

## **Assessment of Complex Renal Cysts with Different Imaging Modalities**

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# Learning objectives

Identify the imaging features of complex renal cysts on US, CT, MRI and CEUS.

Review and apply the Bosniak classification on different imaging modalities.

## Background

Renal cysts are very common abnormalities and with the rise in use of cross-sectional abdominal imaging there has been an increase in the diagnosis of complex renal cysts.

Complex cysts do not meet the strict criteria for simple cysts (Table 1) and include the presence of septations, calcifications, perceptible wall and mural nodularity.

### Criteria for Simple Cysts

1. Anechoic
2. Sharply defined, imperceptible back wall
3. Round or ovoid
4. Enhances sound transmission

Table 1

The Bosniak system classification has been the center of complex renal cyst assessment for more than twenty years. It is used to categorize these lesions by likelihood of malignancy and is the only proven preoperative diagnostic tool.

However, it has limitations like interobserver variability. Another limitation is the difficult evaluation of intermediate lesions, distinguishing lesions II<sub>f</sub> from III, which separates surveillance from intervention. There are malignant lesions included in category II<sub>f</sub> and benign cysts classified as category III.

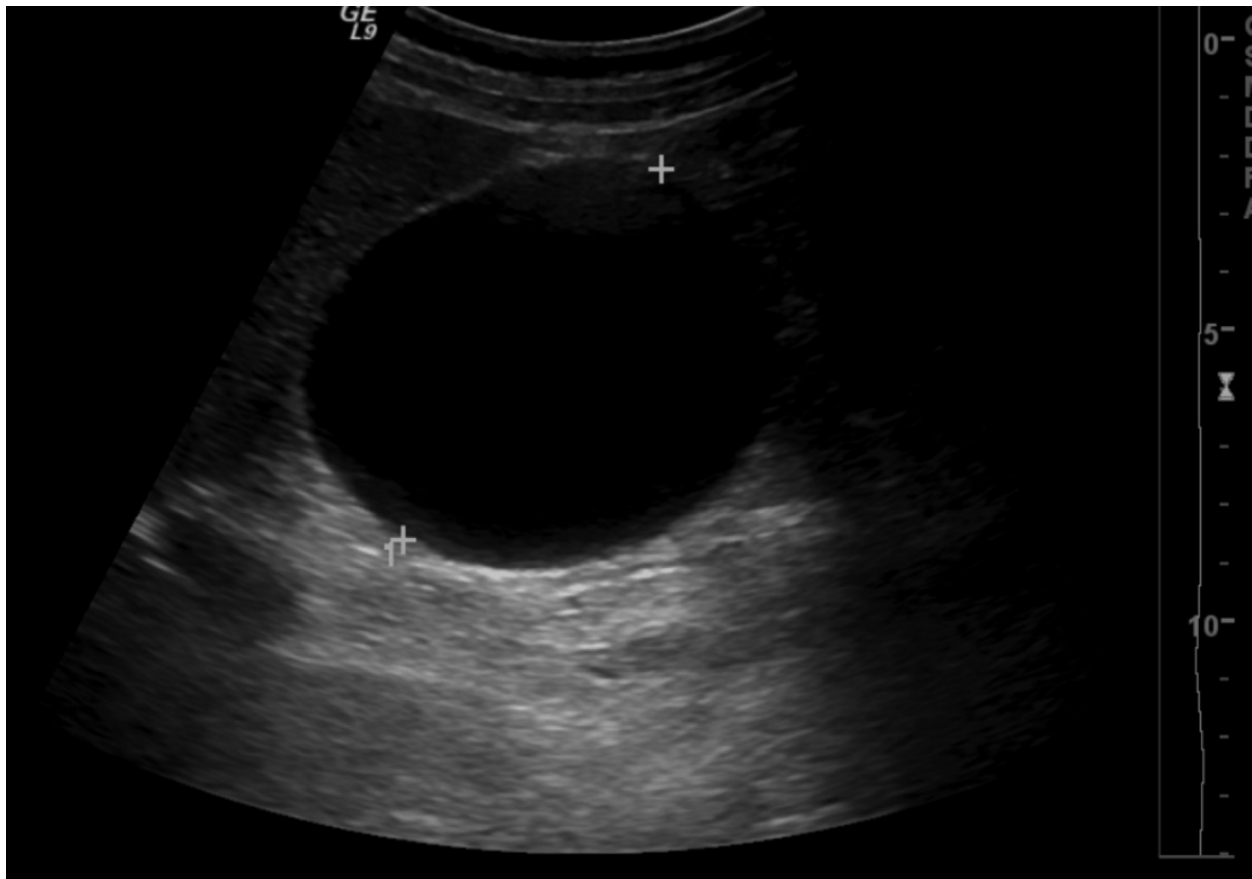
Complex renal cysts pose therefore a major clinical problem, since it can be challenging to differentiate benign from malignant lesions. Cystic renal cell carcinoma represents 5-7% of all renal tumours.

## Findings and procedure details

## ULTRASOUND

US is the most used imaging modality for the study of kidney cysts and differentiates simple ( [Fig. 1](#) on page ) from complex cysts.

However, its role in assessment of complex cysts is limited to minimally complicated cysts (internal echoes and thin septations - generally due to hemorrhage or infection) ( [Fig. 2](#) on page ). Thicker septations, perceptible wall and mural nodules are more worrisome and require further investigation with CT or MRI ( [Fig. 3](#) on page ). Bosniak classification does not apply to US.



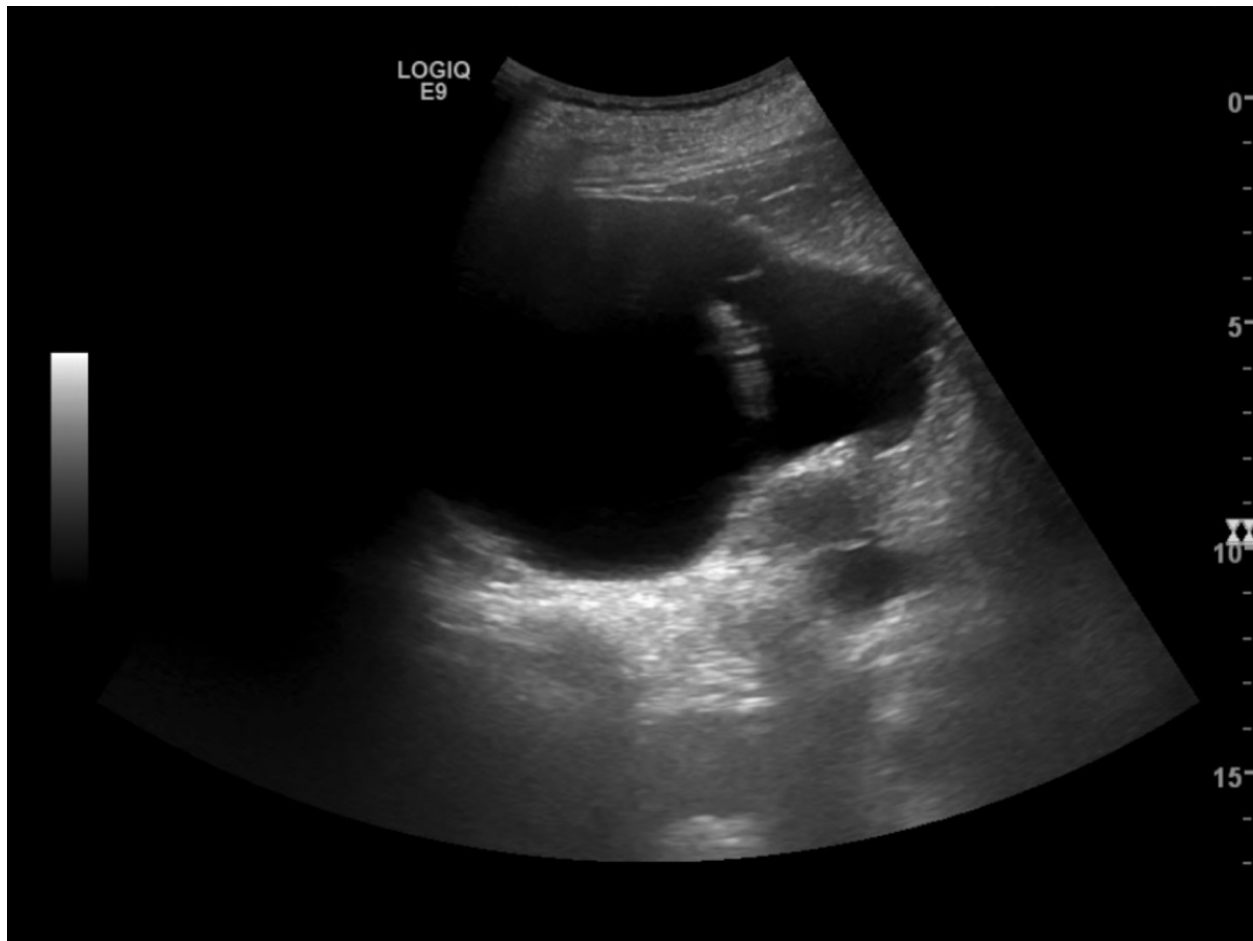
**Fig. 1:** Large simple cyst in the right kidney.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT



**Fig. 2:** Small cyst with a thin septation in the upper third of the right kidney.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

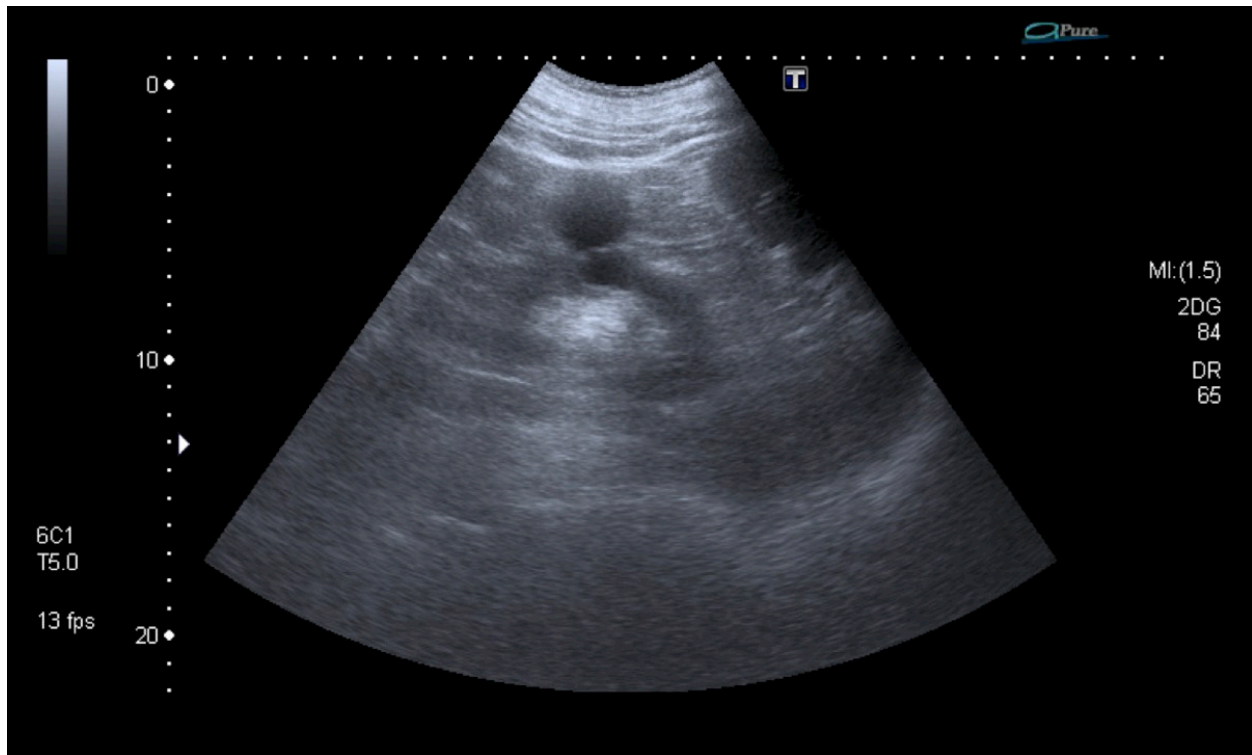


**Fig. 3:** Renal cyst with a thick, measurable septation. Additional investigation was required with CT - check Fig.7.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

Pitfalls:

- Adjacent cysts may mimic a septation ( [Fig. 4](#) on page        ).
- Echogenic foci at the interface of septa or walls may mimic cyst calcifications.



**Fig. 4:** Two adjacent renal cysts simulating a septation.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

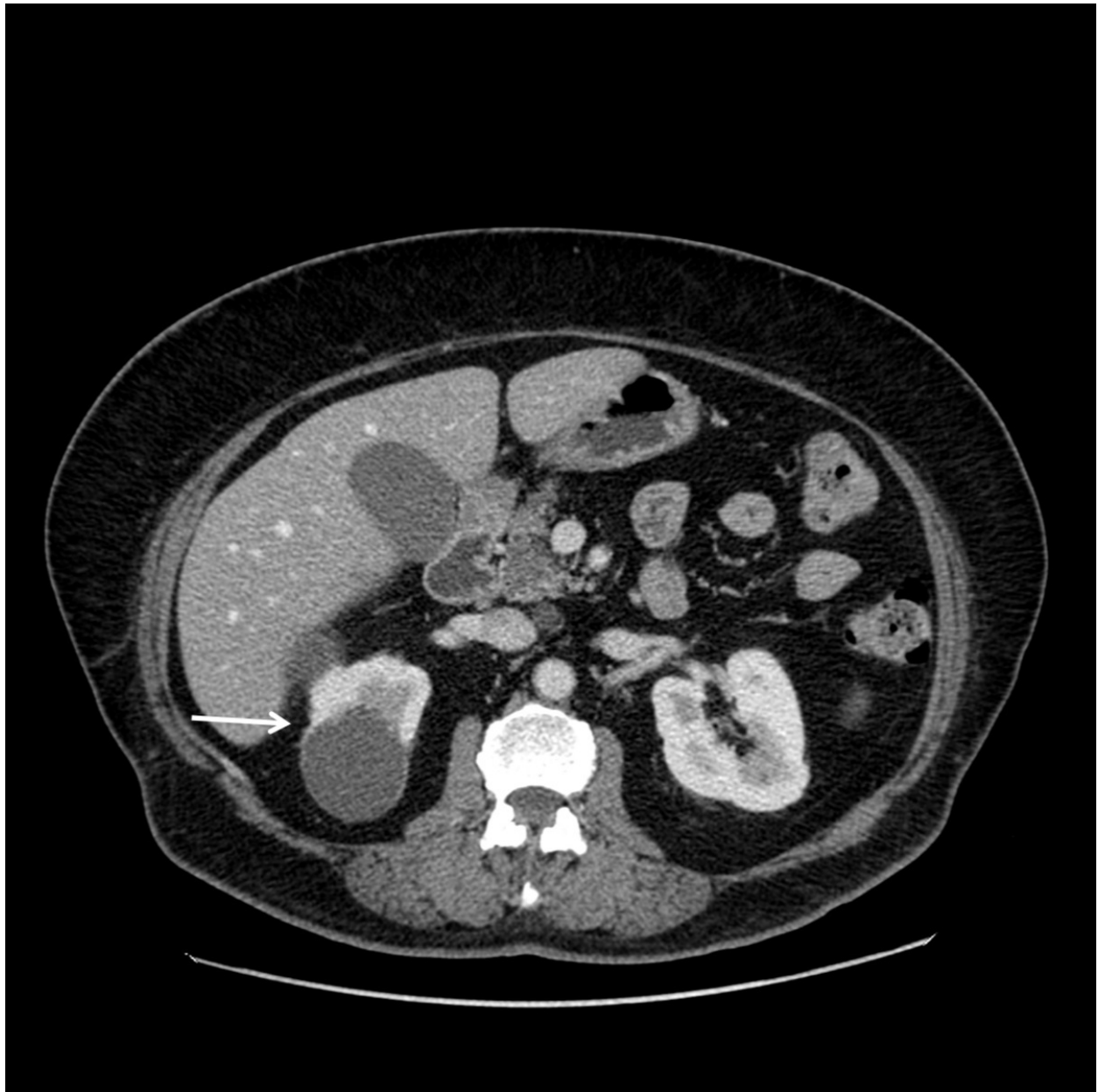
## CT

Contrast-enhanced CT remains the gold standard for evaluation of renal complex cystic lesions and the base for the Bosniak classification. The adequate protocol includes a non-contrast exam and a minimum of two phases with contrast.

The use of contrast is important, because enhancement (increase of 20-30HU) is the critical parameter for malignancy.

Pitfalls:

- Pseudoenhancement - artificial elevation of Hounsfield units of 10 or more on the nephrographic phase. It particularly affects small intrarenal cysts (< 1-2 cm).
- Beak sign - stretching of the renal capsule by cysts located at the surface ( [Fig. 5](#) on page ). It can mimic wall thickening.



**Fig. 5:** Renal cyst at the upper pole of the right kidney with beak sign (arrow). This can mimic cyst wall thickening.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

## **BOSNIAK CLASSIFICATION OF RENAL CYSTS (based on CT)**

### **Category I**



- Simple cyst ( Fig. 6 on page )

Malignancy potential: 0%

Management: No further evaluation



**Fig. 6:** Simple renal cyst at CT - Bosniak I. Check Fig.18.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

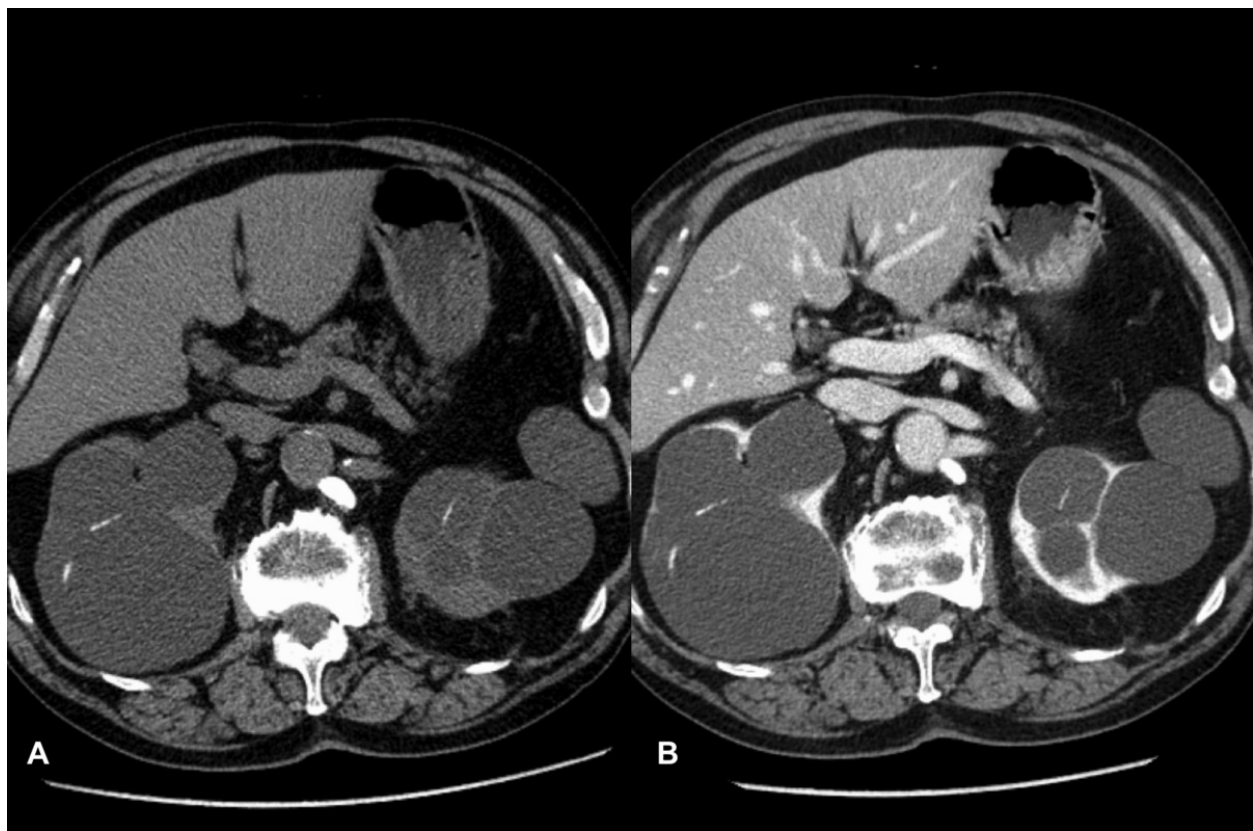


## Category II

- Few hairline thin septa ( Fig. 7 on page )
- Perceived but not measurable enhancement of septum
- Fine calcification in the wall or septa ( Fig. 7 on page )
- Uniformly high attenuation lesion (>20HU): <3cm, well marginated, no enhancement ( Fig. 8 on page )

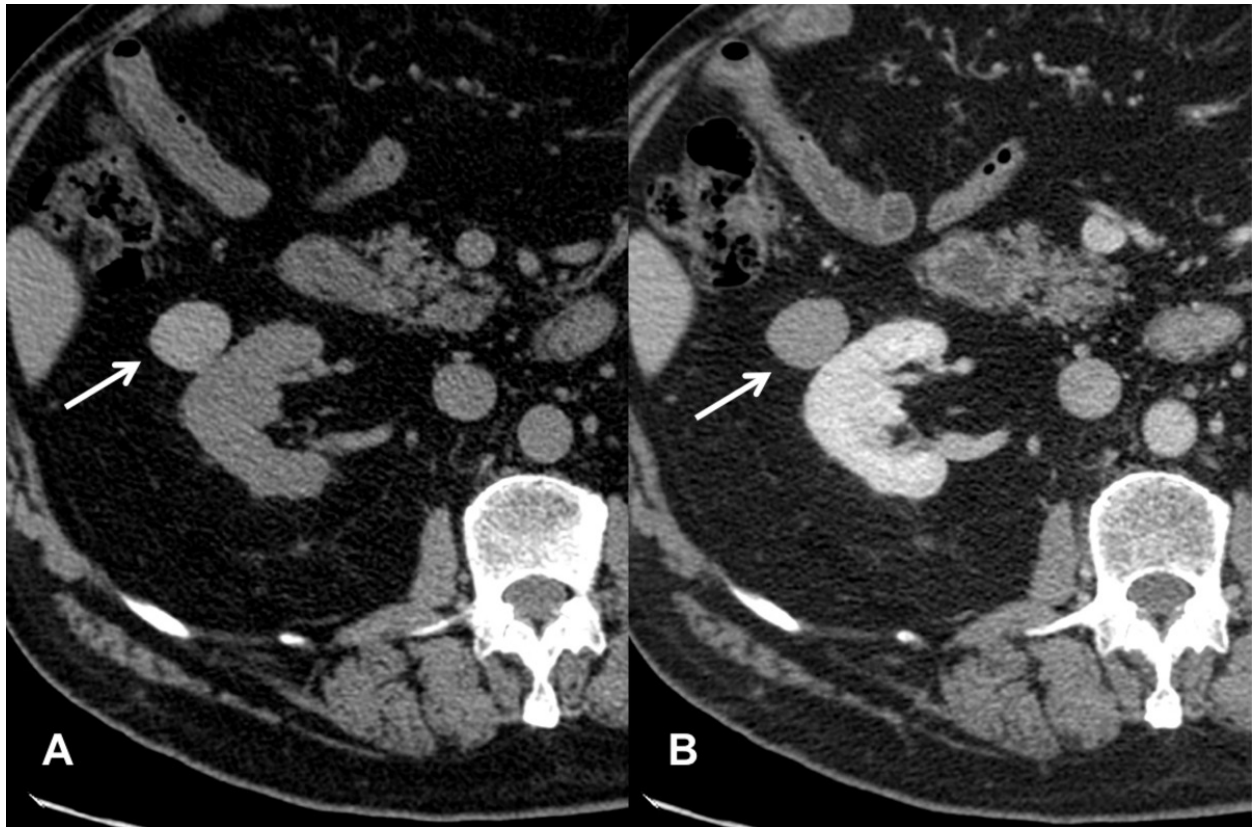
Malignancy potential: 0-10%

Management: No further evaluation



**Fig. 7:** Same patient as in Fig.3. Renal cysts with thin calcified septa - Bosniak II. A - Pre-contrast CT study. B - Contrast-enhanced CT.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT



**Fig. 8:** A - Hyperdense cyst on the right kidney (arrow), well margined, just under 3cm. B - No enhancement after contrast injection (arrow). Bosniak II. Check Fig.19.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

### Category IIb

- Multiple hairline thin septa
- Perceived but not measurable enhancement of septum or wall
- Minimal thickening of septa or wall ( [Fig. 9](#) on page , [Fig. 10](#) on page )
- Thick nodular calcification without enhancing soft tissue elements ( [Fig. 11](#) on page )
- Uniformly high attenuation lesion (>20HU):  $\geq 3$ cm, totally intrarenal, no enhancement ( [Fig. 12](#) on page 23 )

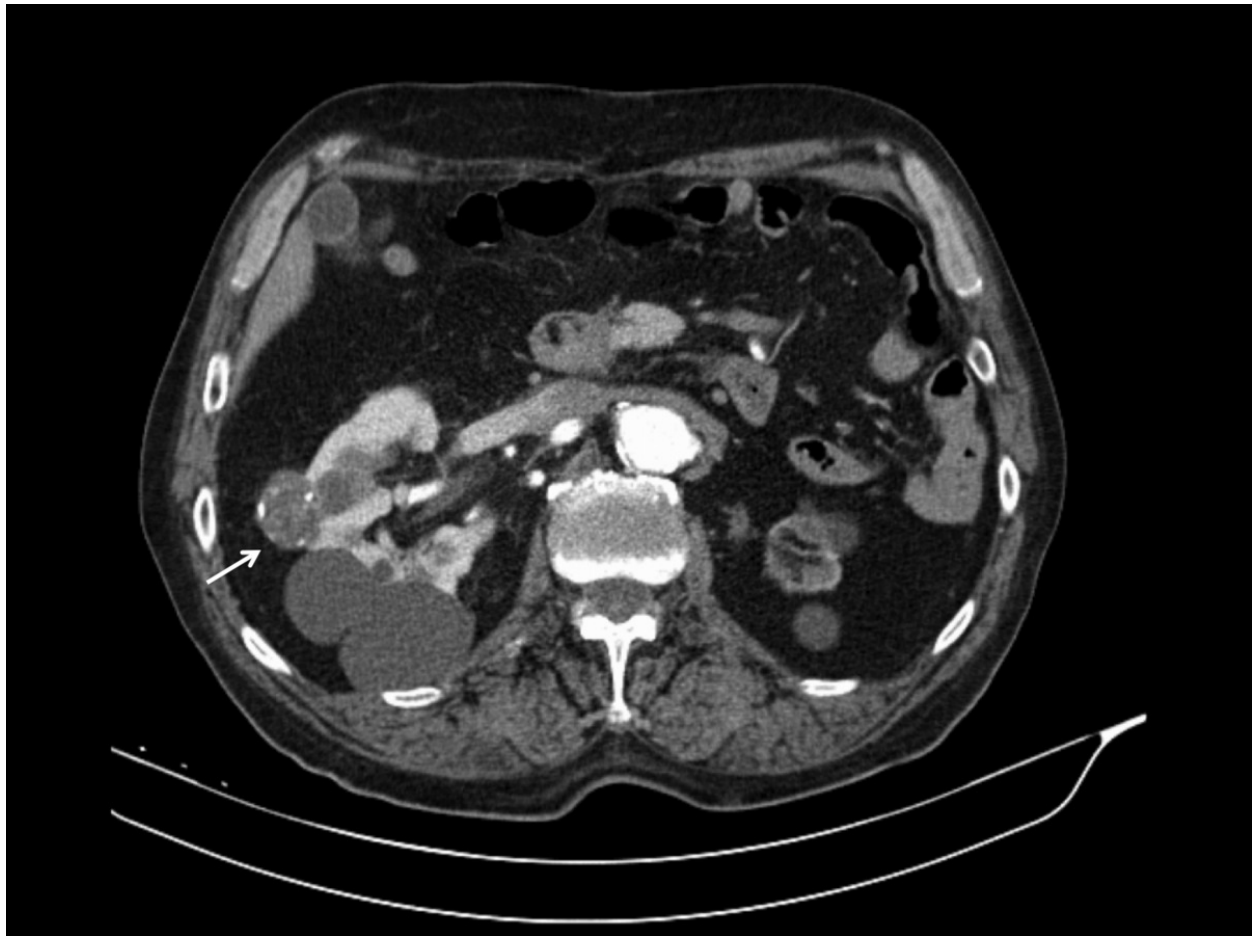
Malignancy potential: 5-25%

Management: Follow up at 3, 6, 12 months on the first year, then annually for a minimum of 5 years



**Fig. 9:** Renal cyst with minimally thickened septum (arrow), with subtle perceived enhancement - Bosniak II<sub>f</sub>. Follow up was recommended.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT



**Fig. 10:** Renal cyst (arrow) with multiple septa, minimally thickened, and associated calcifications. Classified as Bosniak II<sub>f</sub>. Follow up was recommended. Check Fig.22.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT



**Fig. 11:** Cyst with thick calcifications in the right kidney. No associated soft tissue enhancement - Bosniak II<sub>f</sub>. Remained stable on follow up.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT





**Fig. 12:** A - Totally intrarenal hyperdense cyst on the left kidney (arrow). B - No enhancement after contrast injection - Bosniak II<sub>f</sub>.

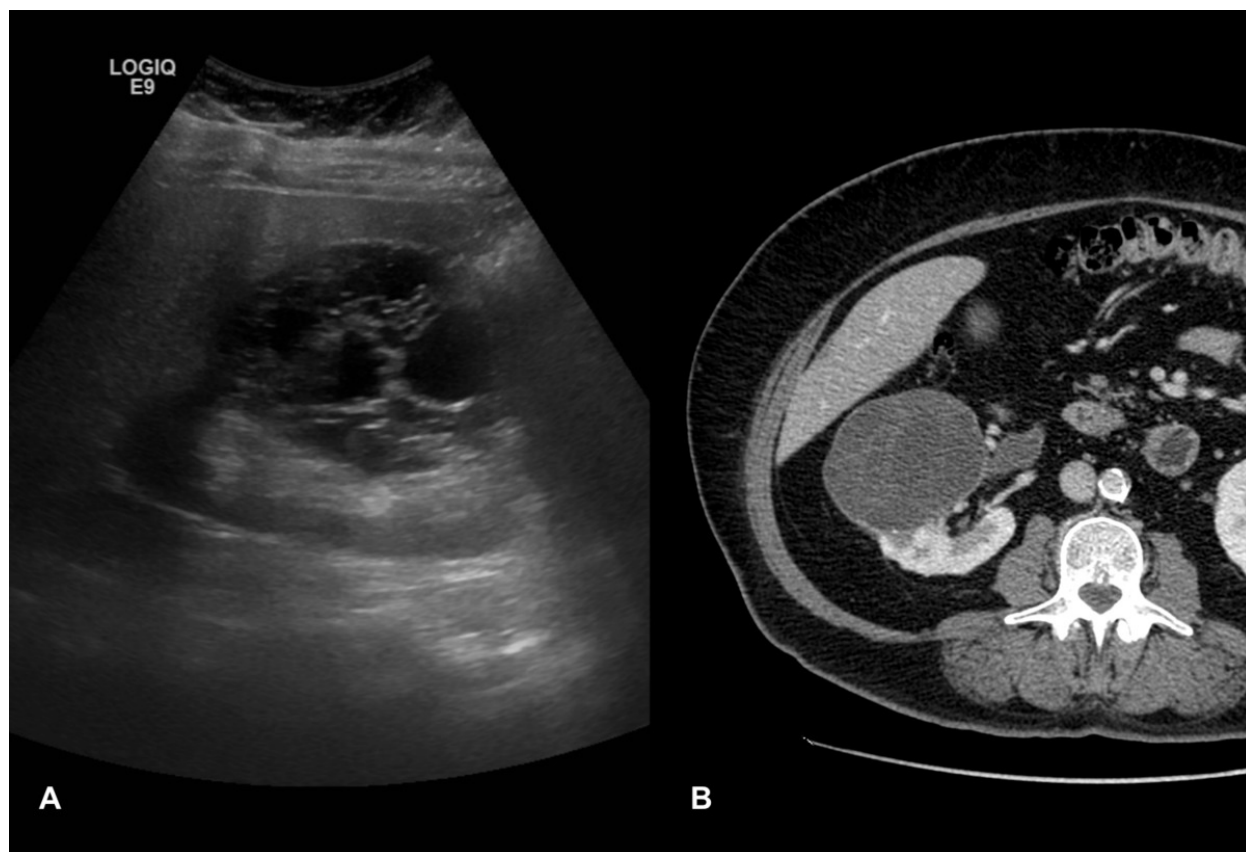
**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

### Category III

- Thickened irregular septa or wall with measurable enhancement ( [Fig. 13](#) on page 24 , [Fig. 14](#) on page , [Fig. 15](#) on page 25 )

Malignancy potential: >50%

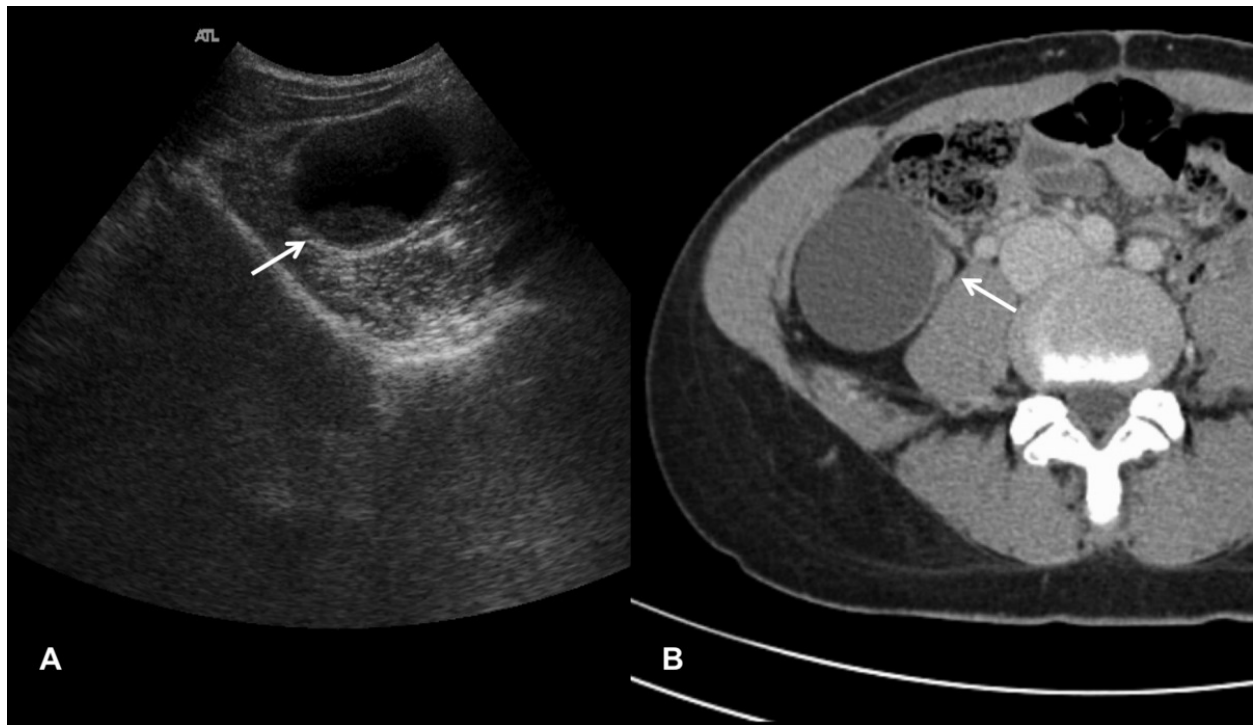
Management: Invasive diagnosis or surgical



**Fig. 13:** A - Complex renal cyst detected at US. Further assessment required. B - Contrast-enhanced CT shows multiple thickened septa with dubious enhancement. Classified as Bosniak III. Check Fig.17.

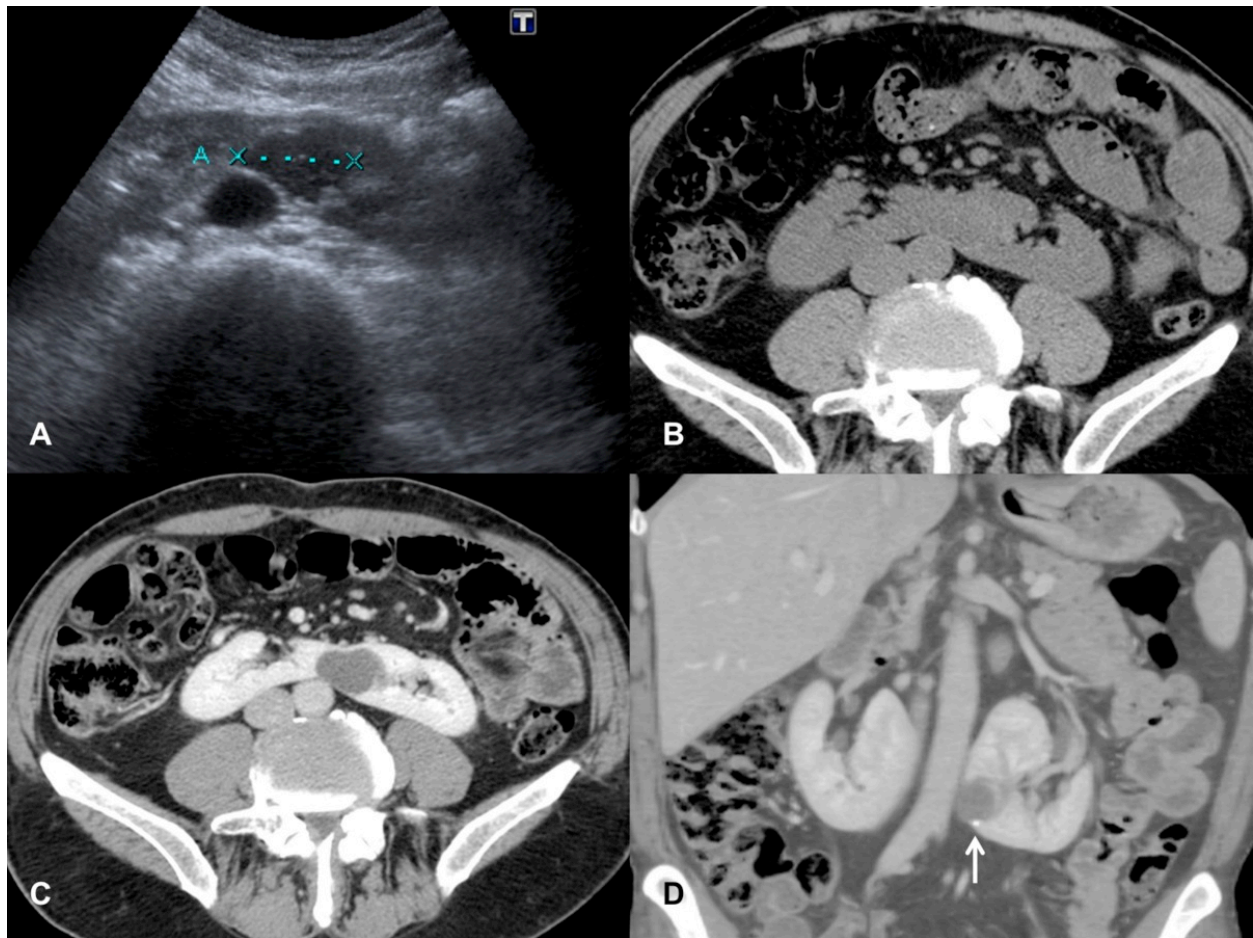
**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT





**Fig. 14:** A - Complex renal cyst at US with focal wall thickening (arrow). No shift with positional maneuvers. B- Contrast-enhanced CT confirms a nodular thickening of the cyst wall - Bosniak III.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT



**Fig. 15:** A - Patient with a horseshoe kidney and a cyst with apparent solid component at US. B - Pre-contrast CT shows a lesion with soft tissue attenuation (30HU). C - After contrast there is slight enhance (15-20HU) - Bosniak III. D - Coronal reformat showing an associated calcification. Surgical resection did not show a neoplasm.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

### Category IV

- Clearly malignant cystic lesion with enhancing soft tissue components ( [Fig. 16](#) on page 26 )

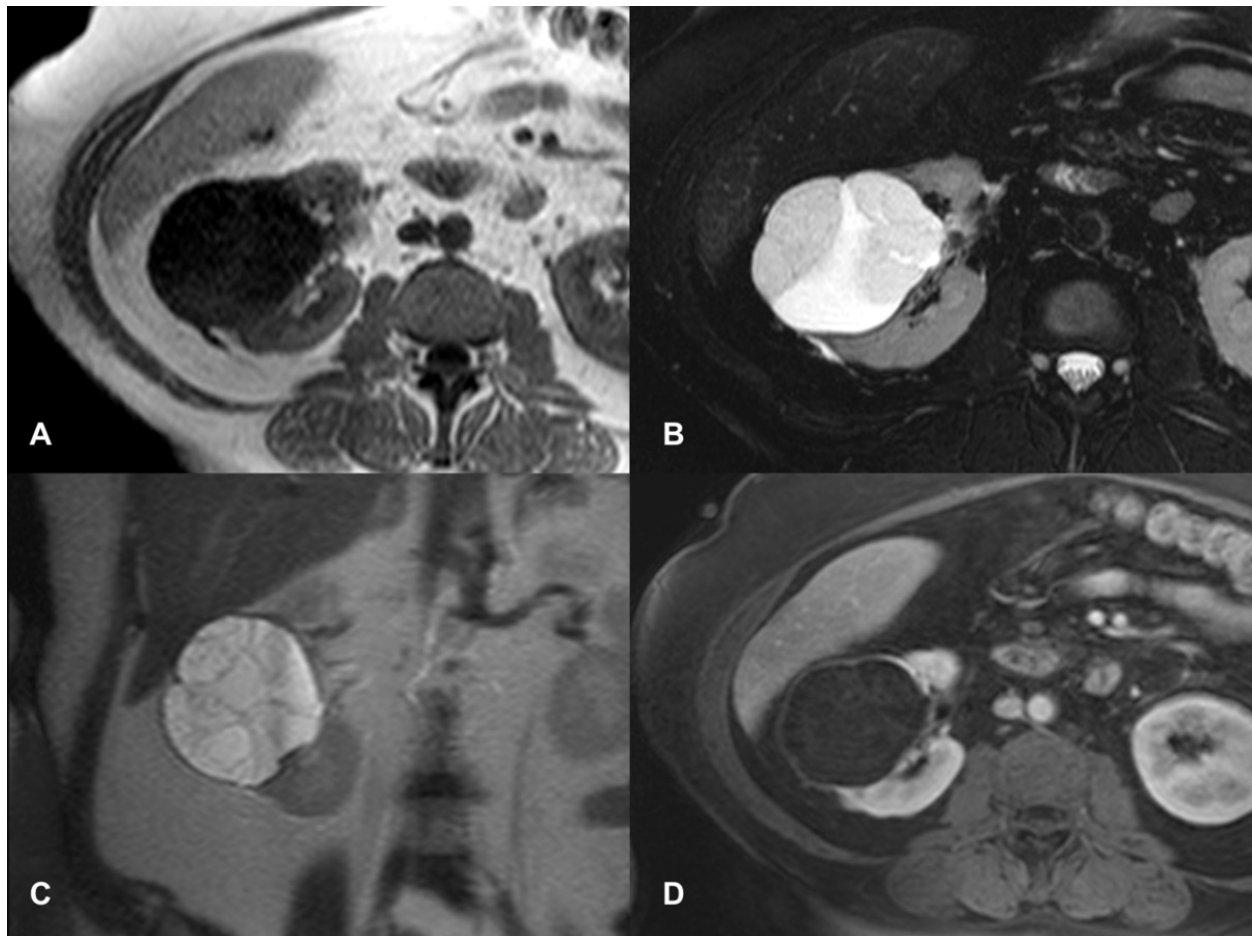
Malignancy potential: >90%

Management: Surgical

### MRI

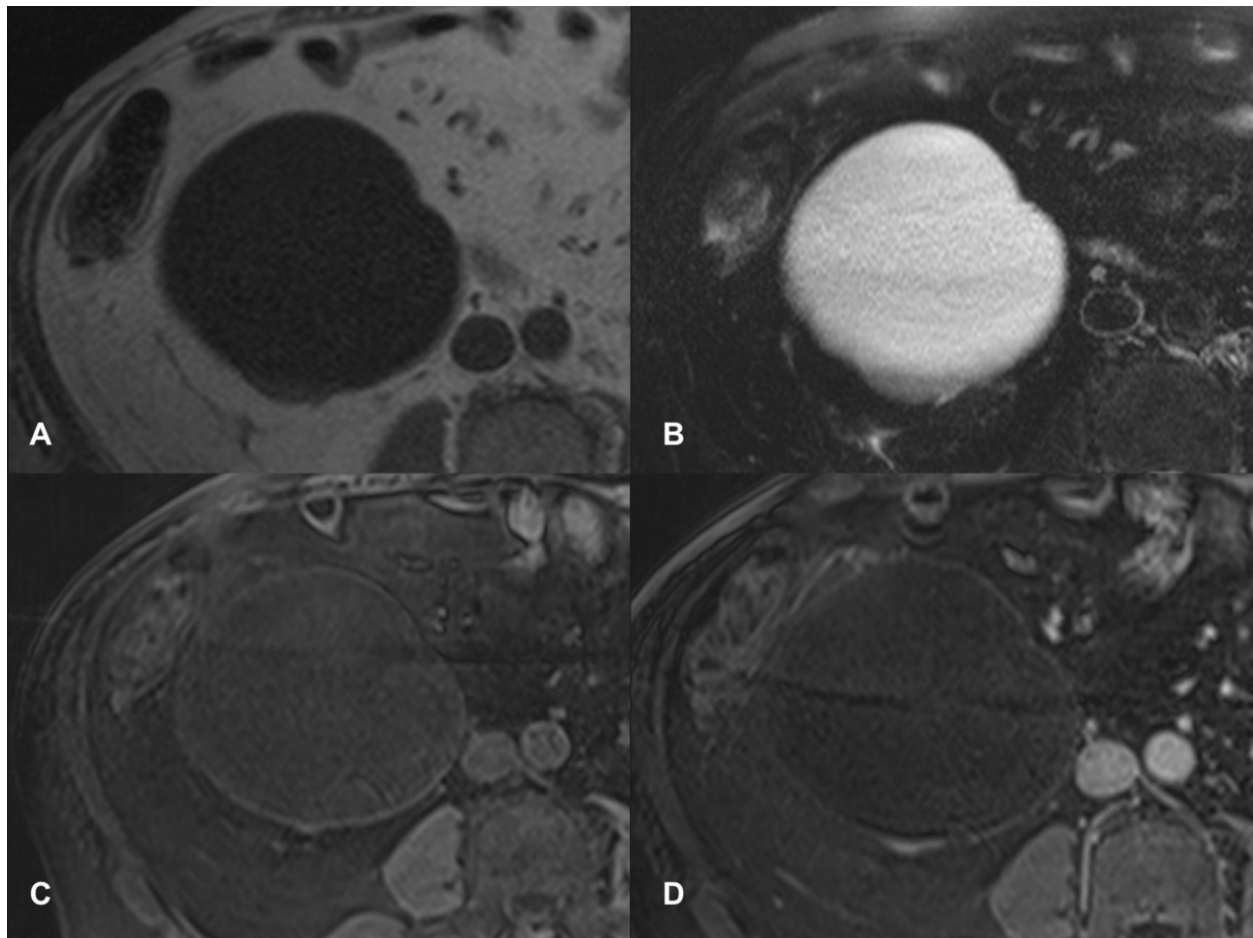
MRI findings correlate well with CT and histopathological findings and it is, therefore, a suitable imaging modality for complex renal cyst classification ( [Fig. 17](#) on page 27 ).

MRI may allow a more precise evaluation of fluid components (simple - [Fig. 18](#) on page , proteinaceous or blood - [Fig. 19](#) on page ). Benign lesions may, however, overlap with malignant ones.



**Fig. 17:** MRI of the same patient as in Fig.13. Renal cyst with normal hypointensity at T1 (A) and hyperintensity at T2 (B - axial plane with fat suppression, C - coronal T2 haste). Presence of multiple thin septa without enhancement (D). Initially classified as Bosniak III by CT, it was reclassified as Bosniak II<sub>f</sub>. Follow up recommended.

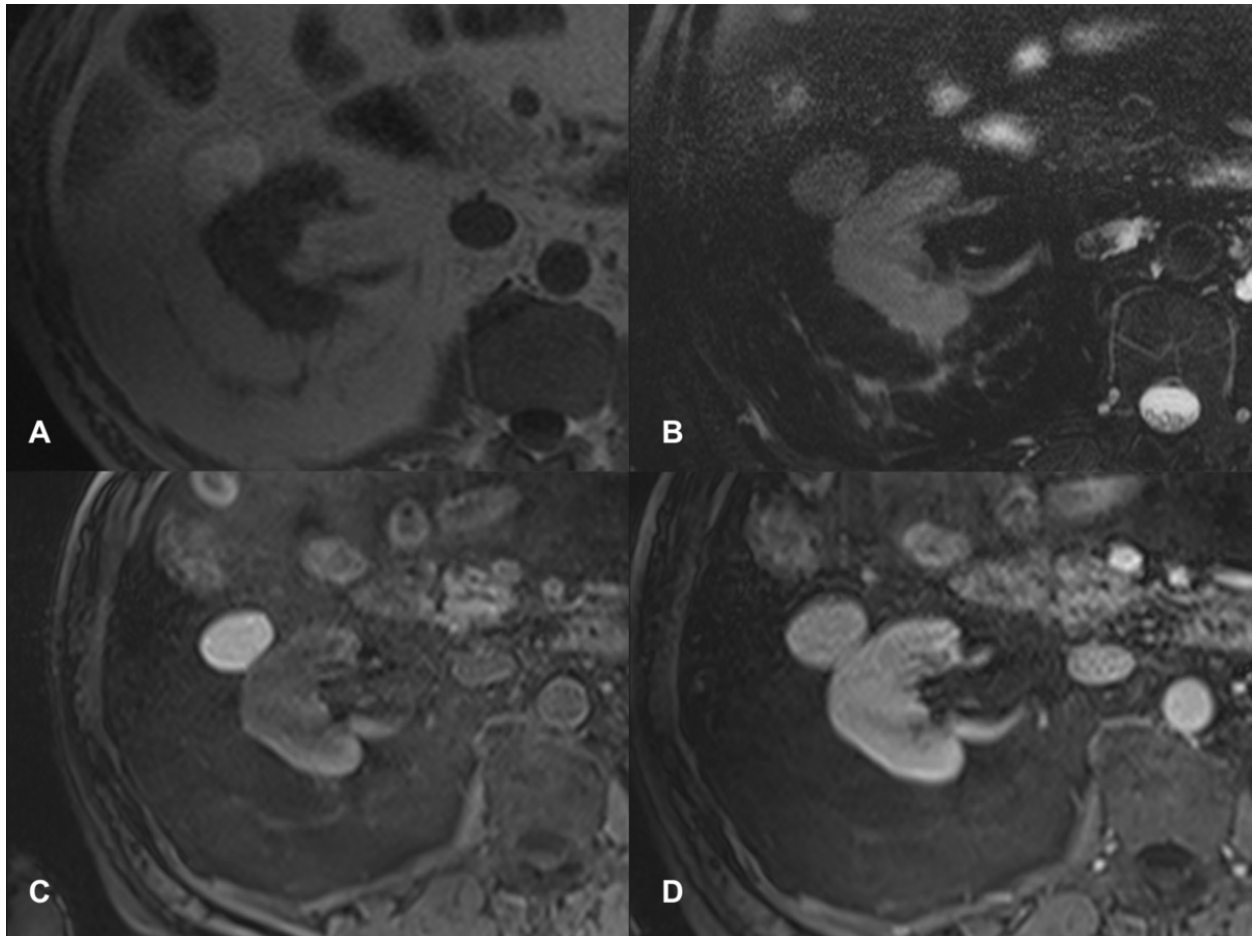
**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT



**Fig. 18:** MRI of a simple renal cyst - same patient as in Fig.6. A - Homogeneous hypointensity at T1. B - Homogeneous hyperintensity at T2. Pre-contrast T1 with fat suppression ( C ) and with contrast ( D ) show no internal enhancement - Bosniak I.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT



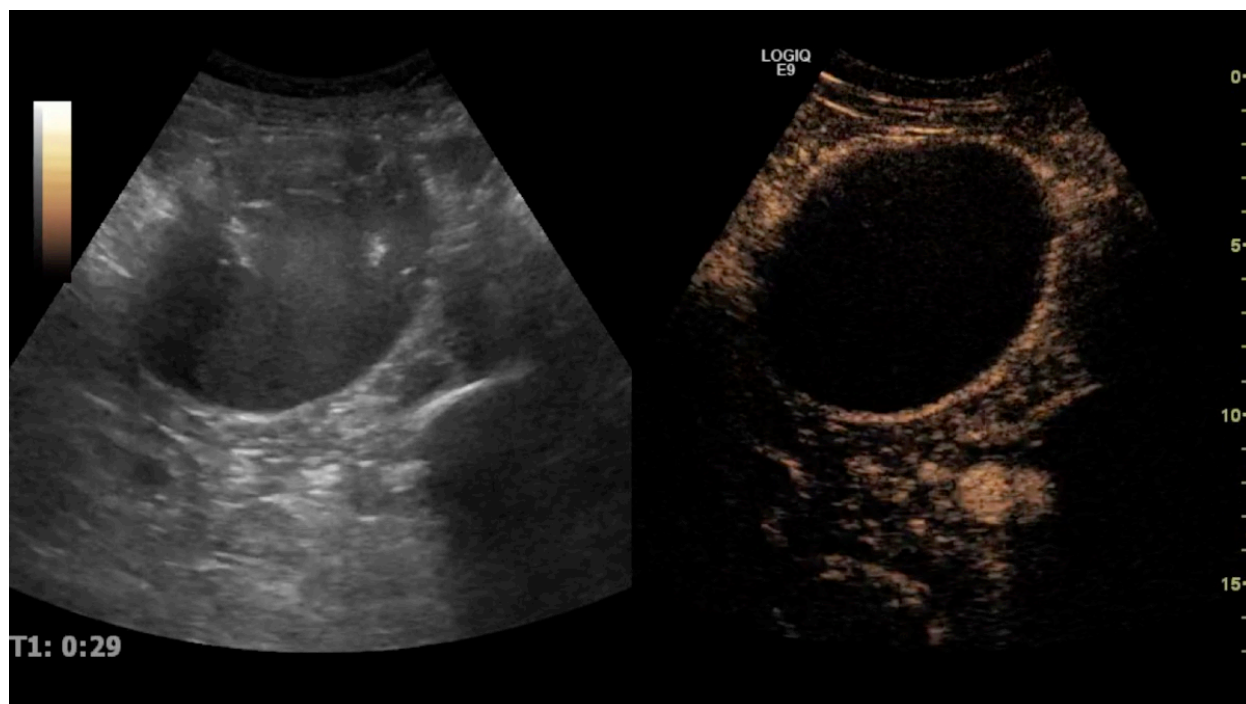


**Fig. 19:** MRI of a hemorrhagic cyst - same patient as in Fig.8. A - Hyperintensity at T1. B - Hypointensity at T2 with fat suppression. Pre-contrast ( C ) and post-contrast (D) T1 with fat suppression show no internal enhancement - Bosniak II.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

## CEUS

Contrast enhanced ultrasound (CEUS) is a very promising imaging modality for the study of complex kidney cysts. It combines the advantages of ultrasound to the administration of a microbubble contrast agent, which is both safe and not nephrotoxic ( [Fig. 20](#) on page ).



**Fig. 20:** Kidney transplantation. Large complex cyst detected in the renal graft. CEUS allowed a safe assessment of this patient, showing no internal enhancement - Bosniak I. Probable hemorrhagic cyst.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

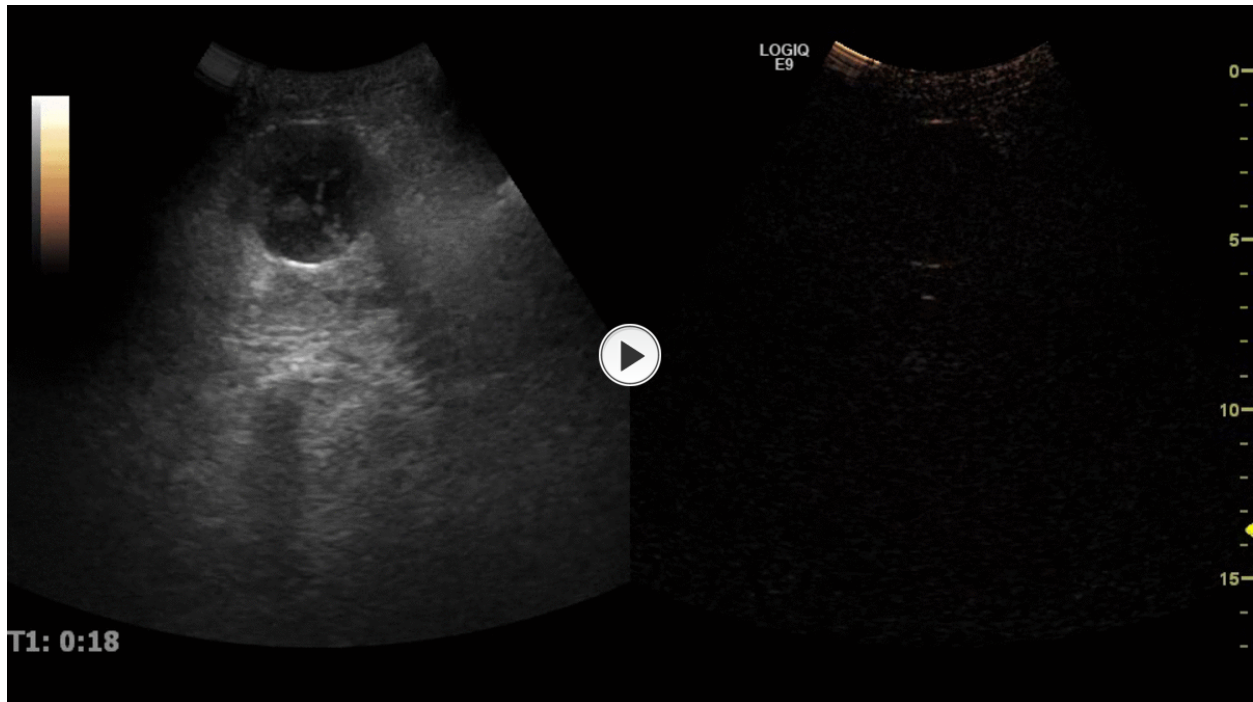
CEUS can adequately characterize complex cystic lesions ( [Fig. 21](#) on page 28 ), considered at least or even more sensitive than CT, due to greater definition of fine septa and small nodules ( [Fig. 22](#) on page 29 ). Consequently, CEUS may lead to an upgrade of cystic lesions.

There is an adapted Bosniak classification for use with CEUS (Table 2).

I	Simple cyst
II	Few hairline thin septa
	Fine or slightly thickened calcifications
	Minimal just perceived enhancement of the septa
IIIf	Multiple hairline thin septa
	Smooth minimal thickening of wall or septa

	Thick or nodular calcifications
	Minimal just perceived enhancement of the septa
III	Thickened wall or septa with measurable enhancement
	No solid enhancing lesions
IV	Soft tissue enhancing mass

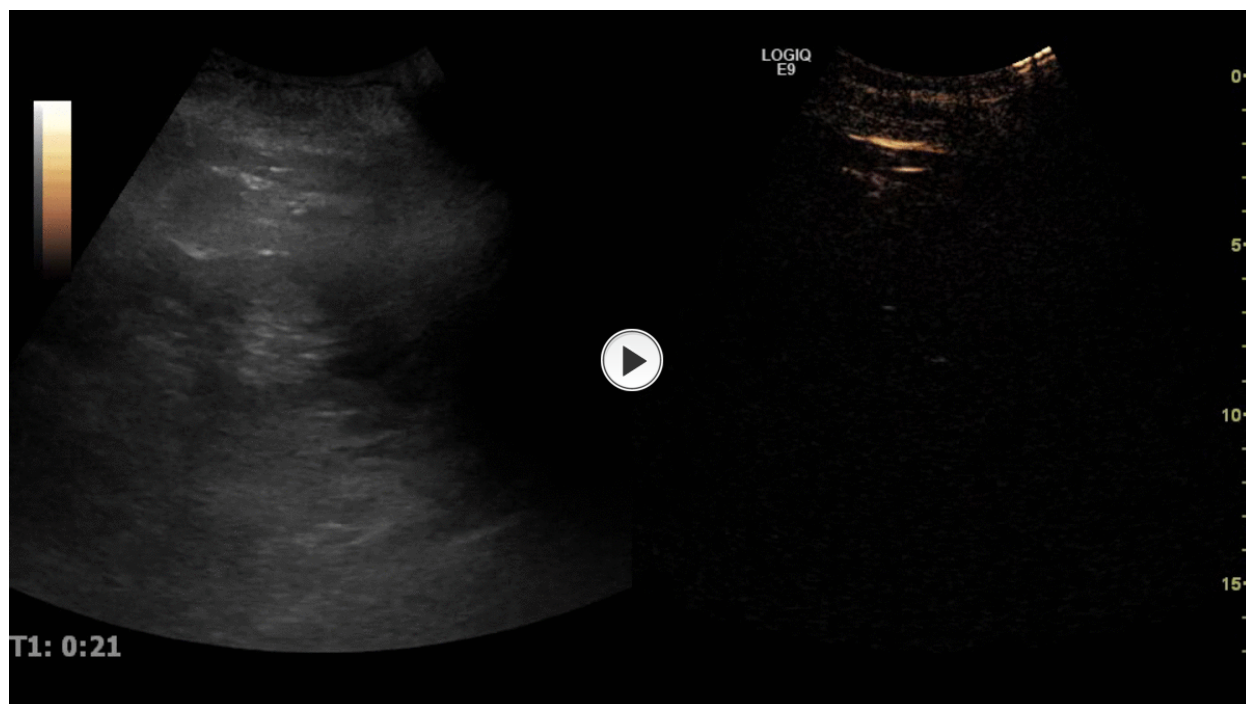
Table 2 - Bosniak classification using CEUS.



**Fig. 21:** Complex kidney cyst detected on US, with thick internal septa. CEUS allowed prompt assessment of the cyst, showing no internal enhancement - Bosniak I. Probable hemorrhagic cyst.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT





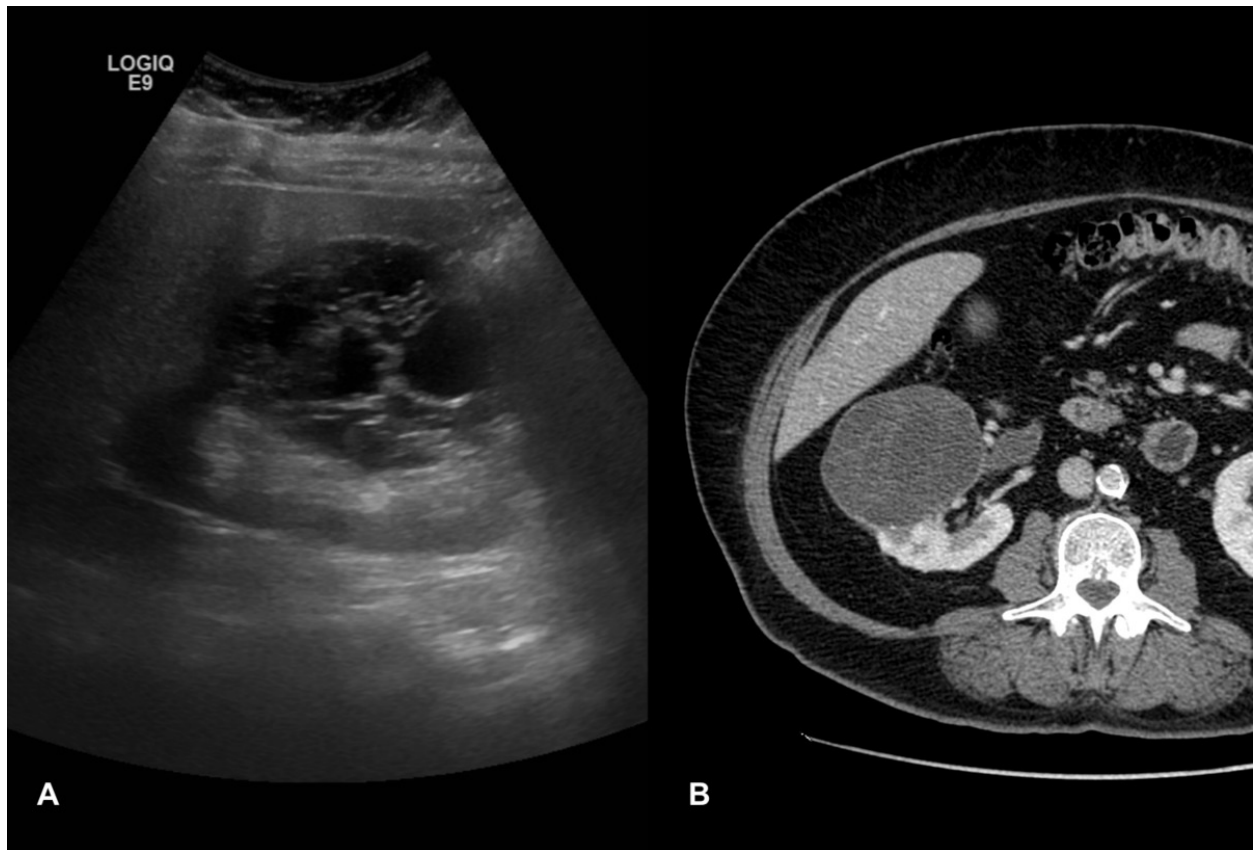
**Fig. 22:** Same patient as in Fig.10. Complex cyst in the middle of the right kidney, classified as Bosniak II by contrast-enhanced CT. CEUS showed clear solid component - Bosniak IV, not apparent at CT. There is also a large inferior cyst with thin internal septa - Bosniak II.

**References:** Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

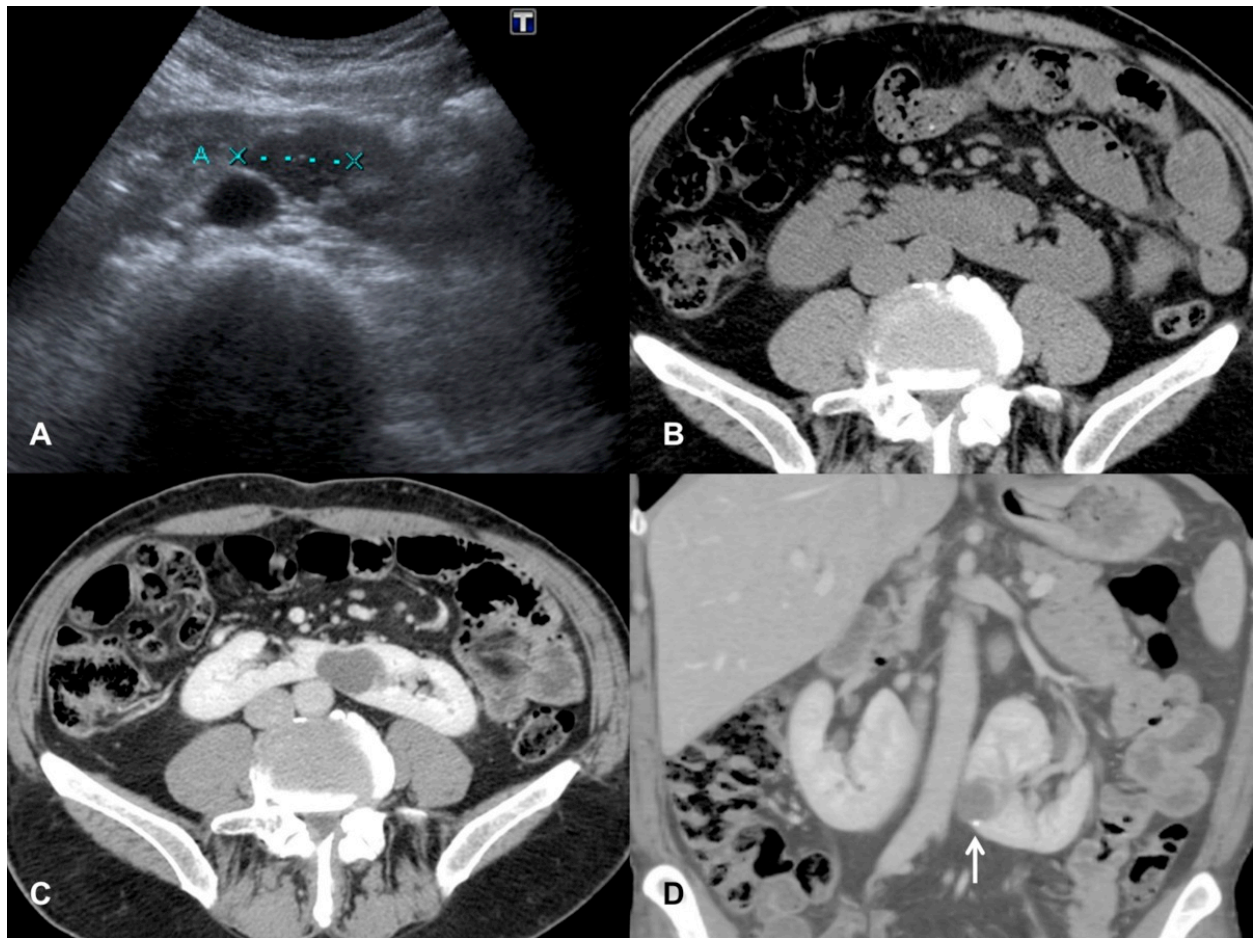
**Images for this section:**



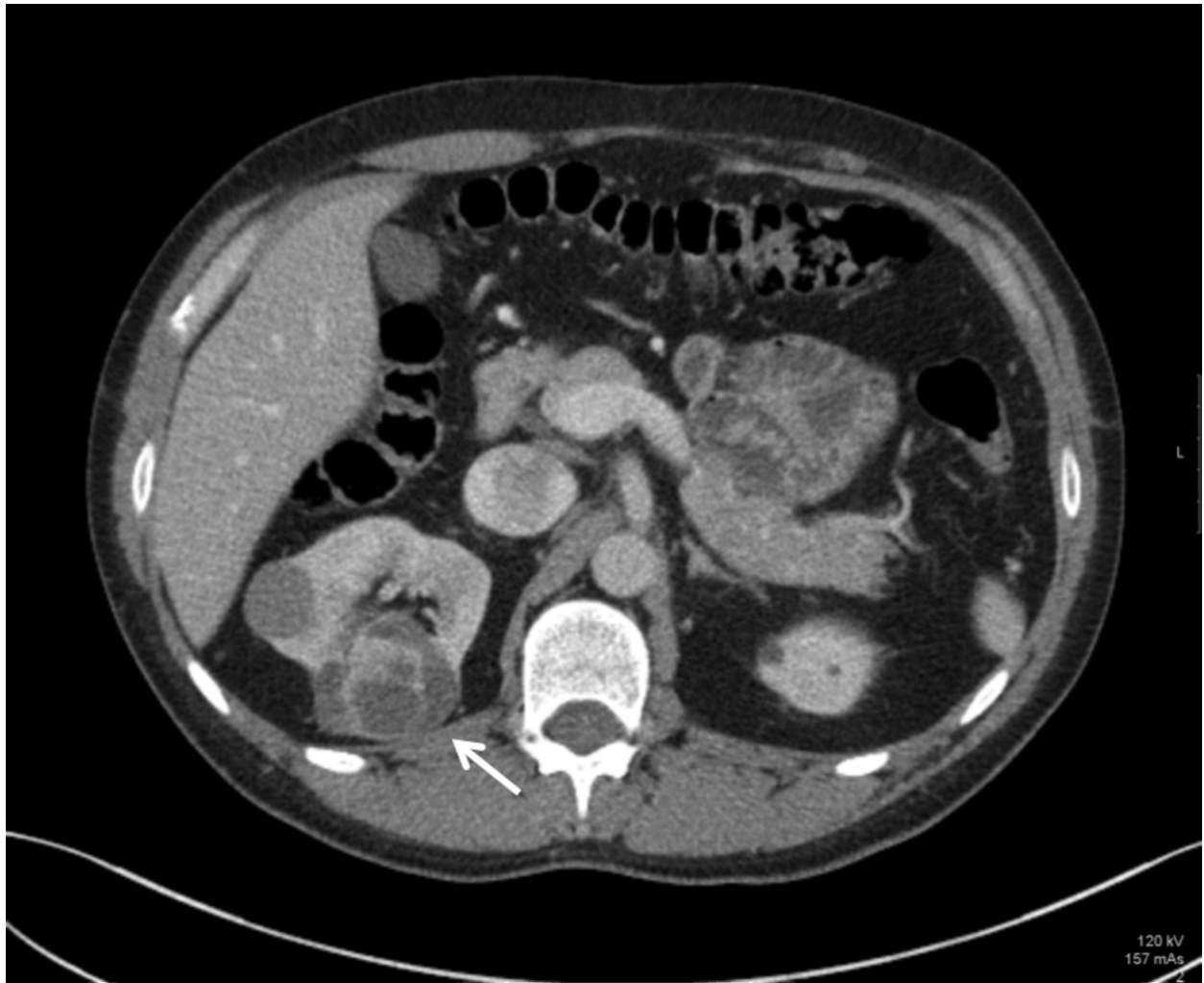
**Fig. 12:** A - Totally intrarenal hyperdense cyst on the left kidney (arrow). B - No enhancement after contrast injection - Bosniak IIc.



**Fig. 13:** A - Complex renal cyst detected at US. Further assessment required. B - Contrast-enhanced CT shows multiple thickened septa with dubious enhancement. Classified as Bosniak III. Check Fig.17.

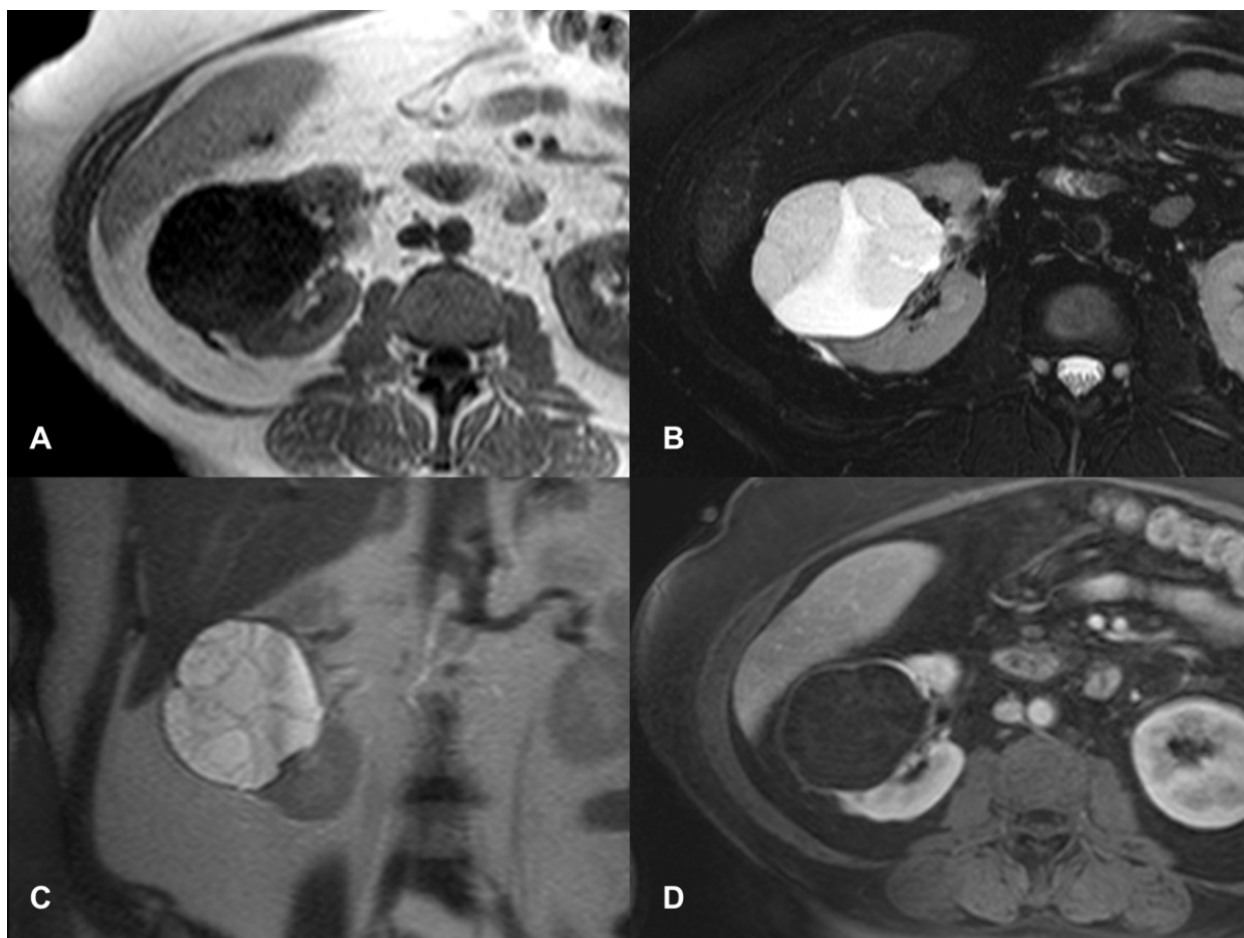


**Fig. 15:** A - Patient with a horseshoe kidney and a cyst with apparent solid component at US. B - Pre-contrast CT shows a lesion with soft tissue attenuation (30HU). C - After contrast there is slight enhance (15-20HU) - Bosniak III. D - Coronal reformat showing an associated calcification. Surgical resection did not show a neoplasm.

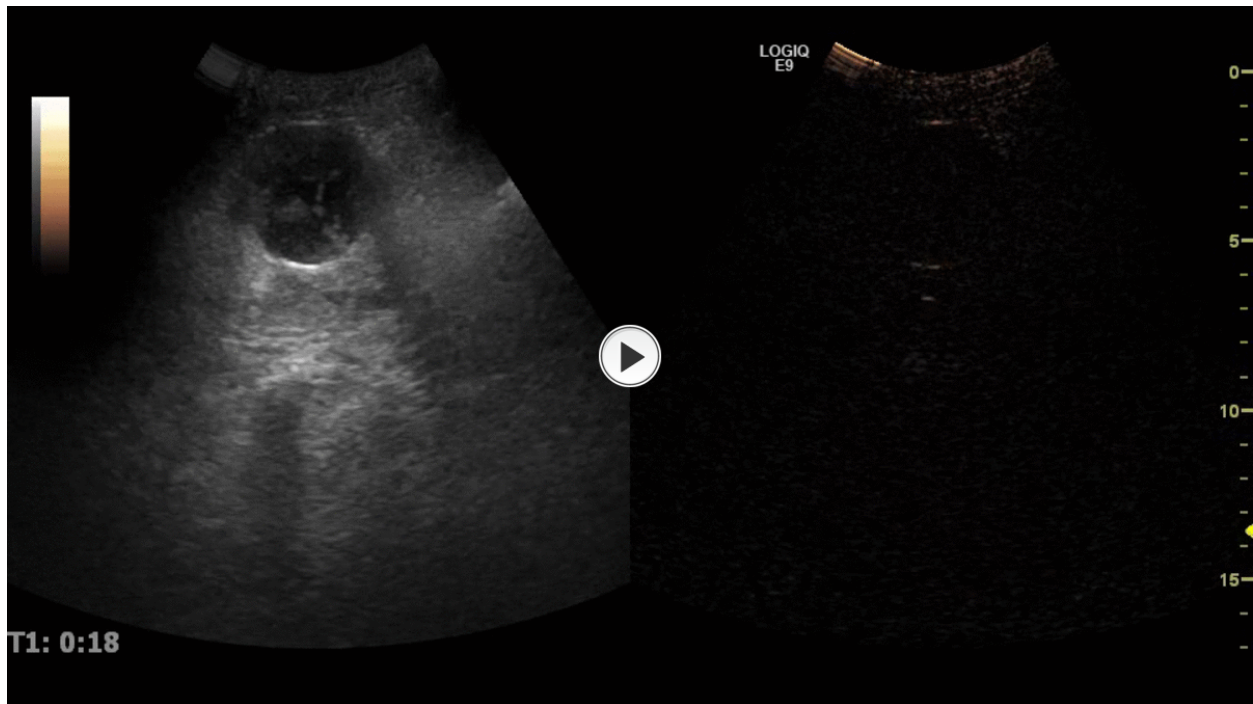


**Fig. 16:** Clearly malignant cystic mass of the right kidney (arrow) - Bosniak IV. Pathologic examination confirmed the presence of a cystic renal cell carcinoma.

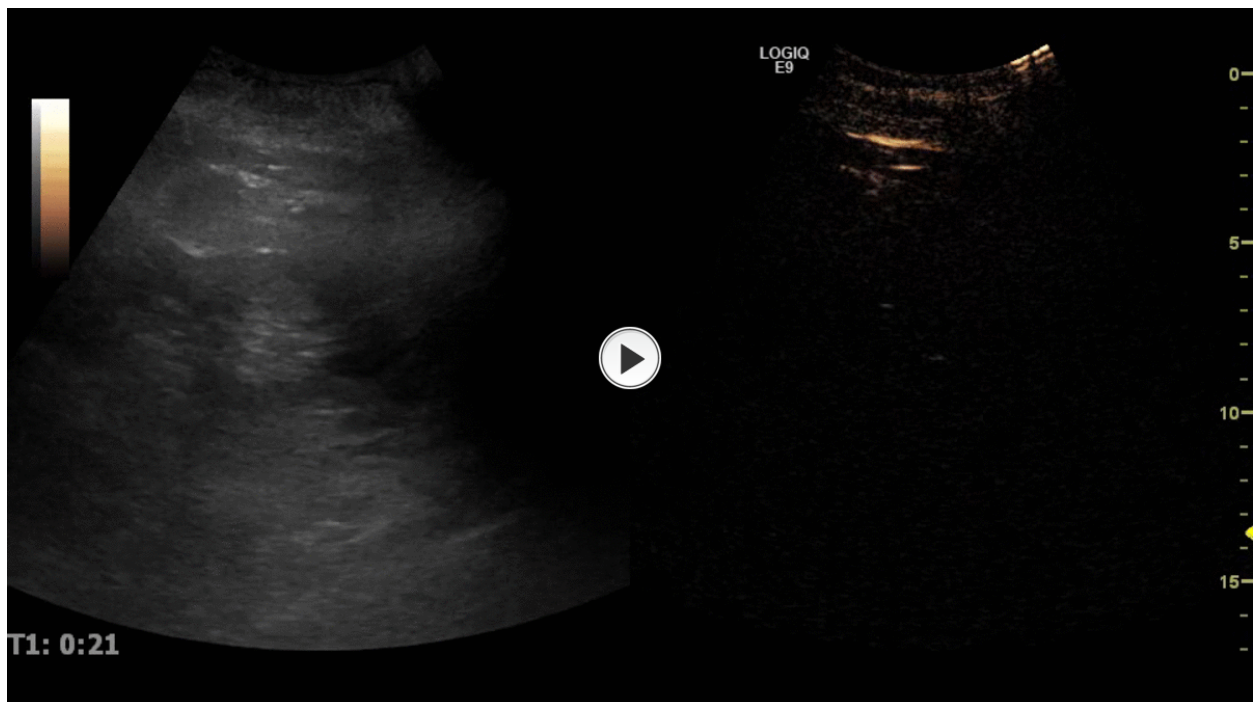




**Fig. 17:** MRI of the same patient as in Fig.13. Renal cyst with normal hypointensity at T1 (A) and hyperintensity at T2 (B - axial plane with fat suppression, C - coronal T2 haste). Presence of multiple thin septa without enhancement (D). Initially classified as Bosniak III by CT, it was reclassified as Bosniak II<sub>f</sub>. Follow up recommended.



**Fig. 21:** Complex kidney cyst detected on US, with thick internal septa. CEUS allowed prompt assessment of the cyst, showing no internal enhancement - Bosniak I. Probable hemorrhagic cyst.



**Fig. 22:** Same patient as in Fig.10. Complex cyst in the middle of the right kidney, classified as Bosniak II by contrast-enhanced CT. CEUS showed clear solid component



- Bosniak IV, not apparent at CT. There is also a large inferior cyst with thin internal septa
- Bosniak II.

## Conclusion

Complex renal cysts are a major clinical problem, since it is often difficult to exclude malignancy.

Bosniak classification, based on CT or MRI findings, is a valuable tool in predicting the likelihood of malignancy, however it has some limitations. It is therefore important to be familiar with the criteria of this classification and know how to categorize complex kidney cysts.

Newer techniques like CEUS show promising results, and may bring advantages to the assessment of these lesions.

## Personal information

## References

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