An Imaging Algorithm for the Differential Diagnosis of Adrenal Adenomas and Metastases

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OBJECTIVE. The purpose of this study was to develop an algorithm using CT and chemical-shift MR imaging for the characterization of adrenal masses in patients with a primary cancer and no other evidence of metastatic disease.

SUBJECTS AND METHODS. Thirty-three patients with 37 adrenal masses (19 metastases, 18 adenomas), all of whom had a known primary cancer, were studied with noncontrast CT and chemical-shift MR imaging (1.5 T). Lesion size and density in Hounsfield units (H) were determined by CT. Adrenal signal intensity normalized to that of spleen was used to calculate adrenal–spleen ratio (ASR), defined as the percentage of signal remaining in the opposed-phase image relative to the in-phase image. Lesions less than or equal to 0 H were classified as benign, lesions greater than 20 H were regarded as malignant, and lesions between 0 and 20 H were regarded as indeterminate. Diagnoses were confirmed by biopsy (for 19 lesions) or by follow-up imaging (for 18 lesions). An imaging algorithm was derived by determining the relative value of CT and MR imaging for diagnosing the lesions. The reimbursement rates for CT-guided biopsy and MR imaging of the abdomen were obtained from Medicare.

RESULTS. All 13 lesions of 0 or less H were correctly classified as benign by CT. ASR was less than 70 in 10 of these 13. In another 13 lesions, H was greater than 20; all were malignant and all had an ASR greater than 80. Of 11 CT-indeterminate lesions, four of five adenomas had an ASR less than 70, and four of six metastases had an ASR greater than 80. Two malignant lesions had ASRs between 70 and 80 and were diagnosed by biopsy findings. One CT-indeterminate adenoma had an ASR of 84 and was diagnosed by biopsy findings. The reimbursement rate by Medicare is similar for CT-guided biopsy with pathologic interpretation and for MR imaging of the abdomen.

CONCLUSION. An algorithm was developed for diagnosis of adrenal lesions that uses the density reading on noncontrast CT as the first step, with chemical-shift MR imaging for CT-indeterminate lesions. In this algorithm, lesions of 0 H or less may be regarded as benign and further work-up is not required. Lesions with a density greater than 20 H are likely malignant and should be biopsied when the result will influence management. For CT-indeterminate lesions, we recommend chemical-shift MR imaging. An ASR threshold of 70 indicates a benign lesion, and no further work-up is required in these patients. Lesions with an ASR greater than 70 should have a biopsy performed, depending on the clinical situation. The above algorithm is cost-effective and reduces the number of biopsies required without reducing the sensitivity of detecting malignant lesions.

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Adrenal masses frequently are discovered during staging of oncology patients. However, a large percentage of adrenal masses are benign, even in patients with a known malignant tumor [1]. Discovery of an adrenal mass presents a diagnostic problem with the oncology patient because the management of a patient with metastatic disease is usually different from the treatment of a locally confined disease. It is desirable to diagnose such masses by imaging and to avoid biopsy.

CT has remained the method of choice for diagnosing such lesions [2–11]. Recently a number of studies have shown chemical-shift MR imaging comparable
to or even more sensitive than noncontrast CT for adrenal lesion characterization [12–16]. However, no study has evaluated the complementary roles of CT and chemical-shift MR imaging. We have attempted to elaborate a diagnostic imaging algorithm for the examination of oncology patients who have adrenal lesions but no other evidence of metastatic disease. The key objective was to determine the role of chemical-shift MR imaging in characterizing adrenal lesions when CT findings are indeterminate in cases in which the diagnosis of an adrenal metastasis will alter therapy.

Subjects and Methods

Patients

Thirty-seven adrenal masses were prospectively identified in 33 oncologic patients on noncontrast CT scans of the chest or abdomen. Any lesion over 1 cm in diameter was classified as an adrenal mass eligible for entry into the study. The minimum diameter was stipulated for two reasons. First, we wished to allow an optimum MR imaging study to be performed. Accurate signal intensity measurement of smaller lesions is difficult because of signal loss at the lesion interface with surrounding fat owing to destructive signal summation. Second, we wished to include only definite masses and to exclude cases of thickening of the gland.

The study group included 22 men and 11 women with a mean age of 63 years (range, 19–81 years). These patients had no evidence of metastatic disease elsewhere. All patients underwent chemical-shift MR imaging within 2 weeks of the CT scan. We found 18 adenomas in 16 patients and 19 metastatic lesions in 17 patients. Patients with pheochromocytomas were not included. The primary malignant lesions were all solid tumors: lung (20 patients), colorectal (2 patients), prostate (2 patients), and bladder (2 patients); seven other types of cancer were each represented once. Four patients had bilateral masses: two had bilateral adenomas and two had bilateral metastatic lesions.

Proof of Lesions

Proof of adenoma was by one of two methods: (1) benign appearance on CT scans with a minimum of 12 months’ follow-up showing no change in size or appearance (14 lesions; mean follow-up interval, 25 months; range 12–72 months; median, 14 months); or (2) biopsy (six lesions). Proof of malignancy was by one of two methods: needle aspiration biopsy (13 lesions) or the appearance of a new adrenal mass or enlargement of an existing adrenal mass on serial CT scans (three lesions). Biopsies were accepted as negative only when one or more specimens showed an adequate sample of normal adrenal cells. Three or more aspirates were obtained from each lesion.

CT

CT was performed as part of a staging evaluation of the abdomen or chest using a General Electric 9800 CT scanner (General Electric, Milwaukee, WI). Five-millimeter slices were obtained at 8-mm intervals through the adrenal glands as part of the routine examination. Only unenhanced images were used for quantitative evaluation.

Analysis of CT Scans

Density readings were obtained using an elliptical region of interest (ROI) set as large as possible entirely within the substance of the adrenal lesion to avoid partial volume averaging with surrounding tissue. All readings were obtained by one investigator. Analysis of the CT images for the purposes of this study was confined to size (cm) and density reading in Hounsfield units (H). Other factors, such as contrast enhancement and shape or morphology of lesions, were not studied. On the basis of a review of threshold densities used in other studies [4, 17, 18], lesions were stratified into three groups based on the density reading to represent benign, indeterminate, and probably malignant lesions: (1) density reading less than or equal to 0 H; (2) density reading between 1 H and 20 H; and (3) density reading greater than 20 H. The wide range of values for CT-indeterminate lesions was chosen because some reports have shown that malignant adrenal lesions may be of low density [4, 17, 18], and bearing in mind that the algorithm should be sensitive to the diagnosis of malignant lesions. The size of the lesion was measured as the greatest diameter in the axial plane seen on the CT scan.

MR Imaging

Chemical-shift MR imaging was performed on a 1.5-T magnet (Signa, General Electric). After a coronal localizer, in-phase and opposed-phase T1-weighted gradient-echo axial images of the adenomas were obtained, each during suspended respiration. For the first 18 patients, a conventional multiplanar spoiled gradient-recalled acquisition in the steady state (GRASS) technique was used: TR = 110–150; TE = 5 for in-phase images, 7 for opposed-phase images. For the last 15 patients, a fast multiplanar spoiled GRASS technique was used that included a TE of 2.3 and 4.6 for out-of-phase and in-phase images, respectively. Matrix size was 256 × 192 with one excitation. Sections 10 mm thick were obtained without an interslice gap. The average time a patient spent on the table was 15 min, with an imaging time of less than 5 min.

Analysis of MR Images

The adrenal lesion-to-spleen ratio (ASR) was the parameter used to evaluate differences between the lesion characteristics on the in-phase and opposed-phase images, as this is the parameter that has been shown to be the most accurate for adrenal lesion characterization [19]; unlike lesion–liver ratios, it is not affected by fatty change in the liver. The ASR reflects the percentage drop-off in signal of the adrenal lesion relative to the internal standard of the spleen on the opposed-phase images and is calculated as follows (SI = signal intensity):

\[
\text{ASR} = \frac{\text{SI lesion (opposed-phase)} / \text{SI spleen (opposed-phase)}}{\text{SI lesion (in-phase)} / \text{SI spleen (in-phase)}} \times 100
\]

This is the same quantity calculated by Bilbey et al. [13] and is a modification of the methods used in previous studies [12, 15]. Elliptical ROIs were used to obtain signal intensity readings of the adrenal lesion, using an ROI as large as possible but fully confined within the lesion to avoid inclusion of the low-signal-intensity zone at the lesion’s edge. ROIs of the splenic parenchyma that were of similar size were also obtained on the same image when possible. Various threshold values for ASR were evaluated based on those suggested by previous studies.

Receiver Operating Characteristic Analysis

Receiver operating characteristic (ROC) curves were generated from the data using the CLABROC program (Charles E. Metz, University of Chicago, Chicago, IL) [20]. For each discriminator (H, ASR, and
lesion size), the ROC curve is a plot of the true-positive fraction (TPF = sensitivity) against the false-positive fraction (FPF = 1–specificity). The CLABROC program fits ROC curves to data from pairs of discriminators, estimating the area under each curve as a measure of effectiveness of each discriminator and providing the likelihood that observed differences could have arisen by chance.

Assessment of Cost

An attempt was made to assess the costs of the CT biopsy versus chemical-shift MR imaging. Charges vary considerably from institution to institution and often bear little resemblance to the rate of reimbursement, which is dependent upon the type of insurance. To reflect a charge that is somewhat nationally standardized, we obtained Medicare reimbursement rates for a CT biopsy plus cytologic or histologic interpretation and for MR imaging of the abdomen (1995 Medicare Locality Fee Schedule for Urban Massachusetts), although these reimbursement rates are considerably below the fees generally charged.

Results

The distribution of the quantitative CT and MR imaging measurements (H and ASR) for benign and malignant lesions is shown in Figure 1.

CT Density

Thirteen lesions had CT density readings of 0 H or less; all were adenomas. Eleven lesions had CT density readings between 1 H and 20 H; six were adenomas, and five were metastatic lesions. Thirteen lesions had CT densities greater than 20 H; all were metastatic lesions.

Chemical-shift MR Imaging

Sixteen lesions had an ASR of 75 or less: 15 were adenomas, and one was a metastatic lesion with an ASR of 75. Twenty-one lesions had an ASR greater than 75: 18 were metastatic lesions and three were adenomas. Use of an ASR less than or equal to 80 as a threshold for classifying lesions as benign would have misclassified only two adenomas as malignant but three malignant lesions as benign. Use of an ASR less than or equal to 70 as a threshold correctly identified 14 of 18 adenomas and misclassified no malignant lesion.

Size of Lesion

The mean diameter of benign lesions was 2 cm (range, 1–4 cm) compared with 4 cm (range, 2–8 cm) for malignant lesions (p = .001). Eighteen lesions were less than 3 cm in maximum diameter: 15 were adenomas, three were metastatic lesions. Of the 19 larger lesions, four were adenomas and 15 were metastatic lesions. Only two lesions, both malignant, were greater than 5 cm in diameter (both were 8 cm).

Value of MR Imaging Measurements and Lesion Size for CT-Indeterminate Lesions

Of the five adenomas with indeterminate CT density, four had an ASR less than 70 and were therefore classified as benign by MR imaging measurements. The fifth had an ASR of 84. Of the six metastatic lesions with an indeterminate CT density, four had an ASR greater than 80 (correctly classified as malignant), and two had ASRs between 70 and 80 (ASR = 75 and 76). Of all lesions with indeterminate CT density, only one malignant lesion was less than 3 cm in maximum diameter compared with four of five benign lesions.

Of the CT-benign lesions, chemical-shift MR imaging correctly categorized all but three lesions using an ASR of 70 as the cutoff. The lesions that were incorrectly diagnosed on the basis of MR imaging measurements had ASRs of 97, 76, and 75 and had CT densities of −4 H, −3 H, and −13 H, respectively. Of the lesions with a CT density greater than 20 H, MR imaging enabled all 13 lesions to be correctly categorized as malignant with the use of ASR greater than 80 as a threshold.

ROC Analysis

By ROC analysis, both CT density and ASR dominated lesion size, and the differences between the areas under the curves were statistically significant (p = .012 for CT; p = .034 for MR imaging). There was no significant difference (p = .41) between areas under the ROC curves generated for CT and for ASR. The difference in FPF at a fixed TPF was used as an additional measure of comparison [21]. Because of the more important clinical impact of missing a metastasis, a relatively high TPF (sensitivity) of 0.98 was set as an appropriate operating point. The FPF at TPF = 0.98 was 0.91 (specificity = 0.09) for CT density and 0.82 for ASR (specificity = 0.18), but the difference again was not statistically significant (p = .65).

Cost Estimates

The Medicare reimbursement rate for CT-guided biopsy with cytologic evaluation alone is $469. If histology is also required, the reimbursement is $543. The reimbursement for MR imaging of the abdomen is $534. These rates include
professional and technical fees. Although chemical-shift MR imaging of the adrenal glands takes only one third to one half the time of an MR imaging examination of the abdomen or pelvis, no separate code for this is listed by Medicare.

Discussion

Although several MR imaging techniques have been reported with varying promise for detecting and evaluating adrenal masses [2, 3, 19, 22–25], CT has remained the technique of choice for diagnosing such lesions [2–11]. CT diagnosis relies largely on the presence of fat in benign lesions [26] resulting in low density on Hounsfield-unit readings. Recent studies using chemical-shift MR imaging, which is also a lipid-sensitive imaging technique, have shown results for chemical-shift MR imaging comparable to or even more sensitive than reported rates for noncontrast CT for adrenal lesion characterization [12–16]. However, no study has addressed the relative roles of CT and chemical-shift MR imaging for diagnosing adrenal lesions.

Various studies have examined the value of CT density in classifying adrenal lesions [3–6, 8–11, 18, 27]. Data from many of these studies are difficult to pool because the study populations and techniques differ considerably. Table 1 summarizes data from some noncontrast studies that are comparable with the present study. Although a threshold of 10 H or 15 H is suggested by some authors as a reliable cutoff point for diagnosing benign lesions, the studies taken altogether suggest that a malignant lesion with a density reading of about 10 H will sometimes be encountered. However, none reports a malignant adrenal mass with a density of less than 0 H.

In our study, CT was very accurate when a threshold of 0 H was used, correctly categorizing 13 of the 37 lesions as benign, and missing no malignant lesions (Fig. 2). If a threshold of 10 H was used, although no malignant lesions would have been misclassified in this study, one benign lesion would have been classified as malignant, with two further benign lesions having borderline CT densities of 10 H exactly. If a threshold of 15 H was used, two metastases would have been incorrectly classified as adenomas (Fig. 3A). At a threshold of 20 H, five metastases would have been misclassified as benign. In the current study, all

<table>
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<th>Study</th>
<th>No. Lesions</th>
<th>Mean CT (H)</th>
<th>Suggested CT Threshold (H)</th>
<th>Lesions Compared</th>
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<td>Nonadenomas</td>
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<td>Mean: 23; no range</td>
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<td>van Erkel et al.</td>
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<td>32.9 ± 10.1</td>
<td>15 Adenomas vs diverse nonadenomatous adrenal lesions</td>
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<td>Katz and Shirkhoda</td>
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<td>No mean; range: 10–60</td>
<td>None Adenoma vs metastases (3 adenomas calcified)</td>
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</table>

Note.—H = Hounsfield units.

Fig. 2.—Adenoma in 76-year-old man with transitional cell carcinoma of bladder. Lesion is unchanged at 4-year follow-up.
A, CT scan shows 4-cm adrenal lesion (arrow) has density reading of 9 H and is therefore indeterminate.
B, In-phase chemical-shift image of same lesion. Signal intensity of adrenal lesion (arrow) is greater than that of spleen (S).
C, On opposed-phase chemical-shift image, signal intensity of adrenal lesion (arrow) is now less than that of spleen. ASR is 39. No further work-up is required.
lesions with a CT density reading over 20 H were malignant. Using size alone as a diagnostic criterion would also have misclassified lesions. Although the trend was for the larger lesions to be malignant, three malignant lesions had a maximum diameter of less than 3 cm, and nine malignant lesions were less than 4 cm in maximum diameter. Other studies have shown that benign adrenal lesions may be large and that size is not always a good indicator of the nature of an adrenal mass [11]. A study of 45 adrenal masses larger than 5 cm in diameter reported that two thirds of such lesions were benign [28].

In our study, chemical-shift MR imaging was very accurate at identifying benign lesions. Fourteen of the 18 adenomas had an ASR of less than 70. One adenoma had an ASR of 75, and three had values of 96, 84, and 76. All 19 malignant lesions had an ASR of 75 or greater (Figs. 3B and 3C). While no malignant lesion was missed using this cutoff value for ASR, two had values that were marginal (ASR = 75 and 76). Using an ASR of 70 as a cutoff correctly identified all malignant lesions and incorrectly categorized four adenomas (22%). However, three of these four adenomas had readings of less than 0 H and were correctly diagnosed as benign by CT.

I-Other studies have examined the value of chemical-shift for diagnosing adrenal lesions [12-16]. The general conclusion of these studies is that chemical-shift MR imaging is useful for such lesions, but the results, as with the many CT studies, are not easy to compare because of the different methods used to quantify signal loss on opposed-phase images or because actual threshold values used for diagnosing lesions were not stated. The method of calculating ASR in our study was used in favor of the more cumbersome method originally described by Mitchell et al. [12] for calculating adrenal-liver ratio (ALR) and modified by Mayo-Smith et al. [16] to calculate adrenal-spleen ratio.

In the study by Mayo-Smith et al., ASR was found to be more accurate than ALR or adrenal-muscle ratio, and was calculated as follows:

\[
\text{ASR} = \left( \frac{\text{SI lesion (opposed-phase)} / \text{SI spleen (opposed-phase)}}{\text{SI lesion (in-phase)} / \text{SI spleen (in-phase)}} - 1 \right) \times 100
\]

resulting in negative values for ASR when signal loss was seen. The values for ASR and ALR in these earlier studies can be corrected to allow comparison with our study and with that of Bilbey et al. [13] by adding 100. The resulting value is the percentage of signal remaining on the opposed-phase image compared with the in-phase image. Use of a threshold of 80 for ASR as suggested by Bilbey et al. would have misclassified three malignant lesions as adenomas in our study. However, that study cannot be directly compared to ours. It was conducted at low field strength, and gradient-echo opposed-phase images were compared with spin-echo T1-weighted images rather than with gradient-echo in-phase images, as was the case in our study.

The study of Mitchell et al. [12], although it does not state the threshold used, correctly characterized 43 of 44 adrenal lesions using a corrected ALR of what appears from the graphed data to be about 80. The study by Reinig et al. [15], which found chemical-shift MR imaging to be more accurate than other quantitative measurements, including contrast enhancement and T2 values, also uses ALR. This study also does not give a threshold, but the graphed data show that an ALR of about 80 appears to be the lowest value for metastases, and several adenomas have values greater than this. A further chemical-shift study of 53 adrenal lesions was 100% accurate for differentiating adenomas from malignant lesions but did not compare the signal intensity of adrenal lesions with an internal standard such as the spleen [14]. This study concluded that a drop-off in signal intensity of over 5% on the opposed-phase images was indicative of a benign lesion.

The most recent study of chemical-shift MR imaging for adrenal lesions suggests a threshold or ASR (corrected for

Fig. 3.—54-year-old man with metastatic lung cancer confirmed by biopsy. A, CT density of lesion (arrow) is indeterminate at 15 H. B, In-phase chemical-shift image of same lesion. Signal intensity of lesion (arrow) is greater than that of spleen (S). C, On opposed-phase chemical-shift image, lesion (arrow) maintains signal intensity relative to that of spleen. ASR is 144.
comparison) of 75 [16], with no malignant lesions misclassified at this level. In our study, if an ASR threshold of 75 or less was used, one malignant lesion would have been missed (ASR = 75), and another malignant lesion had a value that would have been marginal (ASR = 76). Therefore, it seems prudent to use a lower threshold of ASR for the algorithm to avoid misclassifying malignant lesions as benign. We suggest classifying lesions with an ASR between 70 and 80 as indeterminate. In our study, all lesions with an ASR of less than 70 were adenomas. Only two of 11 lesions that were indeterminate by CT were also indeterminate by chemical-shift MR imaging using these values. Both were metastatic lesions. One CT-indeterminate adenoma was misclassified as malignant on the basis of MR imaging findings. Therefore, the use of chemical-shift MR imaging for CT-indeterminate lesions correctly identified five of six benign lesions that were indeterminate by CT. For lesions that had CT density numbers of 0 H or less (benign) or over 20 H (probably malignant), chemical-shift MR imaging provided no additional information.

Although the ASR was slightly better than CT at differentiating benign from malignant lesions overall, neither technique is infallible, and a single cutoff for CT density, size, or ASR cannot differentiate benign adrenal masses from malignant ones, as there is some overlap in all cases. Because the most important consideration is to avoid misclassifying malignant lesions as benign, any diagnostic algorithm should be sensitive to the diagnosis of malignant lesions while keeping the number of benign lesions requiring biopsy to an acceptable level. To our knowledge, malignant adrenal lesions with overall negative H values have not been described, apart from a case report of an adrenal metastasis containing a pocket of fat [29]. Therefore, such lesions that are homogeneous with readings of 0 H or less may be considered benign and require no further workup. Lesions that measure 20 H or greater may be regarded as probably malignant, although some benign lesions may have high-density readings, for example in the setting of hemorrhage. Biopsy will still be required if this is the only evidence of metastatic disease and where diagnosis of a malignant lesion would alter treatment. CT density readings between 1 H and 20 H should be considered indeterminate, and the patient should have chemical-shift MR imaging performed. In this study, about half of CT-indeterminate lesions were malignant. Chemical-shift MR imaging correctly classified five of six adenomas that were indeterminate by CT.

It is not our practice to obtain noncontrast scans through the adrenals in all patients undergoing CT of the abdomen, and about half the patients undergoing abdominal scans have IV contrast administered. For patients who have had contrast, if the CT density of an adrenal lesion is less than 0 H, the lesion can still be regarded as benign without need for further follow-up. If the density is greater than 0 H, a targeted noncontrast scan of the adrenals is usually repeated later that day or at a convenient time. There may be an argument for performing a noncontrast scan through this area routinely prior to administration of contrast, but further evaluation of the cost benefit of this practice would be required, taking into account the incidence of adrenal adenomas in the general population (2-9%) [26].

The cost–benefit ratio of MR imaging for CT-indeterminate lesions must also be taken into account. The Medicare reimbursement rate for CT-guided biopsy is comparable to the rate of reimbursement for MR imaging of the abdomen. However, the true costs are difficult to estimate precisely. The cost of a 15-min MR imaging examination should probably be about half of that of a full abdominal evaluation. The cost of a CT-guided biopsy, which usually takes longer to perform, would be expected to be higher. Although adrenal biopsy is relatively safe in experienced hands, no interventional procedure is entirely without risk. If sedation is used, the patient will have to be monitored for a period before discharge, and there is an associated cost in terms of personnel time and level of staffing and expertise required. The algorithm we propose is for patients in whom the diagnosis of a metastatic adrenal lesion will alter treatment. Obviously, in some cases, neither biopsy nor the MR examination will be indicated even if the lesion is CT-indeterminate, because the result may not alter therapy—for example, in a very elderly or otherwise ill patient, or in a patient with other evidence of metastatic disease. Similarly, in cases where the CT indicates a benign lesion, no further imaging is required. Where CT suggests that the lesion is malignant, there is no need to perform MR imaging that will not add further information; the decision to biopsy is based on how the result will affect patient management.

There are some limitations of this study that apply to all similar studies and are difficult to correct for. First, negative biopsy findings assume there is no sampling error. This may not always be the case. In this study, at least three aspirates were obtained from each lesion in which biopsy was done to reduce the possibility of sampling error. Most adenomas were proven by lack of change on follow-up imaging, with a mean follow-up time of 24 months and a minimum follow-up time of 12 months. It is also possible that some slow-growing malignant lesions would be unchanged in appearance over a 12-month period. Finally, the much rarer adrenal carcinoma can be difficult to distinguish from adrenal adenoma histologically. However, a study of 38 such lesions by Fishman et al. [30] using noncontrast CT showed that carcinomas tend to be large lesions—mostly over 6 cm in diameter—displacing adjacent organs. Central tumor necrosis, as evidenced by areas of low attenuation, and calcification are common. In that study, all carcinomas less than 6 cm in diameter had evidence of endocrine dysfunction. We do not think that any of the lesions classified as adenomas in our series resembled any of the carcinomas described in that large study. All our patients had a known primary malignancy and were thus a somewhat skewed population. In the general population, an adrenal mass is far more likely to be benign than malignant, whereas in this study about half were malignant. Most benign lesions will be diagnosed by noncontrast CT without need for further imaging (72% of adenomas were diagnosed by CT in this study, using 0 H as a threshold). For CT-indeterminate lesions in a patient with no known malignancy, it is even more desirable to diagnose such lesions without the need for biopsy or prolonged follow-up.

In conclusion, the imaging algorithm we propose is as fol-


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**Fig. 4.—** Proposed algorithmic approach to adrenal mass in oncology patient. Biopsy is indicated to prove malignancy when this result will affect patient’s management. Noncontrast CT required only if patient has not already had this examination. Number of lesions for each step in our study is shown. H = Hounsfield units; ASR = adrenal-spleen ratio.

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**Table 1:**

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