# Imaging Characterization of Solid Parenchymal Renal Masses

By

**Tarek A. El – Diasty**

Urology & Nephrology Center,
Mansoura University,
Mansoura, Egypt

# Outline

* Radiologic approach to renal masses.
* Imaging modalities in characterization of renal masses.
* Solid Renal Cell Carcinoma (RCC).
* Staging of RCC.
* Subtypes of RCC, mP MRI.
* Benign renal masses.
* Role of image-guided renal mass biopsy.

# Radiological Approach to renal masses

**Suspicion of renal mass either from history or IVU**

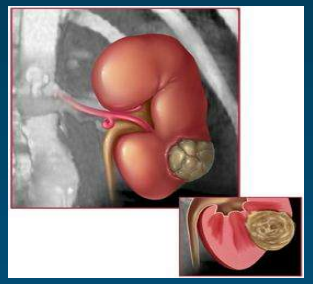
Ultrasonography

Cystic

Simple

Complicated

Stop



**Solid**

**CT**

MRI

Inflammatory

Medical

Aspiration

Benign or **malignant**

Indeterminate

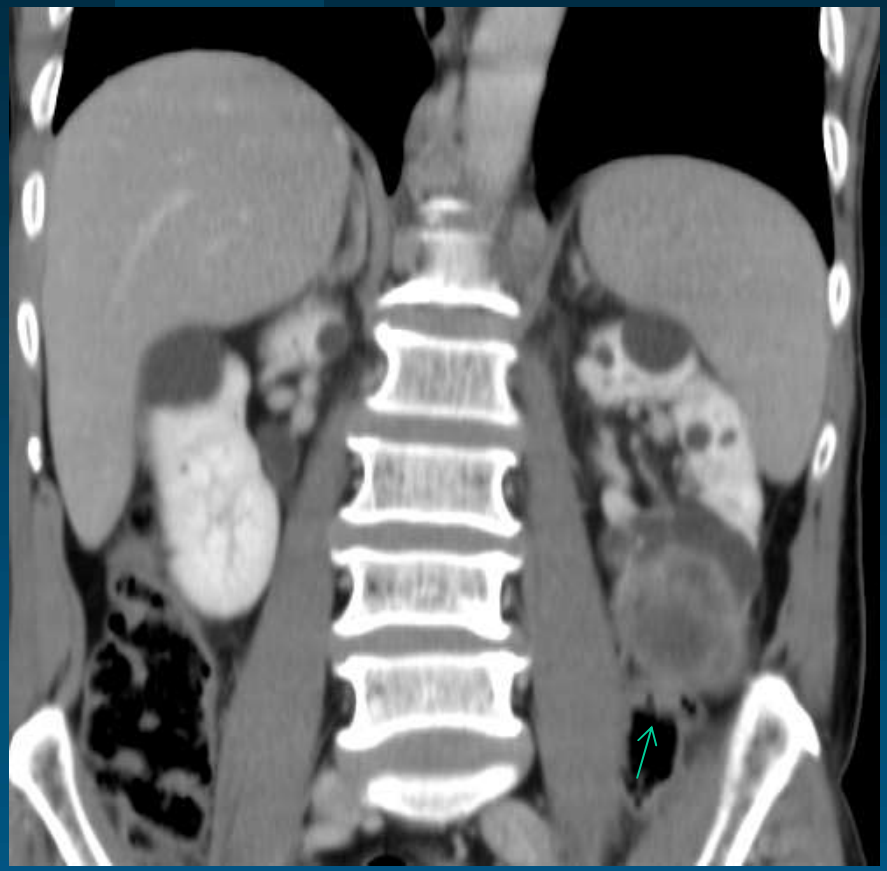
Biopsy

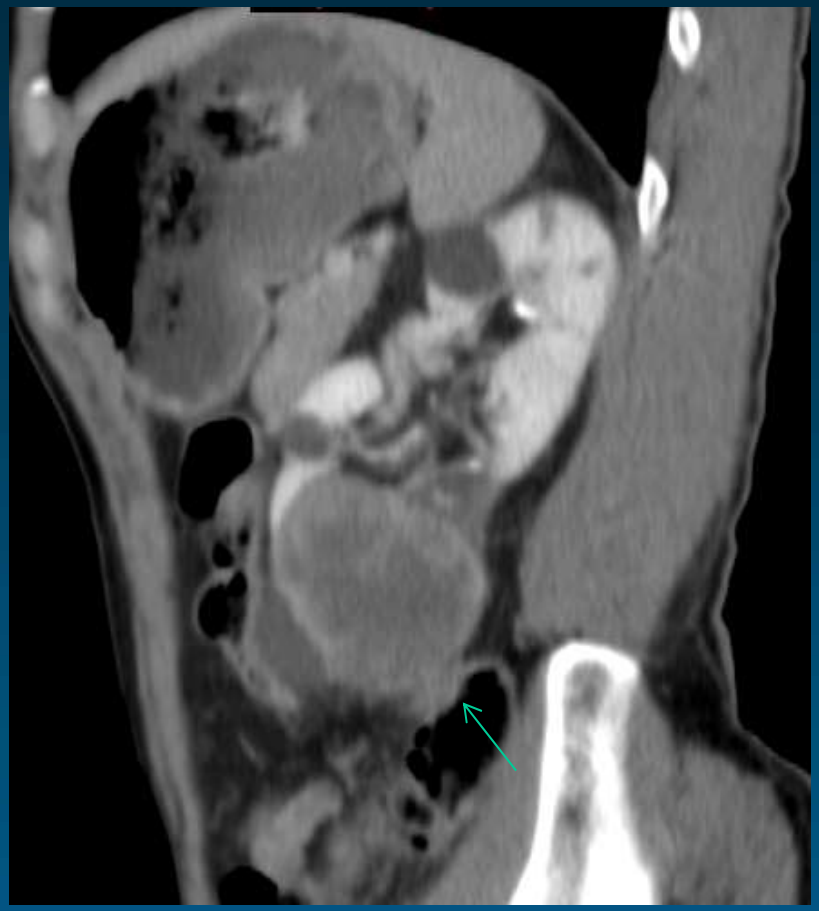
# Imaging modalities

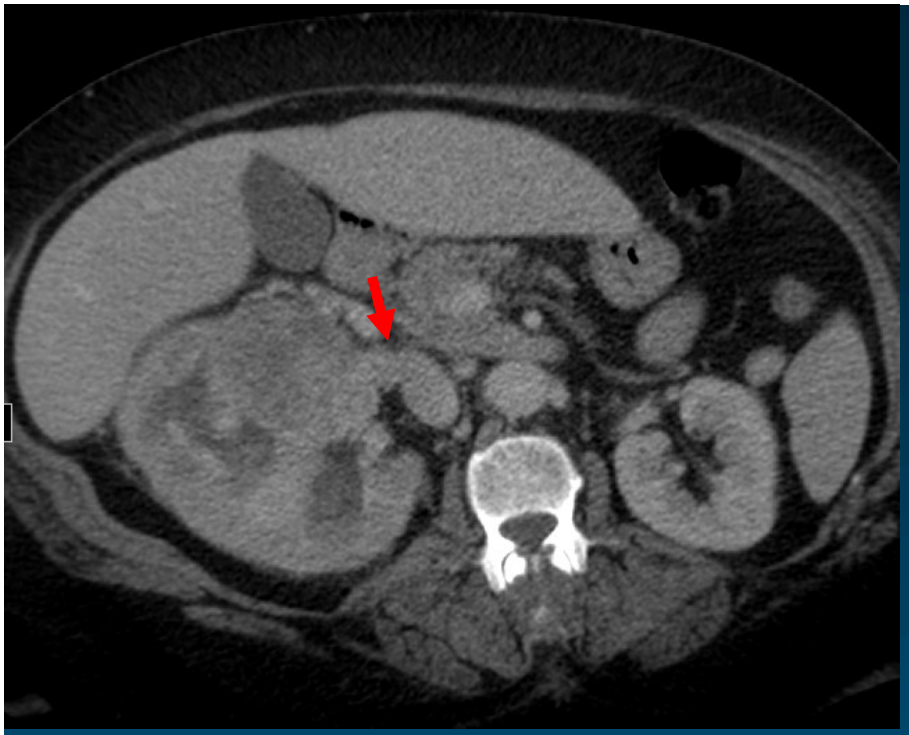
- CT is the modality of choice for detection and characterization of renal masses.

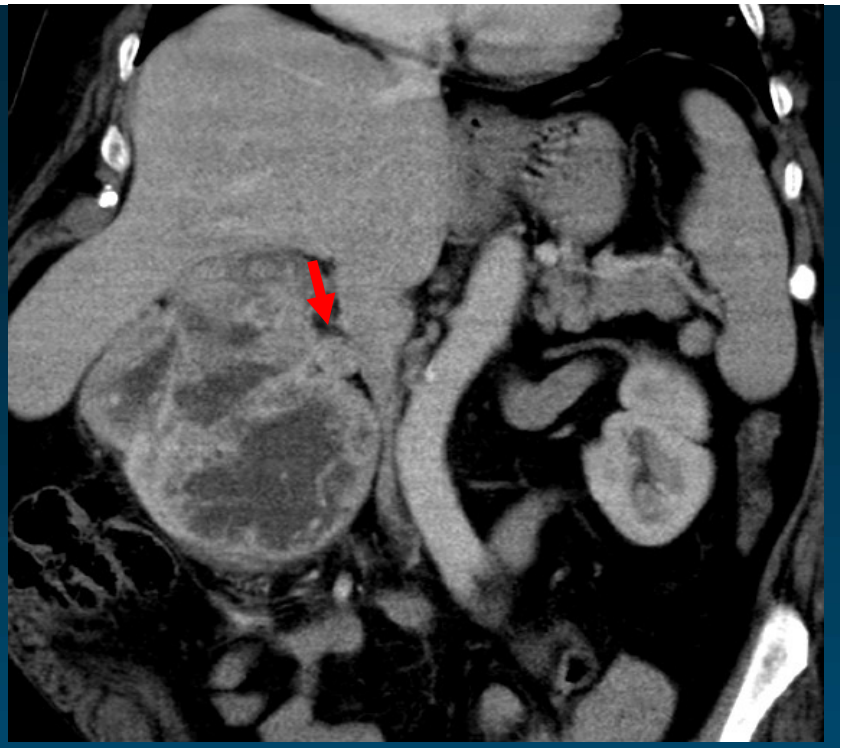
- MRI has played an increasingly important role in imaging patients with renal masses.

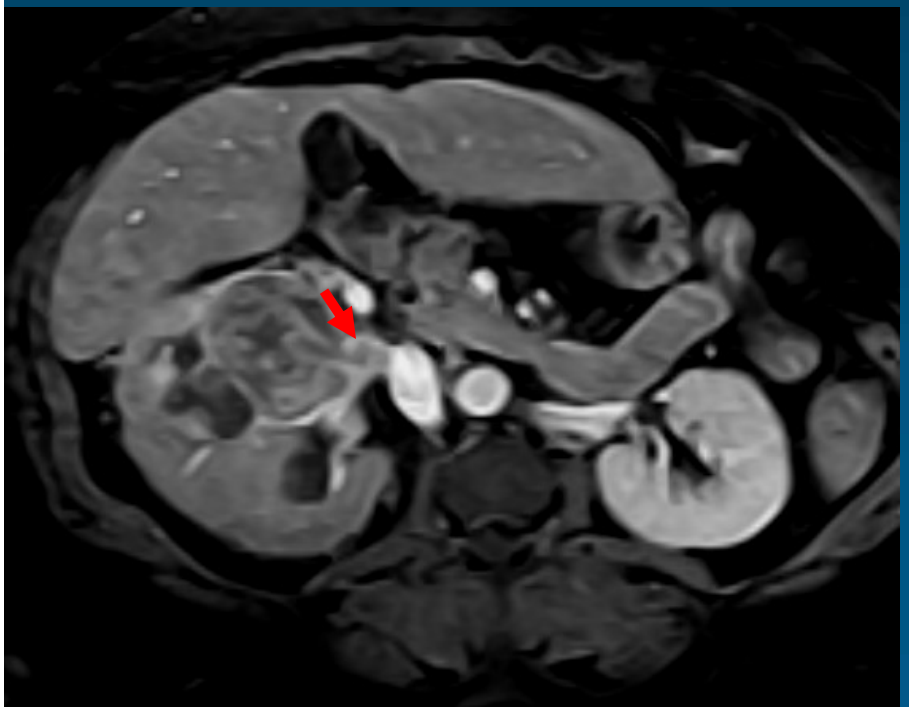
*Dunnick, Abdom Radiol (2016) 41:1079–1085*

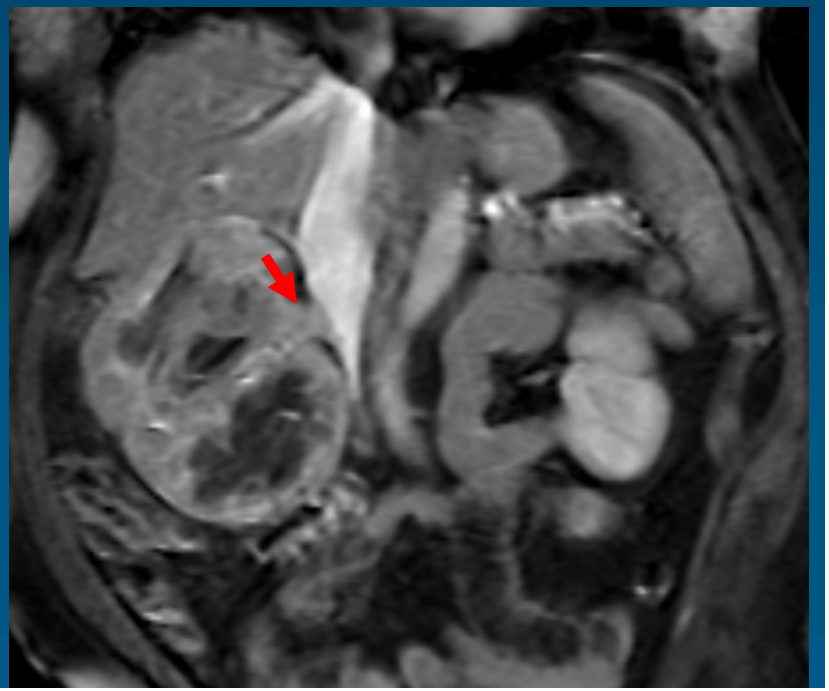












# Imaging modalities

- MRI is currently rated comparable to CT by the American College of Radiology for RCC staging and post-treatment follow-up and for evaluation of indeterminate renal masses (ACR Appropriateness Criteria).

- MRI also represents an attractive option for serial radiographic monitoring of patients with hereditary syndromes affecting the kidneys.

*Sankineni et al.,Urologic Oncology:SeminarsandOriginalInvestigations34(2016)147–155*

# Imaging modalities

- Application of FDG PET/CT is limited for renal cell carcinoma (RCC), mainly due to physiological excretion of 18F-fluoro-2-deoxy-2-D-glucose (FDG) from the kidneys, which may obscure or mask the lesions of the kidneys.

- FDG PET/CT is not recommended for local staging of RCC based on current international guidelines.

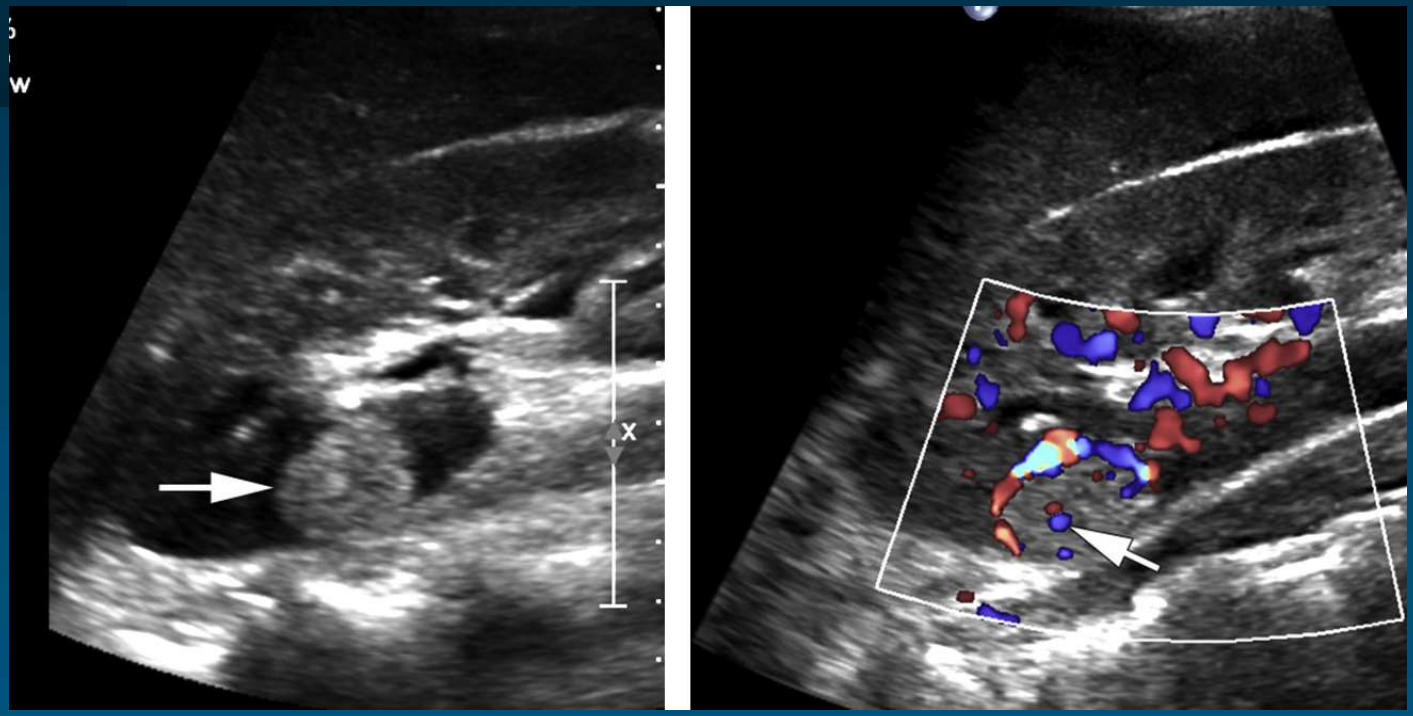
*Liu, Front. Oncol., 06 September 2016*

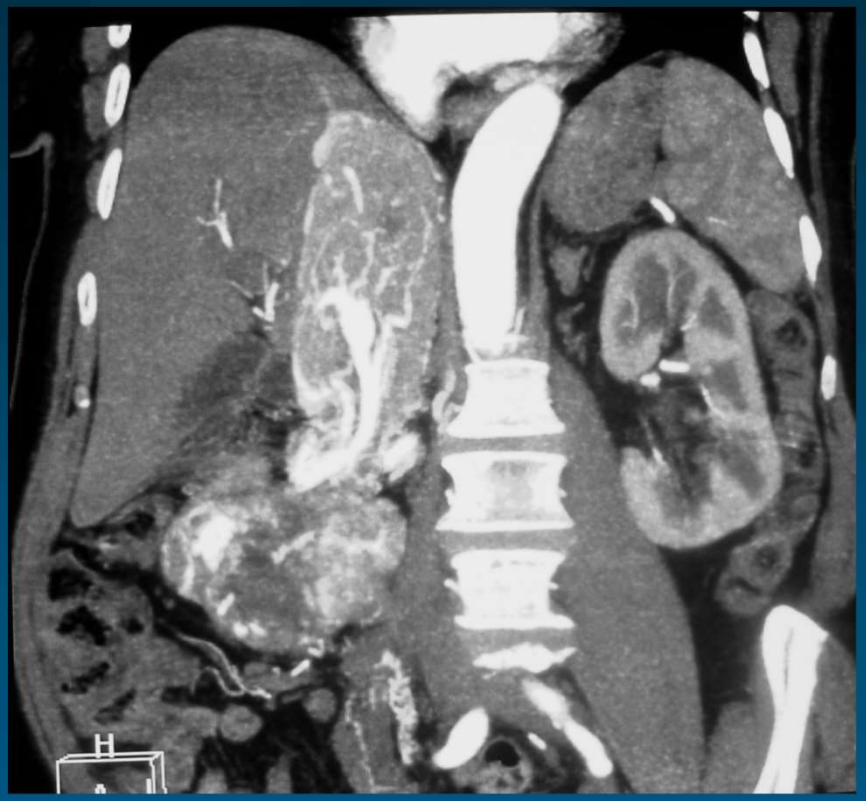
# Characterization

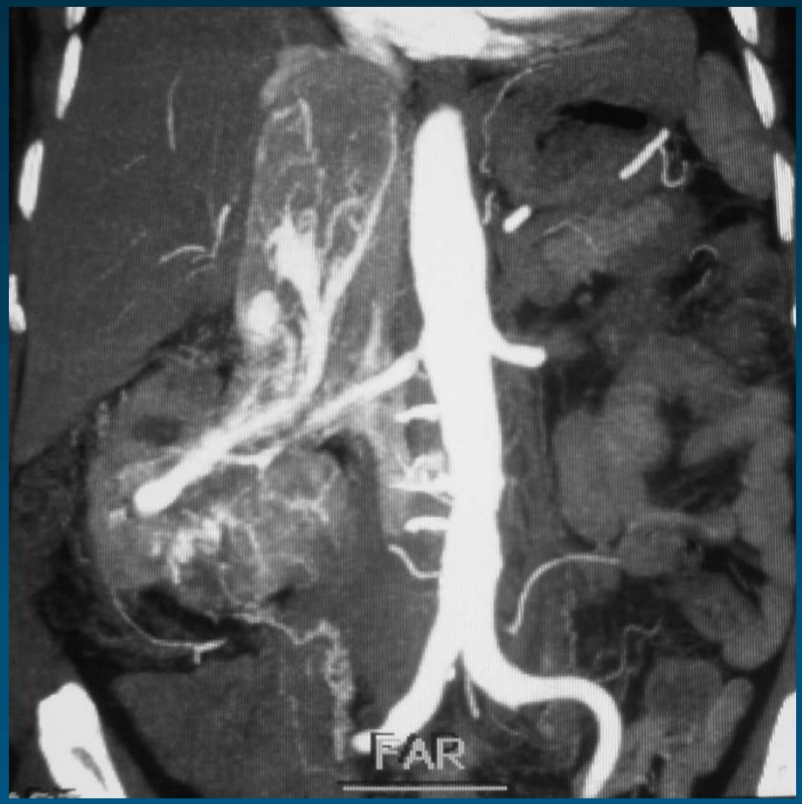
- The presence of vascularity in a renal mass is the most reliable finding to characterize the lesion as a neoplasm:

- Color flow US, Vascular phase CT & MRI
- Enhancement: CT, MRI, USCA

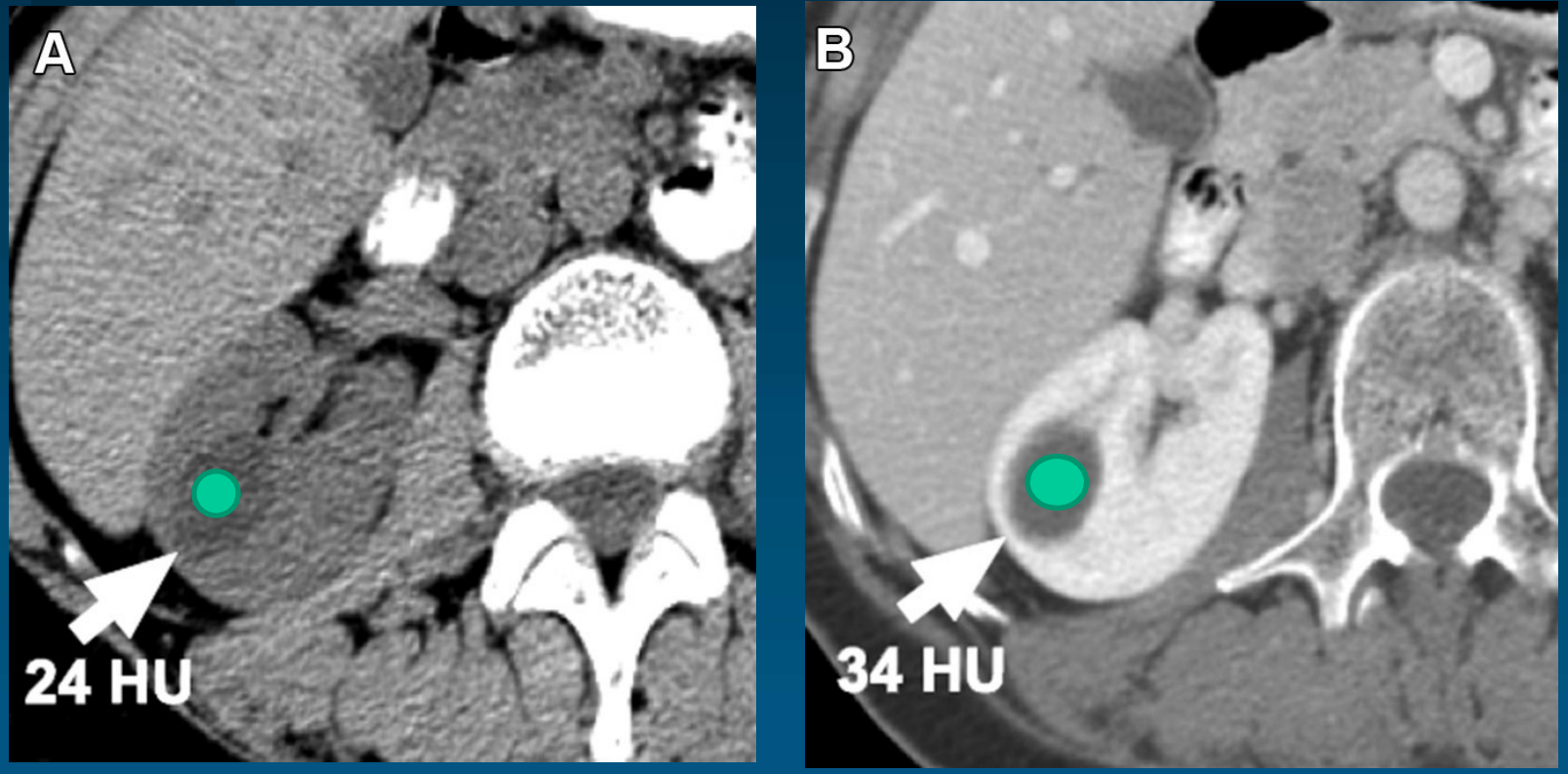
# US

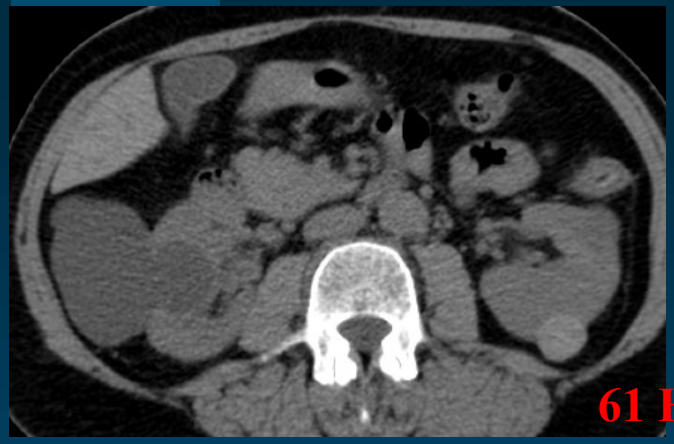





FAR

# Pseudoenhancement

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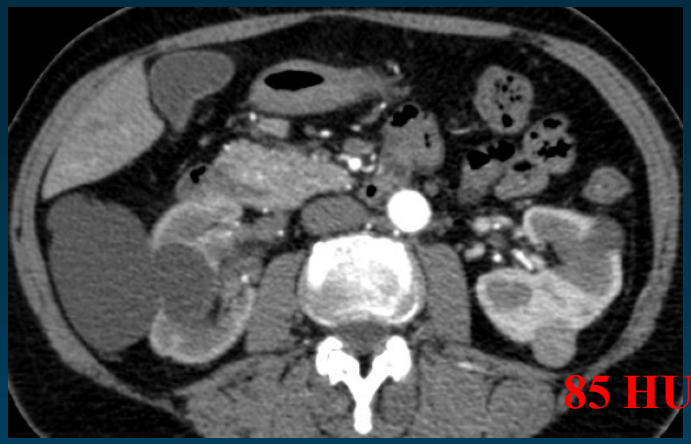
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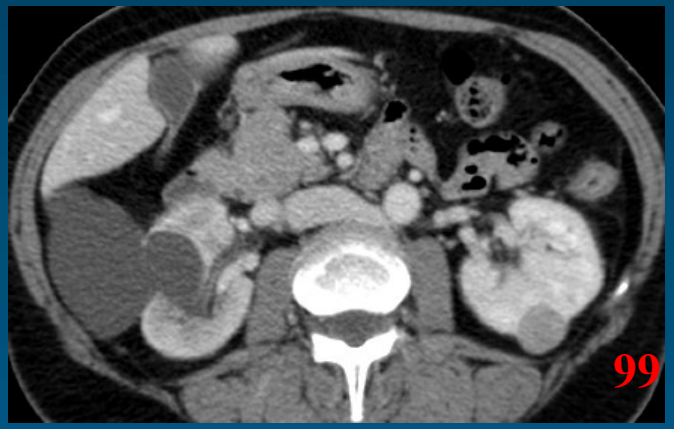
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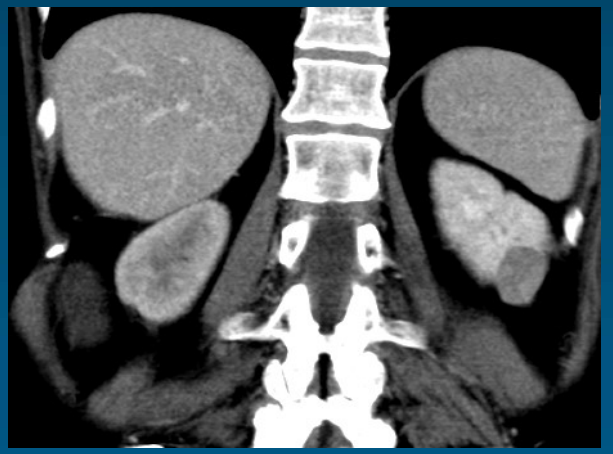


# TNM staging of the American Joint Committee on Cancer, 2010

| | |
|---|---|
| Primary tumors (T) | |
| TX | Primary tumor cannot be assessed |
| T0 | No evidence of primary tumor |
| T1 | Tumor ≤7 cm in greatest dimension, limited to the kidney |
| T1a | Tumor ≤4 cm in greatest dimension, limited to the kidney |
| T1b | Tumor >4 cm but ≤7 cm in greatest dimension, limited to the kidney |
| T2 | Tumor >7 cm in greatest dimension, limited to the kidney |
| T2a | Tumor >7 cm but ≤10 cm in greatest dimension, limited to the kidney |
| T2b | Tumor >10 cm, limited to the kidney |
| T3 | Tumor extends into major veins or perinephric tissues but not into the ipsilateral adrenal gland and not beyond the Gerota fascia |
| T3a | Tumor grossly extends into the renal vein or its segmental (muscle-containing) branches, or tumor invades perirenal and/or renal sinus fat but not beyond the Gerota fascia |
| T3b | Tumor grossly extends into the vena cava below the diaphragm |
| T3c | Tumor grossly extends into the vena cava above the diaphragm or invades the wall of the vena cava |
| T4 | Tumor invades beyond the Gerota fascia (including contiguous extension into the ipsilateral adrenal gland) |
| Regional lymph node (N) | |
| NX | Regional lymph nodes cannot be assessed |
| N0 | No regional lymph node metastasis |
| N1 | Metastasis in regional lymph node(s) |

# TNM Classification - 2010

T1 Tumor 7 cm, limited to kidney

T1a Tumor 4 cm, limited to kidney

T1b Tumor 4–7 cm, limited to kidney

T2 Tumor >7 cm, limited to the kidney

T2a Tumor >7 cm but 10 cm in greatest dimension

T2b Tumor >10 cm, limited to the kidney

# TNM Classification - 2010

T3 Tumor extends into major veins or perinephric tissues but not into the ipsilateral adrenal gland and not beyond Gerota's fascia:

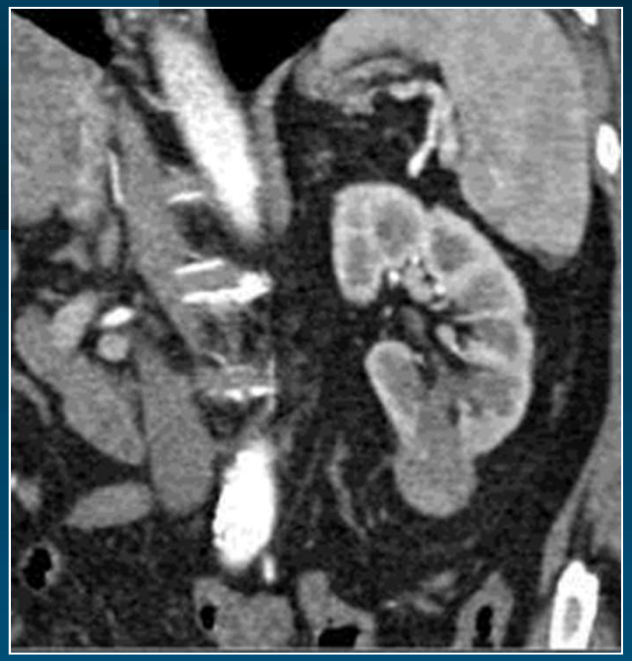
**T3a** Tumor grossly extends into the renal vein or its segmental (muscle containing) branches, or tumor invades perirenal and/or renal sinus fat but not beyond Gerota's fascia

**T3b** Tumor grossly extends into the vena cava below the diaphragm

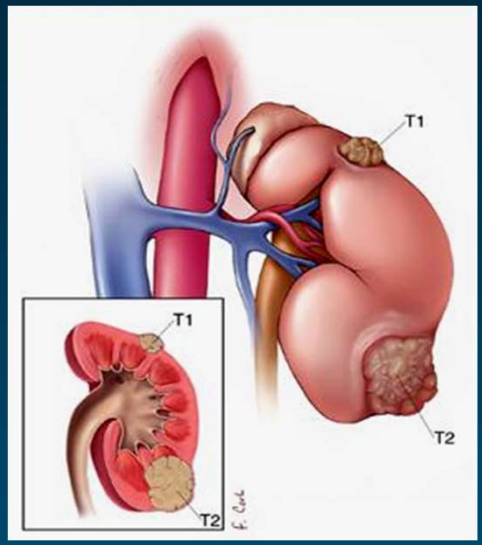
**T3c** Tumor grossly extends into the vena cava above the diaphragm or invades the wall of the vena cava.

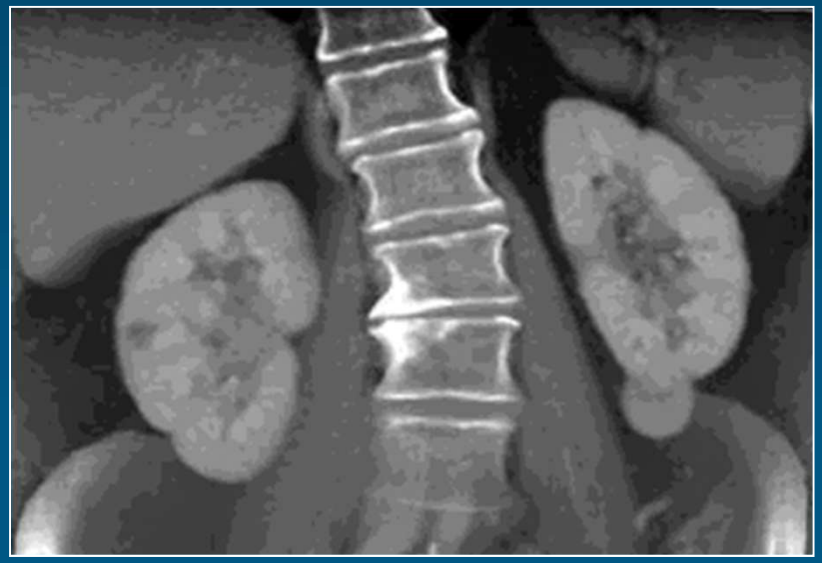
T4 Tumor invades beyond Gerota's fascia (Including contiguous extension into the ipsilateral adrenal gland)

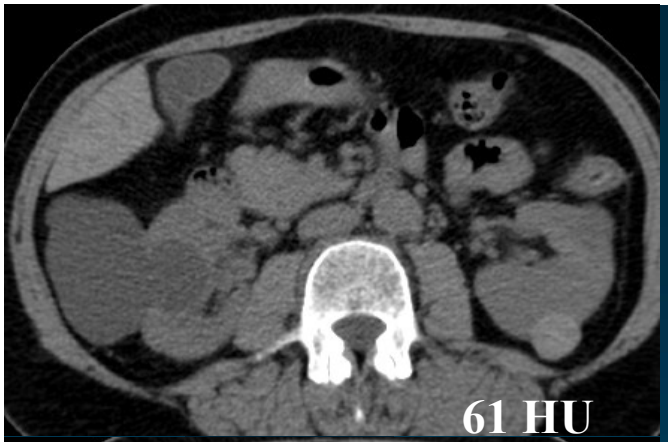
# Solid RCC

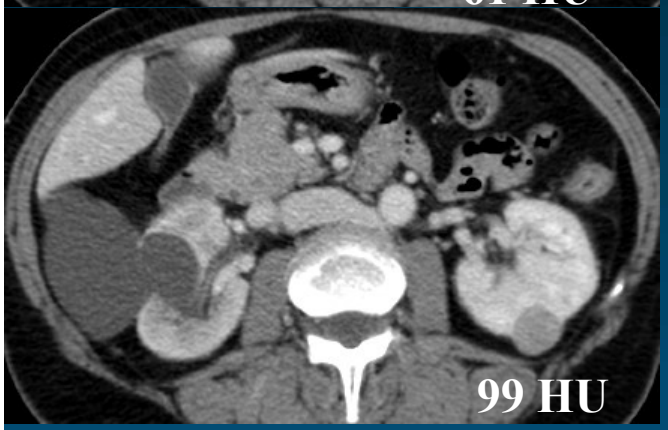


T1 & T2

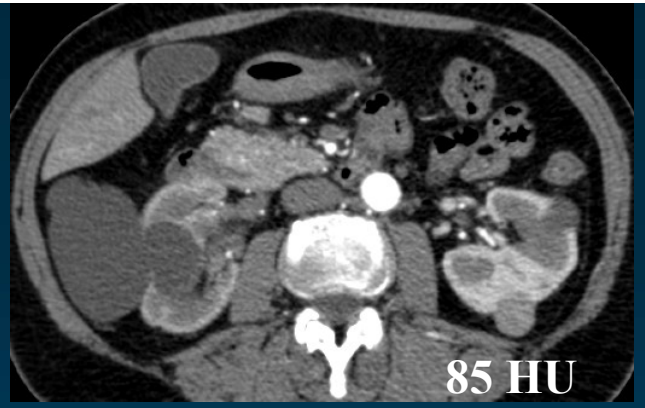


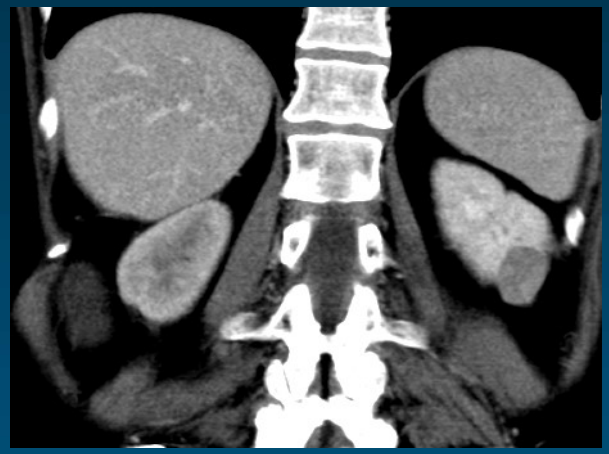



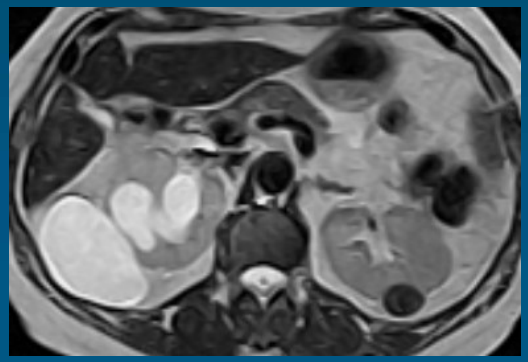


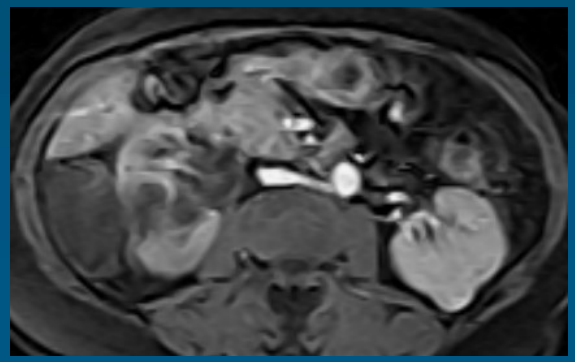



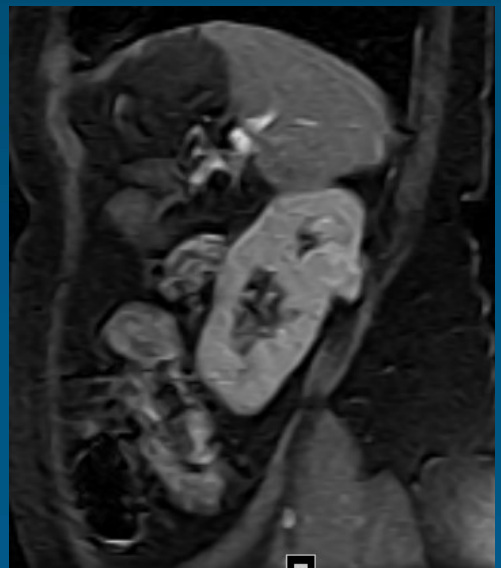

**T1a**

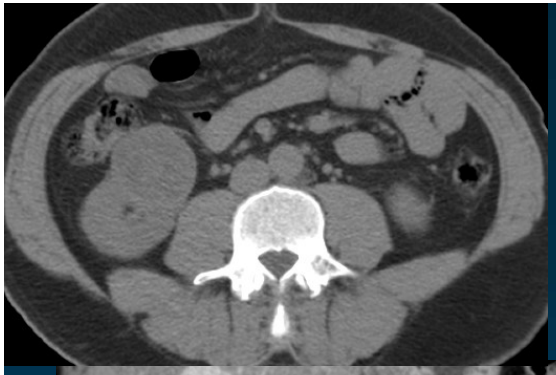


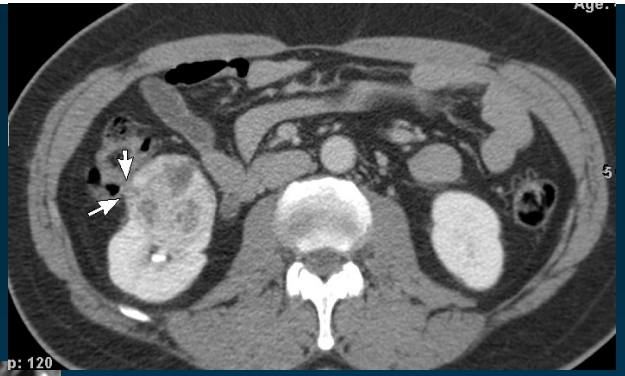



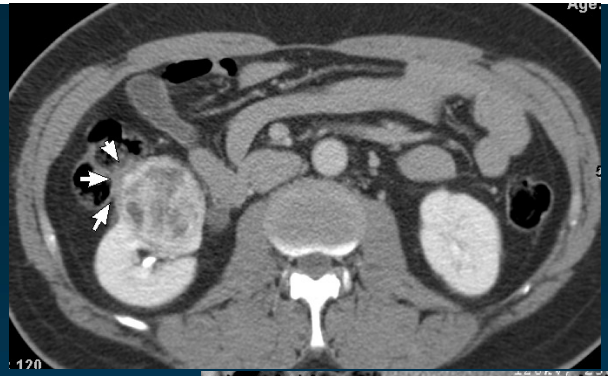


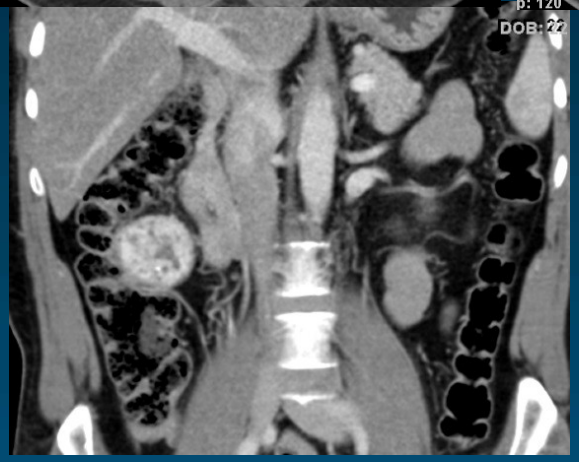


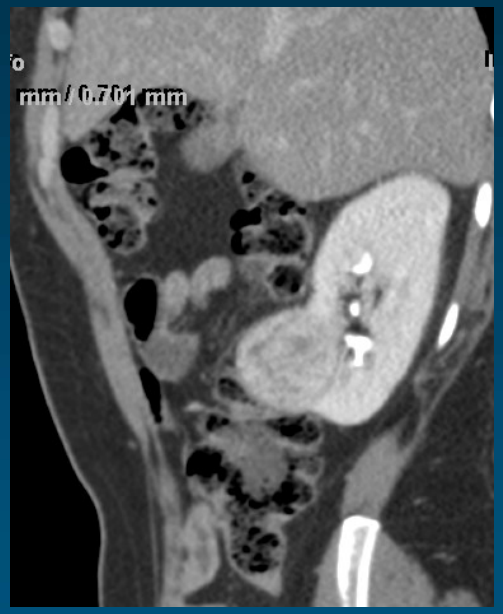


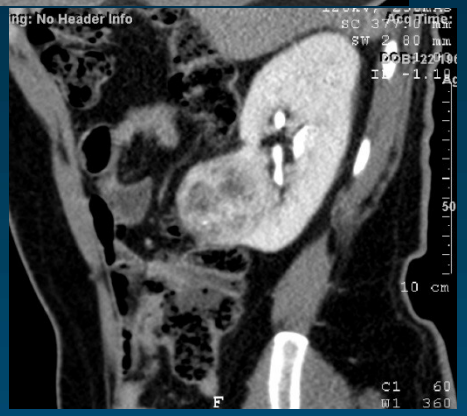


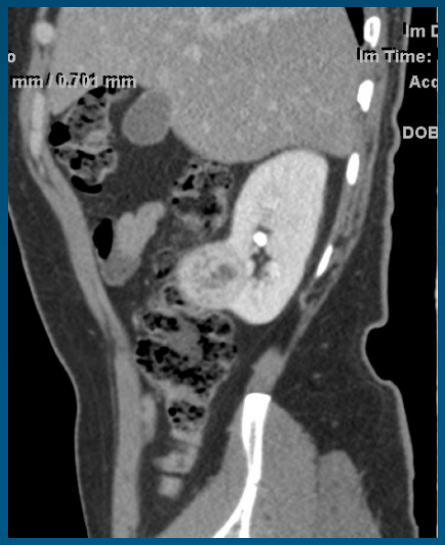


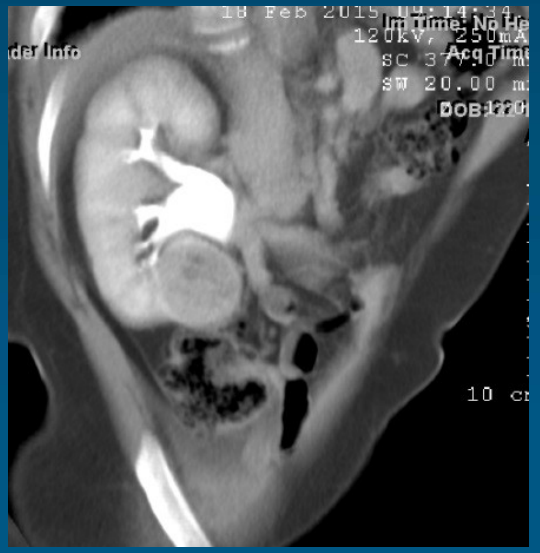




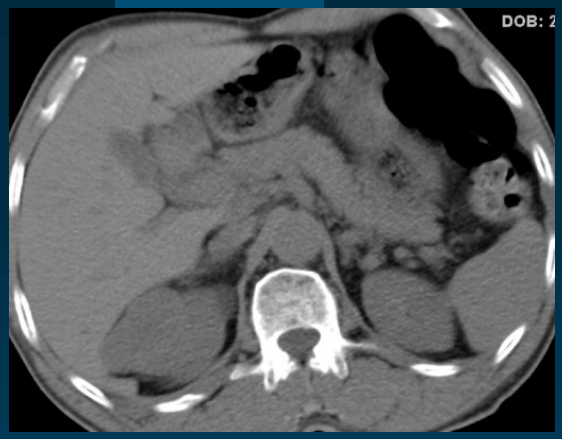


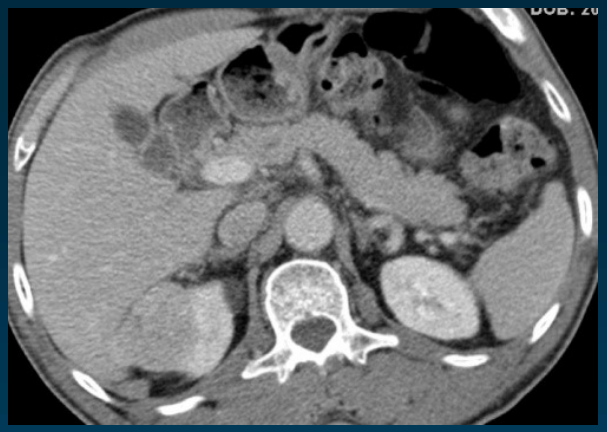


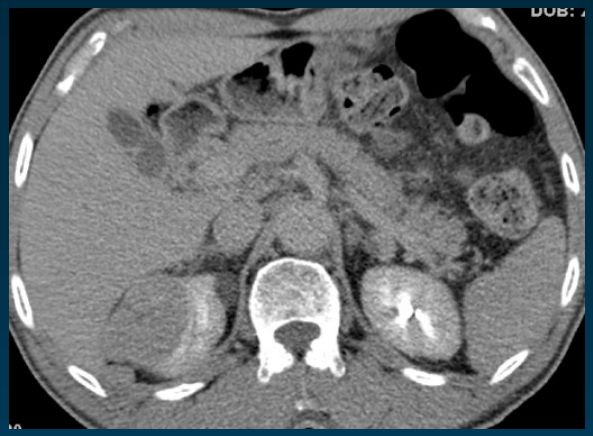


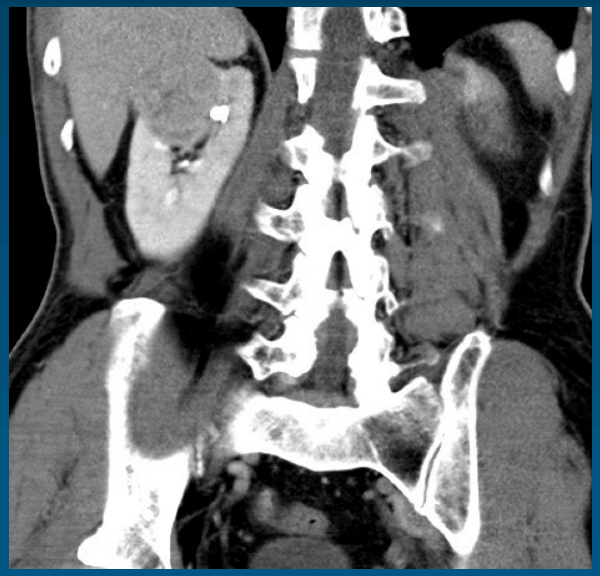


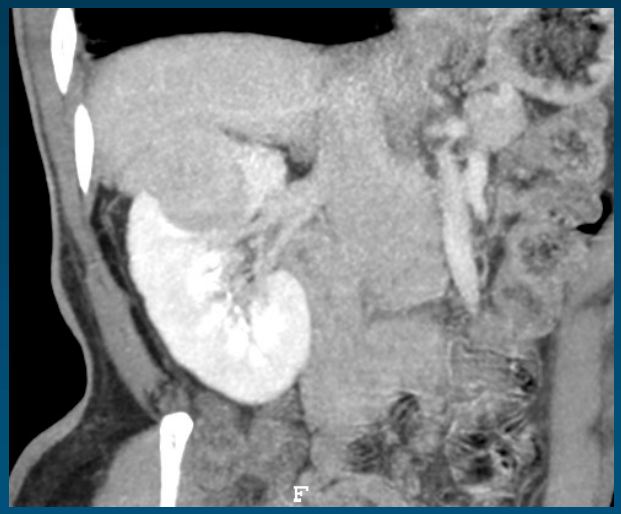
Post-operative pathology :
T1b 5 cm

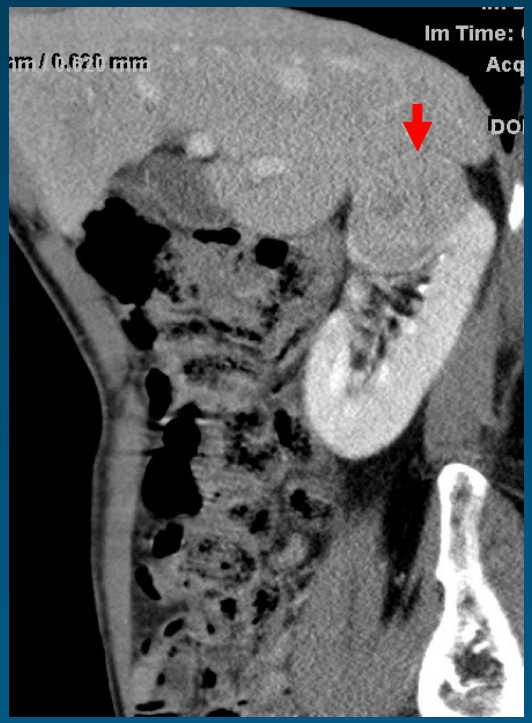






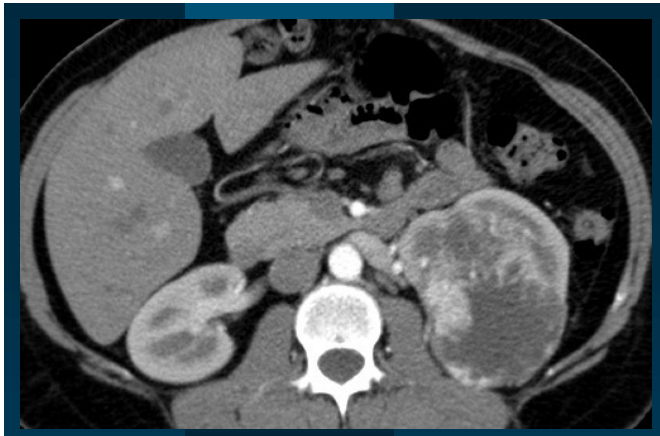


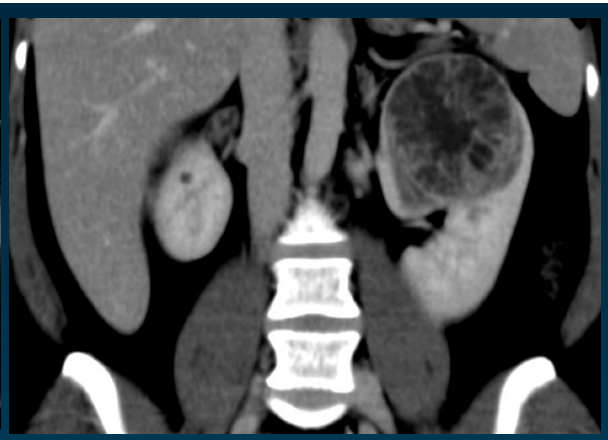


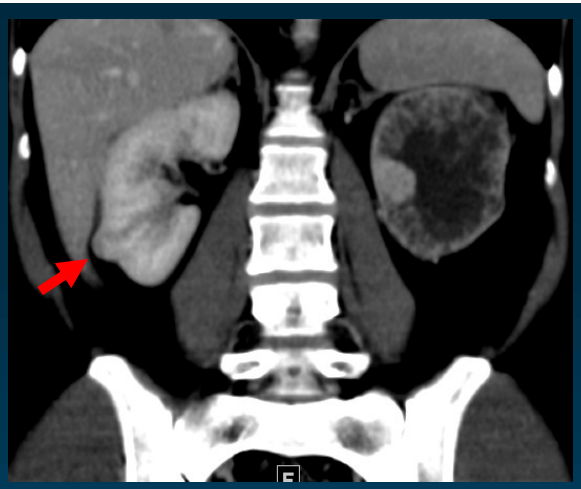


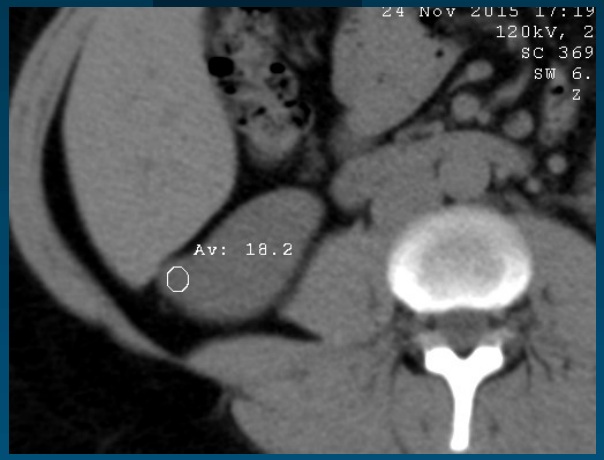

Post-operative pathology : T1b 5 cm

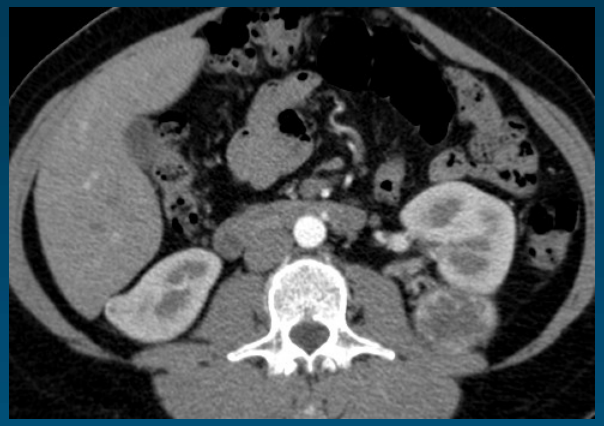
RCC, chromophobe type with intact renal capsule, free renal vein and suprarenal gland.

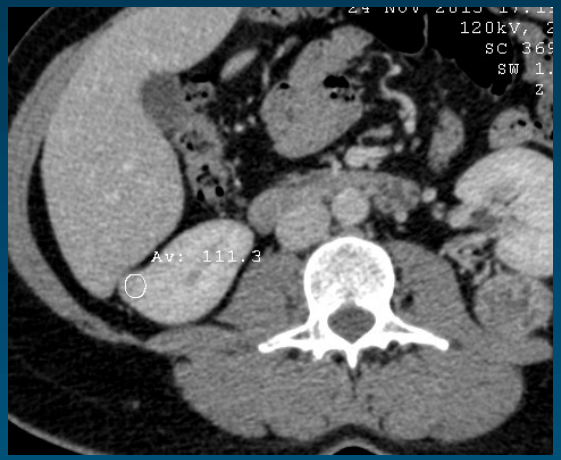


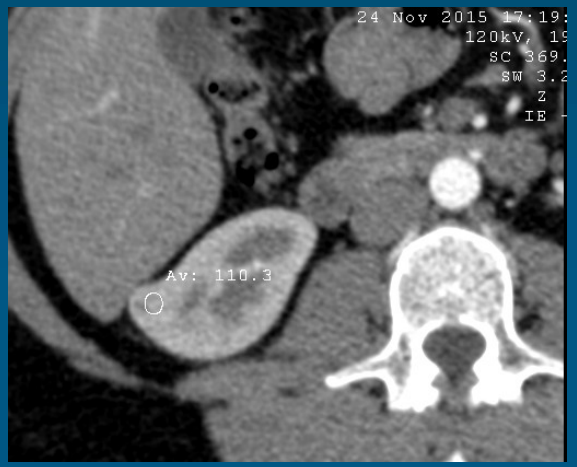






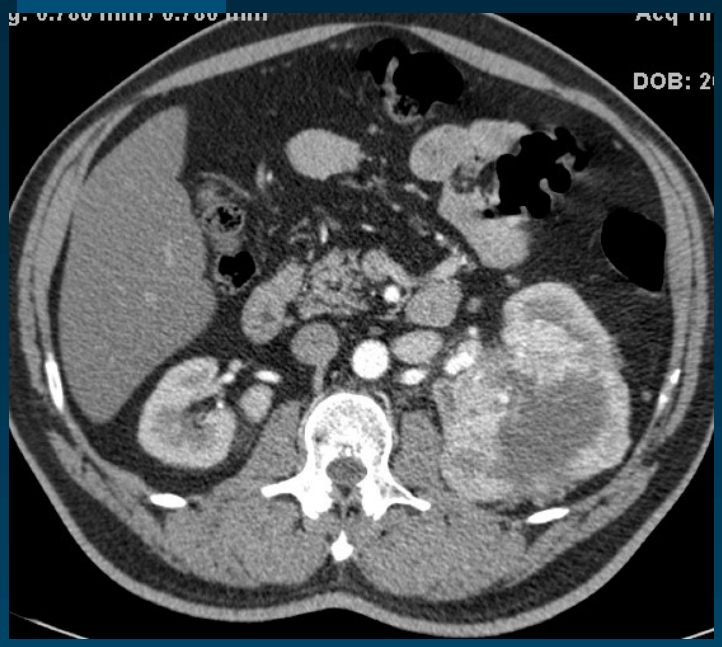



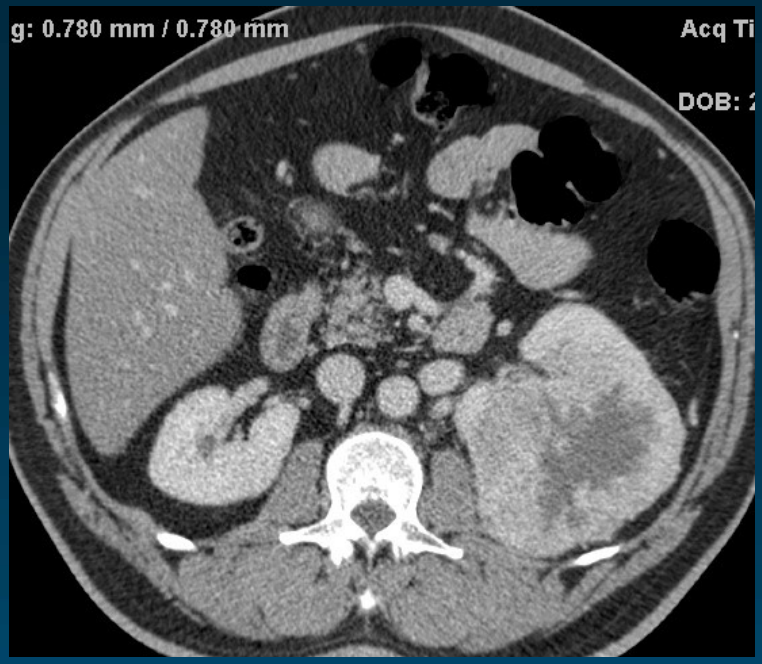


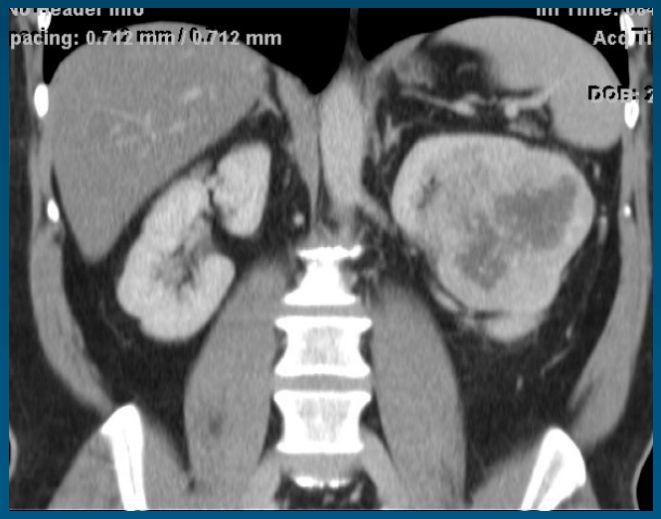



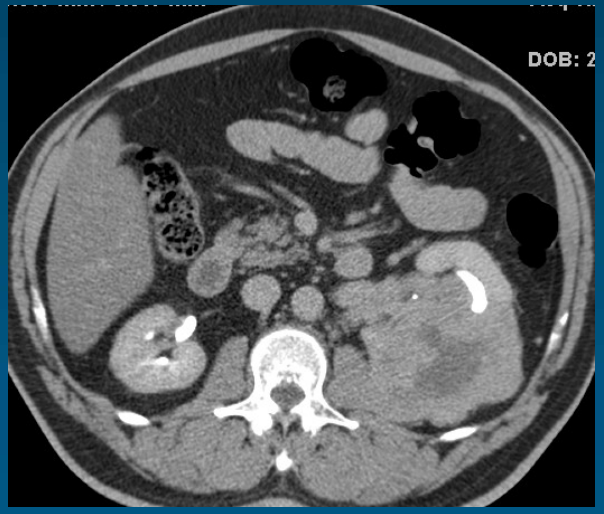

LT: T2b 10.3 cm

RT: T1a 1.5 cm



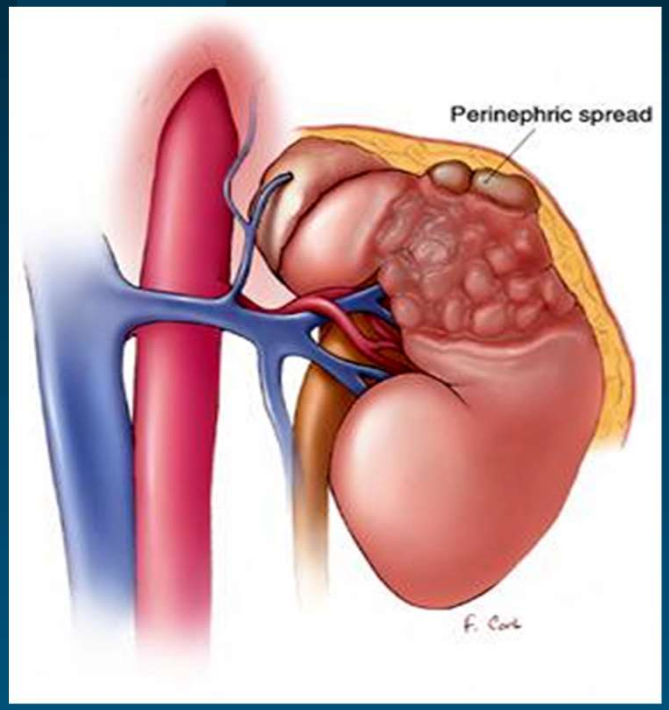


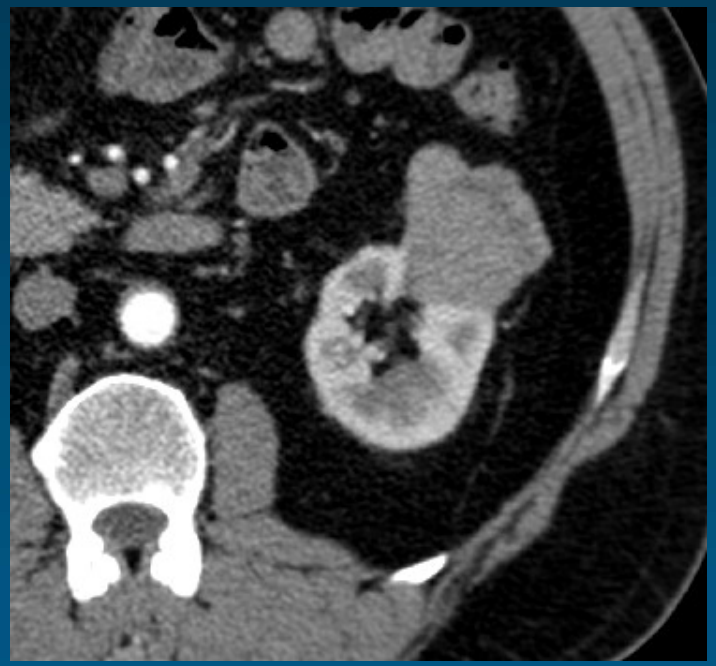


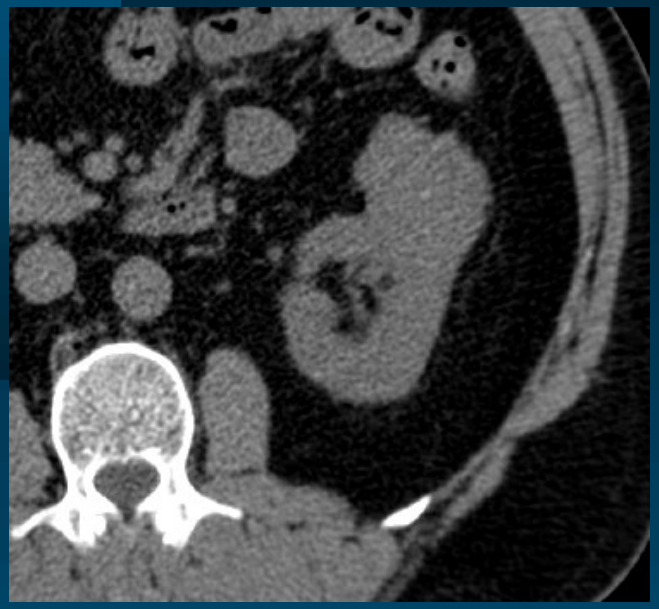
T2a 9cm

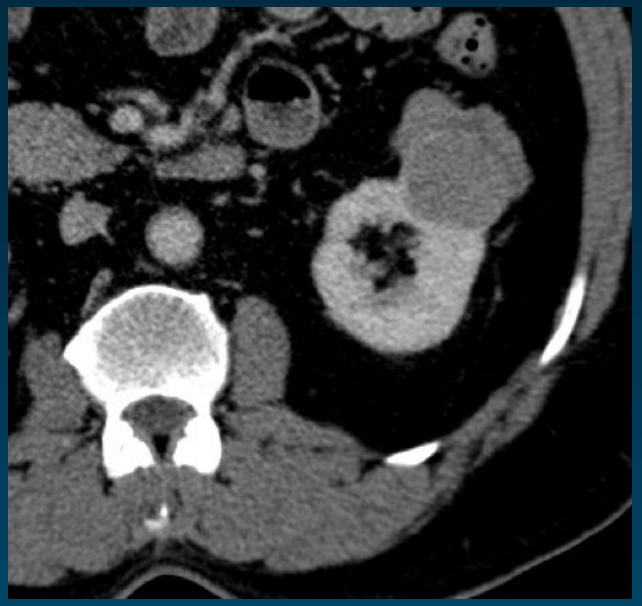
# Solid RCC

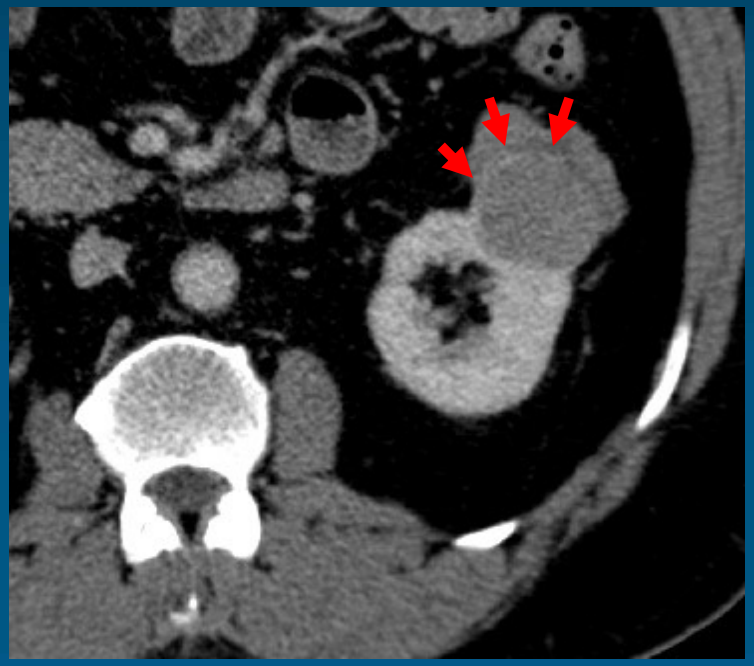



T3

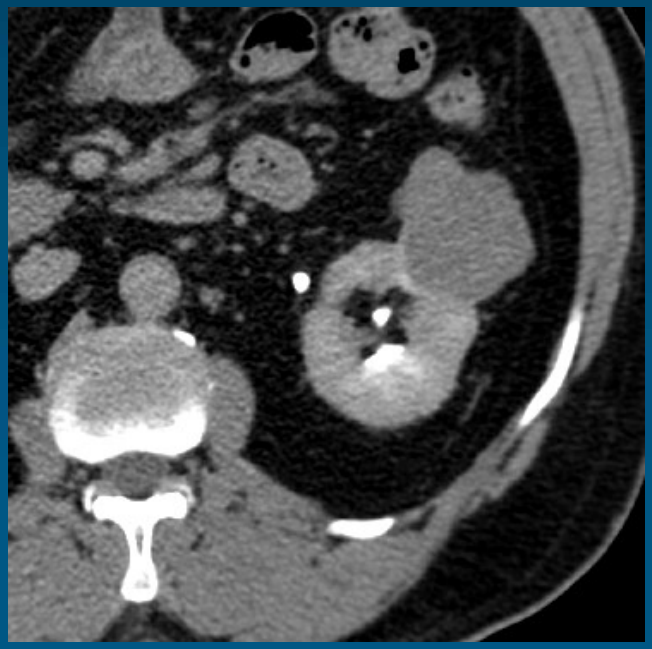




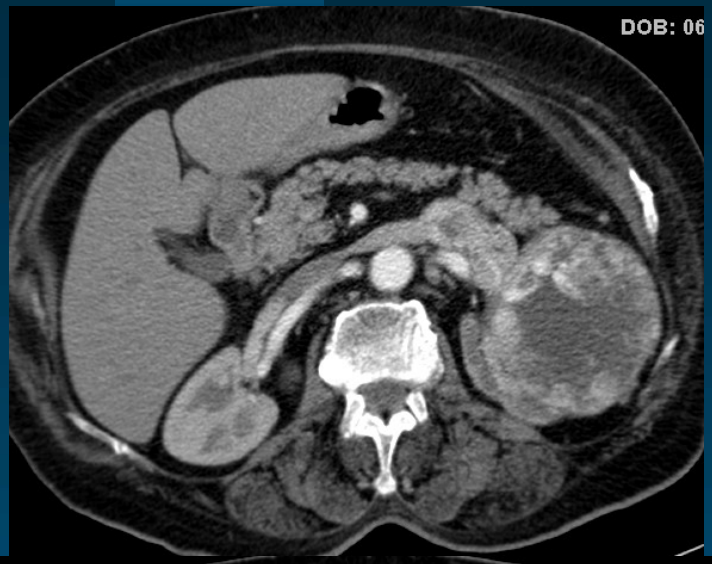


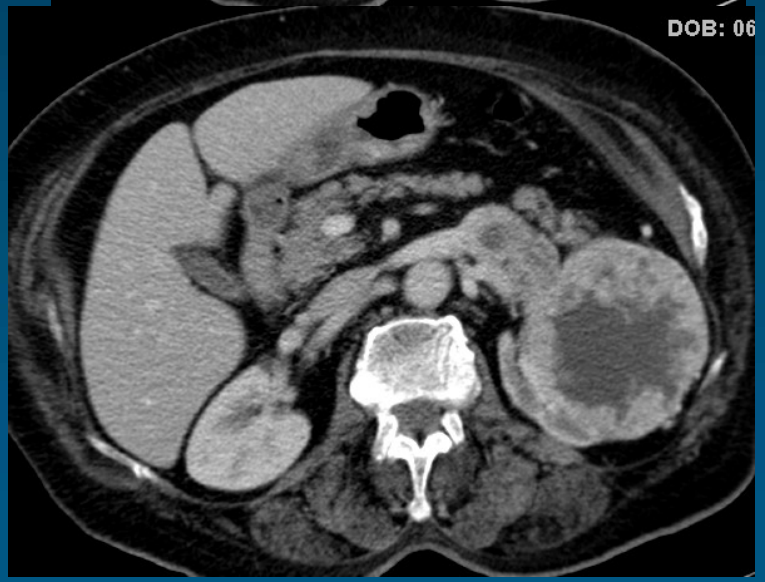


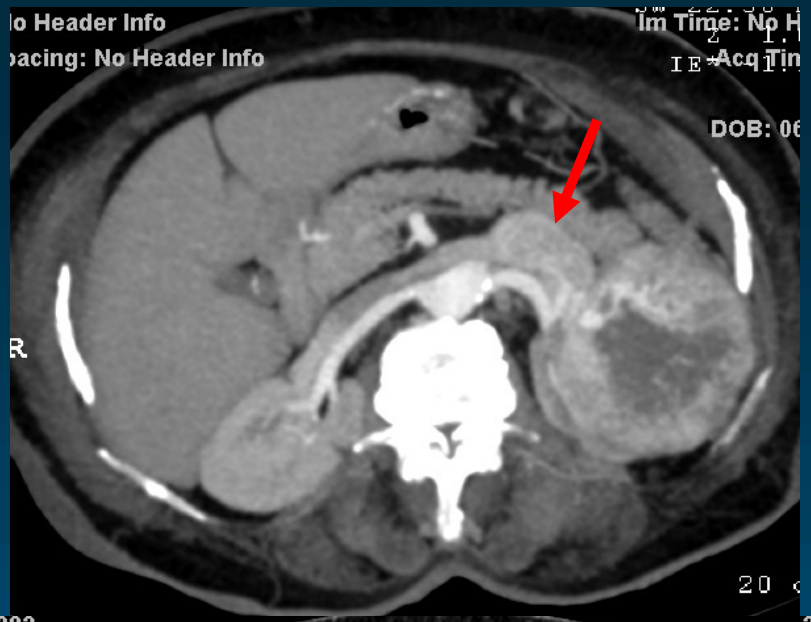
T3a… perirenal fat infiltration

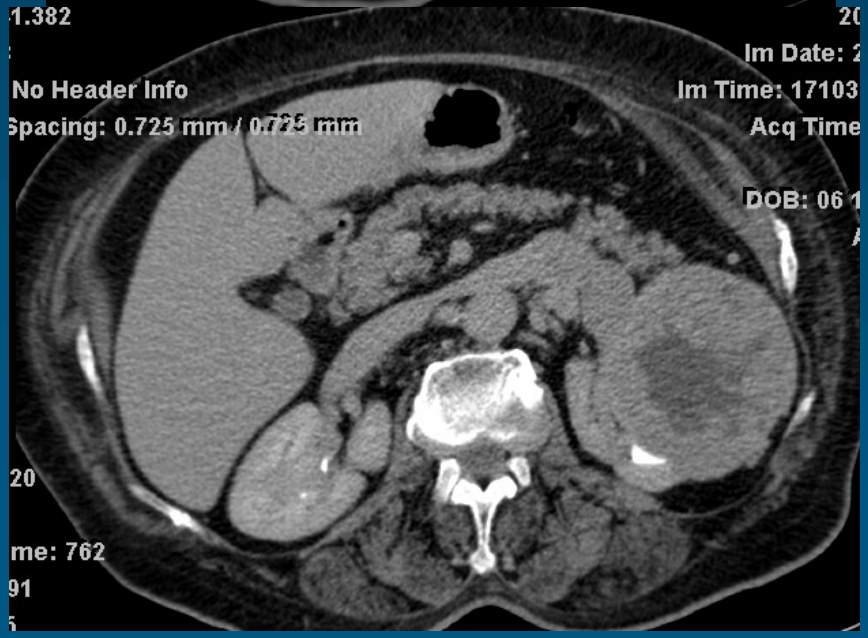


# RCC; Vascular Invasion

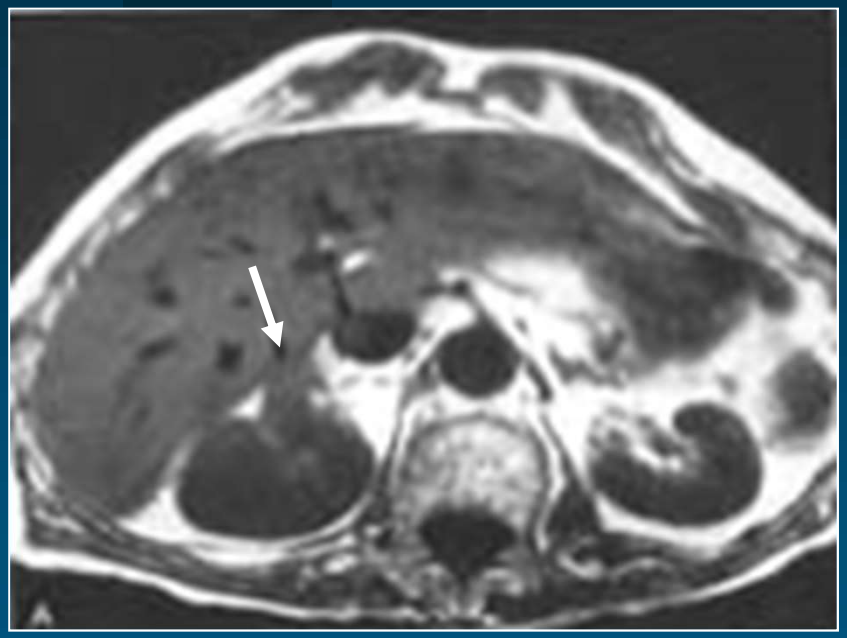


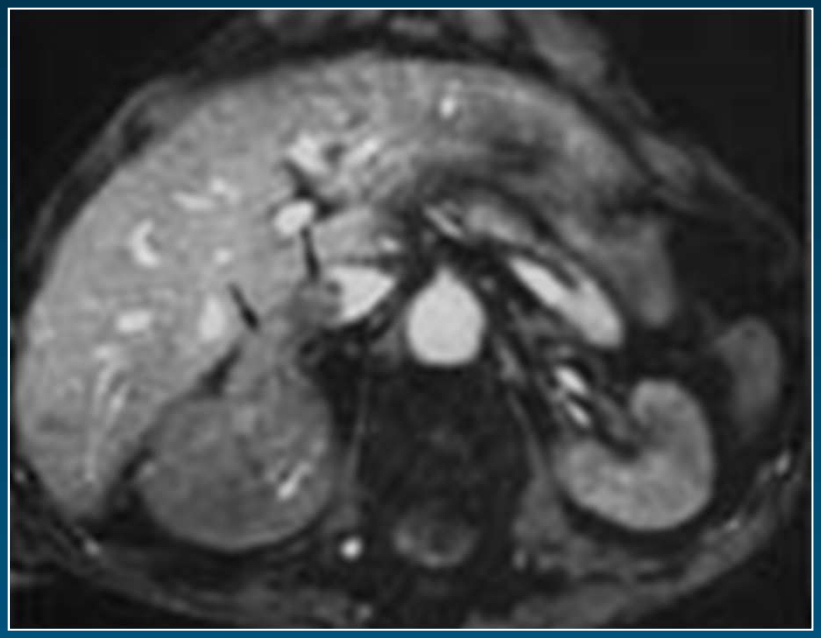



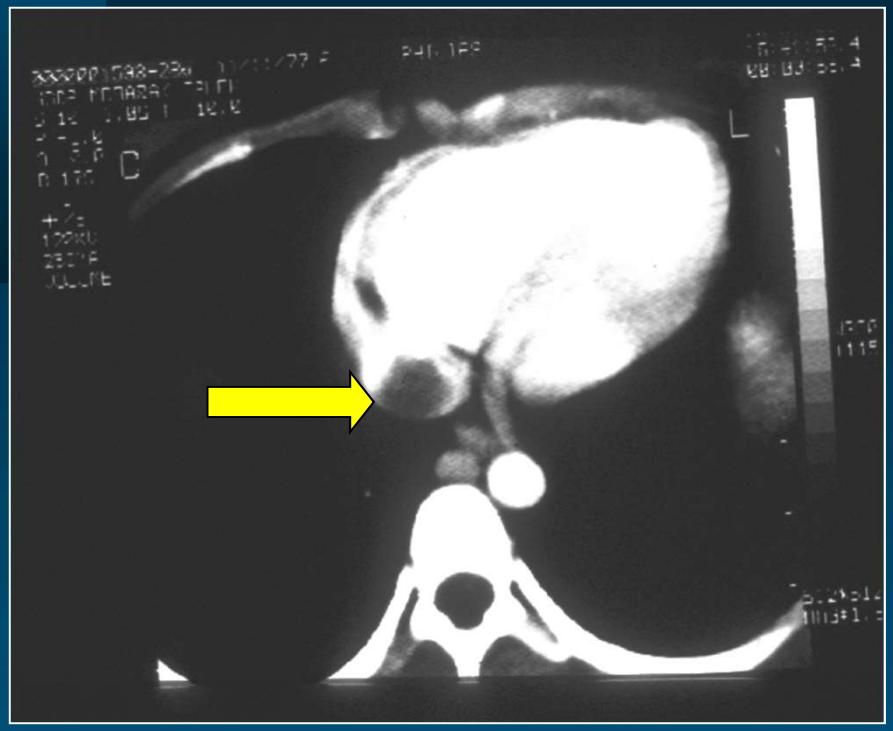




T3a Left renal vein tumor thrombus.

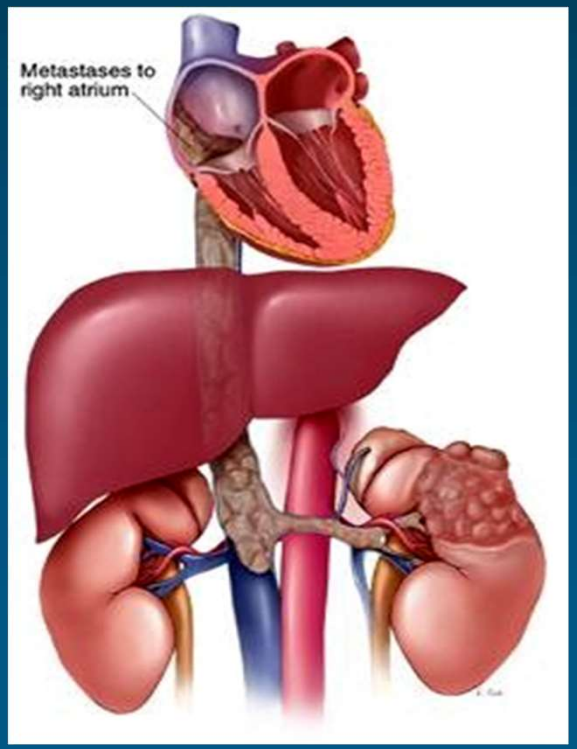


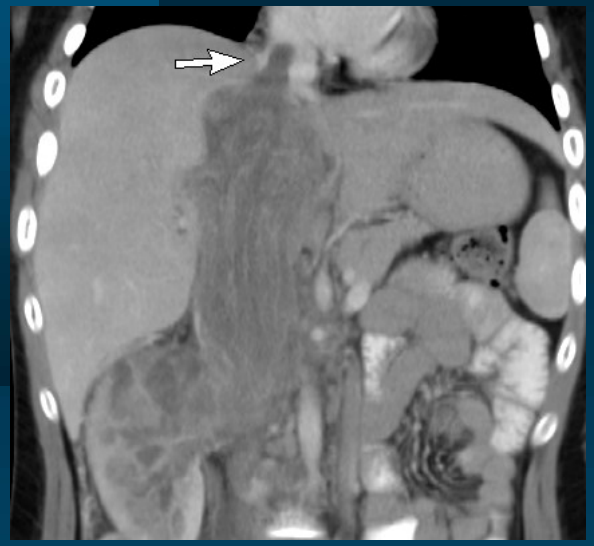


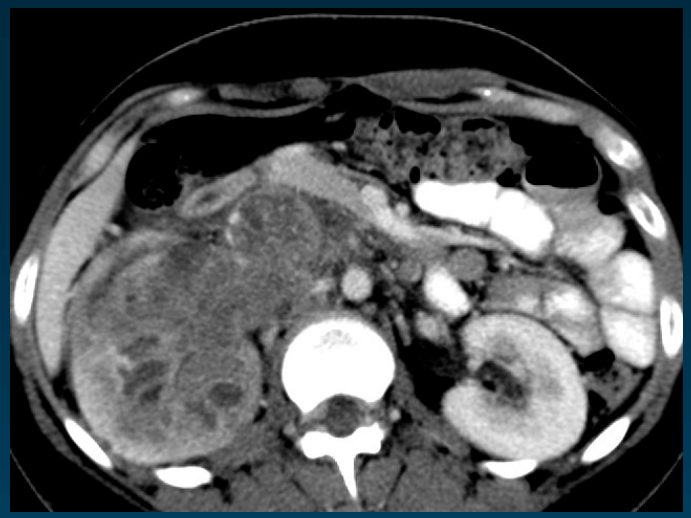
**T3b**

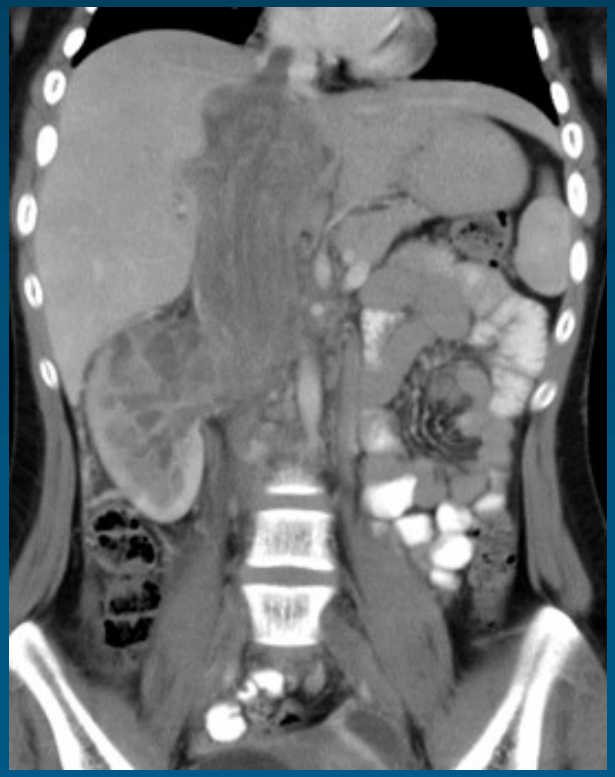


**T3c**

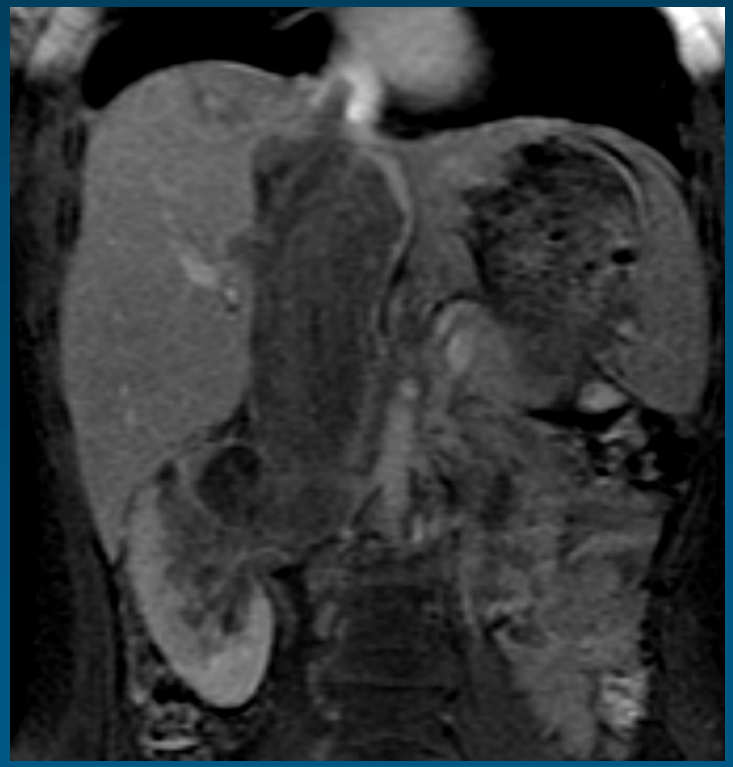


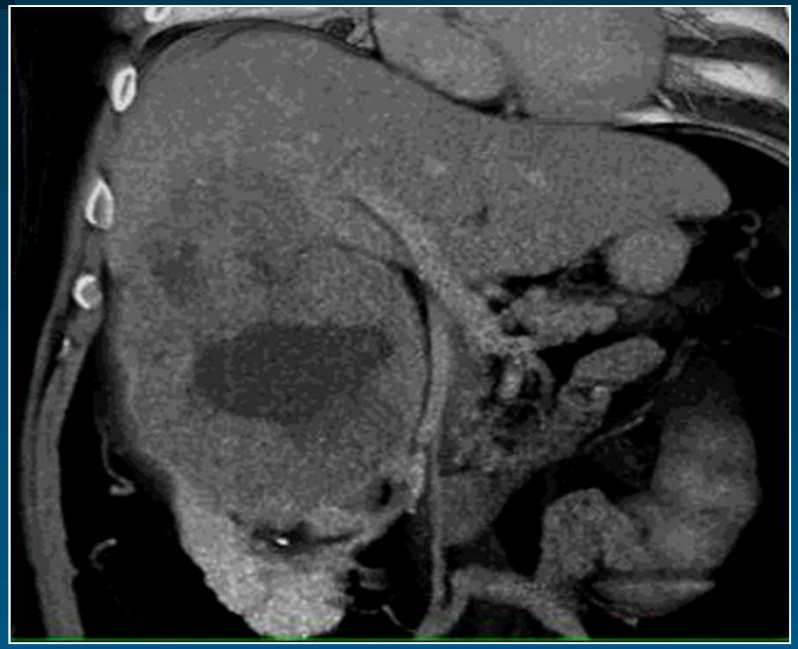


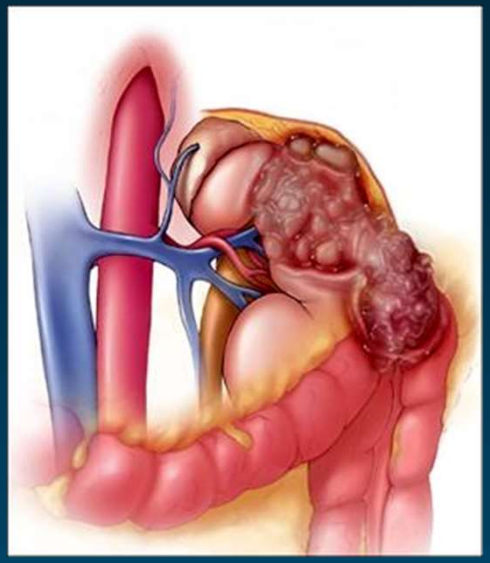




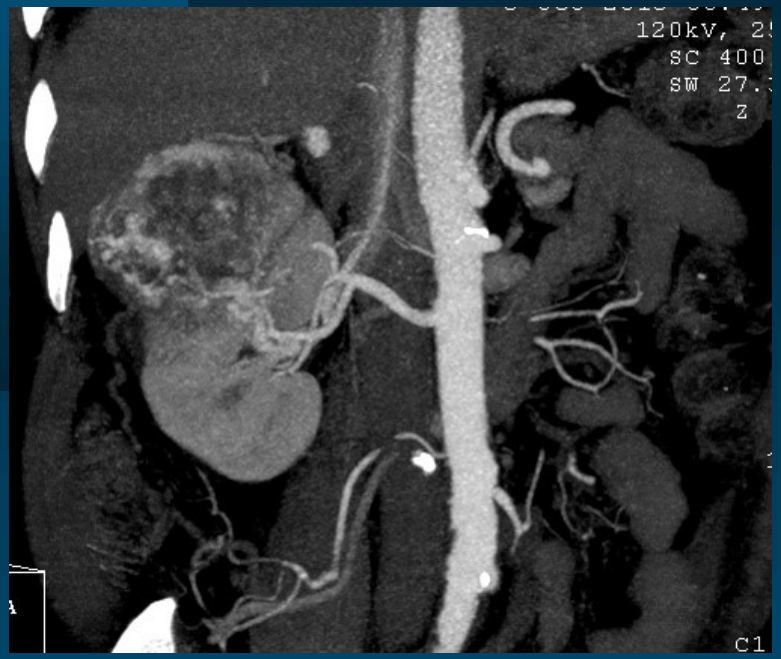
T3 c

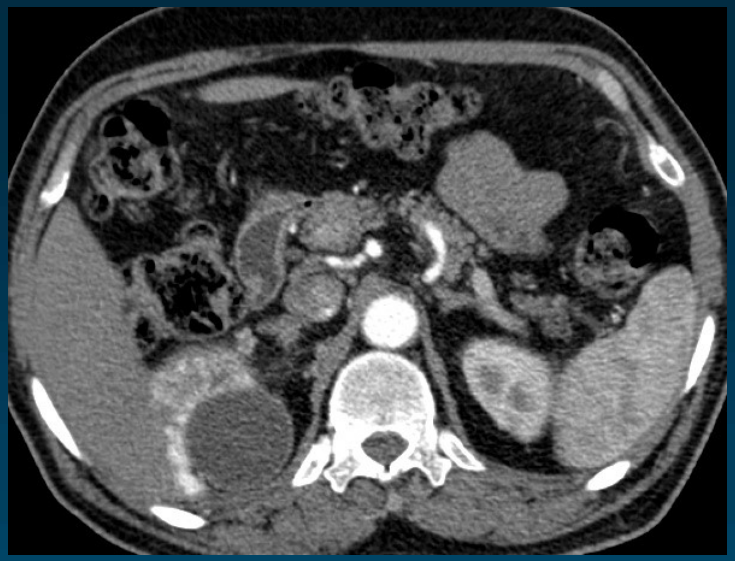


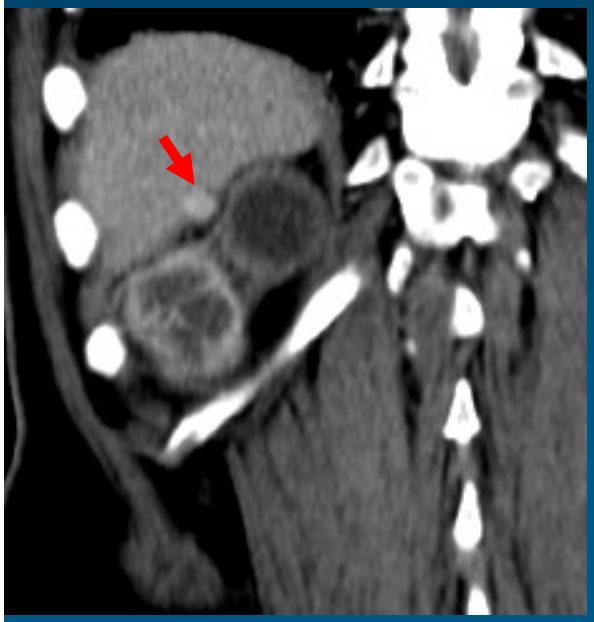


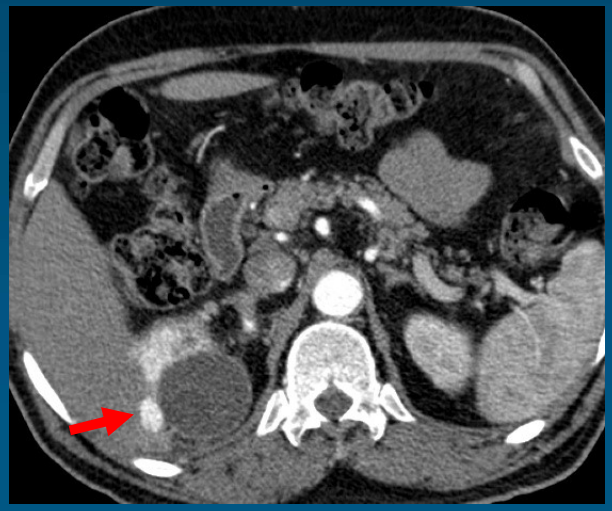


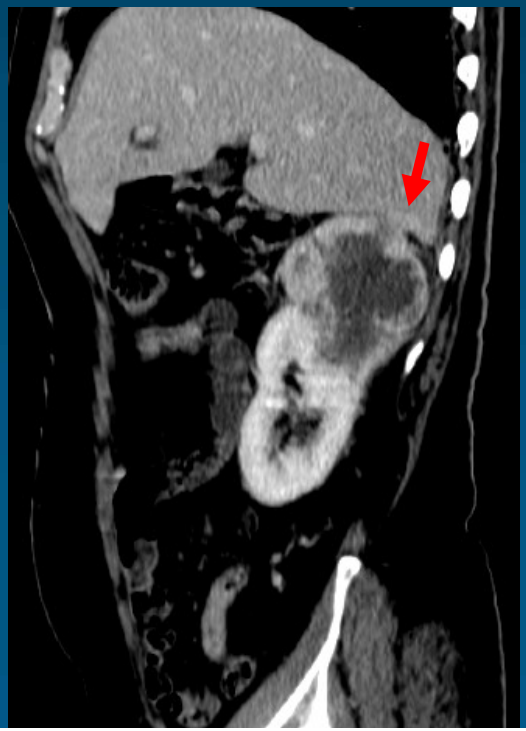
**T4**


120kV, 2
sc 400
sw 27.
z
C1



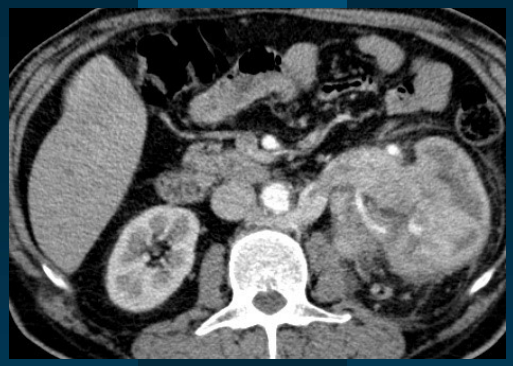
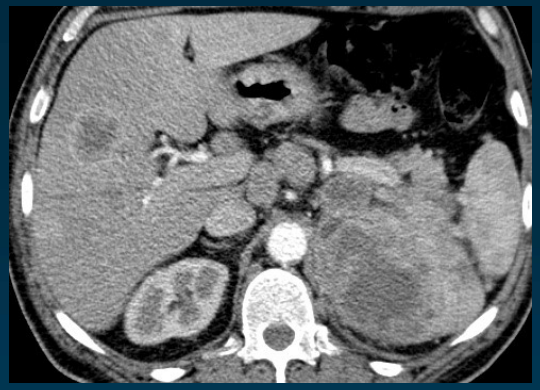
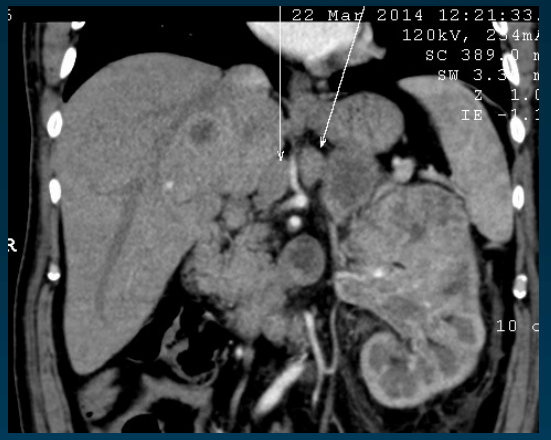
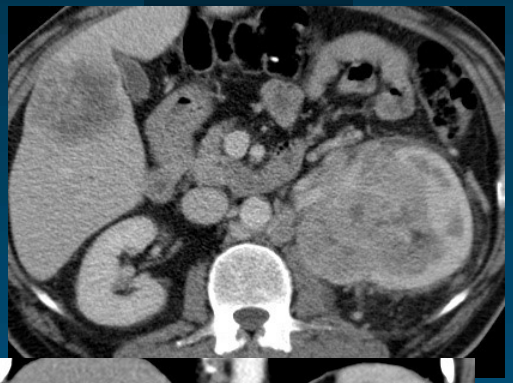
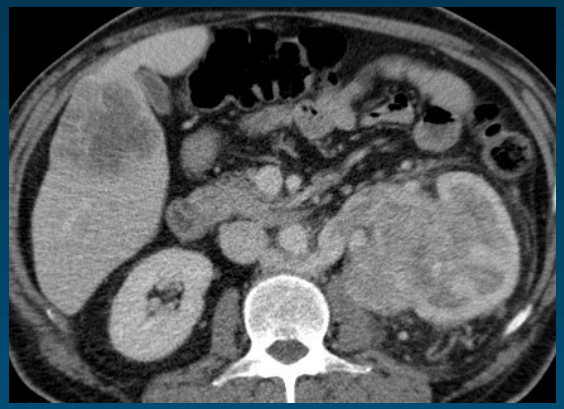
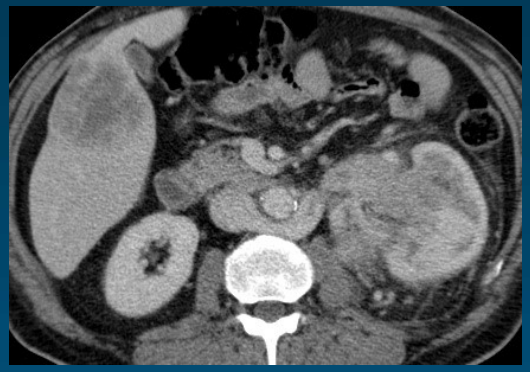
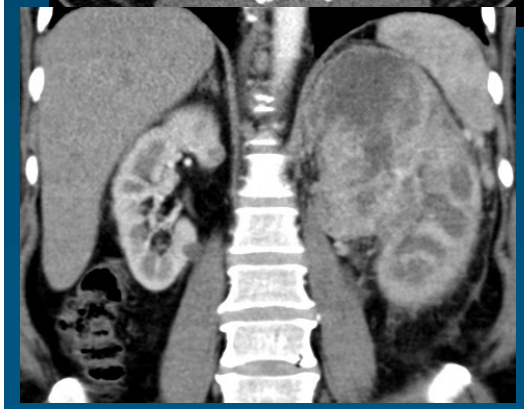
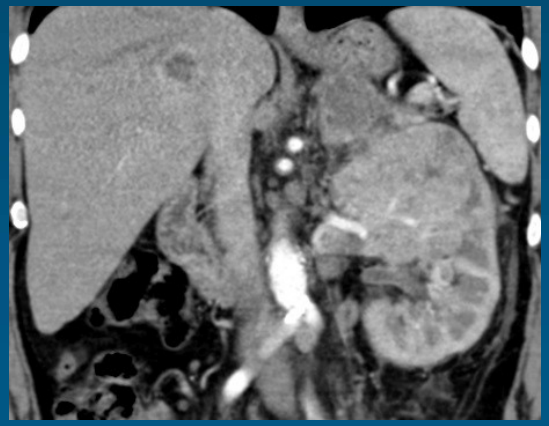
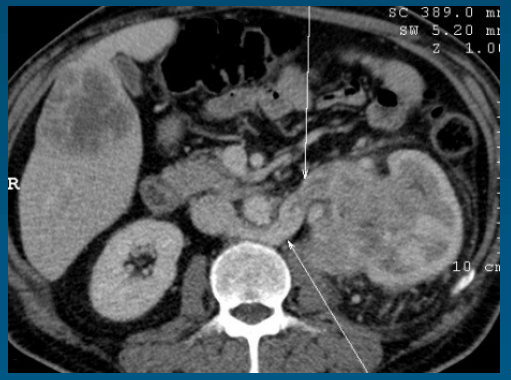




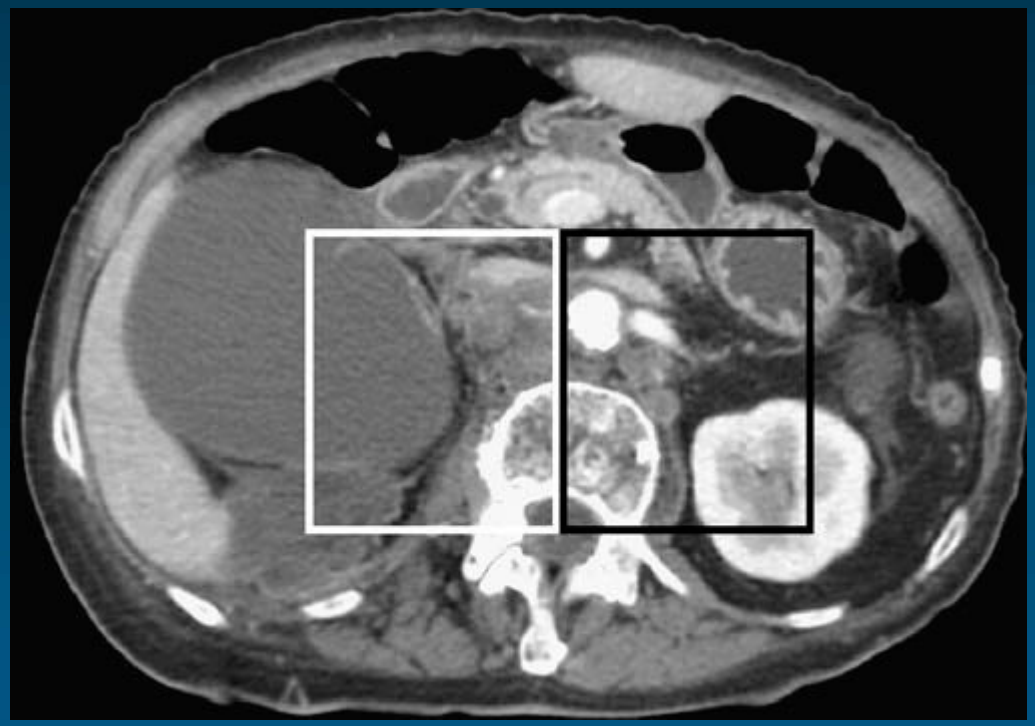


# TNM Classification

| Staging | Characters |
| --- | --- |
| **No** | No regional L.N. metastasis. |
| **N1** | Regional L.N. metastasis. |
| **Mo** | No metastasis. |
| **M1** | Distant metastasis. |

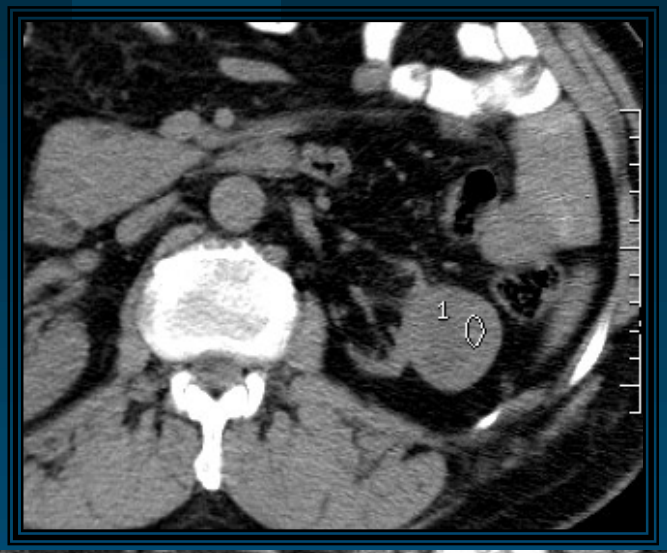



22 Mar 2014 12:21:33
120kV,
SC 389.0
SW 3.3
Z 1.0
IE
R
10 c






SC 389.0 m
SW 5.20 m
Z 1.0
R
10 cm

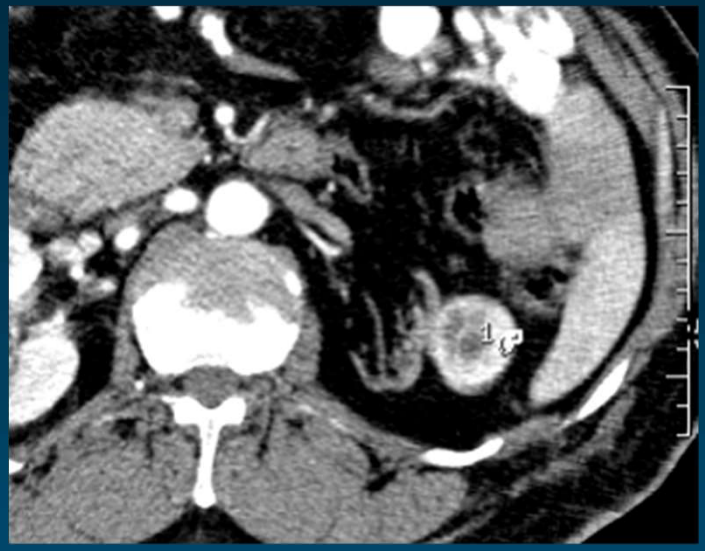
# T3a N1 M1

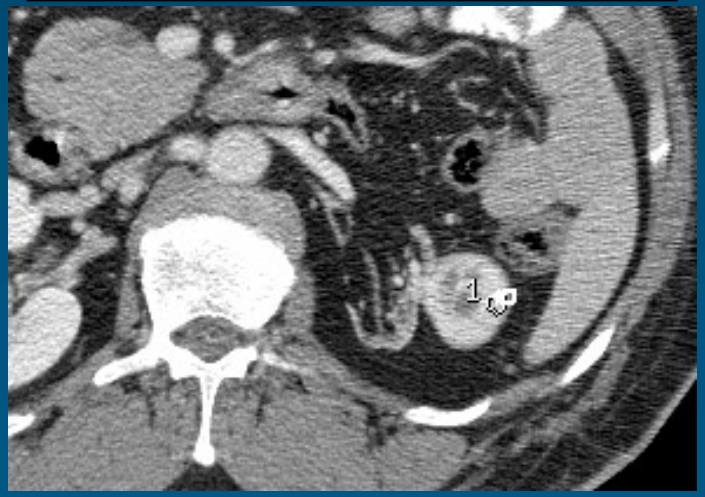


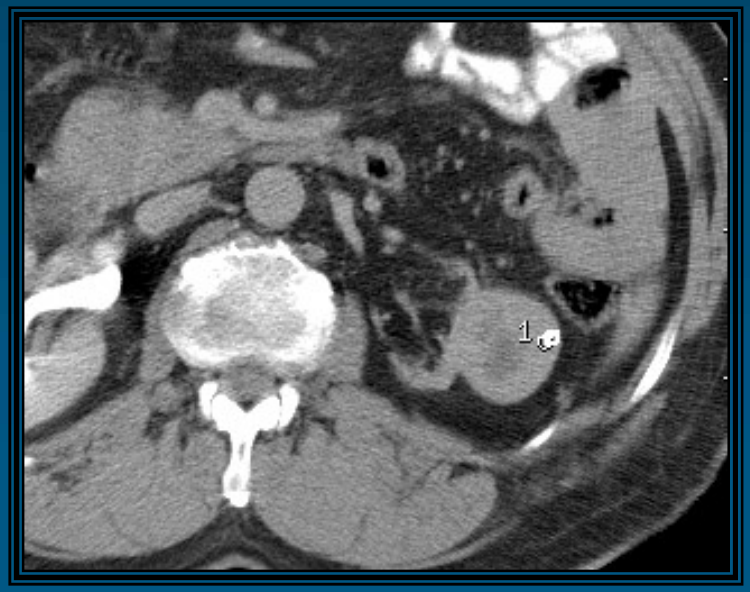
# RCC Subtypes

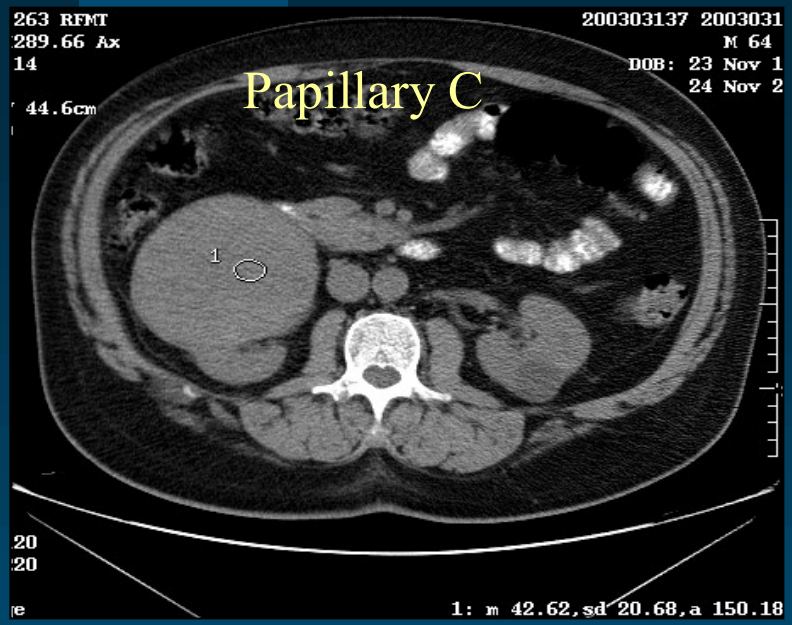
Clear Cell C

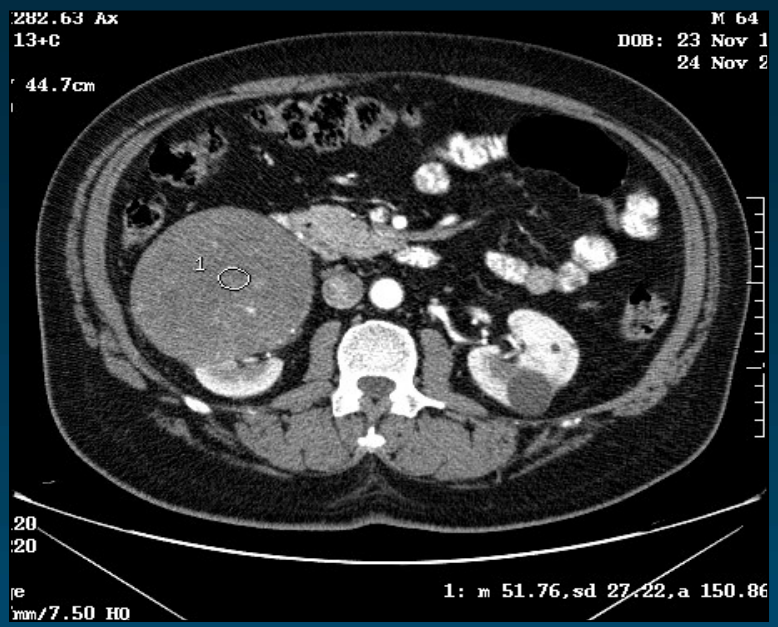


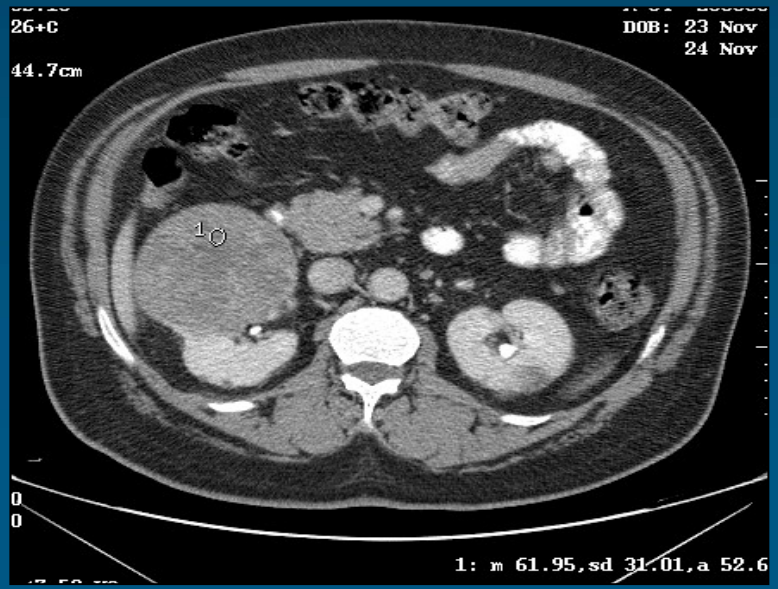


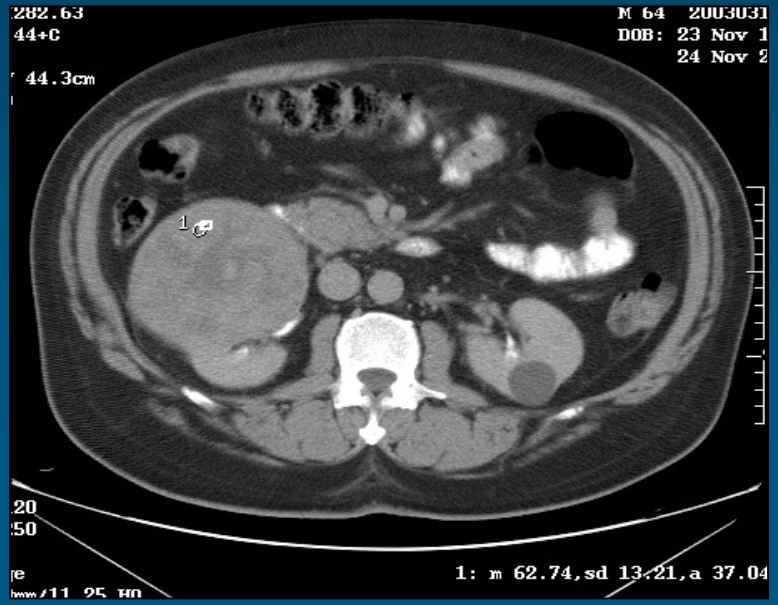





263 RFMT
289.66 Ax
14
44.6cm
200303137 2003031
M 64
DOB: 23 Nov 1
24 Nov 2
Papillary C
1
20
20
1: m 42.62,sd 20.68,a 150.18


282.63 Ax
13+C
44.7cm
M 64
DOB: 23 Nov 1
24 Nov 2
1
20
20
1: m 51.76,sd 27.22,a 150.86


26+C
44.7cm
DOB: 23 Nov
24 Nov
1
0
0
1: m 61.95,sd 31.01,a 52.6


282.63
44+C
44.3cm
M 64
DOB: 23 Nov 1
24 Nov 2
1
20
50
1: m 62.74,sd 13.21,a 37.04

# Characteristics of RCC/MRI features

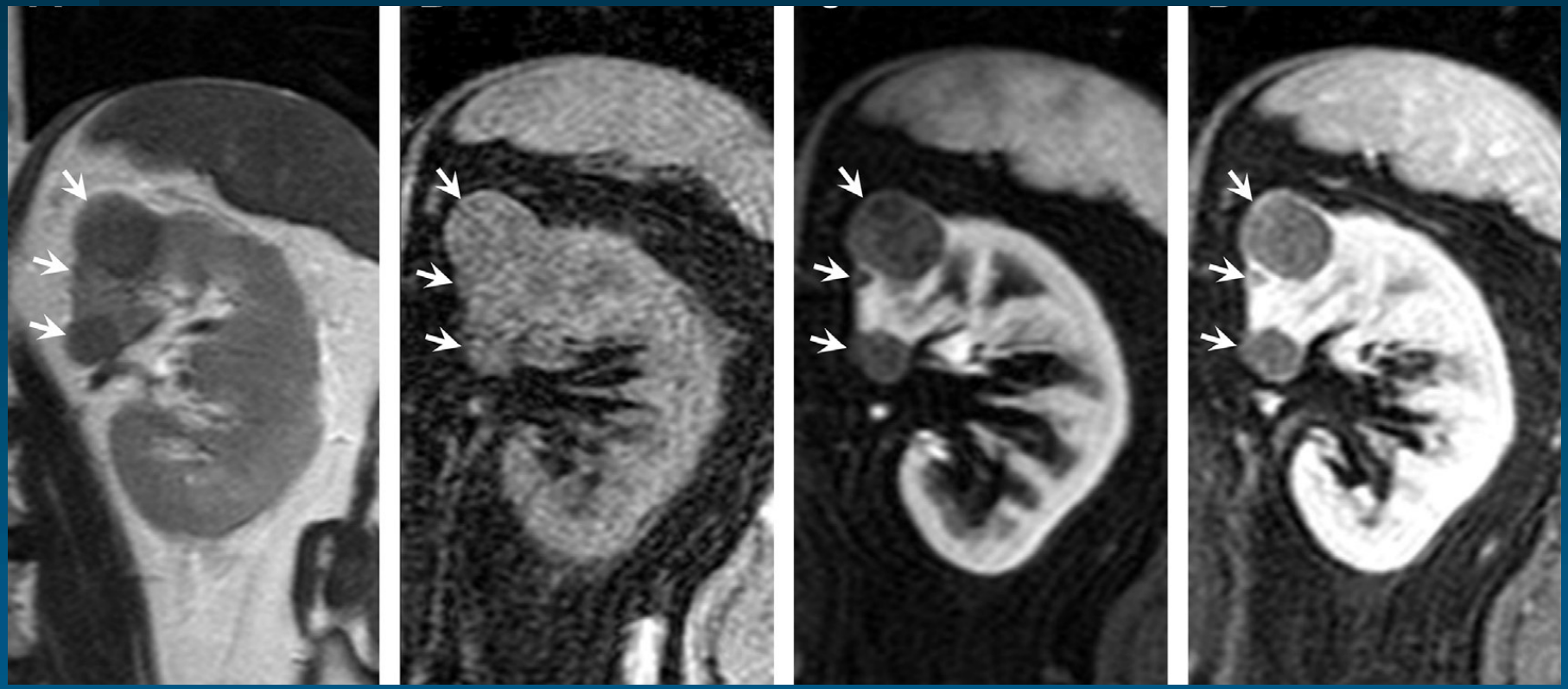
**Table 2: Characteristics of RCC Subtypes**

| RCC Subtypes | Prevalence | Origin | Distinguishing MR Imaging Features | Biologic Behavior |
|---|---|---|---|---|
| Clear cell | 75% | Proximal nephron | High to intermediate signal intensity on T2-weighted images<br>Microscopic fat<br>Avid enhancement<br>Areas of necrosis | Aggressiveness depends on Fuhrman grade, stage, and sarcomatoid transformation |
| Papillary | 10% | Distal nephron | Low signal intensity on T2-weighted images<br>Evidence of hemosiderin (signal loss on in-phase images)<br>Mild enhancement<br>Cystic change may occur | Associated with overall better prognosis than clear cell subtype |
| Chromophobe | 5% | Distal nephron | Intermediate signal intensity on T2-weighted images<br>Homogeneous<br>Moderate enhancement<br>Necrosis not common | 5-year survival rate: 78%–93% |

*Vendrami et al, Radiographics, November-December 2017*

# RCC Subtypes

## Papillary RCC



*Kay & Pedrosa, Radiol Clin N Am 55 (2017) 243–258*

# Papillary RCC

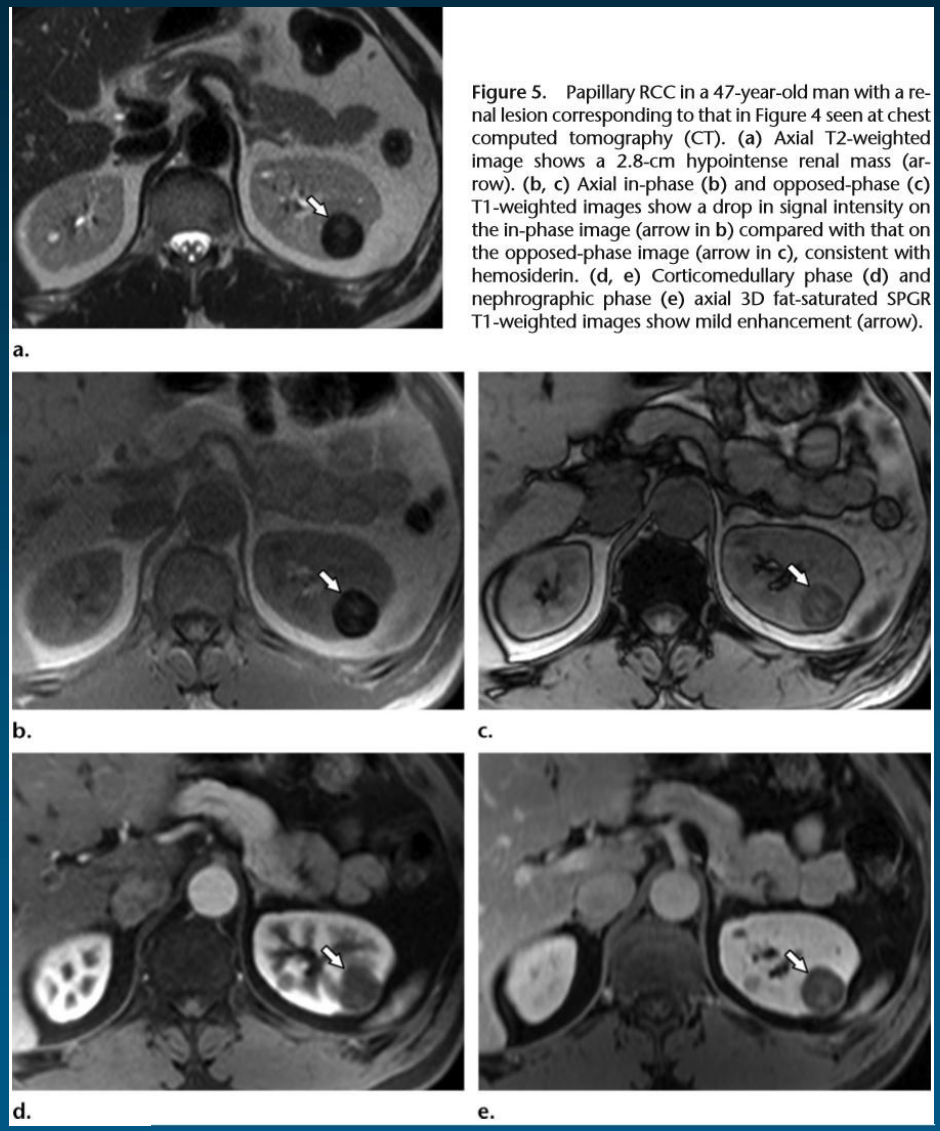
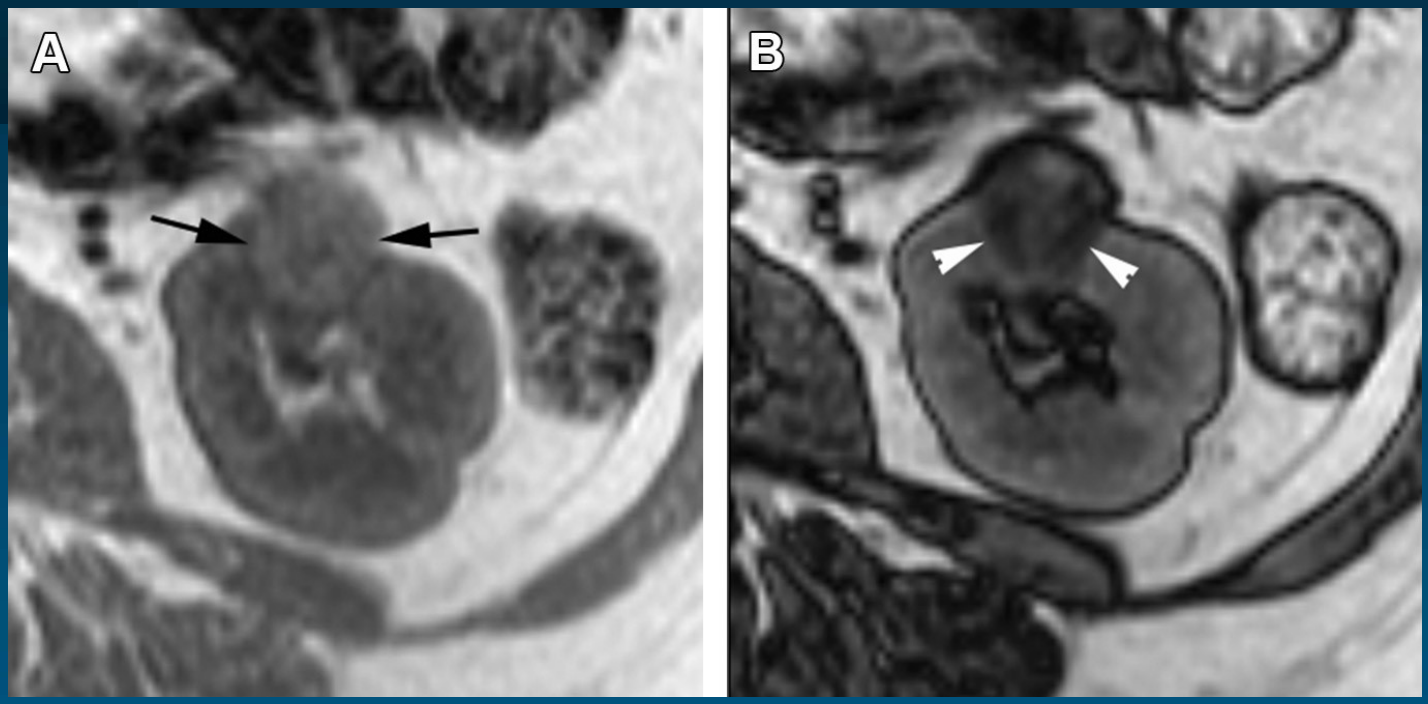


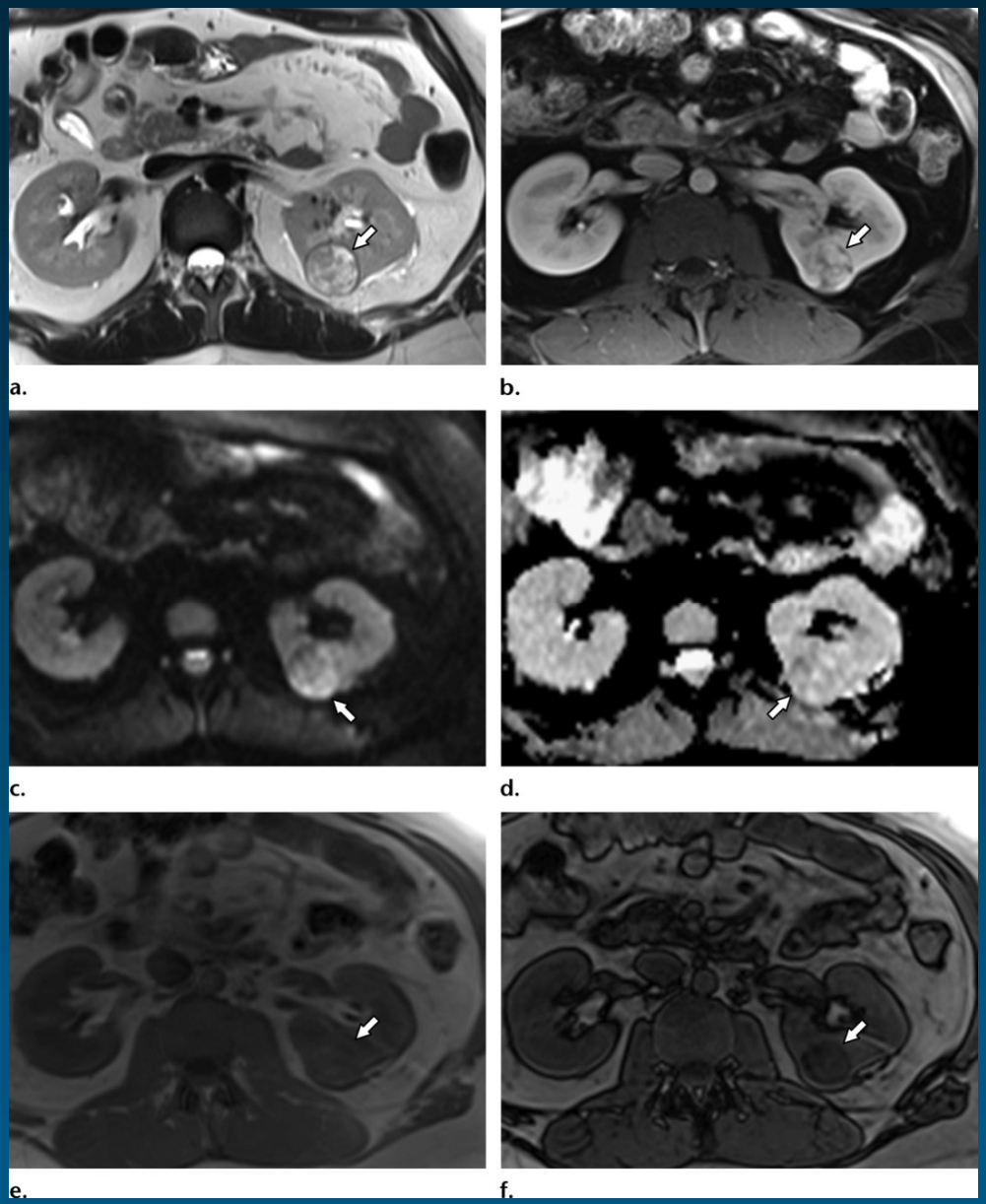
**Figure 5.** Papillary RCC in a 47-year-old man with a renal lesion corresponding to that in Figure 4 seen at chest computed tomography (CT). **(a)** Axial T2-weighted image shows a 2.8-cm hypointense renal mass (arrow). **(b, c)** Axial in-phase **(b)** and opposed-phase **(c)** T1-weighted images show a drop in signal intensity on the in-phase image (arrow in **b**) compared with that on the opposed-phase image (arrow in **c**), consistent with hemosiderin. **(d, e)** Corticomedullary phase **(d)** and nephrographic phase **(e)** axial 3D fat-saturated SPGR T1-weighted images show mild enhancement (arrow).

*Vendrami et al, Radiographics, November-December 2017*

# Chemical Shift imaging



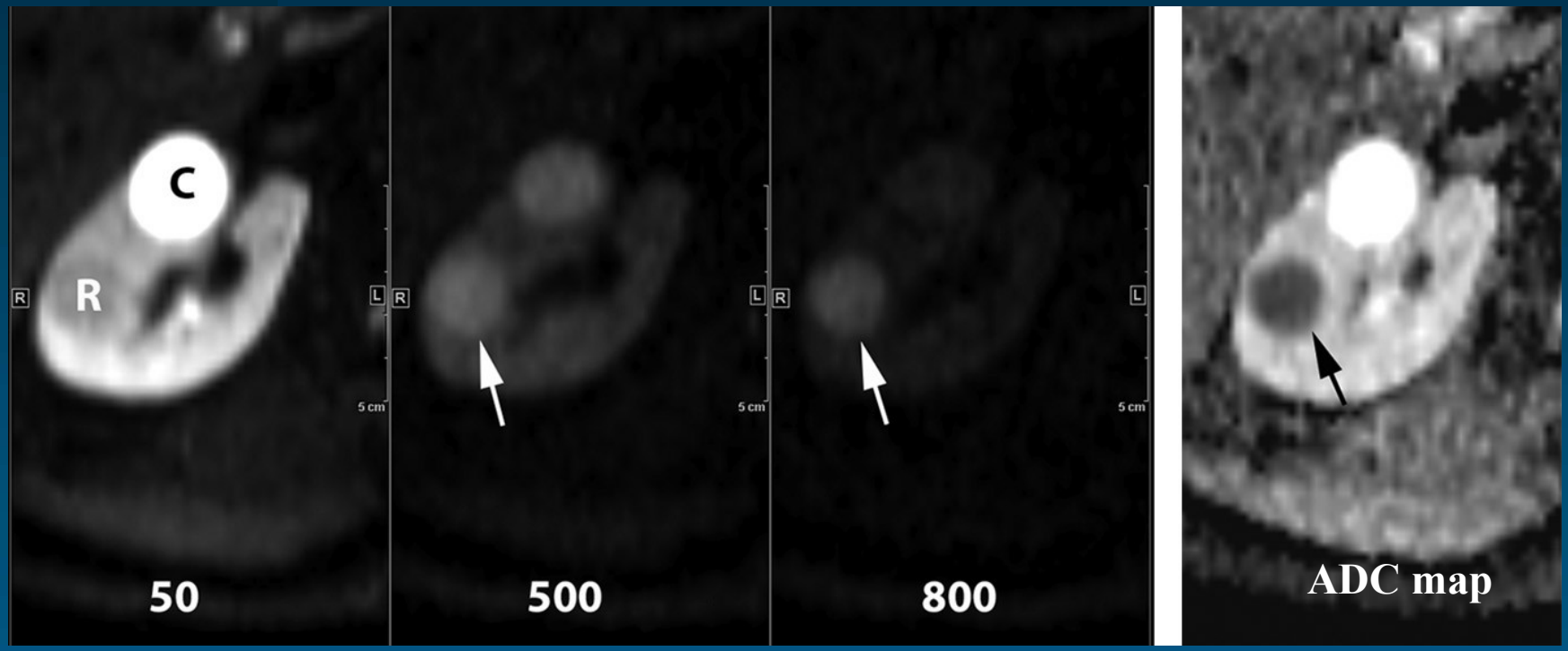
**Clear Cell RCC**




mpMRI

*Vendrami et al, Radiographics, November-December 2017*

# Diffusion WI



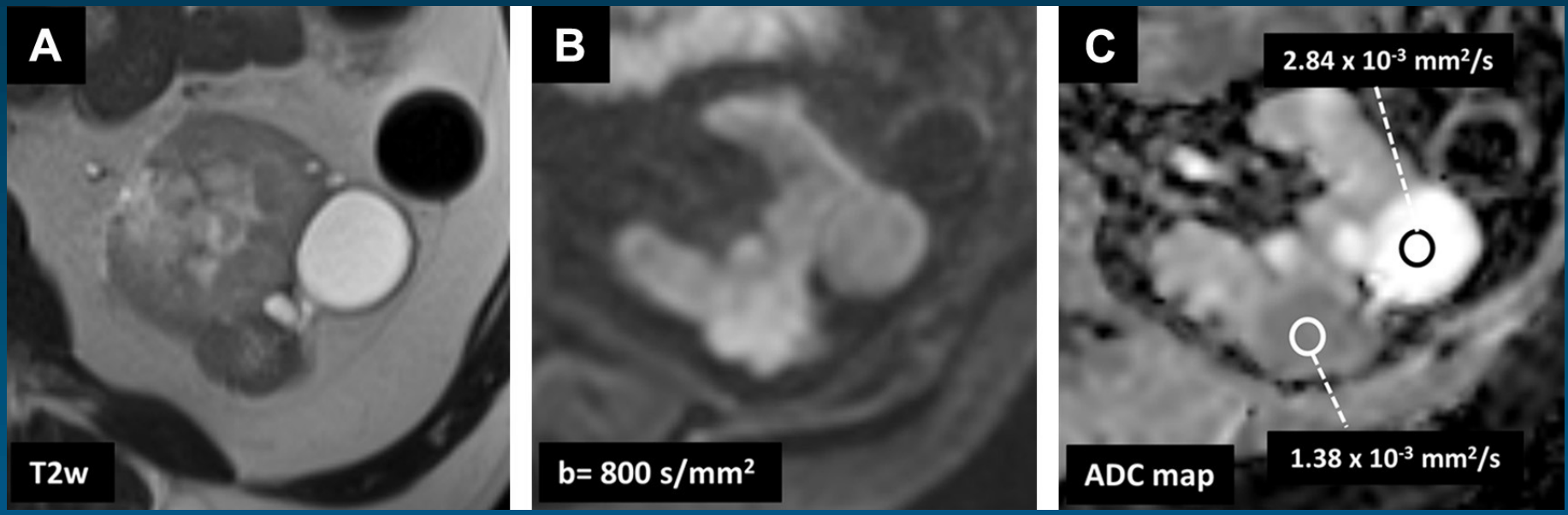
# ADC & Tissues

An anomalous rise in ADC can indicate increased edema, cystic changes, and necrosis; whereas an anomalous reduction in ADC might indicate tumor, ischemia, or infection.

**Restricted diffusion:**

*Malignancy (increased number of cells )
*Ischemia (cytotoxic edema)
*Abscess (increased viscosity)

# DW MRI – ADC




*Maurer et al., Radiol Clin N Am 55 (2017) 393–411*

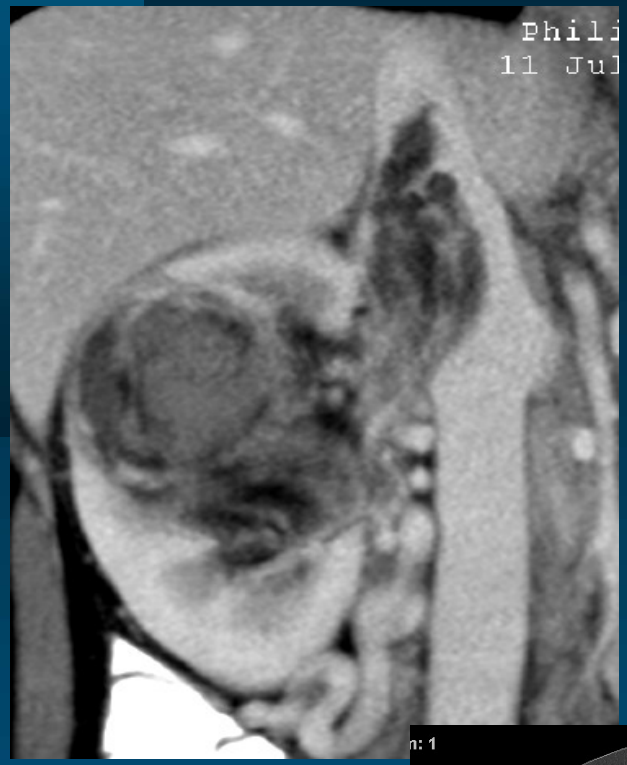
# Benign renal masses

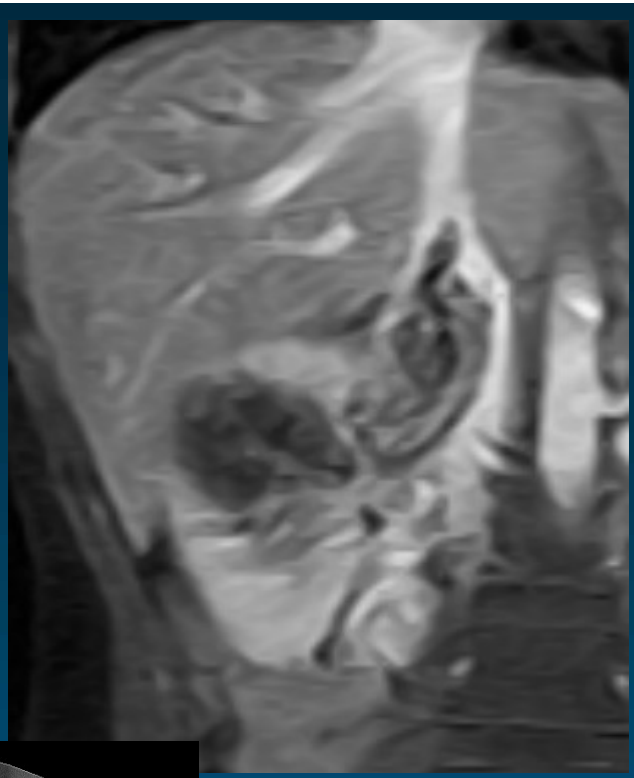
XGP.

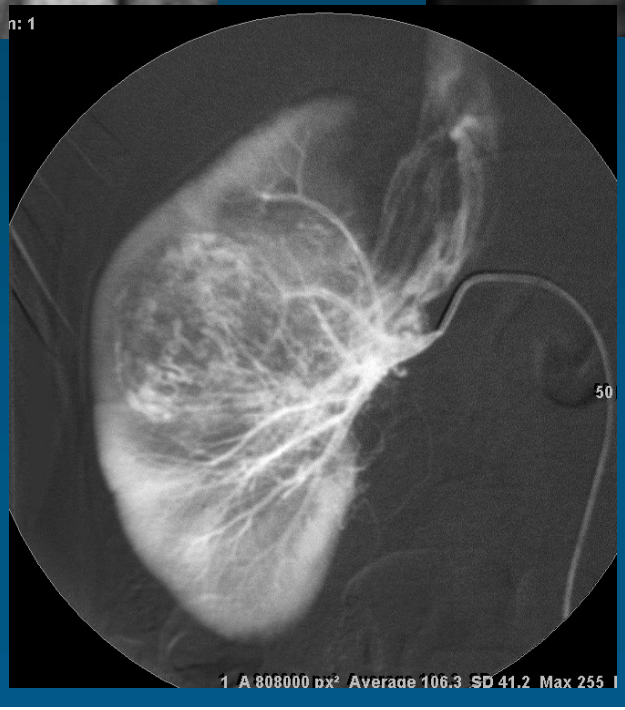
Focal nephritis.

Angiomyolipoma (AML)/Low-fat containing AML.

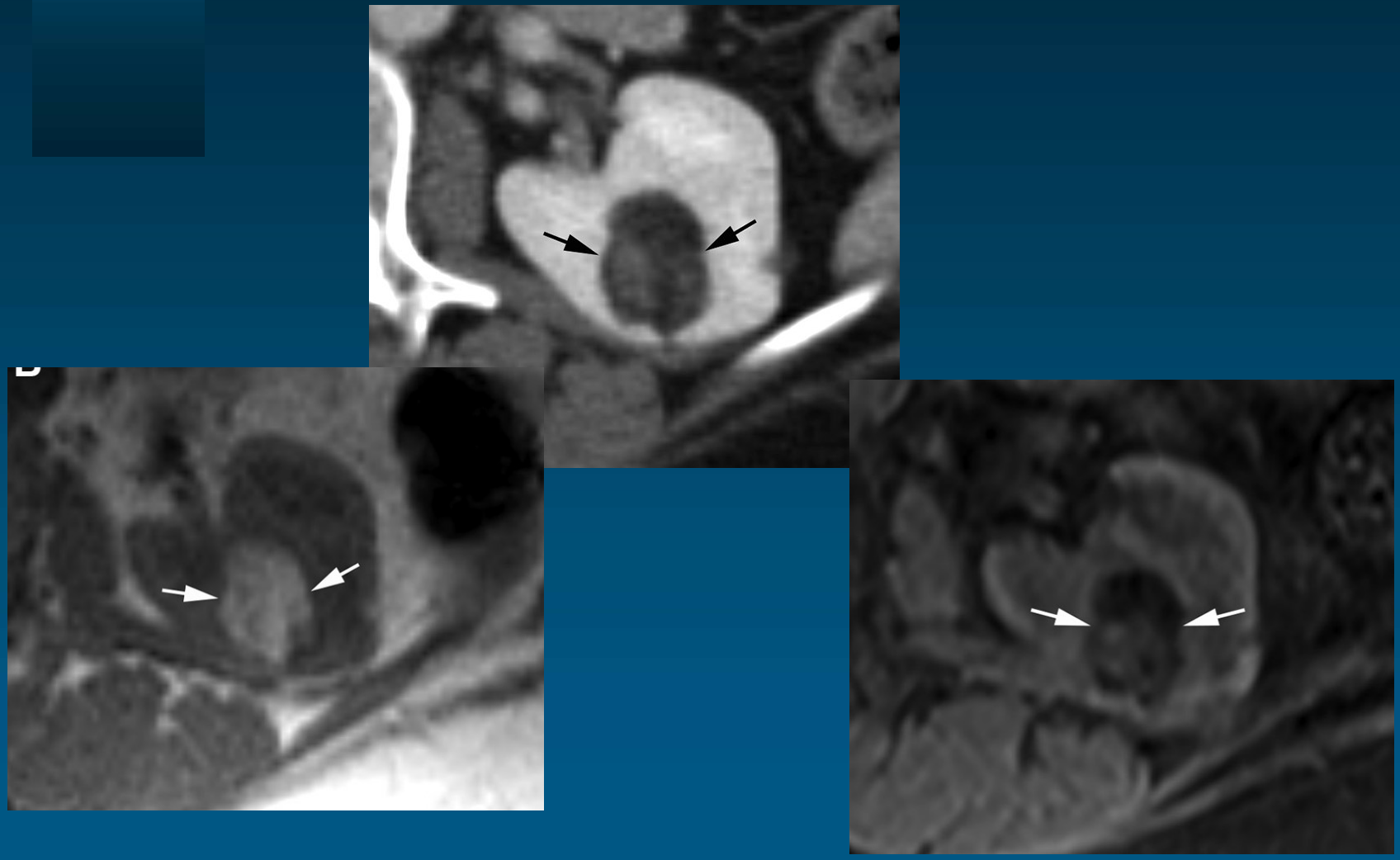
Oncocytoma.


Phili
11 Jul

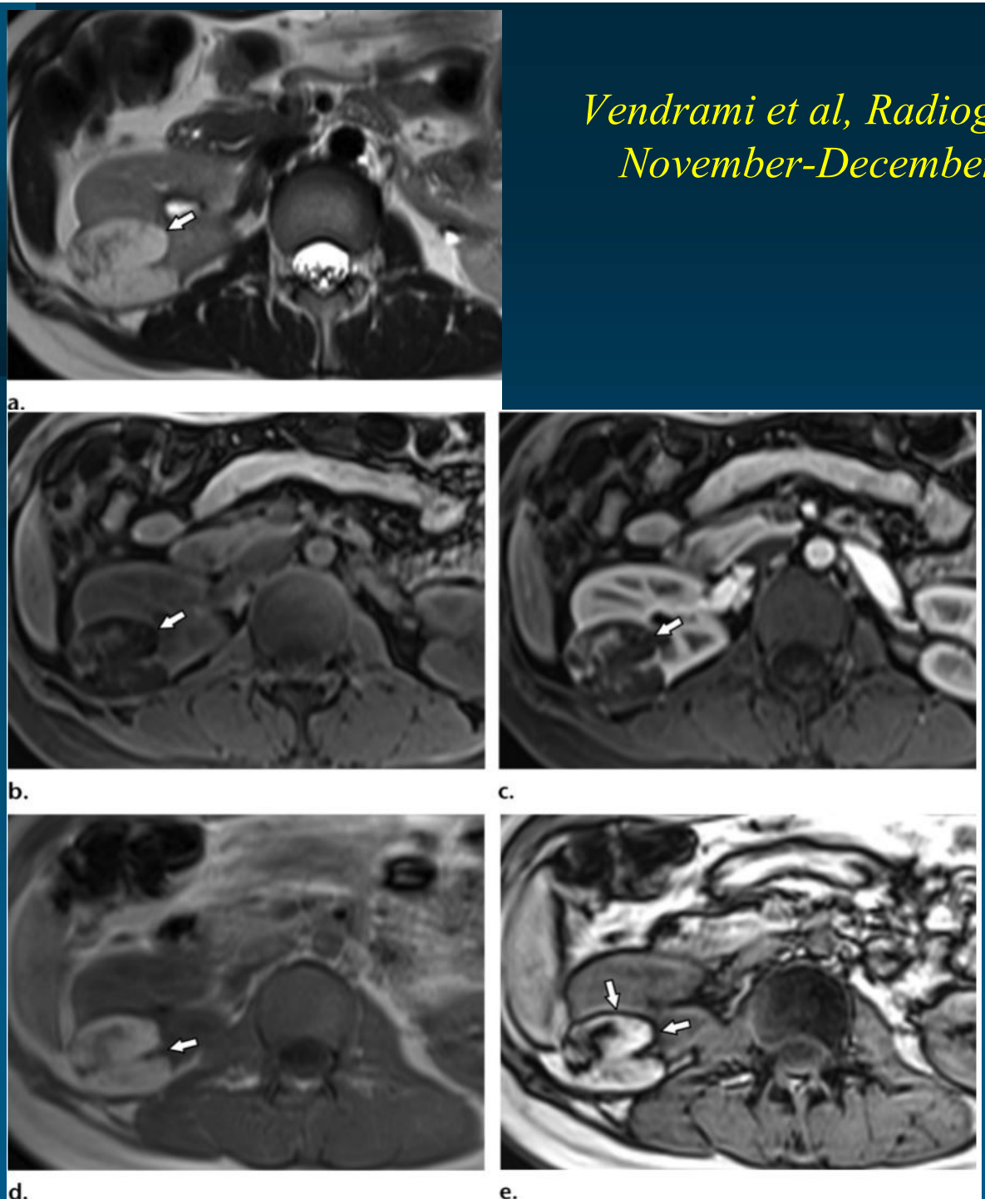



n: 1
50
1 A 808000 px² Average 106.3 SD 41.2 Max 255

# Fat Saturated T1WI



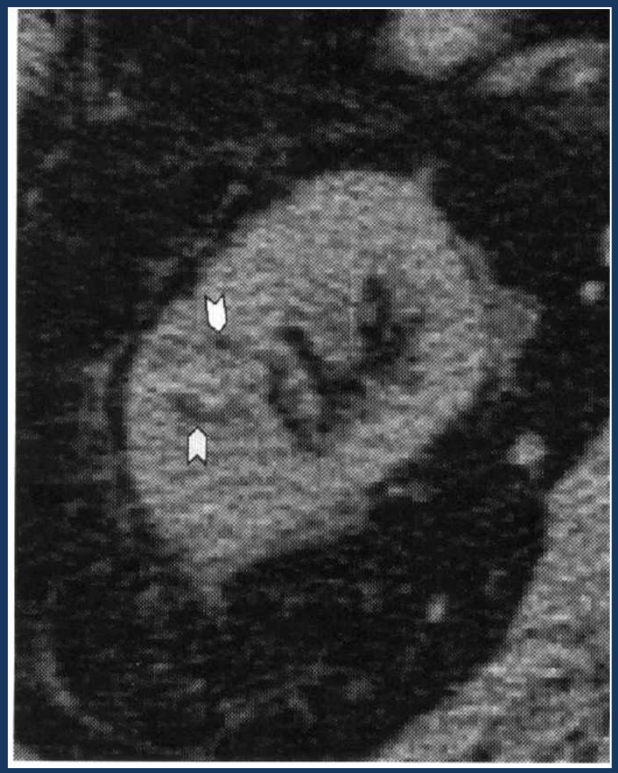
*Vendrami et al, Radiographics, November-December 2017*



# Low fat-containing Angiomyolipoma

- NCCT:
  - Pixel analysis
  - Lack of calcification
  - Uniform iso-hyper density
  - Prolonged enhancement
- MRI:
  - Hypointense in T2WI
  - Significant early enhancement
  - Indian ink artifact
  - Shape

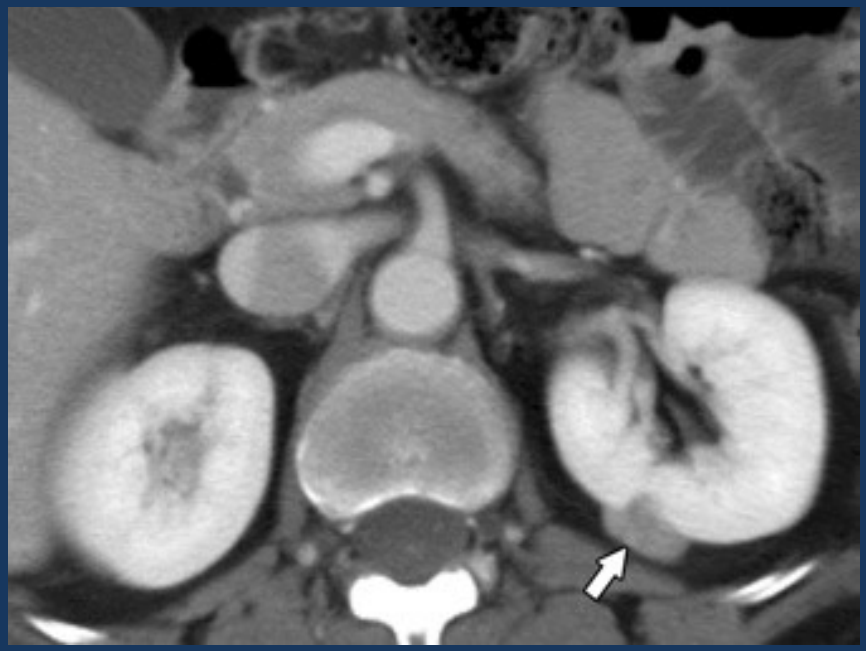
# Low fat-containing Angiomyolipoma

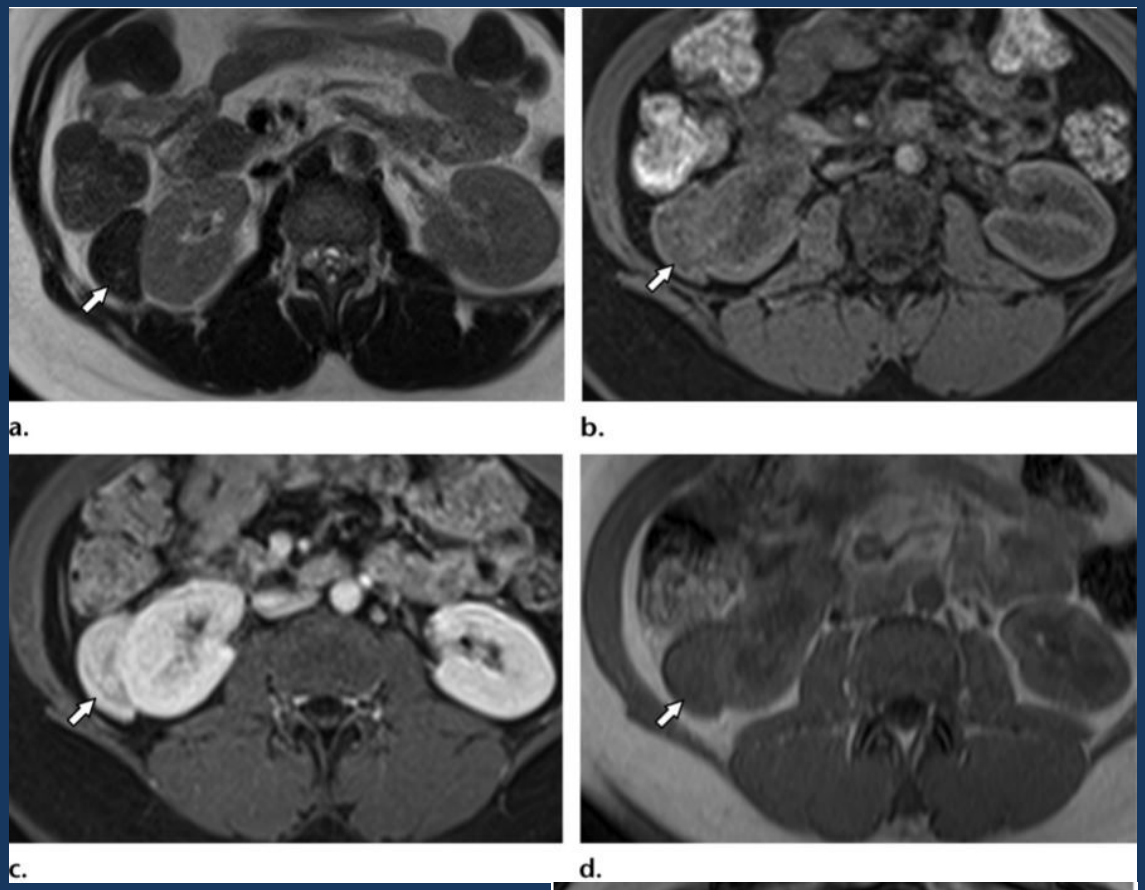


| | 354 | 355 | 356 | 357 | 358 | 359 | 360 | 361 | 362 | 363 | 364 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 259 | -15 | -18 | -28 | -31 | -15 | -41 | -50 | -35 | -35 | -27 | 11 |
| 260 | 20 | 24 | 6 | -47 | -88 | -91 | -81 | -61 | -67 | -115 | -108 |
| 261 | -66 | -98 | -65 | -33 | -51 | -74 | -53 | -65 | -78 | -90 | -69 |
| 262 | -36 | -7 | 9 | 3 | -32 | -69 | -57 | -71 | -49 | -23 | -34 |
| 263 | -17 | -31 | -65 | -87 | -77 | -69 | -41 | -44 | -72 | -68 | -7 |
| 264 | 7 | -17 | -19 | -5 | 17 | 8 | -29 | -67 | -83 | -52 | -28 |
| 265 | 11 | -40 | -36 | -19 | -67 | -60 | -31 | -53 | -38 | -43 | -50 |
| 266 | -10 | -23 | -43 | -44 | -57 | -41 | -38 | -78 | -66 | -76 | -40 |
| 267 | -36 | -27 | -41 | -39 | -60 | -71 | -54 | -34 | -31 | -39 | -54 |
| 268 | -32 | -31 | -47 | -71 | -55 | -43 | -49 | -51 | -49 | -63 | -82 |
| 269 | -50 | -50 | -10 | -2 | -24 | -55 | -71 | -77 | -87 | -87 | -69 |

50 pix

Pixel Map






Low fat-containing AML

*Vendrami et al, Radiographics, November-December 2017*

# Multiparametric MRI of solid renal masses

**Table 3: Key Multiparametric MR Imaging Features of Solid Renal Masses**

| Renal Lesion | Key MR Imaging Features |
|---|---|
| Clear cell RCC | High SI on T2WI + microscopic fat + hypervascularity |
| Papillary RCC | Low SI on T2WI + hypovascularity + may contain hemosiderin |
| Chromophobe RCC | No definitive MR imaging features → pathologic diagnosis |
| Classic AML | Macroscopic fat |
| Lipid-poor AML | Low SI on T2WI + avid early enhancement + may contain microscopic fat |
| Oncocytoma | No definitive MR imaging features → pathologic diagnosis |

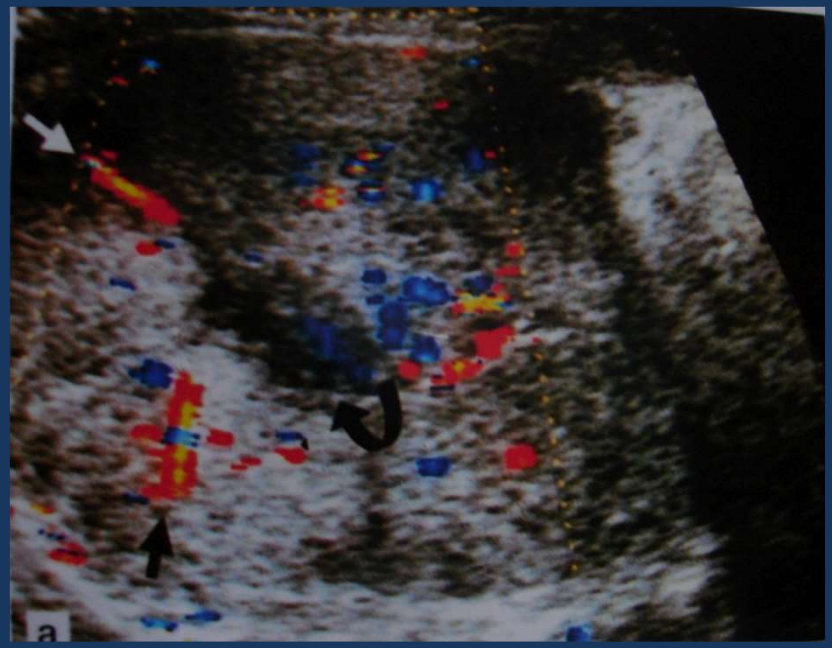
Note.—SI = signal intensity, T2WI = T2-weighted images.

*Vendrami et al, Radiographics, November-December 2017*

# Oncocytoma

Oncocytoma is a benign renal cell neoplasm that accounts for approximately 5% of all adult primary renal epithelial neoplasms.

- The peak age of incidence is in the seventh decade; men are more likely to be affected than women.
- Most tumors occur sporadically in asymptomatic patients.
- Bilateral, multicentric oncocytomas are seen in hereditary syndromes of renal oncocytosis and Birt- Hogg-Dubé syndrome.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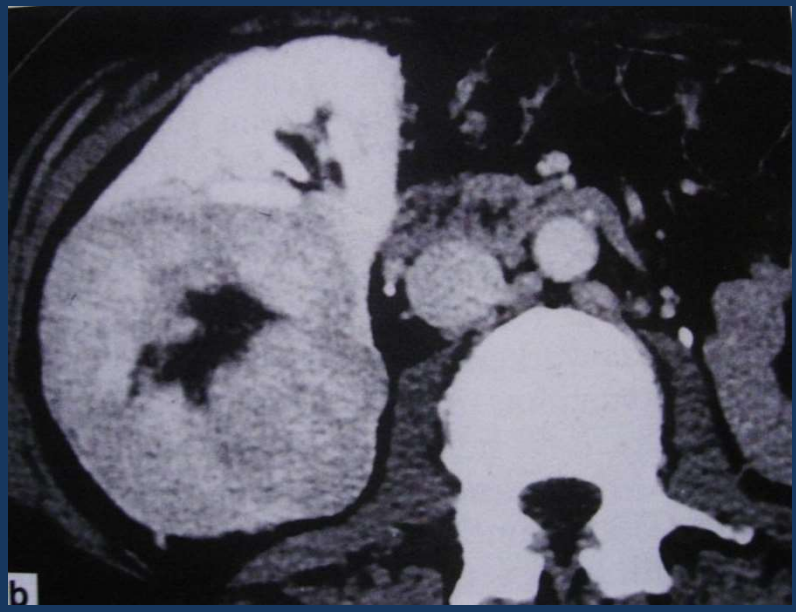
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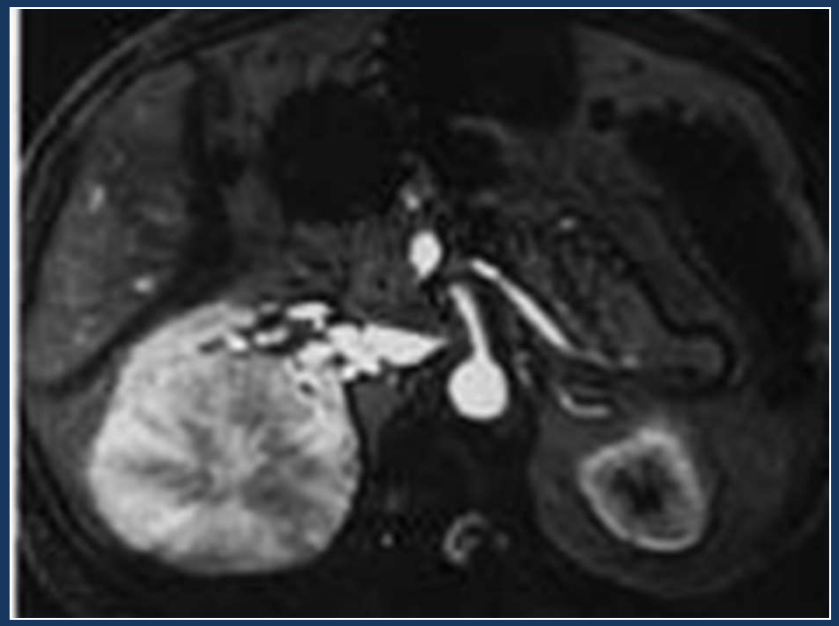


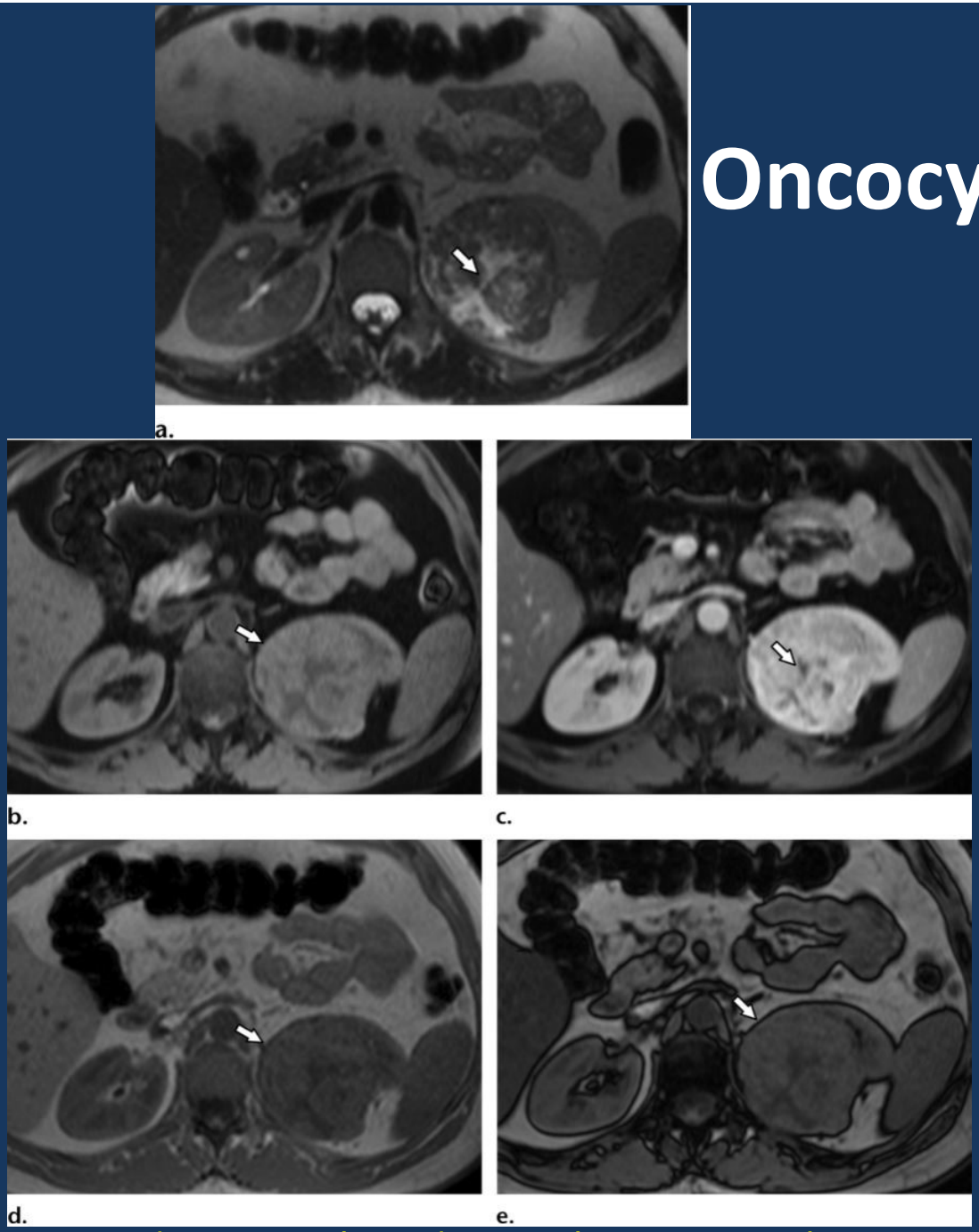
# Oncocytoma Vs Chromophobe RCC

Renal oncocytoma (RO) and ChRCC have much in common regarding morphologic, histologic, immunohistochemical, and ultrastructural aspects.

Oncocytomas are indistinguishable from ChRCCs on imaging studies; sharing features such as central scar, and spoke wheel pattern of enhancement.

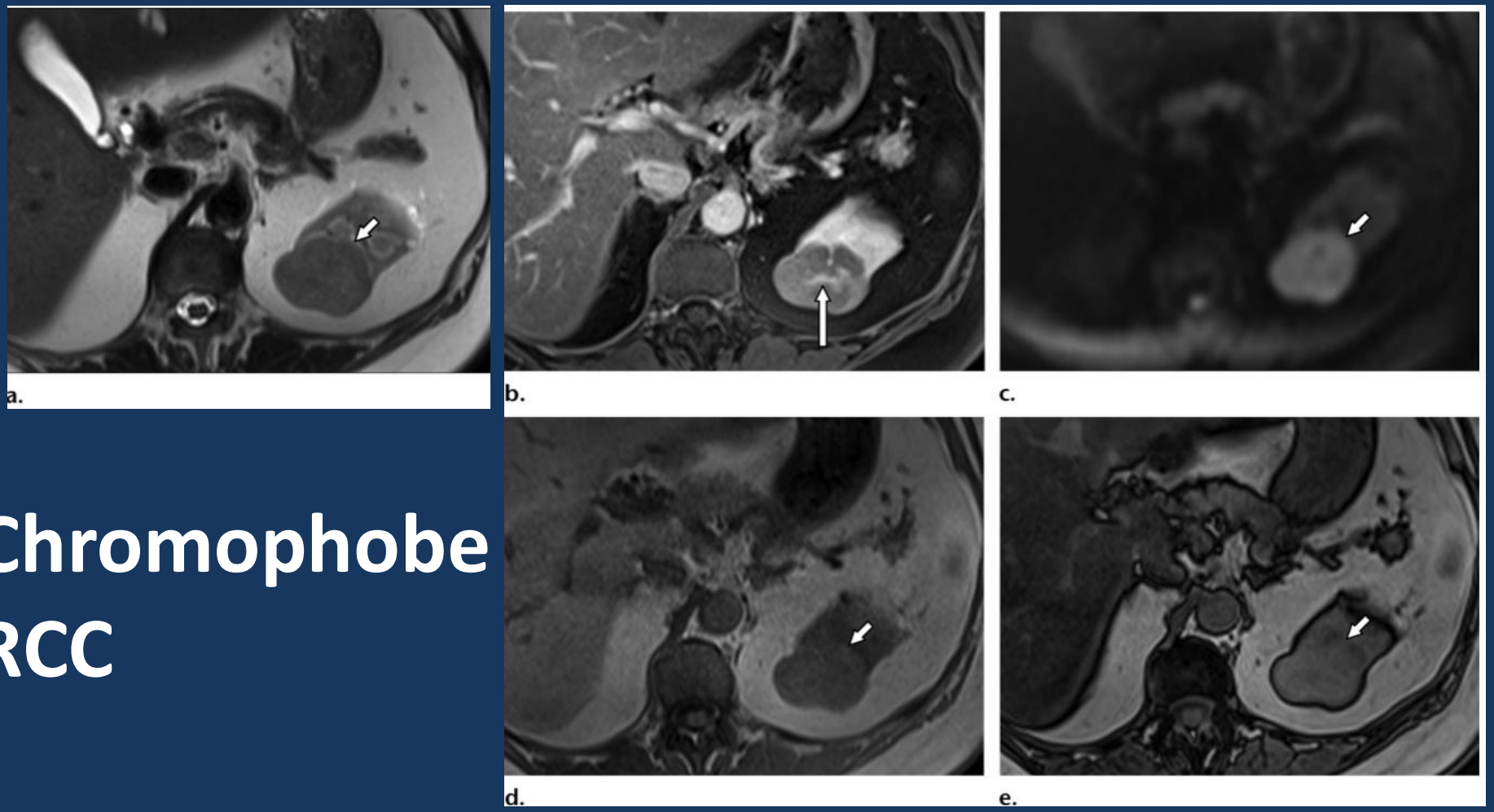
- *Wu et al., Acta Radiologica 2016, 57(4): 500–506*

# Oncocytoma



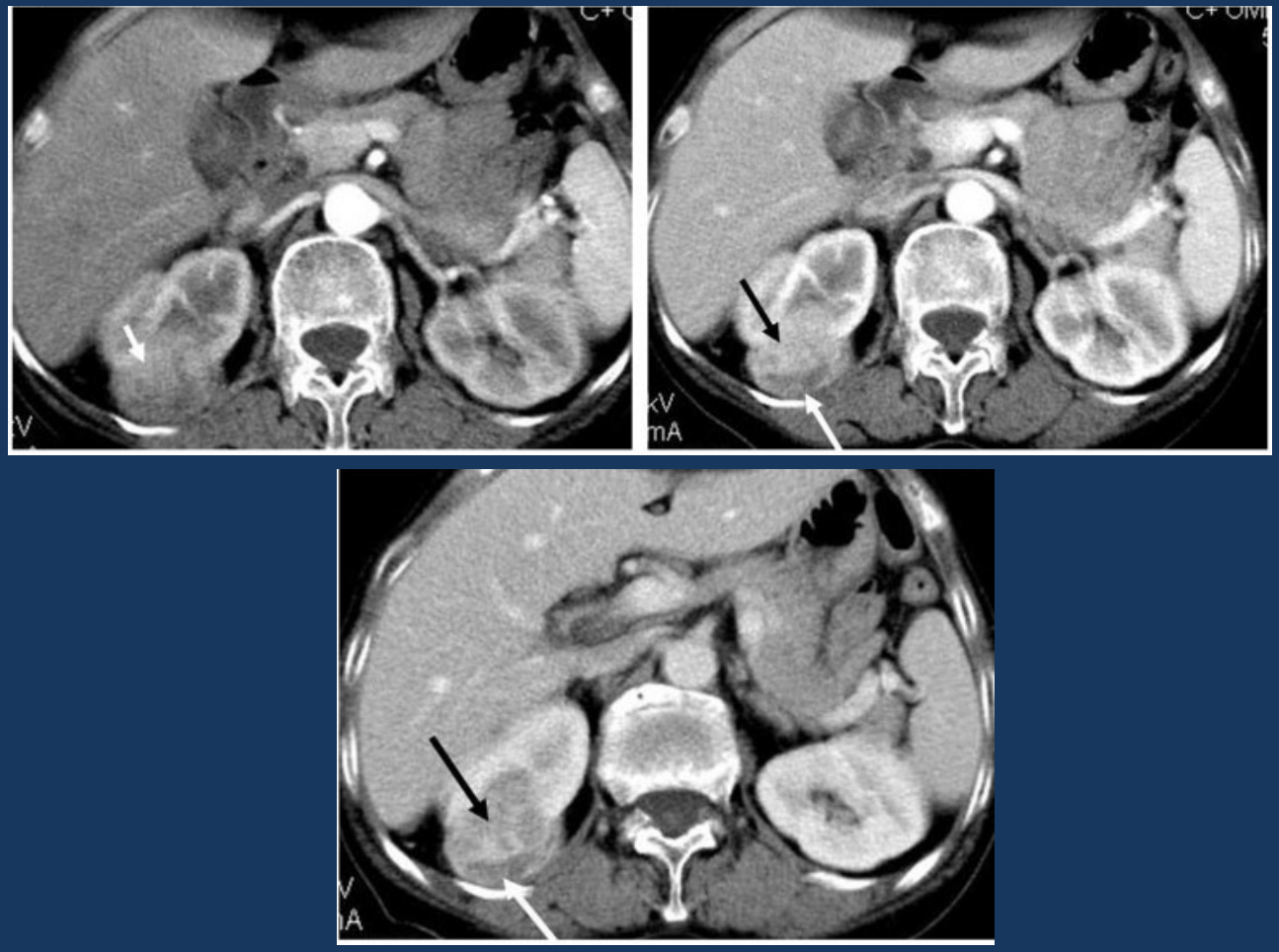

*Vendrami et al, Radiographics, November-December 2017*

# Chromophobe RCC




*Vendrami et al, Radiographics, November-December 2017*

**CT imaging features such as stellate scar, spoken-wheel-like enhancement, and segmental enhancement inversion (SEI) were more common in RO and they may help in differentiating RO from ChRCC.**



*Wu et al., Acta Radiologica 2016, 57(4): 500–506*

# Segmental enhancement inversion (SEI)
# Biphasic CT & MRI

- SEI is not useful for the diagnosis of renal oncocytoma with CT or MRI.
- Highly variable sensitivity.
- Substantial heterogeneity across studies and between institutions.
- Further validation of this imaging finding is necessary.

*Schieda et al., Eur Radiol. 2014 ; 24(11): 2787-94*

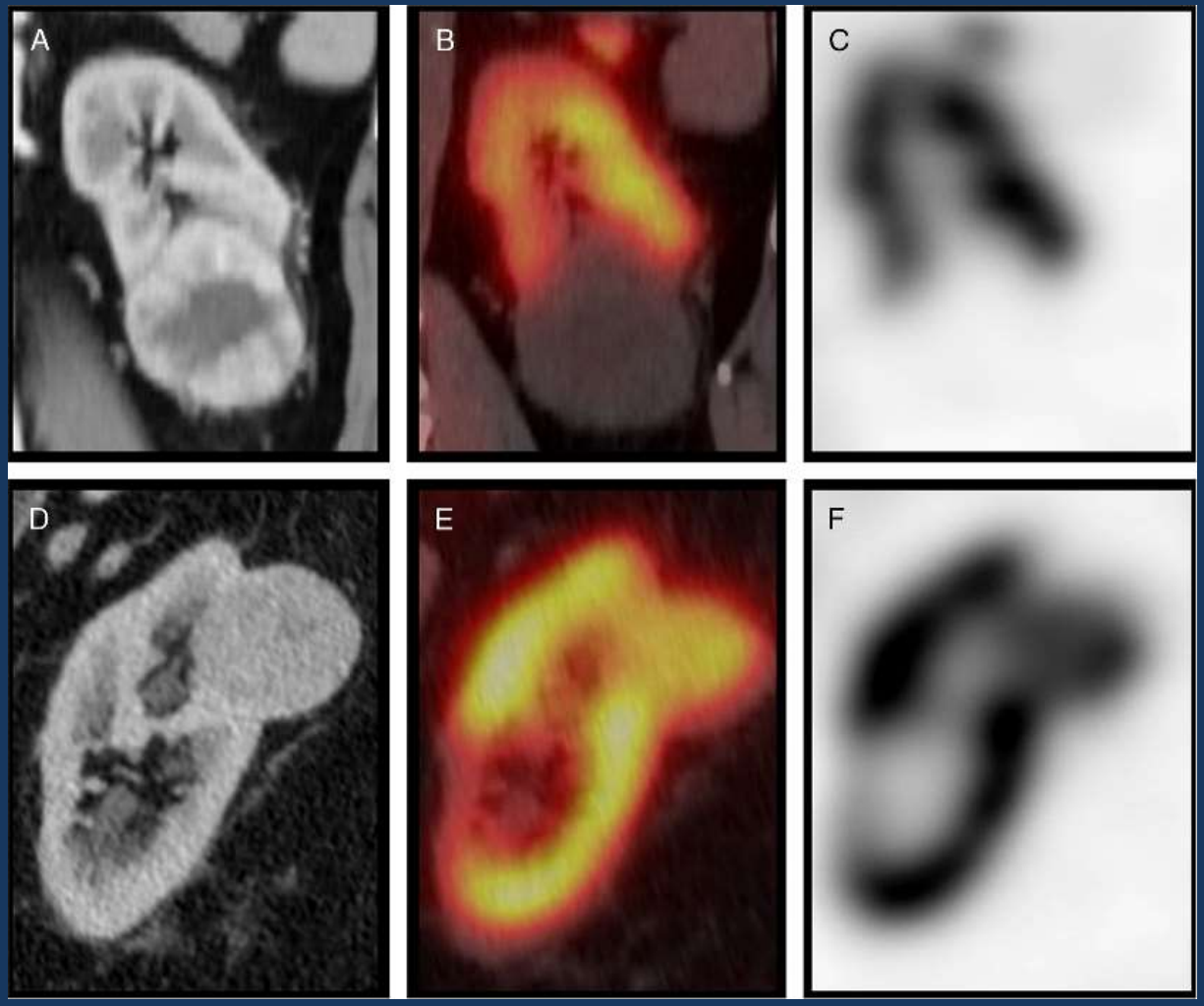
# Renal Masses: added value of 99mTc-MIBI SPECT/CT

**Conclusion**: Preoperative 99mTc-MIBI SPECT/CT enhances the performance of conventional imaging, improving the accuracy and confidence of renal mass classification into benign and malignant subgroups.

- This study proposed that the integration of 99mTc-MIBI SPECT/CT in the management algorithm of solid renal masses can potentially improve the accuracy of risk-adopted approaches.

*Sheikhbahaei et al., Clinical Nuclear Medicine 2017; 42 (4)*

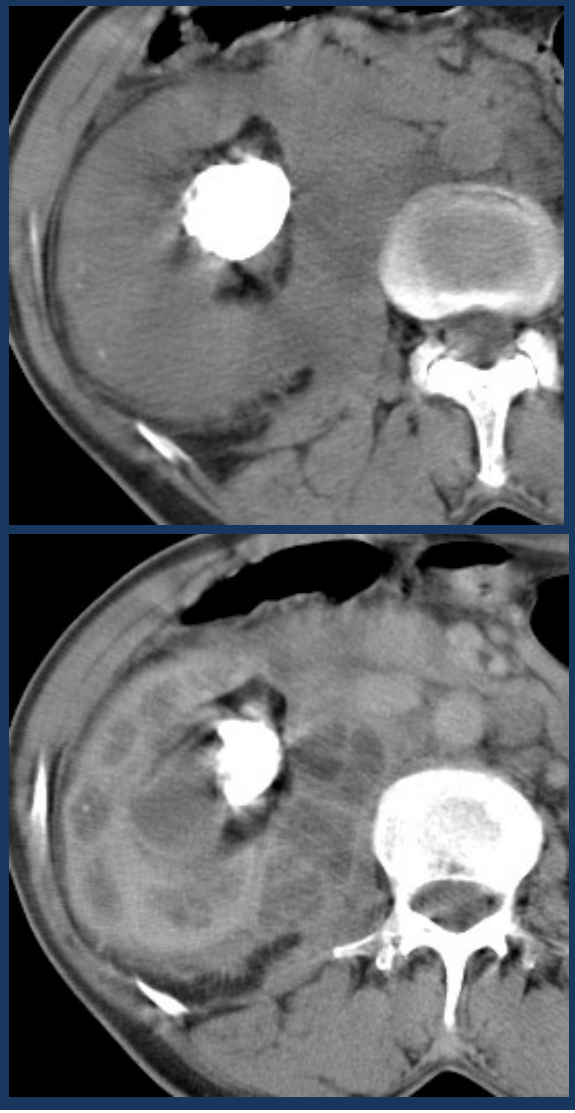
# Renal Masses: added value of 99mTc-MIBI SPECT/CT




*Sheikhbahaei et al., Clinical Nuclear Medicine 2017; 42 (4)*

# XGP

- Non-secreting enlarged kidney.
- A central calculus within a contracted renal pelvis.
- Expansion of the calices, and
- inflammatory changes in the perinephric fat are strongly suggestive .



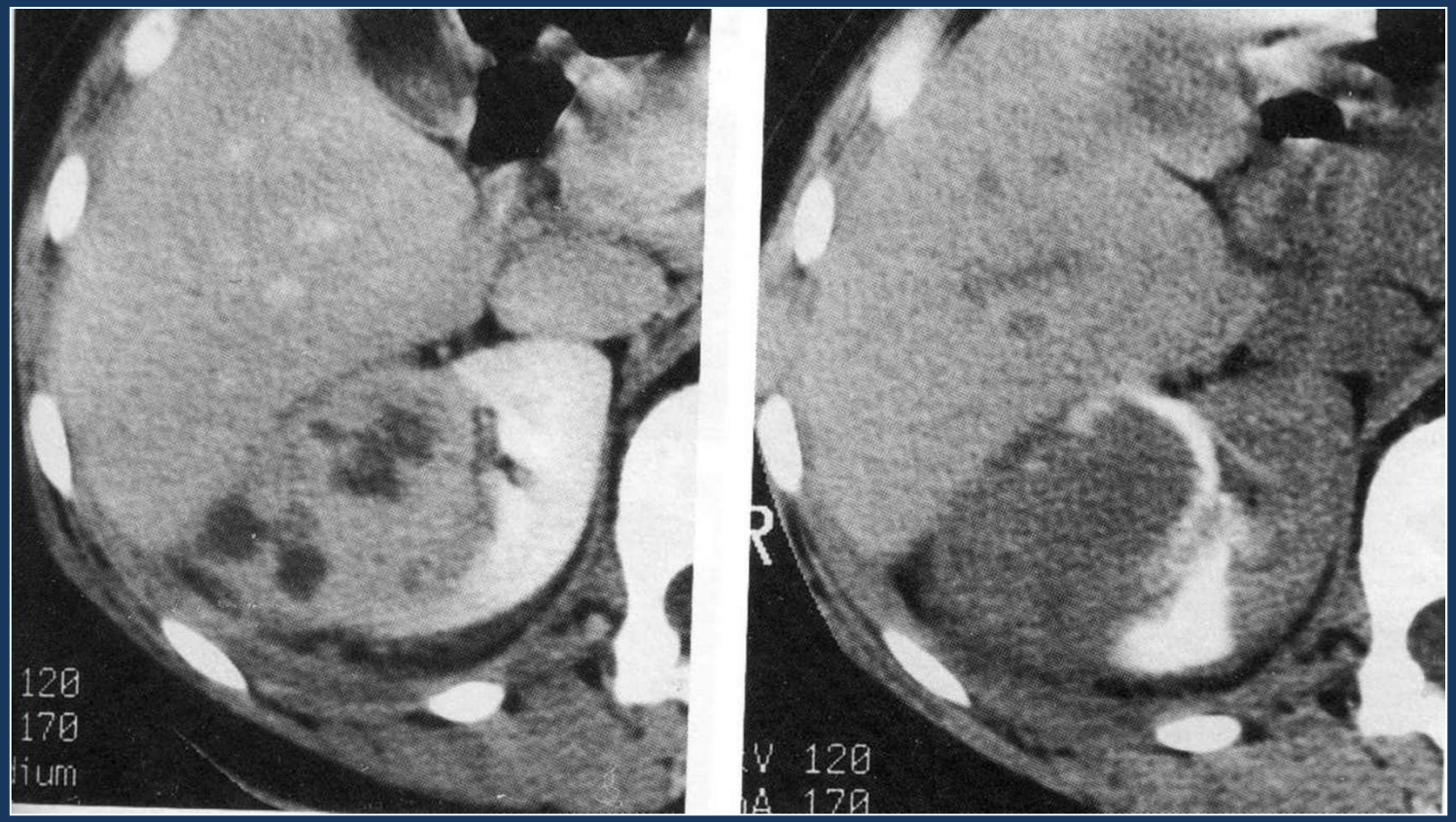
# Acute Pyelonephritis
# Focal Nephritis
## CT Features

- **Postecontrast delayed scan :**

  - Dense , inhomogenous staining of previously low attenuated areas.

  - Staining surrounding the hypodense area.

  - Focal densities localized far away.


120
170
ium
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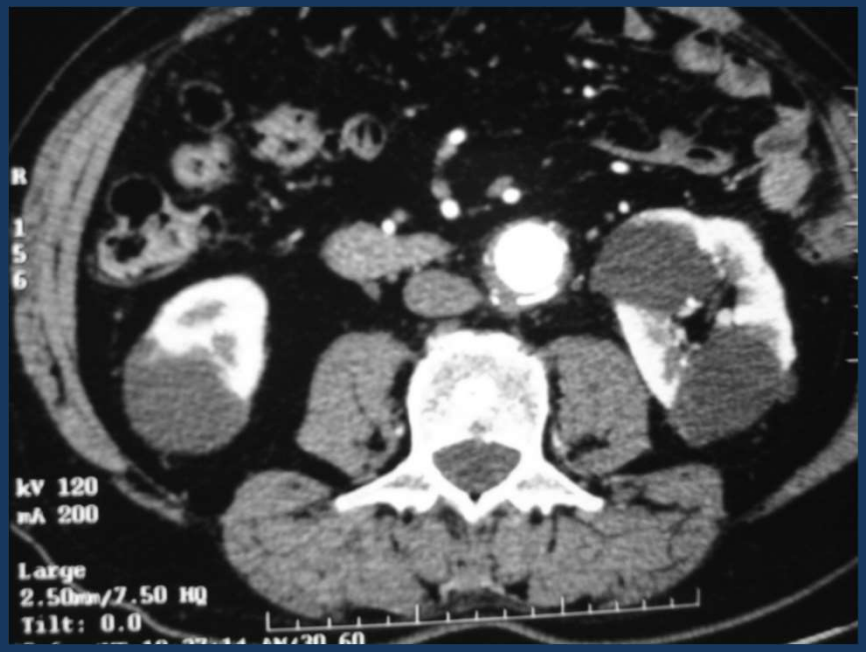
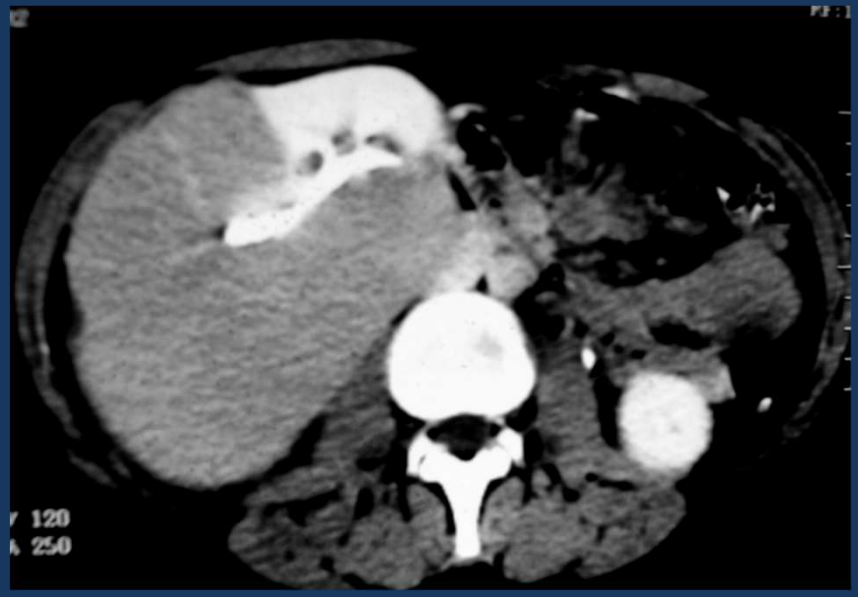
V 120
A 170

# Indications of Renal Mass Biopsy

1. To differentiate RCC from metastasis in patient with extrarenal malignancy.
2. To confirm the diagnosis of unresectable malignant tumor.
3. To diagnose suspecious mass in patients who are poor surgical candidates.
4. To confirm suspected inflammatory mass.

# Renal Lymphoma



# Emerging Renal Mass Biopsy

1. Small, hyperdense, homogenously enhancing mass.
2. In advance of RF ablation.
3. Multiple renal masses (lymphoma, oncocytosis, papillary RCC, metastases).

# Conclusion

Recognition of the most important imaging features of solid renal masses may assist in their proper diagnosis and management.

When a proper technique is used , CT provides high accuracy in detection, staging and characterization of RCC.

# Conclusion

MR imaging functions, not only, as valuable problem-solving tool.

Provides critical information that can help in differentiation of the most common solid renal masses, including the common RCC subtypes and AMLs, using multiparametric MRI.

# Conclusion

The combination of multiple subjective and objective parameters obtained from imaging studies offers an opportunity for evaluating the biology and ultimately the clinical significance of RCC.

teldiasty@hotmail.com

**Urology & Nephrology Center**

**Mansoura-Egypt**