The Bosniak classification system of renal cysts revisited: celebrating 20 years of the F word

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**Learning Objectives**

To recognize the imaging characteristics of frequently encountered cystic renal masses and classify them using the Bosniak grading system in order to avoid unnecessary investigations while simultaneously not dismissing potentially malignant lesions.

**Background**

The increasing use of computed tomography (CT) over the last 30 years has resulted in the frequent discovery of incidental renal cystic lesions. It quickly became evident that a simple system to correctly differentiate between benign and potentially malignant lesions was needed if unnecessary followup of all such lesions was to be avoided.

In 1986 Bosniak proposed a simple, four category classification system for renal cysts, which has since been widely adopted and has been proven to be sound and reliable[1,2]. Its main purpose was to distinguish between cysts that were likely to be malignant and thus required surgical intervention, and those that were almost certainly benign and thus could be safely ignored. Type 1 and 2 cysts could generally be left alone, whilst type 3 and 4 required surgical intervention.

However, in 1993, after the realisation that there was difficulty in categorising a group of cysts that were too complex to be classed as type 2, yet not complex enough to be classed as type 3, the classification system was revised and a fifth category was added, namely type 2F [3]. The 'F' is for follow up, as this group of cysts require imaging follow up to rule out malignancy.

Twenty years on since the introduction of type 2F, the diagnosis of many frequently encountered cystic masses still proves challenging, even to experienced radiologists. Whilst it is relatively easy to distinguish clearly benign appearing type 1 cysts from clearly malignant type 4 cysts, many lesions with intermediate imaging findings are difficult to categorise.

This poster presentation demonstrates the salient features of each grade of renal cyst in the revised Bosniak classification system with both high quality original medical illustrations and multimodality imaging examples.
Imaging Findings OR Procedure Details

Renal cysts are fluid filled lesions that can be broadly classified as either simple or complex, based on their imaging features. Pathologically there are many causes for renal cysts, ranging from simple benign cysts, to infectious or haemorrhagic cysts to renal cell carcinoma. Simple cysts are thin walled, water density fluid filled lesions. Complex cystic masses however can have many other radiologic features.

The computed tomography imaging features most important in determining the malignant potential of a renal cyst include septations, calcification, high attenuation, wall thickening, nodularity, contrast enhancement and the presence of soft tissue elements.

It should be noted that the Bosniak classification system was originally designed to be used with unenhanced and contrast enhanced computed tomography, however many incidental renal cysts are seen on ultrasound as well [4]. Should a lesion seen on ultrasound appear more complex than a simple benign cyst, it is suggested that further characterisation of the lesion is pursued with contrast enhanced CT as ultrasound is not reliable enough to correctly classify complex cystic masses [4]. Magnetic resonance imaging is less frequently used to specifically assess these lesions, however if a lesion is incidentally found on MRI or if there are contraindications to contrast enhanced CT in a patient, the Bosniak classification system has been shown to be reliably applicable to contrast enhanced MRI [4].

**Type 1**

Bosniak type 1 renal cysts are simple benign cysts. They characteristically have hairline thin walls, do not contain any septa and do not enhance [4,5]. They do not contain solid components or any calcification [4,5]. They are considered benign and therefore they can be left alone without need for surgical intervention or follow up [6].

It is not uncommon to see multiple simple benign cysts in the same patient, for example in polycystic kidney disease. However tedious the task may be, it is imperative to thoroughly assess each cyst individually to ensure there are no cysts with concerning features for malignancy, as it is entirely possible that one of the lesions may demonstrate features that carry a higher risk of malignancy.

In summary, the defining characteristics of Bosniak type 1 cysts are:

- Hairline thin walls
- No septations
- Fluid filled
- No enhancement
- No calcification

Fig. 1: Illustration depicting the typical features of a Bosniak type 1 renal cyst.

References: Dr. Matt Skalski
Fig. 2: Multi-modality images of Bosniak type 1 renal cysts. Renal parenchymal phase CT images (case A) demonstrate a cyst with a thin wall, no calcification, no enhancement and no septations. T1 and T2 weighted MRI images (case B) show a cyst of uniformly low T1 and high T2 signal consistent with simple fluid. Ultrasound (case C) demonstrates nicely anechoic fluid within a thin walled cyst.

References: www.radiopaedia.org

Type 2

Type 2 cysts are non-enhancing and may contain a few hairline thin septa and/or fine calcification or a short segment of smooth, thicker calcification[4-6]. The walls should not be thickened [4,5]. Uniformly high-attenuating (>20HU at unenhanced CT), non-enhancing, sharply marginated cysts less than 3cm in diameter are also included in this category [4-5,7]. Like Bosniak type 1 cysts, lesions in this category are also considered benign hence they do not require surgical intervention or follow up [4-6].

It is important to completely exclude any wall or septal enhancement before categorising a cyst as Bosniak type 2. Once enhancement is seen, it is immediately in need of follow up or if not, surgical intervention. Enhancement should not be confused with the normal
surrounding renal parenchyma or 'parenchymal break' which is often difficult to evaluate on axial images of polar lesions [7]. In such cases, coronal and sagittal images are useful, and the wall is better evaluated for thickness or enhancement in the region that it projects outside of the renal parenchyma [7].

In summary, Bosniak type 2 cystic lesions are characterised by the following:

- Hairline thin septations
- Fine calcification or a short section of thicker, smooth calcification
- Non-enhancing homogenously high attenuating lesions less than 3cm in diameter
- No enhancement
Fig. 3: Illustration depicting the typical features of a Bosniak type 2 renal cyst.

References: Dr. Matt Skalski
**Fig. 4**: Axial non-contrast enhanced (A), axial renal cortical phase (B) and coronal renal parenchymal phase (C) CT images of a Bosniak type 2 renal cyst with arrows highlighting a hairline septation with fine calcification.

**References**: www.radiopaedia.org

**Type 2F**

These are slightly more complex than type 2 lesions. They may have more septations, and calcification may be thick and nodular [4,5]. The walls and septa may be minimally thickened but smooth [4,5]. There should be no measurable enhancement, however 'perceived enhancement' may be seen [4-6]. This refers to the phenomenon that occurs when non-contrast images are displayed next to contrast enhanced images and there appears to be enhancement on visual inspection, however when measured there is no actual enhancement [6]. Also included in this category are totally intrarenal, homogenously high attenuating, non-enhancing lesions greater than 3cm in diameter [4,5]. The malignancy rate of these lesions is approximately 5% and hence they require further follow up imaging to prove benignity [4-6].
There is uncertainty with regard to the duration of follow up imaging for these lesions. Bosniak has suggested that for lesions with less worrisome features (meaning they are closer in resemblance to type 2 than type 3), 1-2 years of follow up with CT is sufficient [2]. For lesions that appear more worrisome, 3-4 years of follow up may be necessary [2]. The feature to look for when assessing these lesions at follow up is measurable enhancement. This would essentially upgrade the lesion to type 3, thus indicating the need for surgical intervention. Increasing calcification alone is not sufficient to warrant any intervention apart from further follow up imaging [7].

In summary Bosniak type 2F lesions are characterised by the following:

- Thick and nodular calcification
- Minimally thickened but smooth walls and septa
- Perceived but not measurable enhancement
- Totally intrarenal, homogenously high attenuating, non-enhancing lesions greater than 3cm in diameter
Fig. 5: Illustration depicting the typical features of a Bosniak type 2F renal cyst.

References: Dr. Matt Skalski
Fig. 6: CT images of a patient with a Bosniak type 2F renal cystic lesion. Axial non-contrast enhanced (A) and axial renal parenchymal phase (B) images show a thin but clearly enhancing septation (white arrows). Axial renal cortical phase (C) and coronal non-contrast enhanced (D) images show a wall calcification (black arrows) which is clearly thicker than the hairline calcification of a standard Bosniak type 2 lesion. Both the enhancement of the septation and the thick wall calcification indicate a Bosniak 2F lesion requiring follow-up examination.

References: www.radiopaedia.org

Type 3

This is the first category in which measurable enhancement is seen. These lesions have thicker, more nodular walls and septations that have obvious, measurable enhancement [4,5]. There are no soft tissue components. Malignancy rates approximate 50% [8] which clearly indicates the need for surgical intervention such as nephrectomy or percutaneous biopsy. Though approximately 50% of these lesions will be proven benign on histopathological analysis, the risk remains too high to ignore them.

In summary, Bosniak type 3 cysts have the following defining characteristics:
- Thick walls and septations
- Measurable enhancement
- No soft tissue components

**Fig. 7:** Illustration depicting the typical features of a Bosniak type 3 renal cyst.  
*References:* Dr. Matt Skalski
Fig. 8: Axial non-contrast enhanced (A), axial renal cortical phase (B), axial renal parenchymal phase (C), coronal renal cortical phase (D) and coronal renal parenchymal phase (E) images of a complex left renal cyst in the same patient. Note the thickened wall components (black arrows) and septa (white arrows) which both demonstrate contrast enhancement. These features immediately suggest a Bosniak type 3 or 4 cyst, but since there are no discrete soft tissue components, the correct category for this lesion is Bosniak type 3.

References: www.radiopaedia.org

Type 4

Clearly malignant lesions with enhancing soft tissue components adjacent to but independent of the wall or septa [4,5]. Surrounding structures should be closely assessed to look for evidence of local spread, for example invasion into the renal vein or pathological lymph node enlargement. Approximately all lesions falling within this category are malignant and warrant urgent surgical removal [2,4,5].

The defining features of Bosniak type 4 cysts are:
• All the features of type 3 lesions and
• Enhancing soft tissue components adjacent to but independent of the wall or septa

Fig. 9: Illustration depicting the typical features of a Bosniak type 4 renal cyst.

References: Dr. Matt Skalski
Fig. 10: Axial non-contrast enhanced (A), axial renal cortical phase (B) and sagittal renal parenchymal phase (C) CT images of a patient with a Bosniak type 4 complex renal cystic lesion. Note that despite the relatively homogenous density of the lesion prior to contrast administration (white arrow), once intravenous contrast is given there are multiple enhancing soft tissue components to the cystic lesion (black arrows) indicating malignancy.

References: www.radiopaedia.org

Images for this section:
**Fig. 1:** Illustration depicting the typical features of a Bosniak type 1 renal cyst.
**Fig. 2:** Multi-modality images of Bosniak type 1 renal cysts. Renal parenchymal phase CT images (case A) demonstrate a cyst with a thin wall, no calcification, no enhancement and no septations. T1 and T2 weighted MRI images (case B) show a cyst of uniformly low T1 and high T2 signal consistent with simple fluid. Ultrasound (case C) demonstrates nicely anechoic fluid within a thin walled cyst.
**Fig. 3:** Illustration depicting the typical features of a Bosniak type 2 renal cyst.
**Fig. 4:** Axial non-contrast enhanced (A), axial renal cortical phase (B) and coronal renal parenchymal phase (C) CT images of a Bosniak type 2 renal cyst with arrows highlighting a hairline septation with fine calcification.
**Fig. 5:** Illustration depicting the typical features of a Bosniak type 2F renal cyst.
Fig. 6: CT images of a patient with a Bosniak type 2F renal cystic lesion. Axial non-contrast enhanced (A) and axial renal parenchymal phase (B) images show a thin but clearly enhancing septation (white arrows). Axial renal cortical phase (C) and coronal non-contrast enhanced (D) images show a wall calcification (black arrows) which is clearly thicker than the hairline calcification of a standard Bosniak type 2 lesion. Both the enhancement of the septation and the thick wall calcification indicate a Bosniak 2F lesion requiring follow-up examination.
**Fig. 7:** Illustration depicting the typical features of a Bosniak type 3 renal cyst.
Fig. 8: Axial non-contrast enhanced (A), axial renal cortical phase (B), axial renal parenchymal phase (C), coronal renal cortical phase (D) and coronal renal parenchymal phase (E) images of a complex left renal cyst in the same patient. Note the thickened wall components (black arrows) and septa (white arrows) which both demonstrate contrast enhancement. These features immediately suggest a Bosniak type 3 or 4 cyst, but since there are no discrete soft tissue components, the correct category for this lesion is Bosniak type 3.
Fig. 9: Illustration depicting the typical features of a Bosniak type 4 renal cyst.
Fig. 10: Axial non-contrast enhanced (A), axial renal cortical phase (B) and sagittal renal parenchymal phase (C) CT images of a patient with a Bosniak type 4 complex renal cystic lesion. Note that despite the relatively homogenous density of the lesion prior to contrast administration (white arrow), once intravenous contrast is given there are multiple enhancing soft tissue components to the cystic lesion (black arrows) indicating malignancy.
Fig. 11: Illustration depicting the characteristics and malignant potential of each grade of renal cyst in the Bosniak classification system.
Conclusion

The Bosniak classification system for renal cystic masses is a useful tool in aiding the radiologist to make the correct provisional diagnosis and management recommendation. Most simple cysts and obviously malignant lesions (Bosniak type 1, 2 and 4) are easy to diagnose, however careful analysis of cysts with intermediate features is essential to correctly grade type 2F and type 3 lesions. The single most important feature in determining whether a lesion is 'surgical' or 'non-surgical' is measurable contrast enhancement.

A thorough knowledge of the characteristic imaging findings in each grade is essential in order to avoid misdiagnosis. A high quality illustration depicting the features of each Bosniak grade is provided below to summarise.
Fig. 11: Illustration depicting the characteristics and malignant potential of each grade of renal cyst in the Bosniak classification system.

References: Dr. Matt Skalski

Personal Information

References


