Incidental Finding of Renal Masses at Unenhanced CT: Prevalence and Analysis of Features for Guiding Management

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OBJECTIVE. The purposes of this study were to investigate the frequency and clinical relevance of the incidental finding of renal masses at low-dose unenhanced CT and to analyze the results for features that can be used to guide evaluation.

MATERIALS AND METHODS. Images from unenhanced CT colonographic examinations of 3001 consecutively registered adults without symptoms (1667 women, 1334 men; mean age, 57 years) were retrospectively reviewed for the presence of cystic and solid renal masses 1 cm in diameter or larger. An index mass, that is, the most complex or concerning, in each patient was assessed for size, mean attenuation, and morphologic features. Masses containing fat or with attenuation less than 20 HU or greater than 70 HU were considered benign if they did not contain thickened walls or septations, three or more septations, mural nodules, or thick calcifications. Masses with attenuation between 20 and 70 HU or any of these features were considered indeterminate. The performance of CT colonography in the detection of renal cell carcinoma was calculated for masses with 2 or more years of follow-up.

RESULTS. At least one renal mass was identified in 433 (14.4%) patients. The mean size of the index masses was 25 ± 16 mm; 376 (86.8%) masses were classified as benign and 57 (13.2%) as indeterminate. The 20- to 70-HU attenuation criterion alone was used for classification of 53 indeterminate lesions. Follow-up data (mean follow-up period, 4.4 years; range, 2–6.3 years) were available for 353 (81.5%) patients with masses (41 indeterminate, 312 benign). Four of the 41 indeterminate masses were diagnosed as renal cell carcinoma. The sensitivity and specificity for renal cell carcinoma on the basis of the indeterminate criteria were 100% and 89.4%. The positive and negative predictive values were 9.8% and 100%.

CONCLUSION. The incidental finding of a renal mass is relatively common at unenhanced CT, but imaging criteria can be used for reliable identification of most of these lesions as benign without further workup. Mean attenuation alone appears reliable for determining which renal masses need further evaluation.

Unenhanced CT is playing an increasingly important role in a number of clinical applications, such as the evaluation of flank pain [1], monitoring of urolithiasis [2], and CT colonography [3]. Unenhanced CT also is used to evaluate a variety of conditions in patients who are unable to receive IV contrast material. Renal masses unrelated to the presenting concern are common incidental findings [4]. In an aging population, the frequency of encountering renal incidentalomas is increasing because the prevalence of both renal cysts and renal cell carcinoma increases with age [5–7]. Although most incidental renal masses are benign, most renal cell carcinomas are identified as incidental findings [8, 9]. Most renal masses can be diagnosed with contrast-enhanced CT, but some remain indeterminate and necessitate additional imaging, such as CT both with and without IV contrast material, ultrasound, and MRI. Some of these masses warrant a biopsy or surgical exploration, and others simply need to be observed [10]. Apart from macroscopic fat in angiomyolipomas, the criteria for differentiation of benign entities from potential malignant tumors on unenhanced CT scans have yet to be identified.

To our knowledge, no large-scale studies have been conducted to examine both the prevalence of incidental renal masses on unenhanced CT scans and their imaging features. With the burgeoning use of unenhanced CT, there is a need for such data to help develop a cost-conscious, medically appropriate approach to the incidental detection of a renal

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mass on an unenhanced CT scan. Little is known about the predictive value of features detected only with unenhanced CT. Our screening CT colonography program provided images of a relatively large population without symptoms that could be used to define features that guide the management of renal masses incidentally detected with unenhanced CT. The purposes of this study were to investigate the frequency and clinical relevance of renal masses incidentally identified at screening CT colonography and to analyze the results for features that could be used to guide the evaluation of renal masses detected incidentally at unenhanced CT examinations.

Materials and Methods

This HIPAA-compliant retrospective study was performed with an institutional review board–approved protocol. The requirement for informed consent was waived. Unenhanced CT of the abdomen and pelvis was performed on 3001 consecutively registered persons without symptoms (1667 women, 1334 men; mean age, 57 years) undergoing CT colonographic screening at one institution over the 27-month period April 2004–July 2006. The protocol for cathartic bowel preparation with oral contrast material and for colonic distention has been previously described [11].

CT scans of the abdomen and pelvis were obtained without IV contrast material with an 8- or a 16-MDCT scanner (LightSpeed Series, GE Healthcare) calibrated daily for attenuation. The voltage was 120 kVp with modulated tube current ranging from 30 to 300 mA and the noise index set at 50. Supine and prone acquisitions were performed with 1.25-mm collimation. Images in both series were reconstructed with a 1.25-mm slice thickness at 1-mm intervals for the source data; the supine series was also reconstructed as 5-mm-thick sections at 3-mm intervals to facilitate review of extracolonic structures [3].

Prevalence and Characterization of Masses

The unenhanced CT scans of all 3001 subjects were reviewed for detectable incidental renal masses, both cystic and solid, measuring at least 1 cm in maximal diameter. The 5-mm transverse supine series was used for the primary review, and the supine and prone thin sections were reserved for secondary review of indeterminate masses, as described later. For persons with multiple renal masses, one index mass was defined as the mass most likely to be malignant. The total number of identifiable masses per person also was recorded. The maximum transverse diameter, obtained with electronic calipers, was noted for all index masses. Masses were evaluated for evidence of fat (attenuation of –10 HU or lower) [12], septations, calcifications, thickened walls, and mural nodules. Septations were categorized as either few (one or two) or many (three or more) and as thin (1–2 mm) or thick (3 mm or greater in width). Calcifications were categorized as either thin or thick. Mean CT attenuation in a circular region of interest at least 25 mm² but within the mass to avoid volume average effects was measured and recorded for each index mass.

Index masses were categorized and divided into indeterminate and benign subsets based on criteria adapted from the Bosniak classification of cystic renal masses and additional literature [12–15]. Although the Bosniak classification does not strictly apply to unenhanced CT, we used the defining features as the starting point for lesion classification. First, masses without thick calcifications that contained regions of fat (defined as an attenuation of –10 HU or less) were considered benign; the presence of fat in a noncalcified renal mass allows the diagnosis of a benign angiomyolipoma [12]. Bosniak category I and II masses also are considered benign. Bosniak category I cysts are homogeneously hypodense (< 20 HU) and have smooth, thin walls. Masses were considered Bosniak category II, and therefore benign, if they contained few (< 3) thin (1–2 mm) septa or thin (1–2 mm) calcifications [13]. A benign hyperdense cyst is a subset of Bosniak category II if it measures less than 3 cm in diameter or Bosniak category IIF if it is larger.

Although the definitive diagnosis of a benign hyperdense cyst requires the mass to be nonenhancing, we considered homogeneously hyperattenuating masses with attenuation 70 HU or greater benign. Masses with these features have been found to be benign with high probability [15]. Finally, cystic masses that contained one or more mobile punctate densities (identified by comparing prone and supine scans) were considered caliceal diverticula with stones. The other index masses were considered indeterminate. Unenhanced CT features that rendered the index mass indeterminate included mean attenuation between 20 and 70 HU, thickened (≥ 3 mm) or more than three septations, thick (≥ 3 mm) calcifications, a thickened wall, and mural nodules.

The initial feature data were collected by one coauthor, and all potentially indeterminate renal masses were reviewed by two additional coauthors to verify all positive findings. The secondary review included measurement of renal mass attenuation on both supine and prone images to confirm proper mass categorization.

Clinical Relevance of Incidental Renal Masses

Electronic medical records, including clinic visits and imaging, of all subjects with an index mass were reviewed to assess the number and types of follow-up cross-sectional imaging examinations (whether performed to evaluate a renal mass or for another reason) and to identify any subsequent diagnoses of renal malignancy. Length of clinical follow-up from the time of the initial CT examination was recorded. Masses were considered benign if subsequent imaging and clinical follow-up records did not contain a diagnosis of a renal malignancy in a minimum clinical or imaging follow-up period of 2 years.

Statistical Analysis

With the features used to render masses indeterminate, the diagnostic performance (sensitivity, specificity, accuracy, positive predictive value, and negative predictive value) in detection of renal cancer was assessed.

Results

Mass Prevalence and Characterization

One or more renal masses were identified in 433 of 3001 (14.4%) persons without symptoms.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Original Sample</th>
<th>Patients With Follow-Up Data</th>
<th>Benign Diagnosis¹</th>
<th>Renal Cell Carcinoma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benign</td>
<td>376</td>
<td>312</td>
<td>312</td>
<td>0</td>
</tr>
<tr>
<td>Macroscopic fat</td>
<td>11</td>
<td>10</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>&lt; 20 HU without macroscopic fat</td>
<td>357</td>
<td>295</td>
<td>295</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 70 HU</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>57</td>
<td>41</td>
<td>37</td>
<td>4</td>
</tr>
<tr>
<td>20–70 HU and no other indeterminate feature</td>
<td>52</td>
<td>36</td>
<td>32</td>
<td>4</td>
</tr>
<tr>
<td>20–70 HU and thick calcification⁵</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>&lt; 20 or ≥ 70 HU and thick calcification⁵</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Total 433 353 349 4

¹Based on clinical or imaging follow-up findings.
⁵Thick calcification was the only other indeterminate feature identified beyond mean attenuation between 20–70 HU (i.e., thick wall, thick septations, and mural nodules were not identified).
(Figs. 1−7). Of these, masses were multiple in 169 (39.0%) subjects and bilateral in 103 (23.8%). The mean maximal transverse diameter of the index mass was 25 ± 16 (SD) mm (median, 19 mm; range, 10−114 mm). A total of 376 (86.8%) index masses were classified as benign (Table 1 and Figs. 1 and 4). There were 11 (2.5%) angiomyolipomas. A total of 349 (80.6%) index masses had no apparent complex features at unenhanced CT, and 16 (3.7%) had some combination of thin calcifications (seven masses); few, thin septations (four
masses; and high attenuation (eight masses) (Fig. 4).

There were 57 (13.2%) indeterminate index masses (Table 1). These included 53 masses measuring 20–70 HU (Figs. 2, 3, and 7) and five masses with thick calcifications. One mass was categorized as indeterminate according to both attenuation and calcification criteria. No patient had a mass with thick septations, three or more septations, wall thickening, or mural nodularity. If these criteria for an indeterminate mass had been used clinically to determine which masses warranted further imaging, 1.9% (57/3001) of persons screened with CT colonography would have been selected for further testing. In total, 41 of the 57 patients (71.9%) with indeterminate renal masses underwent further imaging beyond the CT colonographic examination.

The final category of 25 index masses was changed from indeterminate to benign after a secondary review that included both supine and prone scans. In 12 patients the attenuation of the index mass was measured as less than 20 HU on the prone scans only. This finding was related to the presence of dense oral contrast material in the adjacent colon, and artificially increased attenuation is present within pericolonic fat.

Clinical Relevance of Incidental Renal Masses

Data from clinical or imaging follow-up of at least 2 years’ duration were available for 353 (81.5%) patients with index renal masses. Masses in this subset were multifocal in 143 (40.5%) cases and bilateral in 86 (24.4%). The mean maximal transverse diameter of the index mass was 25 ± 16 mm (median, 19 mm; range, 10 –114 mm). The mean attenuation of the 353 index masses with adequate follow-up was less than 20 HU in 308 (87.3%) patients, 20–70 HU in 38 (10.8%), and greater than 70 HU in seven (2.0%) patients.

The morphologic features included few thin septations in five (1.4%) patients, thin...
calcification in nine (2.5%), and thick calcification in five (1.4%). Fat attenuation was found in 10 (2.8%) index masses, all without thick septations or thick calcification and thus benign. According to the predefined unenhanced CT criteria, 41 (11.6%) index masses followed up were classified as indeterminate. These included 37 (10.5%) masses with a mean attenuation of 20–70 HU and five (1.4%) masses with thick calcifications. One mass was indeterminate according to both attenuation and calcification criteria. A total of 312 (88.4%) index masses with follow-up lacked indeterminate features and therefore were classified as benign.

Additional abdominal cross-sectional imaging studies performed at least 2 years after the index CT examination were performed for 123 patients (34.8% of the 433 with index masses) for a variety of indications. Thirty patients were examined for specific evaluation of the renal mass detected at CT colonography. Imaging studies included CT in 111 cases, ultrasound in 32 cases, and MRI in five cases. Clinical follow-up lasted 24–76 months (mean, 53 months; median, 55 months).

Combined imaging and clinical follow-up revealed renal cell carcinoma in four renal masses among the 41 considered indeterminate (Figs. 2 and 7) but none among the 312 considered benign. Two additional patients who had index masses considered benign later were found to have renal cell carcinoma with masses measuring 2.3 and 3.3 cm. Both of these lesions were detected approximately 3 years after the initial CT colonographic examination. Neither tumor originated from the index mass or any other identifiable mass. For both patients, review of the initial CT colonographic images was repeated, and neither mass was identified, even in retrospect.

According to the specific criteria, categorization of renal masses into indeterminate and benign sets resulted in a sensitivity, specificity, positive predictive value, and negative predictive value for renal cell carcinoma of 100% (4/4), 89.4% (312/349), 9.8% (4/41), and 100% (312/312).

**Discussion**

Renal masses are fairly ubiquitous incidental findings at CT, and their management is controversial [16]. Although incidental detection of a renal mass can lead to the serendipitous discovery of renal cancer, most of these masses are benign, and the finding typically leads to unnecessary and costly imaging tests and, in some cases, potentially morbid treatments. Recommendations on how to manage incidentally detected renal masses are based on imaging findings that fully characterize the mass, such as a CT with and without contrast enhancement [10, 16]. Unenhanced CT is being used more frequently to examine patients for a variety of indications, including flank pain and colorectal cancer screening. In addition to its role in evaluation of patients who cannot receive IV iodinated contrast material. As a result, data are needed to develop evidence-based strategies for managing indeterminate renal masses detected with unenhanced CT. To our knowledge, ours is the first study to combine a...
cohort without symptoms, unenhanced CT technique, and clinical and imaging follow-up in the evaluation of renal incidentalomas.

In our cohort, asymptomatic focal renal parenchymal masses measuring at least 1 cm in diameter were identified in 14.4% of subjects. Subcentimeter masses were not considered in our analysis because incidental masses smaller than 1 cm can generally be ignored [10, 17]. The prevalence in our study was similar to that in previous reports, particularly when subcentimeter masses were excluded [6, 18].

This study was not intended to establish the absolute prevalence of incidental renal masses, which would be more appropriately addressed with IV contrast–enhanced CT or MRI. Rather, we sought to determine the prevalence and imaging features of both benign and indeterminate renal masses identifiable at unenhanced CT because this clinical scenario is becoming increasingly common. Identification of a renal mass at unenhanced CT relies on either deformation of the normal renal contour or an attenuation difference compared with normal renal parenchyma. Isodense contour-deforming masses generally are not detectable at unenhanced CT. This may have been why two cases of renal cancer were not diagnosed until several years after CT colonography. An alternative explanation is that these masses simply developed after the examination.

Other authors [19] have found that the Bosniak classification of renal cystic lesions requires contrast-enhanced CT for proper assessment. Our findings support this notion because we did not identify any abnormal soft-tissue elements, such as thick septations or mural nodules within renal masses. Instead, we found that simple assessment with only mean attenuation was effective in categorizing renal masses as benign or indeterminate at low-dose unenhanced CT.

Our definition of an indeterminate mass included both attenuation and morphologic features yet would lead to further testing of only 1.9% (57/3,001) of persons without symptoms. Attenuation between 20 and 70 HU was the predominant reason for considering masses indeterminate. All four index masses later found to be renal cancer were detected. Therefore, our criteria had a 9.8% (4/41) positive predictive value for renal cancer, which may be high enough for malignancy, especially when paired with 100% sensitivity.

The data were derived from CT scans obtained with low-dose technique. The effect of use of low-dose technique on the detection and characterization of renal masses with unenhanced CT is unknown. However, this technique did not preclude differentiation of calcifications potentially associated with malignancy from benign (thin or mobile) calcifications. Furthermore, although image noise increases with lower doses (indicated by a larger SD in HU measurement), the mean attenuation used for lesion categorization does not change meaningfully. Septations are difficult to detect on low-dose unenhanced CT scans. It therefore is not surprising that this feature was rarely identified in our study sample. Nevertheless, lack of identification of septations did not lead to missing a case of cancer, and none of the five masses in which few thin septations were detected were found to be malignant. Mural nodules also were not identified in our patient sample, likely owing to use of unenhanced technique. We posit that renal masses with solid-appearing components, such as mural nodules, would have attenuation between 20 and 70 HU and therefore would fall into the correct, indeterminate category (Figs. 2 and 7). Indeed, our four proven renal cell carcinomas had a 28- to 60-HU range in attenuation.

The range of attenuation of renal cell carcinoma at unenhanced CT examinations has not been fully addressed in the literature. However, information can be gleaned from studies of mass enhancement and reports of renal mass attenuation before and after administration of IV contrast material. Studies to date [20, 21] have shown that the mean attenuation of proven renal cell carcinomas at unenhanced CT rarely extends outside the range of 20–70 HU. Our unpublished ongoing research findings show that the attenuation of proven renal cell carcinoma at unenhanced CT essentially always crosses over into this 20- to 70-HU danger zone when the entire lesion is properly sampled. We therefore believe that an attenuation range of 20–70 HU is a good starting point for mass characterization at unenhanced CT. One limitation of the current study was that only four renal cell carcinomas were encountered; a larger number of cases of cancer is needed to show that the 20- to 70-HU range criterion would be reliable for detecting essentially all cases of renal cancer, and this is the focus of our ongoing research. Nevertheless, that only four renal cell carcinomas were encountered in our cohort emphasizes the relative rarity of the disease in a population without symptoms.

The management of incidental renal masses is a particularly relevant issue for CT colonographic screening, in terms of both clinical efficacy and cost-effectiveness [3]. Incidental renal masses are an important area of concern, given their relatively high frequency and the fact that renal cell carcinoma is generally the most common extracolonic cancer identified at CT colonography [22, 23]. One unexpected issue of our study peculiar to CT colonography was the artfactually higher attenuation of some renal masses on supine compared with prone scans (Fig. 5). Using only supine scans would have led to an indeterminate classification and unnecessary workup. The differences in attenuation were probably due to a phenomenon similar to if not the same as pseudoenhancement of renal masses on contrast-enhanced CT scans and can be recognized by remeasuring the attenuation of the mass on the images on which the mass is not adjacent to contrast-filled colon, usually prone scans [24, 25]. Another benefit of two-scan CT colonography is the ability to visualize mobile stones in a caliceal diverticulum, thus avoiding misclassifying such masses as indeterminate owing to calcifications (Fig. 6).

CT attenuation values were used in this study in an attempt to differentiate benign and potentially malignant renal masses. Although this approach has been used in previous studies of renal masses, the reliability of absolute CT attenuation values has been called into question [26]. However, as long as CT scanners are calibrated daily, attenuation values are helpful in the management of renal masses.

In addition to the fact that there were a small number of cases of renal cancer in this cohort, there were other limitations to our study. We used a retrospective design, but we limited assessment of clinical relevance only to patients with at least 2 years of clinical or imaging follow-up, leading to an average follow-up period of 4.4 years. Renal cell carcinoma can be an indolent disease, and there is no known follow-up period that excludes it completely. We believe, however, that nearly 4 years is a reasonable period from which to make practical recommendations regarding how best to manage incidental findings. As is common in long-term studies, 80 subjects, 18.5% of our population with asymptomatic renal masses, were lost to follow-up. Finally, the number of proven cases of renal cell carcinoma in our study was predictably small. We plan to undertake a separate study to investigate the attenuation of a large number of proven renal cell carcinomas at unenhanced CT to address this important related issue. Finally, we
did not include masses smaller than 1 cm. Although it is conceivable that these very small masses could be malignant, they are almost always benign, particularly when they appear cystic, and are difficult to characterize completely with imaging [10, 17]. If we had included them in our analysis, we might have skewed the results. Nevertheless, it should be noted that such masses were not analyzed in this study.

Conclusion

Asymptomatic renal masses 1 cm in diameter or larger are common incidental findings at unenhanced CT. The results of this study suggest that most of these masses can be considered benign when they are evaluated for attenuation and morphologic features. As has been previously established, angiomyolipoma can be diagnosed when fat is identified in a noncalcified mass. It also appears that noncalcified renal masses that do not cross into the 20–70 HU zone also can be considered benign. Although several morphologic features can render a mass indeterminate, our findings show that unenhanced attenuation alone (i.e., 20–70 HU) is a useful determinant for identifying indeterminate masses that may represent renal cell carcinoma and necessitate further workup. Although malignant renal tumors with attenuation outside the 20–70 HU range were not encountered in our study population, the presence of other indeterminate features (e.g., thick septations and calcification) may still warrant further evaluation. Despite the relatively large scale of our study, further research is needed to validate our findings.

References