test was used to determine statistical significance.

**Results**

Thirteen patients had malignant tumors and fourteen had benign lesions. The characteristics of the malignant and benign tumors are shown in Table 1 and 2. The various classifications of RCC included one clear, one chromophilic, two papillary, four moderately differentiated, and two unclassified cells. Of the 13 malignant patients, nine were men (69.20%) and four women (30.80%). Of the 14 benign patients, six were men (42.90%) and eight women (57.10%). The mean age of patients with malignant and benign tumors was 53.80 and 45.20 years, respectively (\(p=0.063\)), which was not statistically significant. The mean diameter of malignant and benign tumors was 9.6 cm ± SD 3.61 and 7.7 cm ± SD 4.80, respectively (\(p=0.2\)), which was not statistically significant. None of the malignant tumors had fat density and 10 of the benign tumors had intratumoral fat (\(p<0.05\)), which was statistically significant. Six malignant tumors and one of the benign ones had intratumoral calcifications (\(p<0.05\)), which was statistically significant. The other findings found no statistically significant difference between benign and malignant tumors. No association with tuberous sclerosis was presented in the cases of AML. All malignant tumors were treated by nephrectomy, whereas only one organized thrombus and one AML had nephrectomy. CT
Imaging features of solid renal masses and pathologic findings of these benign and malignant lesions are shown in Fig. 1-5.

**Discussion**

This study shows slightly more benign solid masses than malignant ones (15:13). In contrast, previous reports showed that malignant renal masses occurred much more frequently than benign ones.\(^{(2,4)}\) However, the sample size of our study was much smaller than in those reports. Although Li G et al.\(^{(2)}\) reported that the majority of benign tumors were small (< 4 cm), our study showed that most of both benign and malignant tumors were larger than 4 cm. Therefore, the size of the tumors in our study was not helpful in differentiating between benign and malignant tumors, but the presence of intratumoral fat and calcifications were the only two findings in our study that were helpful in revealing these differences.

AML or renal hamartoma was the most common benign renal mass diagnosed in our study. It is usually readily distinguishable from RCC by findings on a CT scan. It has a distinctive fat density, which is less than that of water (-10 to -100 Hounsfield units). Preoperative diagnosis of this lesion is of great significance for proper management. Small AML is asymptomatic, often discovered accidentally but AMLs larger than 4 cm in diameter are more liable to hemorrhage causing flank pain and hematuria. Conservative follow-up alone is sufficient for a small, asymptomatic AML, but large AML with bleeding may require surgery or embolization.\(^{(5)}\) In our study, only one AML required nephrectomy because of a large tumor with hemorrhage and necrosis. Although there have been a few reports of RCC containing fat, they also contain calcifications.\(^{(6,7)}\) However, AML rarely contains calcification.\(^{(8)}\) Therefore, the detection of calcification in the fat containing renal mass is suggestive of RCC. AML occurs about 4.5 times more commonly in women than in men.\(^{(5)}\)
Table 2. The analysis of benign solid renal masses

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Sex/Age (years)</th>
<th>Tumor size(cm)</th>
<th>Site</th>
<th>Imaging</th>
<th>Treatment</th>
<th>Diagnosis</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Density</td>
<td>Peri</td>
<td>Cal</td>
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<tr>
<td>1</td>
<td>M/79</td>
<td>9</td>
<td>R</td>
<td>Hetero, hge</td>
<td>-</td>
<td>Rim</td>
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<tr>
<td>2</td>
<td>M/37</td>
<td>5</td>
<td>L</td>
<td>Hetero</td>
<td>+</td>
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<tr>
<td>3</td>
<td>M/32</td>
<td>6</td>
<td>R</td>
<td>Hetero</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>F/41</td>
<td>3</td>
<td>L</td>
<td>Hetero, fat</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>M/48</td>
<td>7</td>
<td>L</td>
<td>Hetero</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>F/51</td>
<td>1</td>
<td>L</td>
<td>Homo, fat</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>F/55</td>
<td>2</td>
<td>R</td>
<td>Homo, fat</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>F/35</td>
<td>13</td>
<td>L</td>
<td>Hetero, fat</td>
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<td>-</td>
</tr>
<tr>
<td>9</td>
<td>F/48</td>
<td>17</td>
<td>L</td>
<td>Hetero, hge, fat</td>
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<td>-</td>
</tr>
<tr>
<td>10</td>
<td>F/60</td>
<td>9</td>
<td>R</td>
<td>Hetero, fat</td>
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<td>-</td>
</tr>
<tr>
<td>11</td>
<td>M/33</td>
<td>2.5</td>
<td>L</td>
<td>Hetero</td>
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<td>-</td>
</tr>
<tr>
<td>12</td>
<td>F/22</td>
<td>12.6</td>
<td>L</td>
<td>Hetero, fat</td>
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<tr>
<td>13</td>
<td>M/51</td>
<td>10/5</td>
<td>R/L</td>
<td>Hetero, fat</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>F/41</td>
<td>14.2</td>
<td>R</td>
<td>Hetero, hge, fat</td>
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</tr>
</tbody>
</table>

Partial=partial nephrectomy; AML=angiomyolipoma
R=right, L=left, Hetero=heterogeneous enhancement, Homo=homogeneous enhancement, hge=hemorrhage, Peri=perinephric spread
ABO=antibiotics, D=drainage
which is similar to our study.

The other benign lesions in our study were abscesses and an organized thrombus. Abscesses have an infiltrative growth pattern with irregular ill-defined margins and an indistinct interface with the normal kidneys. Imaging features and clinical symptoms of our patients led us to provide correct diagnosis and proper management. In the case of organized thrombus, we gave a preoperative diagnosis in a 79-year-old man of malignant tumor with bleeding because there was a mass with multiple calcifications and bleeding in the right kidney, which had multiple stones and a very thin cortex. This patient had no history of trauma or bleeding tendency. Nephrectomy was performed in this case that revealed recent and old hemorrhage with organized thrombus. Spontaneous renal hemorrhage may be caused by RCC, AML, blood dyscrasias, renal aneurysm and arterivenous malformation, renal vein thrombosis, renal abscess, and rupture of a renal cyst. Therefore, we have to be aware that some benign lesions can complicate the diagnosis.

Adenoma is a benign renal tumor that can be easily confused with RCC. A large tumor may calcify and be indistinguishable from RCC. Therefore, this lesion must be treated as RCC. Oncocytoma is another benign renal tumor that is difficult to differentiate from RCC. Calcification and fat are rarely seen in oncocyto-

Figure 1. Renal cell carcinoma in a 46-year-old man with right varicocele. (a) Axial enhanced CT scan shows enlargement of the right kidney with an 11-cm heterogeneous enhancing solid mass (arrows) with punctuate calcifications (arrowheads). (b) Photomicrograph of renal cell carcinoma, clear cell type, disclosing clear cytoplasm with centrally located small nuclei (H&E, X400 original magnification).

Figure 2. Transcional cell carcinoma in a 49-year-old woman. Axial enhanced CT scan shows a heterogeneous enhancing mass (thick arrow) arising from the renal pelvis causing hydronephrosis with thin renal cortex (thin arrow).
gestive of oncocytoma, but it is seen in one fourth of US and one third of CT studies. A ‘spoke-wheel’ vascular pattern is also suggestive of oncocytoma, but it is not pathogenomonic since this finding can be found in RCC. We did not have adenoma or oncocytoma in our study.

The CT appearance of RCC varies extremely depending on its size, vascularity and the extent of necrosis or cystic change. RCC can range from small, slow-growing and accidentally discovered lesions to aggressive neoplasms that may metastasize. Small RCC is difficult to differentiate from other benign renal lesions, e.g. oncocytoma, AML with scanty fat, and inflammatory mass. However, large RCC and urothelial carcinoma (TCC, SQCA) are not difficult to differentiate from

![Figure 3](image_url1) **Figure 3.** Angiomyolipoma in a 22-year-old woman. (a) Axial enhanced CT scan shows a 12-cm predominantly fat-containing mass with heterogeneous enhancement (arrows) arising from the left kidney. Partial nephrectomy was performed. (b) Photomicrograph shows spindle smooth muscle cells with the presence of adipose tissue and blood vessels (H&E, X400 original magnification).

![Figure 4](image_url2) **Figure 4.** Organized thrombus in a 79-year-old man. Axial enhanced CT scan shows a large heterogeneous enhancing mass with calcifications (arrows) occupying almost the entire right kidney.

![Figure 5](image_url3) **Figure 5.** Abscess in a 32-year-old man. Axial enhanced CT scan shows an ill-defined mass (arrows) in the right kidney with a large inhomogeneous perinephric extension (*).
benign renal masses. We were able to give the correct diagnosis of all malignant renal masses. Unfortunately, we could not perform renal conserving surgery in our cases, due to large tumors.

**Conclusion**

The most common solid renal masses in our study were benign lesions. Tumor size was not helpful in differentiating between benign and malignant masses. The presence of intratumoral fat or calcifications is the most reliable imaging feature for differential diagnosis of benign from malignant masses. Hence, the proper management can be provided.

**References**

ลักษณะเอกซเรย์คอมพิวเตอร์ของเนื้องอกไตที่จะช่วยในการรักษาที่เหมาะสม

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บทคัดย่อ

วัตถุประสงค์ ศึกษาลักษณะเอกซเรย์คอมพิวเตอร์ของเนื้องอกไตที่อาจช่วยในการวินิจฉัยแยกโรคกลุ่มเนื้องอกชนิดที่เป็นมะเร็งกับชนิดที่ไม่เป็นมะเร็ง เพื่อการรักษาที่เหมาะสม

วัสดุและวิธีการ ศึกษาทั้งหลากรายการเอกซเรย์คอมพิวเตอร์ของกลุ่มเนื้องอกไตที่เป็นก้อนเนื้อที่ได้รับการรักษาในโรงพยาบาลมหาวิทยาลัยเชียงใหม่ จำนวน 27 ราย เทียบข้อมูลดังกล่าวตามรายงาน จำนวน 248 โดยมีผลอยู่มาจากการคลีนิก จำนวน 20 ราย ทำการปฏิบัติการ จำนวน 27 ราย และคิดผลการรักษา จำนวน 4 ราย ข้อมูลของกลุ่มเนื้องอกไตทับทิมที่มีผลจากห้องปฏิบัติการได้แก่ ขนาดที่ใหญ่ที่สุด ความเป็นเนื้อเดียวกันหรือต่างกัน หินปูน และการรุกลามไปบริเวณรอบไต รวมทั้งการมีลิ่มเลือดในหลอดเลือดดำใหญ่และต่อมน้ำเหลือง โครงสร้างเดิมหรือไม่

ผลการศึกษา มีผู้ป่วย 13 รายเป็นมะเร็ง โดยเป็นชนิด renal cell carcinoma (RCC) = 10, urothelial carcinoma = 3 และ 14 ราย เป็นเนื้องอกที่ไม่เป็นมะเร็ง เทียบอยู่ที่ 15 ราย จำนวนเป็น Angiomyolipoma = 10, Abscess = 4, Organized thrombus = 1 ทุกอย่างมีข้อมูลที่เป็นก้อนเนื้องอกชนิดที่เป็นมะเร็งและไม่เป็นมะเร็งมากกว่า 33.8 และ 45.2 ปีตามลำดับ (p<0.0063) ขนาดของกลุ่มเนื้องอกที่เป็นมะเร็งและไม่เป็นมะเร็ง ทางก่อน (9.6 และ 7.7 ซม) และทางหลัง (9.8 และ 7.9 ซม) ซึ่งไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ (p>0.2) ซึ่งไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ (p>0.05) พบมีหินปูนภายในกลุ่มเนื้องอกเป็นมะเร็ง 6 ราย และไม่เป็นมะเร็ง 1 ราย (p<0.005) กลุ่มนี้มีขนาดเนื้องอกที่ใหญ่ในการรักษา ขยายผลคลีนิก แต่ก้อนเนื้องอกชนิดที่ไม่เป็นมะเร็งมีพื้นที่ 2 รายที่ทำให้การคลีนิก

สรุป จากการศึกษาพบว่าข้อมูลของกลุ่มเนื้องอกที่เป็นมะเร็งขนาดของกลุ่มไม่ช่วยในการวินิจฉัยแยกโรคกลุ่มนี้เนื้องอกที่เป็นมะเร็งกับชนิดที่ไม่เป็นมะเร็ง การตรวจพบหินปูนหรือหินปูนภายในกลุ่มนี้ยังมีนัยสำคัญในการแยกโรคที่สุด ทำให้การรักษาได้เหมาะสม เชิงวิทยาการ 2549;45(3):105-112.

คำสำคัญ: ไต, เนื้องอก, เอกซเรย์คอมพิวเตอร์