The Bosniak classification of renal cystic masses

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INTRODUCTION

The increasing use of ultrasonography (US) and CT over the last 30 years has led to the frequent discovery of asymptomatic renal masses. Simple cysts and solid tumours are usually straightforward to diagnose, but differentiating between complex renal cysts and cystic renal tumours can be difficult. There is a narrow margin between performing unnecessary surgery and missing a cancer; ≈6% of asymptomatic renal masses are cystic renal cancers [1]. The Bosniak classification of renal cystic masses is widely used to assist clinical decisions, but has not been prospectively evaluated. This review draws together the available evidence on the use of this classification and assesses alternative techniques for evaluating complex renal cysts.

DIAGNOSIS OF RENAL MASSES

The principle techniques for imaging renal masses are US and CT, and when all diagnostic criteria are present the accuracy of a well conducted scan is very high [2]. MRI is used infrequently [3], and there have been no large pathologically confirmed studies to assess the accuracy of MRI for simple cysts. Selective angiography can help to diagnose small indeterminate masses, but a negative angiogram cannot exclude malignancy. Cyst puncture is also less frequently used at present; it is only really useful if malignant cells are seen, but occasionally it might help with the diagnosis of infected cysts. Hayakawa *et al.* [4] reported positive preoperative aspiration cytology in only 14% of cysts later shown to be RCC.

RENAL CYSTS

Benign cystic renal disease is very common in the general population; about half of the population aged >50 years have renal cysts [5]. Most cysts are benign and asymptomatic. A palpable mass, pain from haemorrhage into the cyst, obstructive symptoms and infections are rare presentations. A simple cyst is a fluid-filled, non-neoplastic lesion; most are unilocular, contain straw-coloured fluid, arise from the cortex and are smooth-walled. On CT they are sharply marginated, round, smooth, homogenous and thin-walled, and have attenuation values of −10 to 20 Hounsfield Units (HU), with no enhancement on administration of intravenous contrast medium.

RENAL CYSTIC CARCINOMA

RCC accounts for 85% of all renal malignancies, and affects 6–8 per 100 000 persons. Most RCCs are incidental discoveries on imaging, and only 10% present with the 'classic triad' of loin pain, haematuria and a palpable mass. RCCs are usually solid, but 5–7% are cystic; cystic tumours usually have a slower growth rate, more favourable pathological stage and lower histological grade, and thus have a better prognosis [6]. Simple cysts are easy to differentiate from cystic RCC, but as cysts become more complex the differentiation becomes less clear and the probability of malignancy increases. Up to 8% of renal cysts do not meet the strict criteria for a simple cyst or cystic neoplasm and are therefore indeterminate. Features which arouse suspicion of malignancy are:

- Calcification; although a small amount of calcification in the wall or septa might be benign.
- Abnormal density; masses with a density >20 HU do not meet the criterion for cysts. A change of >10 HU before and after contrast studies suggests vascularity.
- Septations; if thin and smooth, these can be considered benign. Signs of malignancy include irregularity and thickness >1 mm.
- Nodularity; solid tissue within the cyst wall indicates malignancy.
- Wall thickening; the wall of a simple cyst is imperceptible.
- Small masses; these are difficult to image and are therefore indeterminate [7].

Several studies have examined pathologically confirmed cystic RCCs to assess whether they have distinctive radiological features. Parienty *et al.* [1] examined 15 cystic tumours and identified four criteria helpful for diagnosis. In 15 cases the characteristic CT pattern included size ≥10 cm (12 tumours), localized thickening of cyst walls with contrast enhancement (all 15), irregularly and poorly defined implantation in the kidney (14 tumours), and heterogeneous cyst contents (six tumours). They considered that they had never seen a cystic RCC that was truly misleading on CT, as at least one view would show enhancing neoplastic tissue. However, despite the increased accuracy of radiological techniques, the diagnosis is still difficult; RCC might have a cystic growth pattern and cysts might appear complex, particularly after haemorrhage or infection.

THE ORIGINAL BOSNIAK CLASSIFICATION OF RENAL CYSTS

In 1986, Bosniak [8] proposed a classification of renal cysts. The diagnosis and management of complex renal cysts was contentious, and a combination of CT, US and urography was being used to distinguish between benign and malignant lesions. Bosniak described the US features of a benign lesion; good 'through transmission', no echoes within the mass, and sharply marginated smooth walls. He noted the potential difficulties with US, such as clustering of cysts, vascular malformations and operator variability. He also described the CT findings suspicious for malignancy; septa, calcification, irregular margins, solid vascular elements, and high-density cyst fluid (20 HU is the acceptable upper limit of water density [9]). All these features have spectra of severity and in isolation might not cause concern.

The classification (Table 1) assigns simple cysts into category I, and benign cystic lesions with minimal complications into category II; neither of these requires intervention.

Category III contains more complicated cystic lesions that show some radiological features of malignancy, and should be explored surgically. Category IV lesions are clearly malignant. Bosniak emphasized the need for the diligent use of standardized imaging studies to diagnose complex cysts, and the need for experience when diagnosing difficult lesions.

DEVELOPMENT OF THE BOSNIAK CLASSIFICATION SYSTEM

The Bosniak classification is simple and elegant, and was widely adopted, but some problems led to later modifications [10]. Hyperdense cysts are a distinctive finding; those which are hypodense or isodense after giving intravenous contrast medium can be assumed to be benign as long as they have no other malignant characteristics, but concern is raised if cysts remain hyperdense after intravenous contrast medium. Bosniak defined the criteria for diagnosing benign hyperdense cysts [2,11] as a cyst diameter of <3 cm; the cyst must extend outside the kidney; the lesion must be round, sharply marginated and homogenous; and show no enhancement.

In a follow-up paper in 1997, Bosniak [12] acknowledged that the separation between some of the categories was not clear, and attempted to establish when the system can be definitively used. With high-quality radiological examinations, Bosniak claimed that category I and IV cysts can be diagnosed with virtually complete accuracy. Problems arise in differentiating between category II and III cysts, and Bosniak suggested that they should be categorized by the feature of the lesion causing most concern. If there are doubts about a lesion it should be placed in category III and explored, but otherwise follow-up scans should be at 6 months and 1 year. If the lesion is stable after this time it can be considered benign. Bosniak suggested a new IIF category; cysts that are not complex enough to be in category III but too complicated for category II (Table 1). A retrospective review of 41 patients with category IIF lesions with a mean follow-up of nearly 6 years showed that 36 masses remained unchanged on CT and three decreased in size; all were considered benign. Two lesions increased in size and were removed, both being found to be RCCs [13].

TABLE 1 The Bosniak classification of renal cysts

Bosniak category	Features
I	A simple benign cyst with a hairline thin wall that does not contain septa, calcification or solid components. It measures as water density and does not enhance with contrast material.
II	A benign cyst that might contain a few hairline thin septa. Fine calcification might be present in the wall or septa. Uniformly high-attenuation lesions of <3 cm that are sharply marginated and do not enhance.
IIF	These cysts might contain more hairline thin septa. Minimal enhancement of a hairline thin septum or wall can be seen and there might be minimal thickening of the septa or wall. The cyst might contain calcification that might be nodular and thick but there is no contrast enhancement. There are no enhancing soft-tissue elements. Totally intrarenal non-enhancing high-attenuation renal lesions of ≥3 cm are also included in this category. These lesions are generally well marginated.
III	These lesions are indeterminate cystic masses that have thickened irregular walls or septa in which enhancement can be seen.
IV	These lesions are clearly malignant cystic lesions that contain enhancing soft-tissue components.

TABLE 2 The amount of cystic calcification as a predictor of malignancy [14]

Bosniak category	N lesions	Mean Ca score	N malignant cysts found at surgery	N cases with no pathological findings on f/u
II	21	1.4	0/0	21
IIF	19	3.1	0/3	16
III	25	2.1	9/21	4
IV	16	2.2	16/16	0

A further retrospective study in 2003 [14] attempted to evaluate whether calcification in cystic renal masses is important; calcification was scored on a scale of 1–4 in 81 lesions (Table 2). The authors concluded that many lesions containing larger amounts of calcium could be safely followed as long as there are no other features of malignancy, but lesions showing soft-tissue enhancement should be placed in category III and explored surgically.

EVIDENCE TO SUPPORT THE BOSNIAK CLASSIFICATION

Several studies have examined the reliability of the Bosniak classification (Table 3) [5,15–21,23]. All of these studies suffer from the usual criticisms of retrospective series, and involve a considerable selection bias, as most patients had a surgical intervention. However, they are the only information presently available for assessing the validity of the classification.

Aronson *et al.* [15] correlated the radiological and pathological findings of 16 complex renal cysts. All of the category II lesions were benign, but four of seven category III and all category IV cysts were malignant.

Cloix *et al.* [16] assessed 30 patients with 32 complex renal cysts; CT and US were retrospectively analysed, categorized and compared with pathological findings. They found that 13 of 32 lesions were malignant, including some category I and II cysts, and suggested that a more aggressive surgical approach was required. However, the cyst classified as category I using CT and found to be a RCC had been categorized as IV using US. This cyst was initially enucleated after intraoperative pathological examination of the margins was negative for cancer, but the tumour recurred at 3 years and a radical nephrectomy revealed a solid RCC.

Wilson *et al.* [17] reviewed 22 renal cystic masses that were confirmed pathologically either surgically or at biopsy. The CT

Reference	Bosniak cat., n malignancies/N in group			
	I	II	III	IV
[5]	0/22	1/8	5/11	26/29
[15]	–	0/4	4/7	5/5
[16]	1/2	1/7	4/13	7/10
[17]	0/7	4/5	4/4	6/6
[18]	0/15*	–	29/49	18/18
[19]	–	3/28	8/29	–
[20]	–	–	28/179†	–
[21]	–	–	17/28	–
[23]	0/11	1/2	10/10	12/12
Total	1/57	10/54	109/330	74/80
% malignancy	1.7	18.5	33.0	92.5

TABLE 3
Summary of studies correlating pathology with Bosniak category

**category I and II combined; †category II and IIF combined.*

appearances of these lesions were reviewed by three radiologists and categorized by consensus. All category I cysts were benign, and all category III and IV cysts were malignant; four of five category II cysts were RCCs (Table 3). The authors suggested that a larger proportion of category II and III lesions might be malignant than previously thought. Bosniak [22] was highly critical of the study of Wilson *et al.*; he thought the series was too small, that the CT scans were technically inadequate, and called for a larger objective study rather than small series of 'anecdotal, biased and incompletely collected and studied cases'.

Siegel *et al.* [5] reviewed 46 patients with 70 cystic renal masses to assess the clinical usefulness and interobserver variability of the Bosniak classification. The study included all patients who had had CT within 4 months of surgery. Three independent reviewers interpreted the CT scans. Most interobserver variability occurred in distinguishing category II from III. A κ analysis showed considerable variability in distinguishing between category II and III lesions, posing difficulties in recommending surgical or conservative management.

Koga *et al.* [23] evaluated 35 patients with 11 simple and 24 complex cysts. Preoperative CT was reviewed retrospectively and categorized by two radiologists. They found that all category I lesions were benign, and all category III and IV were malignant. However, one of two category II cysts was also malignant. They concluded that category I cysts did not require surgery and category III and IV did.

Curry *et al.* [18] evaluated 116 lesions retrospectively and a Bosniak classification was assigned by two radiologists; 82 masses were surgically removed, and found to have good concordance with the classification (Table 3); 34 category I and II lesions were followed for between 3 months and 10 years, during which they showed no evidence of progression to malignancy. The authors concluded that the Bosniak classification is useful for separating surgical from non-surgical patients.

OTHER TECHNIQUES FOR DIAGNOSING INDETERMINATE CYSTS

Although the Bosniak classification is good at classifying category I and IV lesions, there is a problem in confidently diagnosing the indeterminate cyst. Several methods have been proposed to try and resolve this.

Limb *et al.* [19] attempted a laparoscopic evaluation of indeterminate cystic lesions; 57 cysts (28 category II and 29 category III) were located by transperitoneal laparoscopy, and the cyst wall and base aspirated. Eleven patients were found to have RCC, of whom three had been classified as category II. There was no evidence of laparoscopic port-site or peritoneal seeding on follow-up (mean 40 months). Laparoscopy might therefore allow a definitive diagnosis without major surgery.

Lang *et al.* [20] assessed CT-guided biopsy in cysts classified as IIF or III by radiologists in a blind-coded study. Of 199 biopsies, 179 had adequate material for definitive diagnosis. The 20 indeterminate biopsies were all surgically explored. All other lesions were either explored or followed with interval US/CT (mean follow-up 5.6 years). Overall, 20 of 28 malignancies were correctly diagnosed on biopsy; two were missed but followed up radiologically, and six were in the indeterminate group. In addition, 27 of 31 benign lesions warranting treatment were correctly identified; two were incorrect and two were indeterminate. Most benign complex cysts were correctly identified (128/140); 12 were indeterminate. The authors concluded that cyst biopsy was reliable, with 90% of specimens being suitable for histological diagnosis, and that all indeterminate lesions should be explored, given the high rate of malignancy in this group. In this study, the combination of biopsy and follow-up meant that only 30% of patients were surgically explored.

Harisinghani *et al.* [21] studied the incidence of malignancy in Bosniak category III cysts with CT-guided biopsies; they found malignancy in 17 cases and benign lesions in 11. Definitive histology of the malignant lesions was identical to the biopsy histology in all cases. All benign lesions were followed up radiologically for 1–2 years and none required further biopsy. The authors concluded that the incidence of malignancy in category III lesions is 61% (SD 18%), and that biopsy could reduce surgical intervention rates.

Goldberg *et al.* [24] used fluorine-18-2-fluoro-deoxy-D-glucose positron emission tomography (PET) to evaluate its potential efficacy in detecting renal tumours and characterizing indeterminate cysts. They scanned 21 patients with known renal masses; PET accurately depicted malignancy in nine of 10 patients confirmed by surgery or biopsy, but a diabetic patient with bilateral RCC was missed. Eleven patients with 12 indeterminate cysts (all Bosniak category III in this study) were scanned and 11 were correctly shown as benign by surgery (five), needle aspiration (three) and imaging follow-up (three). The false-negative case was found to have a small malignant lesion in its wall after a negative PET scan and negative cyst aspiration; it was removed because of the haemorrhagic nature of the aspirate. There were no false-positive PET interpretations, and the authors concluded that a negative PET scan and negative cyst aspiration instilled confidence in diagnosing a benign lesion.

CONCLUSION

The Bosniak classification system has been widely accepted because it addresses a

difficult clinical problem, is easy to apply, and is well liked by radiologists and urologists. Only a few studies have correlated cyst classification with pathological findings; none of them has managed to recruit many patients, and all have case-selection bias.

The most important aspect of diagnosing renal cystic lesions is to differentiate between benign and malignant, non-surgical and surgical masses. The diagnostic performance of the Bosniak system is broadly sound, but it can be difficult to accurately classify category II and III cysts. There is a lack of evidence supporting the classification's ability to distinguish between these surgical and non-surgical cases. In addition, interobserver variation is greatest in these cases [5]. Errors can be minimized by ensuring that CT is technically adequate and conducted by experienced radiologists with all relevant clinical information available.

Although the Bosniak classification system is useful to evaluate renal cystic lesions and communicate findings, it is not definitive at the boundary between category II and III cysts. Until there are results from larger prospective follow-up studies to help stratify the risk, such cysts should be viewed with suspicion and followed accordingly.

CONFLICT OF INTEREST

None declared.

REFERENCES

1 **Parienty RA, Pradel J, Parienty I.** Cystic renal cancers: CT characteristics. *Radiology* 1985; **157**: 741–4
2 **Israel GM, Bosniak MA.** Renal imaging for diagnosis and staging of renal cell carcinoma. *Urol Clin North Am* 2003; **30**: 499–514
3 **Bosniak MA.** The use of the Bosniak classification system for renal cysts and cystic tumours. *J Urol* 1997; **157**: 1852–3
4 **Hayakawa M, Hatano T, Tsuji A, Nakajima F, Ogawa Y.** Patients with renal cysts associated with renal cell carcinoma and the clinical implications of cyst puncture: a study of 223 cases. *Urology* 1996; **47**: 643–6
5 **Siegel CL, McFarland EG, Brink JA, Fisher AJ, Humphrey P, Heiken JP.** CT of cystic renal masses: analysis of diagnostic performance and interobserver variation. *Am J Roentgenol* 1997; **169**: 813–8
6 **Bielsa O, Lloreta J, Gelabert-Mas A.** Cystic renal cell carcinoma: pathological features, survival and implications for treatment. *Br J Urol* 1998; **82**: 16–20
7 **Hartman DS, Aronson S, Frazer H.** Current status of imaging indeterminate renal masses. *Radiol Clin North Am* 1991; **29**: 475–96
8 **Bosniak MA.** The current radiological approach to renal cysts. *Radiology* 1986; **158**: 1–10
9 **Balfe DM, McClennan BL, Stanley RJ, Weyman PJ, Sagel SS.** Evaluation of renal masses considered indeterminate on computed tomography. *Radiology* 1982; **142**: 421–8
10 **Bosniak MA.** Problems in the radiologic diagnosis of renal parenchymal tumours. *Urol Clin North Am* 1993; **20**: 217–30
11 **Bosniak MA.** Difficulties in classifying cystic lesions of the kidney. *Urol Radiol* 1991; **13**: 91–3
12 **Bosniak MA.** Diagnosis and management of patients with complicated cystic lesions of the kidney. *Am J Roentgenol* 1997; **169**: 819–21
13 **Israel GM, Bosniak MA.** Follow-up CT of moderately complex cystic lesions of the kidney (Bosniak Category IIF). *Am J Roentgenol* 2003; **181**: 627–33
14 **Israel GM, Bosniak MA.** Calcification in cystic renal masses: is it important in diagnosis? *Radiology* 2003; **226**: 47–52
15 **Aronson S, Frazier H, Baluch JD, Hartman DS, Christenson PJ.** Cystic renal masses: usefulness of the Bosniak classification. *Urol Radiol* 1991; **13**: 83–90
16 **Cloix P, Martin X, Pangaud C *et al.*** Surgical management of complex renal cysts: a series of 32 cases. *J Urol* 1996; **156**: 28–30
17 **Wilson TE, Doelle EA, Cohan R, Wojno K, Korobkin M.** Cystic renal masses: a re-evaluation of the usefulness of the Bosniak classification system. *Acad Radiol* 1996; **3**: 564–70
18 **Curry NS, Cochran ST, Bissada NK.** Cystic renal masses: accurate Bosniak classification requires adequate renal CT. *Am J Roentgenol* 2000; **175**: 339–42
19 **Limb J, Santiago L, Kaswick J, Bellman GC.** Laparoscopic evaluation of indeterminate renal cysts: long term follow-up. *J Endourol* 2002; **16**: 79–82
20 **Lang EK, Macchia RJ, Gayle B *et al.*** CT-guided biopsy of indeterminate renal cystic masses (Bosniak 3 and 2F): accuracy and impact on clinical management. *Eur Radiol* 2002; **12**: 2518–24
21 **Harisinghani MG, Maher MM, Gervais DA *et al.*** Incidence of malignancy in complex cystic renal masses (Bosniak category III): should imaging-guided biopsy precede surgery? *Am J Roentgenol* 2003; **180**: 755–8
22 **Bosniak MA.** Letter to the Editor. Cystic renal masses: a re-evaluation of the usefulness of the Bosniak Classification System. *Acad Radiol* 1996; **3**: 981–4
23 **Koga S, Nishikido M, Inuzuka S *et al.*** An evaluation of Bosniak's radiological classification of cystic renal masses. *BJU Int* 2000; **86**: 607–9
24 **Goldberg MA, Mayo-Smith WW, Papanicolaou N, Fischman AJ, Lee MJ.** FDG PET characterisation of renal masses: preliminary experiences. *Clin Radiol* 1997; **52**: 510–5

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Abbreviations: **US**, ultrasonography; **PET**, positron emission tomography; **HU**, Hounsfield Units.