CT Diagnosis of Renal Angiomyolipoma: The Importance of Detecting Small Amounts of Fat

Six patients were reviewed who had renal angiomyolipoma (1.2–4.0 cm) in which only minimal amounts of fat were evident on CT. The fat content of the lesion was appreciated because tissue attenuation measurements of small areas of low attenuation within the tumors were performed and because thin-section (5-mm) and nonenhanced CT scans were used. The fat content of the lesions could be identified on 10-mm sections in three cases but only on 5-mm sections in three others. In two cases, fat was seen only on the nonenhanced 5-mm thin sections. Careful sampling of low-density regions within the mass must be performed because a single region of interest over the entire tumor will produce an average attenuation in the soft-tissue range. The use of 5-mm thin sections and thin, nonenhanced CT sections increases spatial and density resolution and decreases susceptibility to partial-volume effects. In a correlative study, no areas of fat were detected in a review of 100 well-circumscribed (4.0 cm or smaller) renal cell carcinomas.

Detecting the existence of fat in a renal lesion will establish the diagnosis of angiomyolipoma and is the only radiologic finding that can differentiate it from renal cell carcinoma. Thus, unnecessary surgery will be avoided in these cases.

Angiomyolipoma of the kidney, also called renal hamartoma, can be diagnosed noninvasively and with great accuracy by modern imaging techniques because fat within these tumors is usually shown readily by sonography and CT [1–6]. However, some angiomyolipomas contain only tiny amounts of fat that can be easily overlooked unless searched for carefully in the CT study. Careful sampling of low-density regions within the mass must be performed, and the use of nonenhanced scans and thin sections (5 mm) will increase the chances of establishing the presence of fat within the tumor. Presentation of representative cases and a discussion of the techniques necessary to improve the detection of small amounts of fat are the purposes of our report.

Materials and Methods

Six patients were reviewed who had small angiomyolipomas (1.2–4.0 cm) that contained tiny amounts of fat. A GE 8800 scanner was used in two patients and a GE 9800 in five; in one patient, one scan was obtained with each machine. Standard 10-mm-thick sections were used in all cases; four patients also were studied with 5-mm sections. In all patients, scans were obtained with IV contrast material; three patients had unenhanced scans as well. In total, 45 g of iodine were administered by the rapid bolus-infusion technique. Fatty tissue was considered to be present within a tumor if a region-of-interest value of −10 H or lower was found within the tumor. Region-of-interest measurements were used that included at least a total of three adjacent pixels. In three cases, the region-of-interest measurement included nine pixels or more. CT scanners were calibrated daily with a phantom. Water-density structures did not measure less than 0 H. Internal checks in each case were used to test the validity of the CT numbers by measuring known fat and fluid areas within the body on each scan. Sonographic findings in two cases and angiographic findings in one case were correlated with the CT findings. Follow-up studies were available in three cases, and pathologic results were available in three cases.
The CT scans of 100 patients with pathologically confirmed well-circumscribed renal cell carcinomas 4 cm in diameter or smaller were included in the study; the three men and three women were 43–68 years old (Table 1). Fat was identifiable within the lesion on 10-mm-thick contrast-enhanced CT sections in three cases (−10 H or lower), was suggestive in one case (0 to −9 H), and was not seen in two cases. In the one patient in whom 10-mm contrast-enhanced CT sections were only suggestive of fat, the 5-mm enhanced scan indicated it was definitely present. In three patients, 5-mm CT sections were obtained without IV contrast material. In one of these, the fat content of the tumor was detected more readily than on the contrast-enhanced scan. In the other two, the nonenhanced 5-mm CT sections were the only scans in which the fat content of the tumor could be documented. CT, sonographic, and angiographic findings in all six patients are illustrated in Figures 1–6.

Two patients had sonography, which showed highly echogenic tumors that led to further study of the lesions. One patient had angiography, which showed irregular vessels. Three patients had surgical resection, in two cases because of the insistence of the surgeon. In one of these two, a tumorectomy was performed because hamartoma was strongly suspected. In the third, the fat content of the tumor was not appreciated initially but only after the pathologic diagnosis was made. Three patients did not undergo surgery. Follow-ups of 2, 3, and 4 years, respectively, have shown no change in the size or character of the lesion. Surgery was avoided in two of the patients because fat in the tumor was clearly established, on both 5-mm sections (but not the 10-mm section) in one and on only the 5-mm nonenhanced section in the other.

In the evaluation of the 100 cases of renal cell carcinoma, no tissue indicative of fat was found within the tumors. The lowest CT number obtained was 5 H, found in a tumor containing cystic spaces.

Discussion

Renal angiomyolipoma is a fairly common incidental finding in the kidney. It can be diagnosed with great accuracy by modern imaging techniques, especially CT, because of the fat content of the tumor. Patients with asymptomatic lesions require no treatment. Treatment for symptomatic lesions often is surgical, but renal embolization has also been used, especially to stop acute bleeding [7]. In the past, surgical removal was common because of the inability to distinguish the lesion from renal cell carcinoma.

We studied six patients with renal angiomyolipomas in which minimal amounts of fat were evident on CT, and we

**TABLE 1: Angiomyolipomas with CT Evidence of Small Amounts of Fat**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age</th>
<th>Gender</th>
<th>Size (cm)</th>
<th>Lowest Attenuation Number (H) on CT Sections</th>
<th>10-mm</th>
<th>5-mm</th>
<th>5-mm</th>
<th>5-mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Enhanced</td>
<td>Enhanced</td>
<td>Enhanced</td>
<td>Nonenhanced</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>68</td>
<td>M</td>
<td>2.0</td>
<td>−5</td>
<td>−26</td>
<td>−35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>64</td>
<td>F</td>
<td>1.2</td>
<td>73</td>
<td>15</td>
<td>−17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>45</td>
<td>M</td>
<td>2.9</td>
<td>−13</td>
<td>−26</td>
<td>NP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>59</td>
<td>M</td>
<td>2.0</td>
<td>−12</td>
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<td>NP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>43</td>
<td>F</td>
<td>4.0</td>
<td>−26</td>
<td>NP</td>
<td>NP</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>43</td>
<td>F</td>
<td>2.5</td>
<td>98</td>
<td>9</td>
<td>−10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note—Sonography, performed only in cases 2 and 3, showed hyperechoic lesions. Cases 4 and 5 had nephrectomies and case 6 had a tumorectomy. Cases 1, 2, and 3 had follow-ups of 2, 3, and 4 years, respectively. NP = not performed.

Fig. 1.—Case 1: Angiomyolipoma of the kidney with small areas of fat within the tumor. A 68-year-old man had a CT study to evaluate renal masses seen on urography performed for prostatism.

A, IV contrast–enhanced CT scan (10-mm section) shows 2-cm mass in anterior aspect of midpole of right kidney. Some areas within lesion are of lower attenuation. The entire lesion measured 41 H. Other areas of decreased attenuation posteriorly placed in parenchyma represent partial voluming of cysts seen on adjacent images.

B–D, IV contrast–enhanced CT scans (5-mm sections). Areas of lower attenuation within mass are defined more clearly than in A. Lesion measured with large cursor in C) was 35 H. Portion of lesion measured with small cursor (arrow in D) was −26 H, indicating fat content of tumor.

The diagnosis of angiomyolipoma was established. A 2-year follow-up scan showed no change in lesion size.
Fig. 2.—Case 2: Angiomyolipoma of the kidney not diagnosed on 10-mm sections but only on nonenhanced 5-mm sections. A 64-year-old woman had sonography to evaluate a left renal mass.

A, Longitudinal sonogram of right kidney reveals highly echogenic focus at upper pole (arrow).

B, IV contrast–enhanced CT scan (10-mm section) shows large cyst in upper pole of left kidney (12 H). A 1.2-cm-diameter area of decreased attenuation relative to enhancing renal nephrogram is noted at lateral margin of upper pole right kidney (arrow). Lesion measured 73 H.

C, IV contrast–enhanced scan (5-mm section) also shows cyst at upper pole of left kidney. Area of decreased attenuation is seen at upper pole of right kidney. However, within lesion is area of lower attenuation (arrow) that measures 15 H. In view of sonographic findings, nonenhanced CT was repeated.

D, Noncontrast CT scan (5-mm section) shows area of low attenuation in upper pole of right kidney (arrow). Measurements as low as −17 H were obtained.

Because of fat detected in lesion, surgery was avoided. Follow-up sonography and noncontrast CT over a 3-year period revealed no change in lesion size.

Fig. 3.—Case 3: Angiomyolipoma in kidney of patient with lymphoma. A 45-year-old man had a CT study to stage known lymphoma. IV contrast–enhanced CT scan (5-mm section) shows retroperitoneal adenopathy representing known lymphoma. Area of relatively decreased attenuation in right kidney measures 40 H with large cursor over entire lesion. However, at tiny region of interest (arrow), measurements as low as −25 H were obtained, indicating lesion represented an angiomyolipoma.

Patient has been followed for lymphoma for 4 years. No change has been seen in the size of angiomyolipoma.

Fig. 4.—Case 4: Angiomyolipoma not diagnosed preoperatively. A 59-year-old man had a CT survey for upper abdominal discomfort.

A, IV contrast–enhanced CT scan (10-mm section) shows 2-cm lesion off posterior surface of left kidney. Lesion measures 68 H. Subsequently, measurement of −12 H (at tip of arrow) was obtained, indicating fat content of lesion.

B, Selective left renal arteriogram with epinephrine enhancement reveals tiny cluster of abnormal-appearing vessels (arrow). (Fig. 4B courtesy of R. Bernstein, New York.)

Patient underwent angiography and surgery at another hospital. Pathology indicated angiomyolipoma. CT scan was reevaluated and small area of fat was then appreciated.
analyzed the CT techniques that best show the fat. All six patients had negative attenuation (Hounsfield) values. If the lesion is measured with a large region of interest that includes higher attenuating portions of the lesion, positive attenuation values will be obtained. The negative numbers indicative of fat will be obtained only if tissue attenuation measurements of small areas of low attenuation within the tumor are made. If there is suspicion that the lesion might contain fat, but negative numbers below −10 H are not found in the lesion on 10-mm thick sections, the existence of fat in the lesion can be investigated by using 5-mm sections as well as by rescanning the patient without contrast enhancement. The use of 5-mm thin sections and nonenhanced scans improves the chances of detecting and measuring these small areas of fat because of the increased spatial and density resolution afforded by thinner sections and because the CT value is less susceptible to partial-volume effects (cases 1, 2, and 6). Showing that an area of the tumor suspected of being fatty tissue measures even more negatively on thinner sections is in itself further proof of the reliability of the negative measurement and the existence of fat in the lesion. In fact, if a negative CT number (particularly in the −1 to −10 H range) obtained on a 10-mm section cannot be reproduced and shown to be even lower on 5-mm sections, the accuracy of the CT number on the initial study must be seriously questioned and a diagnosis of fat-containing tumor cannot be established. The use of non–contrast-enhanced 5-mm CT sections is particularly important in proving the presence of small amounts of fat in these tumors. These lesions often are vascular, and the increased attenuation of the enhancing tissues on the contrast-enhanced scan tends to obscure the fat and makes negative measurements in these small areas of fat more difficult to obtain. This was seen in two of our patients in whom negative CT numbers were obtained only on the 5-mm nonenhanced scans.

Some authorities [8, 9] consider absolute CT numbers relatively unreliable. It has been shown that there is a significant difference in absolute CT numbers between scanners and that there may be a significant difference in absolute CT numbers on the same scanner on different days. Factors such as peak kilovoltage, orientation of the area of interest with respect to the scan aperture (the position of the structure within the body), and the CT numbers of surrounding tissues also can affect the absolute CT numbers. However, the use of CT to distinguish fatty tissue on the basis of negative attenuation is well established [1–6].

The characteristic highly echogenic appearance of angiomyolipomas on sonography is well known and described in the literature [1–3, 10–12]. Although this is not a specific finding (because other renal lesions occasionally will be highly echogenic), the presence of this pattern in a renal lesion should alert the radiologist to the possibility of an angiomyolipoma and should suggest more studies to look for a focus of fat in the lesion if it is not appreciated initially. This occurred in cases 2 and 3. In both cases, the characteristic sonographic findings alerted the radiologist to the possibility of angiomyolipoma, which was then proved by repeat examination with 5-mm sections and follow-up studies.

Other fat-containing renal tumors might be encountered such as lipomas, well-differentiated liposarcomas, and per-
haps teratomas. Lipomas contain more fat and are treated the same way as an angiomyolipoma. Liposarcomas generally are larger, tend to be invasive, and probably would be treated surgically because of their size and tendency to be symptomatic. We were unable to find a small, well-marginated liposarcoma that could be confused with an angiomyolipoma in our own material or in a literature search. Teratoma is extraordinarily rare and can be recognized by its calcium content.

It is only a small percentage of hamartomas of the kidney that do not contain fat (angiomyomas) [13, 14]. One such case has been reported that was diagnosed correctly without biopsy because of its association with lymphangiomyomatosis [15]. In patients with tuberous sclerosis, some of the multiple renal hamartomas will not show fatty areas within the tumors. However, in such cases, the diagnosis is assumed and rarely is a clinical problem. However, when tuberous sclerosis or lymphangiomyomatosis is not associated with the case, a hamartoma that does not contain fat cannot be diagnosed without biopsy.

CT of renal cell carcinoma does not reveal islands of fat in the tumor similar to those in angiomyolipoma. None of the CT scans in patients with well-margined (4 cm or smaller) carcinomas in our series showed the presence of fat within the tumor, and we were unable to find reference in the literature to such an occurrence. Care must be taken to be certain that fat in the renal sinus or perirenal tissues, which occasionally becomes engulfed within the tumor, is not confused with the intrinsic tissues of the tumor. However, the nature of the growth pattern of the neoplasm and its position in the kidney should indicate whether any fat seen in the tumor is part of the neoplasm or encompasses adjacent fatty tissue, particularly in the comparatively small, marginated lesions described in our series. In one report of two children with Wilms tumor [16] fatty elements were found. This can occur because the nonepithelial stromal portion of the tumor may undergo metaplastic change to cartilage, bone, adipose tissue, and muscle [17]. However, these cases of Wilms tumor would not be confused with the kind of tumors discussed in this article.

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REFERENCES