

Cystic Renal Masses: Usefulness of the Bosniak Classification

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Abstract. To determine the usefulness of the Bosniak classification of cystic renal masses, the computed tomographic (CT) and ultrasound findings of 16 pathologically proven cystic renal masses were retrospectively reviewed. All imaging studies were reviewed and categorized utilizing the Bosniak classification without knowledge of the final pathologic diagnosis. There were no category I lesions (classical simple cyst), four category II (minimally complicated), seven category III lesions (more complicated), and five category IV lesions (probable malignant). All category II lesions were benign, all category IV lesions were malignant. Of the seven category III lesions, three were benign and four were malignant. We conclude that the Bosniak classification is extremely useful in the management of cystic renal masses.

Key words: Kidney, CT, US — Kidney neoplasms — Kidney cyst — Kidney neoplasm diagnosis.

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In 1979 McClennan *et al.* carefully evaluated the computed tomographic (CT) findings of 56 cytologically verified benign renal cysts [1]. This landmark paper established the CT criteria for a simple cyst and concluded that cyst aspiration need not be performed when lesions meet all CT criteria for a benign cyst. In 1985 Rosenberg *et al.* concluded that “one or more thin septations alone (within an otherwise simple cyst) is probably of no clinical significance” [2].

In 1986 Bosniak suggested categorizing cystic renal masses in an attempt to broaden the radiologic findings for lesions not requiring surgery or for those which should be explored surgically in an attempt to salvage normal renal parenchyma [3]. In addition to the classic benign cyst (category I), Bosniak felt “minimally complicated” cysts (category II) need not be operated upon [3]. Lesions in this category included septated cysts, minimally calcified cysts, infected cysts, and high-density cysts [3]. According to Bosniak “more complicated cystic lesions” (category III) should be explored surgically (unless clinically contraindicated) but often could be managed by parenchymal sparing procedures (*e.g.*, open biopsy, enucleation, and heminephrectomy) [3]. Category IV lesions were obvious cystic malignancies best treated by radical nephrectomy [3]. This “state-of-the-art” article was based upon extensive personal experience, but verifiable results were not published [3].

Since this time, few pathologically proven series have been published to confirm or refute the ac-

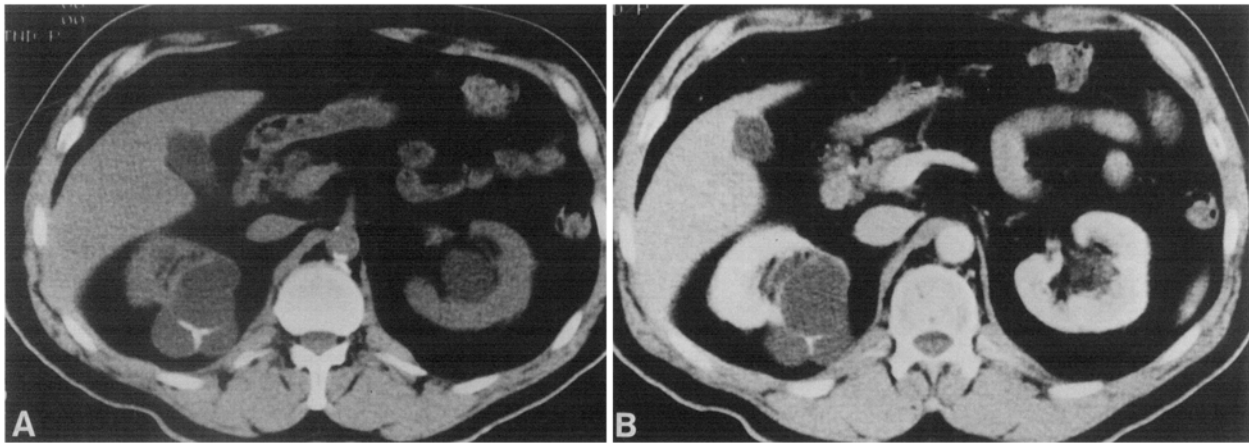


Fig. 1. Benign calcified cyst (category II). Unenhanced CT scan (A) demonstrates a cluster of three cysts in the right kidney with thin septal calcifications. There was no enhancement following intravenous contrast administration (B).

Table 1. Radiologic-pathologic findings

Radiologic finding	Bosniak category	Number	Pathology	
			Benign	Malignant
Thin (≤ 1 mm) septation	II	2	2	
Thin, fine calcification	II	2	2	
Thick, irregular calcification	III	1	1	
Multiloculated mass	III	2		2
Nodularity (nonenhancing)	III	1	1	
Thick wall (uniform)	III	2	1	1
Indeterminate hyperdense	III	1		1
Nodularity (enhancing or large)	IV	1		1
Thick wall (nonuniform or enhancing)	IV	2		2
Solid component	IV	2		2
Total		16	7	9

curacy of this categorization. We are aware of only one published abstract which retrospectively analyzed the predictive value of this classification [4]. The purpose of this paper is to correlate the radiologic and pathologic findings of 16 pathologically proven cystic renal masses and to evaluate the accuracy of the Bosniak classification.

Materials and Methods

Between 1986 and 1990, 72 nephrectomies or local excisions were performed at the National Naval Medical Center to remove suspicious renal masses. Fifteen patients had a total of 16 cystic masses not fulfilling the radiologic criteria of an uncomplicated simple cyst.

All masses were evaluated by CT (General Electric 9800 or 8800). Sonography was performed on 11 of these cases utilizing a variety of commercially available scanners. All imaging studies were reviewed without knowledge of the final pathologic diagnosis. Masses were evaluated for wall thickness, enhancement,

calcification, septation, density number, nodularity, presence of a solid component, and homogeneity of the cyst fluid. All masses were categorized according to the criteria established by Bosniak [3]. These observations were then correlated with the surgical and pathologic results.

Results

There were three women and 12 men ranging in age from 27 to 67 years, with a mean age of 53 years. The radiologic and pathologic findings of the 16 cystic masses are summarized in Table 1. There were no category I (classic simple cyst) masses in this series. All four category II masses were benign and all five category IV masses were malignant. Three of the seven category III masses were benign and four were malignant.

Discussion

The results of this study support the hypothesis that cystic renal masses can be accurately categorized and that practical management decisions can be based upon this categorization [3, 4]. In addition to the classical simple cyst (category I), cysts with thin (< 1 mm), smooth septa, with thin, fine calcifications, or "benign" hyperdense cysts (all category II lesions) can be considered benign and do not require surgery [2, 3]. All four category II cases in this series and the four category II cases in Brown's series were benign [4].

It is imperative that these "minimally complicated" cysts be carefully scrutinized [3]. A calcified cyst is considered benign only when (1) the calcium is thin and is in the wall or septa; (2) there is no associated soft tissue mass; (3) the center of the mass is of water density; and (4) no portion of the mass enhances (Fig. 1) [3, 5]. A calcified cyst cannot be

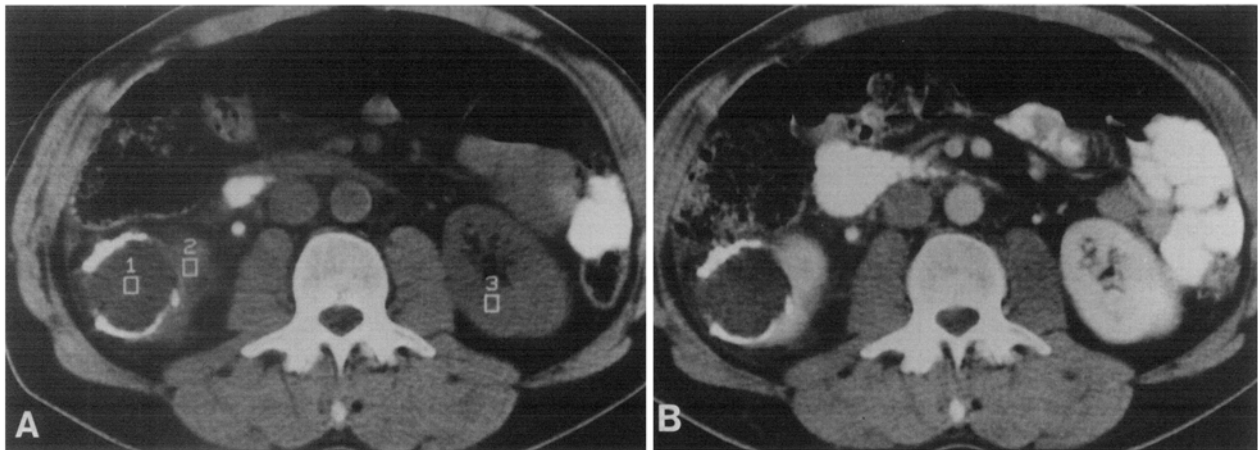


Fig. 2. Thick calcification (category III). Despite the presence of thick irregular mural calcifications, the mass was a benign cyst: Unenhanced (A); enhanced (B) scans.

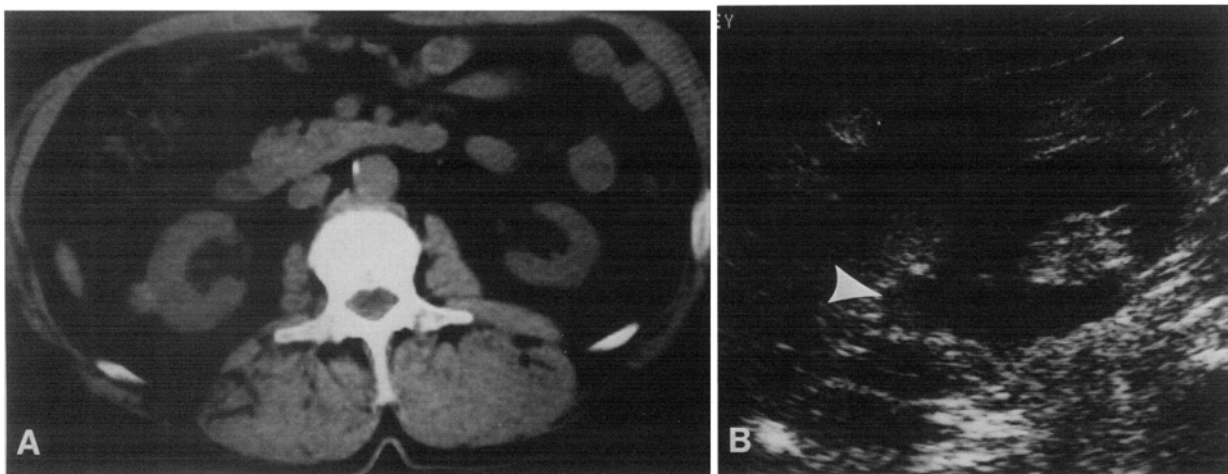


Fig. 3. Indeterminate hyperdense mass (category III). Unenhanced CT (A) demonstrates a small, exophytic right renal mass. The mass is slightly heterogeneous. Contrast could not be administered in this case. Ultrasound shows that the mass (arrowhead) is not cystic. Nephrectomy confirmed that the mass was a renal cell carcinoma.

considered benign (category II) when (1) there is thick, irregular, extensive calcification especially when nonperipheral (Fig. 2); (2) a soft tissue mass extends beyond the calcification; (3) the center of the mass is not water density; (4) noncalcified areas of the cyst wall demonstrate thickening; and (5) any portion of the mass enhances [3, 5–8]. On pathologic examination, some of these masses may indeed be benign, however (Fig. 2).

One or more septations within a cystic mass are not uncommonly detected on CT or sonographic examination. Septations may result from two adjacent cysts sharing a common wall or may be a manifestation of healing or organization of a cyst which has been complicated by hemorrhage or infection. Septations are often partial.

Before a septated cyst is considered category II, it is important to be certain that all septa are thin (1 mm or less), smooth, and attached to the walls without associated thickened elements [2, 3]. Delicate calcification in thin septa is occasionally encountered (Fig. 1). Irregularity of the septa, thickness greater than 1 mm, or associated solid elements at the septal attachment, however, are indications that the lesion might be malignant and further evaluation is warranted.

Hyperdense cysts were also included in category II by Bosniak [3]. The following CT criteria must be present for a hyperdense cyst to be considered benign: (a) the lesion must be perfectly smooth, round, sharply margined, and homogeneous; (b) the lesion must not enhance upon intravenous ad-

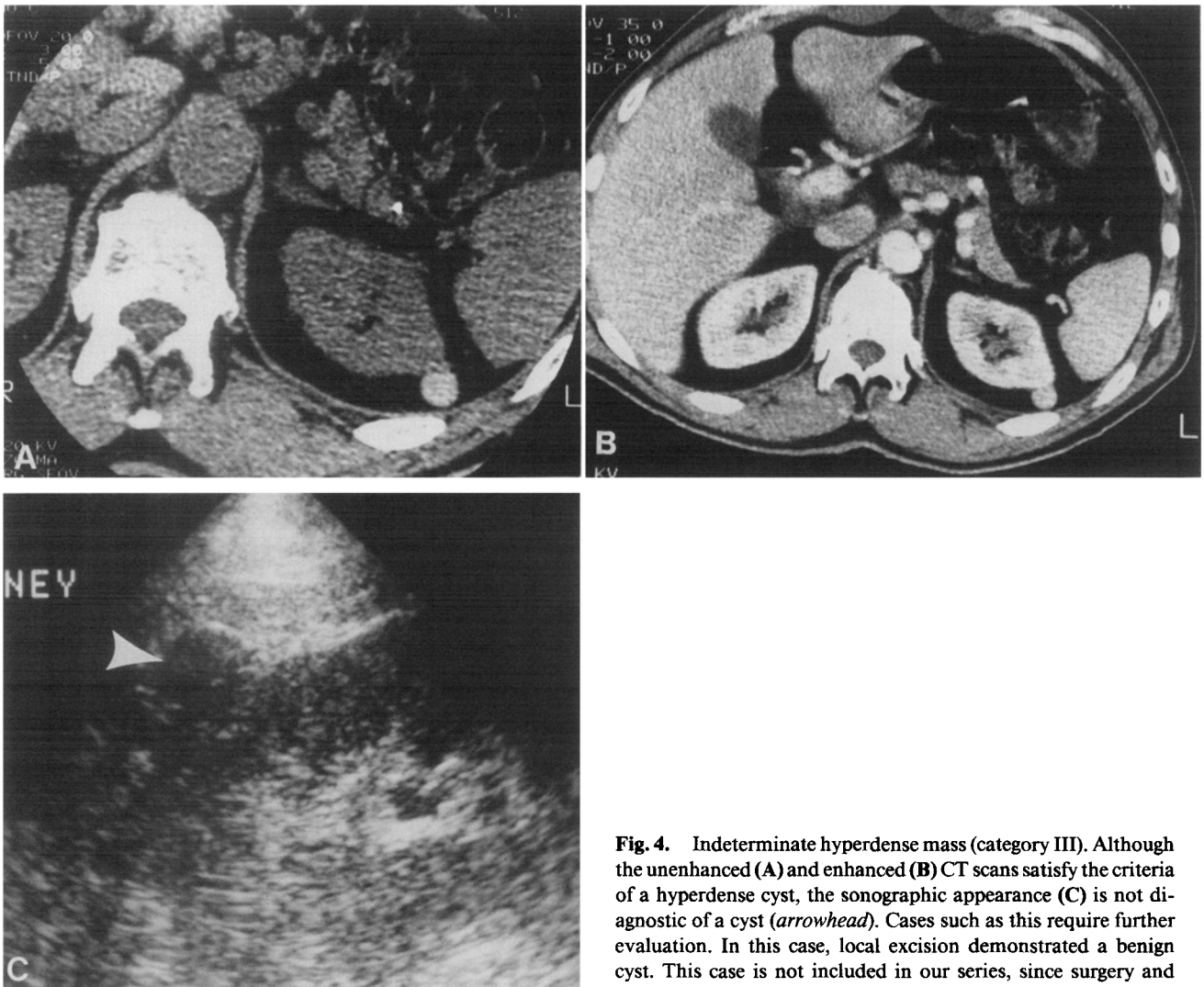


Fig. 4. Indeterminate hyperdense mass (category III). Although the unenhanced (A) and enhanced (B) CT scans satisfy the criteria of a hyperdense cyst, the sonographic appearance (C) is not diagnostic of a cyst (*arrowhead*). Cases such as this require further evaluation. In this case, local excision demonstrated a benign cyst. This case is not included in our series, since surgery and pathologic evaluation were performed elsewhere.

ministration of contrast material and its configuration must remain unchanged; and (c) the lesion must be 3 cm or less in size [3]. Three centimeters was chosen based upon the availability of proved case material. Volume averaging of adjacent tissues may spuriously increase the attenuation coefficient of small lesions on enhanced scans [9]. Thus, nonenhancing cysts may appear to enhance. Cysts with inhomogeneous areas of hyperdensity cannot be considered benign.

Sonography may be complementary to CT to confirm that a presumed hyperdense mass is indeed a cyst and, therefore, benign. Careful sonographic examination is especially helpful in cases in which contrast cannot be given, masses greater than 3 cm, and hyperdense masses still indeterminate after careful CT [3, 10]. A hyperdense mass in our series was inhomogeneous on CT, was not clearly cystic on ultrasound (therefore a category III lesion), and

proved to be a renal cell carcinoma at surgery (Fig. 3) [11]. Some hyperdense cysts which appear benign on CT examination may appear solid sonographically or may show scattered internal echoes possibly due to the semisolid material or clot retraction which may be present pathologically (Fig. 4) [9, 10, 12, 13].

A hyperdense mass is considered indeterminate or malignant when any of the following CT or ultrasound features are noted: (1) inhomogeneous texture, (2) lack of a smooth contour, (3) lack of a sharp interface, (4) enhancement, and (5) solid on sonographic examination (Figs. 3 and 4). Baum *et al.* reported a case of a 2.5-cm, hyperdense, nonenhancing mass in which sonography was not performed [14]. Subsequent surgery demonstrated a solid renal cell carcinoma with several smaller "satellite" tumor nodules which had not been detected radiologically [14]. The patient was evaluated uti-

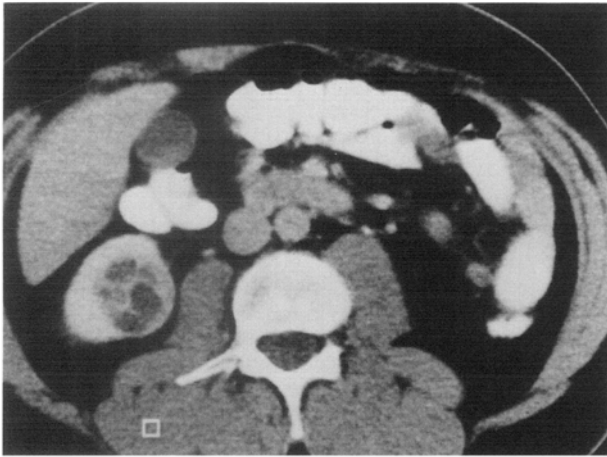


Fig. 5. Multiloculated renal cell carcinoma (category III). The patient was a 47-year-old man. Enhanced CT scan shows a multiloculated renal mass. Nephrectomy confirmed that the mass was a renal cell carcinoma.

lizing 10-mm cuts, and Baum *et al.* speculates that enhancement (or inhomogeneity) might have been detected if 5-mm sections had been taken [14]. The validity of this case report must also be questioned, since the attenuation of the mass *decreased* from 52 to 33 HU after intravenous contrast [14].

CT is probably more accurate than ultrasound in the evaluation of hyperdense masses. Indeed, if all CT criteria for a benign hyperdense cyst are present, ultrasound may be unnecessary and, if performed, may be confusing (Fig. 4). We are unaware of any large pathologically proven series comparing the accuracy of these two procedures in evaluating hyperdense masses.

When all criteria for benign hyperdense cysts are present, no further evaluation is required [3]. If it is not certain that the hyperdense mass is a benign hyperdense cyst, however, further evaluation is mandatory. In perplexing or indeterminate cases, puncture with opacification might prove helpful [3]. If the cytology is normal and there are no suspicious findings morphologically, conservative management similar to that of a benign cyst is sufficient. Exploratory surgery and/or nephrectomy should be performed in cases in which aspiration results are equivocal or indicative of a neoplastic process [15]. Cyst puncture may be difficult, especially if the cyst contains a firm coagulum, and cytologic results may be confusing if the fluid is hemorrhagic [13, 15].

Bosniak considered infected cysts to be category II lesions [3]. Although there were no infected cysts in our series, a diagnosis based solely on radiologic findings is usually not possible. Rather, when a diagnosis of focal renal infection is present clinically and imaging studies are consistent with an infected

cyst, the diagnosis is best confirmed utilizing cyst puncture.

Radiologic findings for category III masses include: inhomogeneous cyst fluid, thick irregular calcification (Fig. 2), the presence of a multiloculated mass (Fig. 5), small nonenhancing nodularity (Fig. 6), and uniform wall thickening (Fig. 7). It is impossible to predict utilizing radiology alone, whether category III lesions will be benign or malignant. In our series, of the seven category III masses, three were benign and four were malignant. Nine of 12 category III lesions reported by Brown were benign [4]. Because these findings may be present in benign or malignant masses, some form of tissue and/or cytologic confirmation is mandatory.

While many diverse disease processes may result in multiloculated renal masses, the two most common in the adult are renal cell carcinoma and multilocular cystic nephroma [16]. Multiloculated renal cell carcinoma (Fig. 5) more commonly affects men than women, whereas in the adult, multilocular cystic nephroma is much more common in women. Approximately 50% of cases of von Hippel Lindau syndrome have one or more renal cell carcinomas, which are frequently multiloculated.

The multilocular cystic nephroma is an uncommon, nonhereditary cystic neoplasm. It is characterized by a well-developed capsule, fibrous stroma, and septa that separate multiple epithelial lined, noncommunicating cysts [17]. There is a bimodal age distribution: the lesion most often occurs in infants and children from 3 months to 4 years, or in adults in the fourth through the eighth decades. In children, boys are more commonly affected; however, in the adult group, there is a predominance in women. The clinical findings are nonspecific.

Although there are no unequivocally reliable diagnostic signs to help determine the malignant potential of the multilocular renal lesions, differentiation between multiloculated renal cell carcinoma and multilocular cystic nephroma is often possible [16]. The presence of intravascular extension or distant metastases favors the diagnosis of renal cell carcinoma. Calcification may be seen in either tumor. Other features suggestive of renal cell carcinoma include blood on CT or cyst puncture, relatively large solid areas within the tumor mass on sonography or CT, and discrete hypervascular foci on angiography.

In the adult, the multilocular cystic nephroma is almost always seen in women. At any age, herniation of a multilocular cystic lesion into the renal pelvis is highly suggestive of multilocular cystic nephroma. Hemorrhage within a multilocular cystic

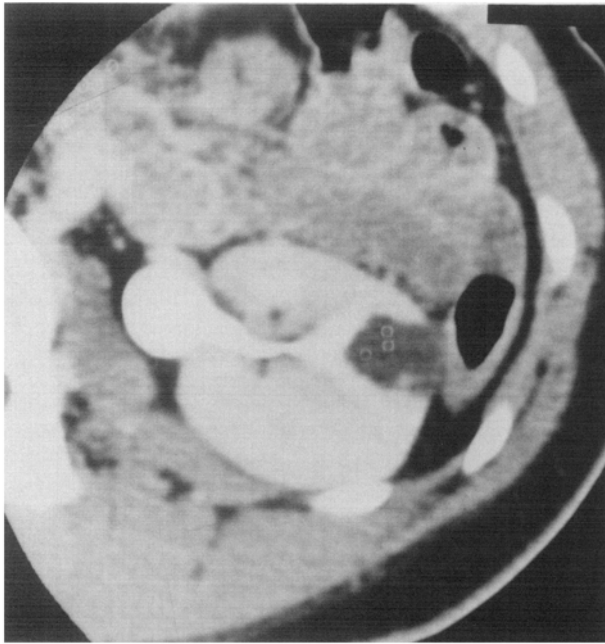


Fig. 6. Small nonenhancing nodularity (category III). Enhanced CT demonstrates a well-circumscribed but slightly lobulated mass in the lateral aspect of the left kidney with CT numbers of 20 and a small mural nodule posteriorly. The nodule did not enhance. The mass was enucleated. On cut section, several peripheral trabeculae projected into the lumen of the mass. Careful microscopic evaluation demonstrated no evidence of malignancy.

nephroma is extremely uncommon. When blood is detected on gross examination, CT, or cyst puncture, a presumptive diagnosis of a malignant neoplasm should be considered. Although both are treated surgically, multiloculated renal cell carcinoma should be treated by radical nephrectomy, whereas multilocular cystic nephroma can be successfully treated by local excision [17].

One of the most worrisome features that can be observed in a cystic mass is the presence of a large solid nodular component, especially if the nodule enhances. Any evidence of solid tissue within the cyst wall or a mass abutting the wall excludes the radiologic diagnosis of a benign cyst. When present, malignant nodules are frequently in the base of the cyst near the normal parenchyma and enhance [18]. Occasionally, normal renal parenchyma may protrude into a simple cyst and mimic a tumor nodule [19]. Likewise, incomplete septa or trabeculated cysts may appear to have a mural nodule (Fig. 6). The presence of nodularity mandates further evaluation. Very small nonenhancing nodules not in the base of a cyst can be considered category III lesions (Fig. 6). Large, enhancing nodules, especially when multiple, in the base of a cyst, must be classified as category IV masses.

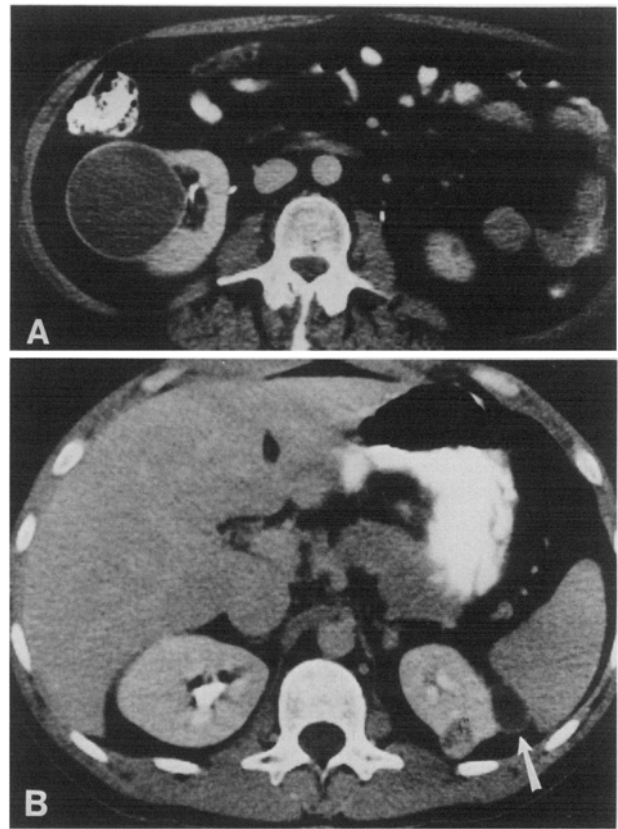


Fig. 7. Two cases of wall thickening (category III). **A** Benign cyst. Enhanced CT demonstrates a well-circumscribed cystic mass in the right kidney with diffuse, uniform wall thickening. Because cystic renal cell carcinoma could not be excluded, the mass was removed. Pathologic examination showed no evidence of malignancy. **B** Renal cell carcinoma. Enhanced CT scan shows a cystic mass (12 HU) with uniform wall thickening (arrow) in the left kidney. A second mass posteriorly was felt to be a solid malignant tumor. At surgery both masses were renal cell carcinoma.

The wall of a simple uncomplicated cyst is imperceptible. The radiologic detection of a thick wall precludes the diagnosis of a simple uncomplicated cyst and, therefore, requires further evaluation. Although a thick-walled cystic mass may be seen in cases of benign nonneoplastic cysts (Fig. 7A), such as an infected cyst, abscess, or organizing hematoma, it may be the only manifestation of a cystic renal cell carcinoma (Fig. 7B). A beak of normal renal parenchyma adjacent to a cyst may give the illusion of a thick-walled cyst on axial images and can lead to an erroneous diagnosis of a thick-walled malignancy [20].

Lesions with enhancing nodularity, nonuniform wall thickening or enhancement (Fig. 8), and/or an obvious solid mass are category IV lesions, and are usually treated by radical nephrectomy. All five of our category IV lesions were malignant and four of six cases reported by Brown were malignant [4].

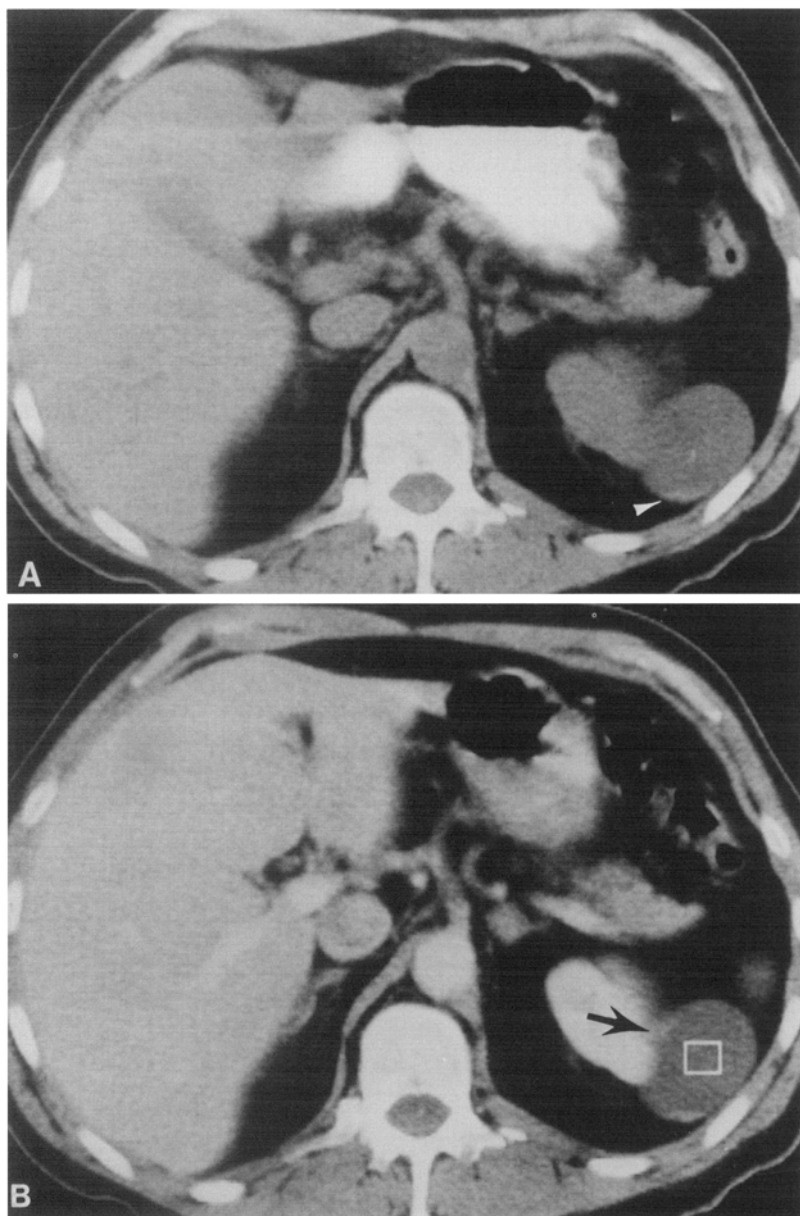


Fig. 8. Focal wall thickening with enhancement (category IV). Unenhanced CT scan (A) shows a well-defined cystic mass with a focal thickening of its dorsal wall (*arrowhead*). On the enhanced CT scan (B) this thickened segment enhanced from 50 to 80 HU. The enhancement near the renal margin (*arrow*) could be a beak of normal enhancing parenchyma or a second area of wall thickening. At surgery, frozen sections were negative. Permanent sections demonstrated well-differentiated renal cell carcinoma lining the entire cyst.

Summary

We conclude from this series and a review of the reported cases in the literature that the Bosniak classification of cystic renal masses is an extremely useful management tool. The following cystic renal masses do not require surgery, cyst puncture, or radiologic follow-up: (a) classical simple cyst, (b) "benign" appearing calcifications, (c) thin, nonnodular septations, and (d) "benign" appearing hyperdense cysts.

All other cystic renal masses need further evaluation which might include follow-up radiologic studies, cyst puncture, local excision, or nephrec-

tomy. Masses demonstrating inhomogeneous cyst fluid, thick irregular calcification, the presence of multiple locules, small nonenhancing nodules, or uniform wall thickening are considered category III and may be benign or malignant.

Cystic masses with an associated solid component, enhancing nodularity, and nonuniform wall thickening (category IV) are almost always malignant and are usually managed by nephrectomy.

Addendum. Four additional cystic renal masses have been explored since this manuscript was submitted for publication. Two of the cysts were category III lesions and two were category IV lesions. Both category IV lesions were malignant. However, in

keeping with our previous results, 50% of our category III lesions were malignant. Radical nephrectomy continues to be the mode of management of category IV lesions, but partial nephrectomy, when possible, has been used to manage category III lesions.

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