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Review

Cystic renal masses: An imaging update

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ABSTRACT

Management of incidental renal masses is in evolution. Recognition that cystic renal tumors generally act in an indolent fashion has led to less aggressive intervention. The ability of radiologists to stratify risk of malignancy, and in some cases, specify a precise diagnosis, is paramount to patient management. We review pathologies that present as cystic renal masses and how to best stratify malignancy risk.

1. Introduction

Cystic renal masses are commonly encountered in clinical practice. Improved resolution of imaging modalities has, in part, led to the improved ability to detect these abnormalities. It is important to recognize and appropriately characterize cystic renal masses, as they are generally low-grade, low-stage and less aggressive than their solid counterparts as has been recently noted in the American Urologic Association guidelines for management of localized neoplasms [1–4]. While there is considerable overlap in the imaging features of cystic renal masses and histologic examination is often required for definitive diagnosis, in some cases, unique imaging features, when combined with demographic information, can help stratify patient risk and guide therapy. As such, appropriate characterization of cystic lesions may guide surgeons toward nephron-sparing surgical techniques.

Cystic renal masses have variable radiological features and can be categorized as acquired, neoplastic, or congenital in etiology. We review the spectrum of cystic renal lesions including benign entities (simple, proteinaceous and hemorrhagic cysts, localized renal cystic disease, and mixed epithelial and stromal tumor family), as well as, the subtypes of renal cell carcinoma that may manifest as a cystic renal mass (clear cell, multilocular cystic, papillary, and the newly defined tubulocystic and acquired cystic disease-associated renal cell carcinoma).

2. Characterizing cystic lesions

The Bosniak classification system (Fig. 1), originally developed in 1986 and subsequently updated, is a commonly used system using CT to risk-stratify cystic renal lesions [5–7]. In the system, lesions are graded from I to IV based on imaging features, with increasing category demonstrating higher likelihood of malignancy. Since the Bosniak uses a qualitative approach to classification, some variability in interpretation is to be expected, particularly with grading II, IIF, and III lesions. Studies have reported “good” intra- and inter-observer agreement (weighted $\kappa \geq 0.69$) to “very good” intra- and inter-observer agreement (weighted $\kappa \geq 0.85$) among readers [8,9].

In short, Bosniak I or II lesions describe water-attenuation cysts with no thick or enhancing septa. These lesions have essentially no risk of malignancy and require no additional imaging surveillance. Bosniak IIF lesions are usually benign, but follow-up is indicated to identify morphologic change or new areas of enhancement over time. Approximately 11%-15% of Bosniak IIF lesions will become malignant within 6 months to 4 years [10,11]. Two studies evaluating outcomes in these patients found no metastasis or locally advanced disease at the time of upgrade, which suggests that conservative imaging follow-up for these lesions is appropriate [10,12].

Bosniak III cysts have enhancing thickened and irregular walls or septa and are more challenging for radiologic interpretation, as a wide range of malignancy rates have been reported, ranging from 31 to 100% [4,11–17]. However, many of these studies were performed with small study populations, older equipment, and before and after the designation of Bosniak IIF. Though one study performed after the introduction of the Bosniak IIF category found a malignancy rate of 82% [11], larger and more recent studies suggest the true malignancy rate is between 54% and 72% [4,12,16,17]. Bosniak IV lesions have distinct nodular enhancing components and are clearly malignant with malignancy rates at excision of 85–86% [4,17]. The presence of an enhancing nodule alone is a strong predictor of malignancy and the larger the solid component, the higher the rate of malignancy [4].

Lesions graded III or IV generally require surgical intervention. However, the natural history of the Bosniak IIF-IV cysts is difficult to

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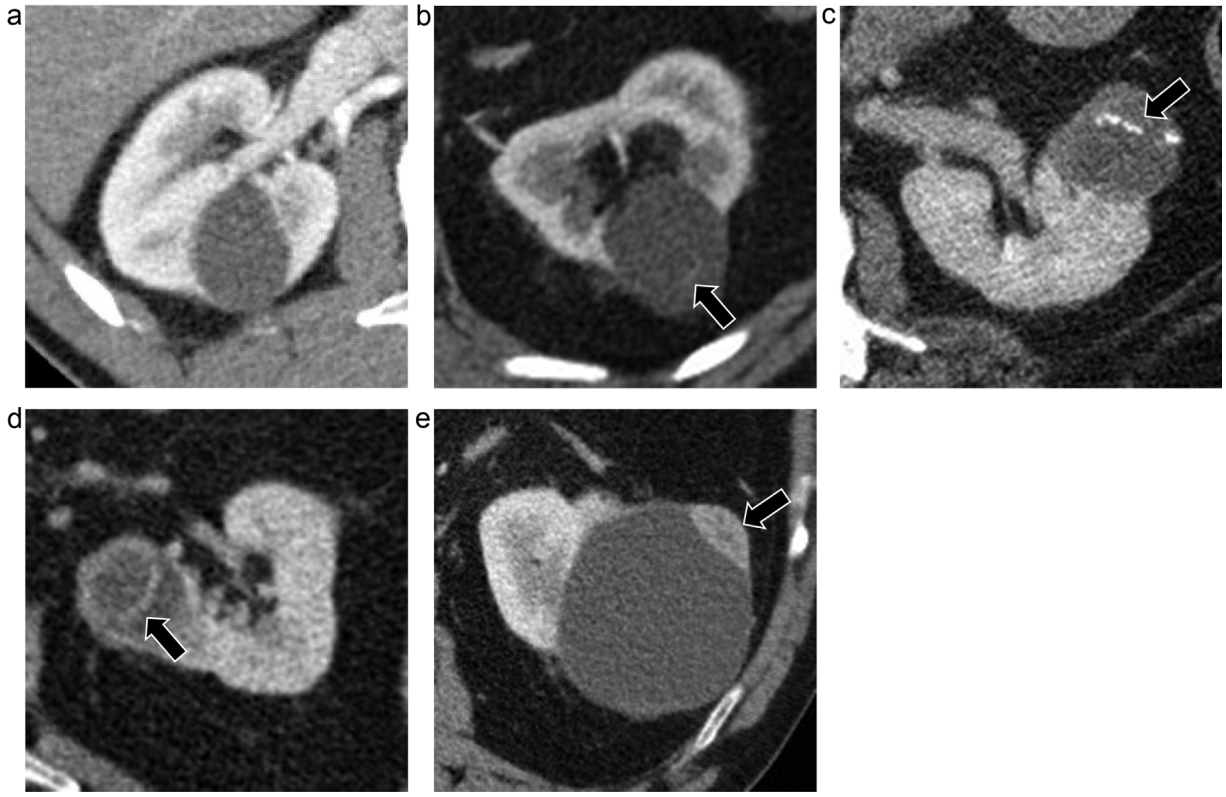

Fig. 1. Bosniak Classification System.

predict. Studies modeling risk factors to include lesion size, body mass index, and previous history of renal cell carcinoma has shown some promise in predicting which of these lesions are malignant [18]. The recent AUA management guidelines recommend that active surveillance is an option for Bosniak III or IV lesions, especially if < 2 cm and that active surveillance or expectant management should be prioritized when the risk of intervention or risk of death from comorbidities outweigh the potential oncologic benefit of active treatment [3].

A recent *meta*-analysis found that the Bosniak system is 89.6% sensitive and 65.1% specific for detecting malignancy [19] and other studies have provided similar validation, provided that a dedicated renal CT is performed [15]. Attempts have been made to prospectively and retrospectively apply the Bosniak criteria using MRI and contrast-enhanced ultrasound. One challenge with applying the criteria across modalities is that the criteria for each category appear intrinsically different, for example, the improved contrast resolution and contrast enhancement of MRI makes enhancing septa appear thicker which may cause the reader to upgrade the lesion. Nonetheless, some lesions are upgraded while others are downgraded keeping overall concordance rates of approximately 80% [20].

It is important to note that the Bosniak system emphasizes enhancement pattern and morphology rather than size. However, lesions must be of sufficient size to adequately assess enhancement characteristics. In the case of subcentimeter lesions, extra care must be taken in the evaluation after administration of contrast, as the attenuation of lesions that would otherwise measure < 10HU can be artificially increased through a phenomenon known as pseudoenhancement. This effect becomes more pronounced with patient-level factors such as smaller lesion size and greater enhancement of adjacent parenchyma and technical factors such as increased iodine concentration and decreasing peak kV [21,22]. MRI with subtraction imaging can be a useful tool to problem-solve in equivocal cases.

In general, the smaller the lesion is, the more likely it is to be benign. While there remains a dearth of data on outcomes of patients with < 1.5 cm lesions, patient age and history should be considered in the evaluation [23] and sub-centimeter cystic appearing masses that are homogenously low in attenuation without apparent enhancement, nodularity, or calcifications generally may not warrant further workup because, in the adult population, they are highly likely to be simple cysts [24–26].

3. Indeterminate cystic lesions

A lesion measuring 20–70HU on pre- or post-contrast (in the absence of a comparative non-contrast CT) imaging is considered hyperdense and indeterminate in that it may represent a proteinaceous or hemorrhagic cyst, or a poorly vascularized renal cell carcinoma, as there is some overlap in attenuation amongst these entities. This “danger zone” has been reinforced with one study finding the average minimum HU in malignant tumors to be 27.5, with regional areas of minimum attenuation < 20HU in 24.9% of cases [27]. However, almost all RCC in the study had at least some areas of attenuation measuring between 20 and 70 HU. Another study found that on post-contrast images, a homogenous simple renal cyst may measure up to 30HU whereas homogenous RCC can measure as low as 42 HU [28]. These studies reinforce the notion that lesion heterogeneity is an important characteristic to evaluate, because in general, the more heterogeneous the renal mass, the more likely it is to be malignant.

Since most routine abdominal CTs are performed with a single phase, timed to opacify the portal-venous system, lesions > 20HU are indeterminate because there is no non-contrast CT with which to compare and the true enhancement is unknown. Current recommendations suggest that these hyperdense lesions are incompletely evaluated and need further assessment with a dedicated renal CT or MRI to be appropriately characterized into the Bosniak system [26].