

Unusual benign solid neoplasms of the kidney: cross-sectional imaging findings

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ABSTRACT

Kidney neoplasms are common diseases with varying prognoses depending on the subtype of the tumor. The most common solid lesion of the kidney is renal cell carcinoma, and the treatment is typically surgical removal. With increasing use of cross-sectional imaging in the last two decades, the detection of renal lesions has significantly increased, especially in asymptomatic patients who are scanned for other reasons. In this article, we present the imaging findings of rare solid benign primary kidney neoplasms including renal leiomyoma, reninoma, carcinoid tumor, metanephric adenoma, solitary fibrous tumor of the kidney, lipomatous hemangiopericytoma of the kidney, renal schwannoma, inflammatory myofibroblastic tumor of the kidney, extramedullary hematopoiesis in the kidney, and extranodal renal Rosai-Dorfman disease. Accurate preoperative or prebiopsy diagnoses of these lesions are unusual; however, informed radiologists may sometimes be able to favorably change the patient management and treatment.

Kidney neoplasms are common clinical disorders now being detected in even greater numbers due to the widespread use of cross-sectional imaging. Benign kidney neoplasms, once thought to be highly unusual, are being diagnosed in ever increasing numbers. In one series, 16.1% of patients who underwent partial nephrectomy for a presumed solitary renal cell carcinoma turned out to have a benign diagnosis in the final pathological analysis (1). Recent developments on computed tomography (CT) and magnetic resonance imaging (MRI) have limited value in differentiation between benign and malignant renal masses. Diffusion MRI studies yielded significantly different apparent diffusion coefficient (ADC) values between benign and malignant renal masses. These studies mostly evaluated the different ADC values between oncocytoma/angiomyolipoma and renal cell carcinomas (2). The role of ADC values in differentiation between uncommon benign renal masses and malignant renal masses has not been well established due to the scarcity of the lesions that we present in this article. Perfusion CT has been reported for the assessment of tumor angiogenesis in renal cell carcinoma and in the evaluation of tumor response to antiangiogenesis drugs and cryoablative therapies (3). Despite all these promising new imaging techniques, conventional approach based on imaging findings and percutaneous/surgical tissue diagnosis remain as the mainstay for diagnosis of solid renal lesions. The aim of this pictorial essay is to give practicing radiologists an overview of the imaging findings of rare solid benign neoplasms of the kidney.

Renal leiomyoma

Renal leiomyomas are uncommon lesions which originate from the smooth muscle cells in the renal capsule or renal pelvis or from the tunica media layer of the cortical vasculature (Fig. 1) (4). They typically present as hyperattenuating solid lesions on unenhanced CT. Morphologically they are peripherally located with well-defined margins and associated buckling of the renal cortex (5). On MRI, they are commonly of low signal intensity on T1- and T2-weighted images. The capsular location of the lesion may provide a clue to the diagnosis. Although the role of positron emission tomography (PET) is not known for the diagnosis of renal leiomyomas, in one of our cases no significant ¹⁸F-FDG avidity was detected within the lesion (Fig. 2). Because of the overlapping features on histology, differentiation of leiomyoma from leiomyosarcoma may be difficult unless the mass demonstrates evidence of invasion on imaging studies.

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Reninoma

A reninoma is a renal juxtaglomerular cell apparatus tumor that is characterized with excessive production of renin that results in secondary hyperaldosteronism, hypokalemia and hypertension. Renal vein sampling and cross-sectional imaging are the two major tools of diagnosis in affected patients (6). On unenhanced CT scans, they appear as hypo- or isodense solid masses with well-defined borders (Fig. 3a). On arterial phase images they remain hypovascular due to vasoconstriction from the excreted renin by the tumor. On T1-weighted images they are iso- or hypointense, while on T2-weighted images they appear hyperintense (Fig. 3b, 3c).

Carcinoid tumor

Carcinoid tumors are low-grade malignancies that arise from neuroendocrine tumor cells, particularly from enterochromaffin and from amine precursor uptake and decarboxylation cells. Primary renal carcinoids are extremely uncommon tumors. In the great majority of the reported patients the lesions were found to be solid. Dystrophic calcification within the lesion is detected in 30% of cases (Fig. 4) (7). The presence of horseshoe kidney has been commonly noted in the reported patients. Carcinoid tumor arising from a teratoma is even rarer, described in 11.4% of the reported cases (Fig. 5) (7). Renal carcinoid tumors are hypodense, mildly enhancing lesions which may contain calcifications on CT.

Main points

- With increasing use of cross-sectional imaging in the last two decades, the detection of renal lesions has significantly increased.
- Benign kidney neoplasms, once thought to be highly unusual, are being diagnosed in ever increasing numbers.
- Recent developments on CT and MRI have limited value in differentiation between benign and malignant renal masses.
- Imaging characteristics of renal masses on cross-sectional imaging such as size, location, contour, growth rate, fat content, presence of angular interface with the renal parenchyma, contrast enhancement pattern, perirenal soft tissue and/or renal vein invasion, presence of enlarged lymph nodes and/or distant metastasis can be helpful for the correct diagnosis.
- Detection of a solid renal mass necessitates histopathological analysis mostly performed by surgical removal of the mass.

Metanephric adenoma

Metanephric adenomas are benign kidney tumors accounting for about 0.2% of all adult epithelial renal neoplasms (4). As a group, metanephric neoplasms overall comprise metanephric adenoma (epithelial tumor), metanephric stromal tumor (stromal neoplasm) and metanephric adenofibroma (mixed epithelial and stromal neoplasm). Among these, metanephric adenofibromas and metanephric stromal tumors comprise pediatric age abnormalities. On unenhanced CT they may be seen as hypo- or hyperattenuating, well-margined lesions tending to appear more heterogeneous as the tumor size increases, often with foci of hemorrhage and necrosis (Fig. 6a). They tend to be hypointense on T1-weighted and slightly hyperintense on T2-weighted images (Fig. 6b, 6c).

Solitary fibrous tumor

Solitary fibrous tumor is a rare spindle cell neoplasm that is most commonly seen in the pleura. Renal location of this tumor is extremely rare. The renal capsule has been thought to represent its tissue of origin; however, intrarenal growth pattern without any connection to the renal capsule and or renal pelvis has also been recognized (8). Solitary fibrous tumor of the kidneys appears as well-circumscribed masses with avid enhancement on CT; while on MRI, they are of low signal intensity on T1-weighted and high or low signal intensity on T2-weighted images (Fig. 7) (9). Most of the reported cases are benign but the biological behavior of these tumors is unpredictable, therefore long-term follow-up is recommended.

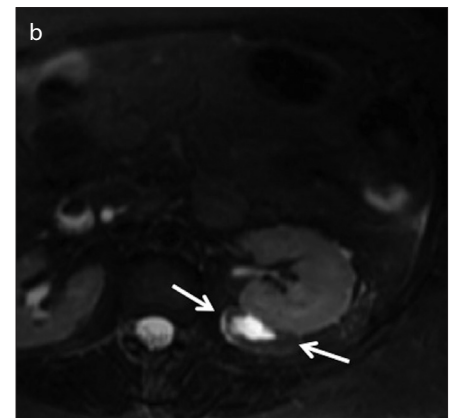
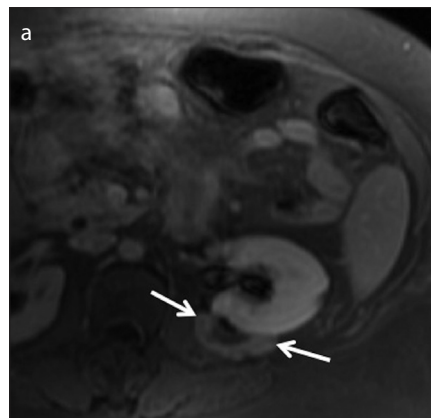


Figure 1. a, b. Renal leiomyoma. Incidental renal capsule leiomyoma of the left kidney in a 78-year-old female. Post-contrast T1-weighted image (a) shows contrast enhancing, well-defined, solid lesion with central cystic area (arrows). T2-weighted image of the lesion (b) confirms the solid and cystic areas within the lesion (arrows). Although nonspecific, the strictly capsular location of the lesion may be a clue for the diagnosis.

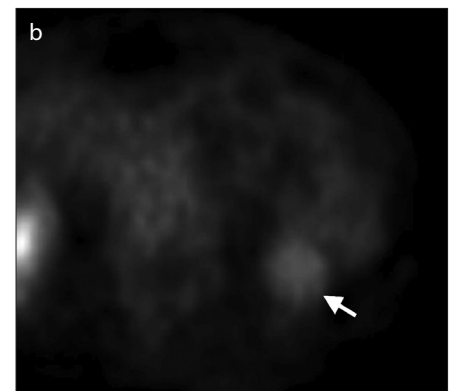


Figure 2. a, b. Incidental, pathologically proven leiomyoma of the left kidney in a 64-year-old female. CT scan (a) shows mildly contrast-enhancing lesion of the left kidney (arrow), with no evidence of FDG avidity (arrow) on the corresponding PET image (b).

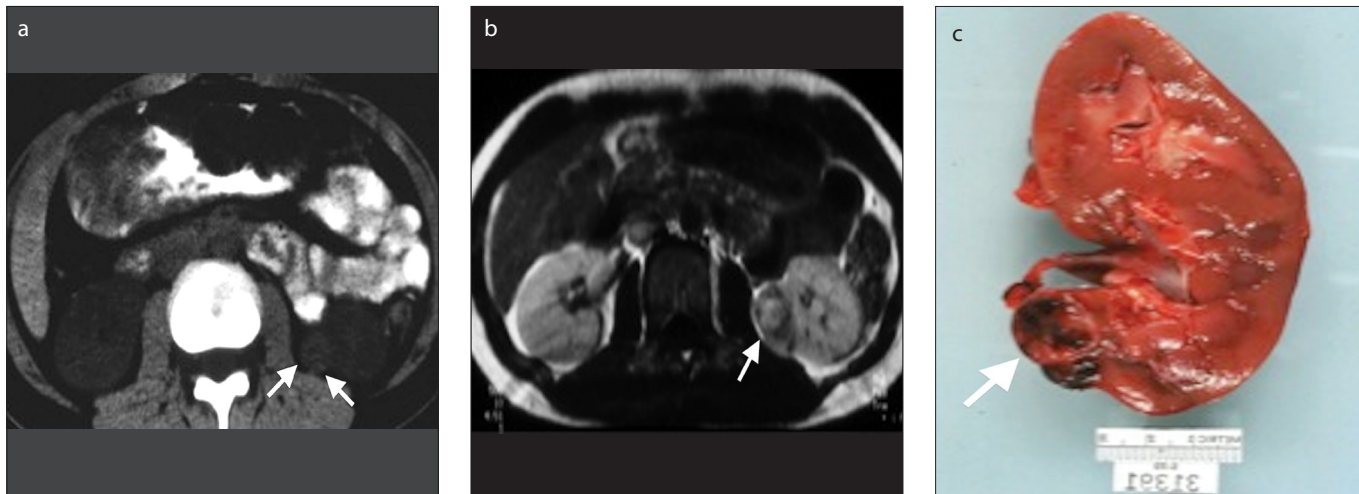


Figure 3. a–c. Reninoma in an 11-year-old girl with hypertension. On axial unenhanced CT image (a) well-circumscribed mildly hyperattenuating lesion is seen in the lower pole of the left kidney (arrows). Same lesion demonstrates heterogeneity with alternating hyper- and hypointense areas (arrow) on T2-weighted MRI (b). Macroscopic examination of the same lesion (c) in the lower pole of the left kidney (arrow). Note the solid nature of the lesion.

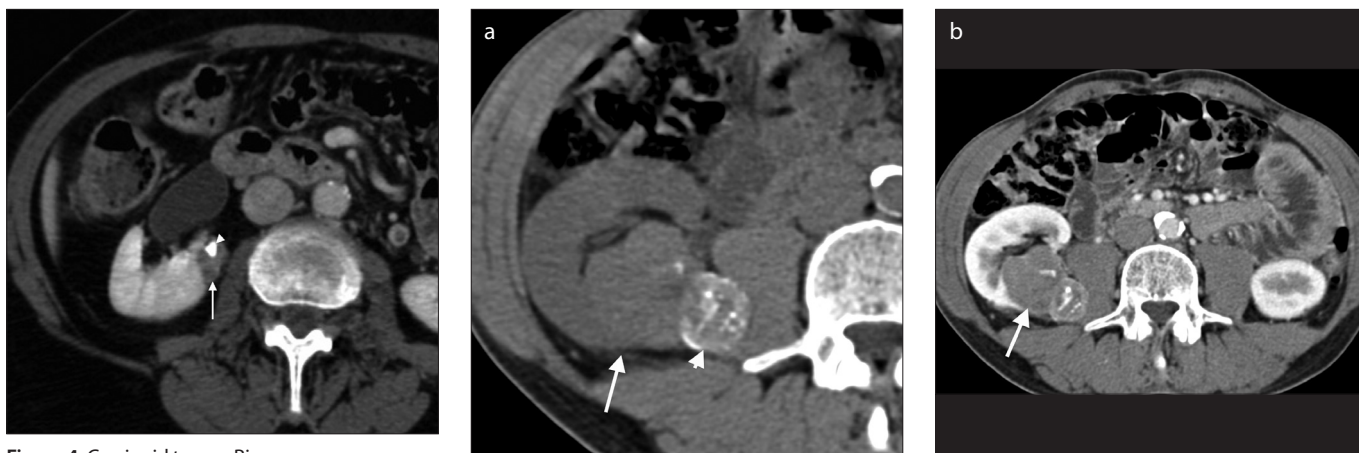


Figure 4. Carcinoid tumor. Biopsy-proven carcinoid tumor (arrow) arising from a teratoma in the medial portion of the right kidney in a 42-year-old male. Note the calcification within the lesion (arrowhead).

Figure 5. a, b. Carcinoid tumor. Unenhanced CT (a) of a different patient with renal carcinoid tumor demonstrates a solid mass (arrow) arising from the right kidney. A calcified portion of the mass (arrowhead) is localized eccentrically with well-circumscribed appearance. Renal mass enhances less than renal parenchyma after intravenous contrast administration (b).

Lipomatous hemangiopericytoma

Lipomatous hemangiopericytoma has been described in the literature as solid fat-containing mass arising from the deep soft tissues of the thigh and retroperitoneum (10). It has not been reported in the visceral organs previously, except for one case affecting the kidney (10). In the previously reported case macroscopic fat tissue has not been reported. In patients with macroscopic fat, as seen in our case, differentiation of the lesion from macroscopic fat-containing angiomyolipomas may be difficult or impossible (Fig. 8). They appear as well-demarcated, heterogeneously enhancing lesions. Fat component, if present, can be detected on CT and MRI.

Renal schwannoma

Schwannomas of the kidney are extremely rare neoplasms, and only around 20 patients have been reported in the literature. The reported cases are mostly located in the renal hilum, like our case, abutting or compressing the hilum and renal pelvis (11). In one reported patient, the MRI signal characteristics of the lesion were similar to schwannomas detected elsewhere, hypointense on T1 and hyperintense on T2 with an avid enhancement after intravenous gadolinium injection (11). In our patient the mass did not show intense contrast enhancement on CT. In case of a well-defined, solid mass in the renal hilum, schwannoma must be considered in differential diagnosis and biopsy should also be considered (Fig. 9).

Inflammatory myofibroblastic tumor

Inflammatory myofibroblastic tumor (IMT) of the kidney is a rare benign disease of the kidney which is characterized with mass forming proliferation of myofibroblasts, fibroblasts, histiocytes, and plasma cells in the affected portion of the kidney (12). Inflammatory myofibroblastic tumor of the kidney mimics renal malignancy on imaging studies with appearance of heterogeneous mass and contrast enhancement. Diagnosis of IMT usually depends on suspicion of a benign condition with clinical and imaging findings of a renal mass. Follow-up imaging studies reveal regression of such lesions. IMT of the kidney presents with hypoechoic heterogeneous mass on US



Figure 6. a–c. Metanephric adenoma of the left kidney in a 44-year-old male. Postcontrast CT (a), T1-weighted MRI (b), and diffusion-weighted imaging (DWI) (c) of the lesion confirm the solid nature of the lesion. Diffusion restriction was confirmed on ADC map (not shown).

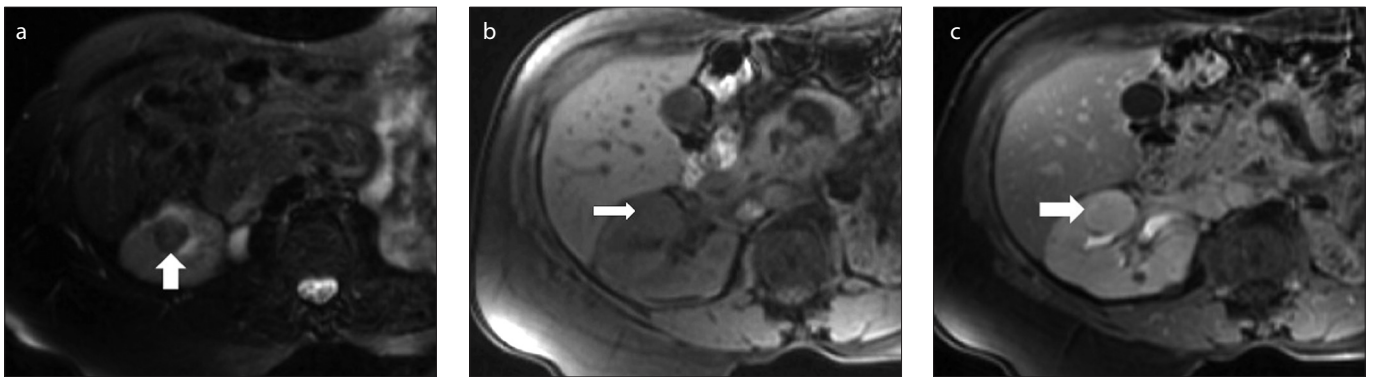


Figure 7. a–c. Solitary fibrous tumor of the right kidney in a 47-year-old woman. T2-weighted image (a) shows hypointense lesion in the right kidney (arrow). Hypointense signal characteristics likely reflect the fibrous nature of the tumor. Pre- (b) and postcontrast (c) T1-weighted images show that the lesion enhances with gadolinium (arrows).

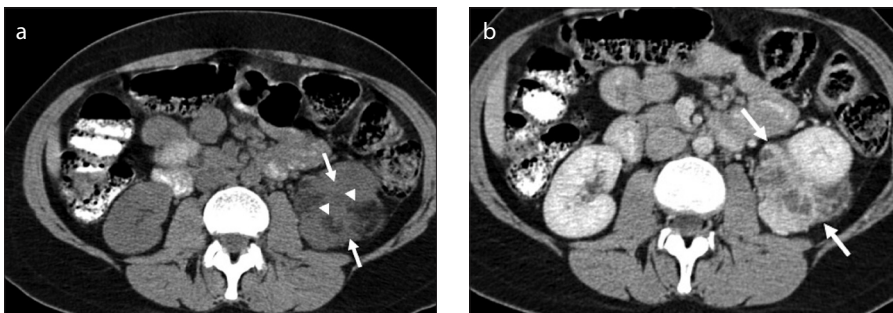


Figure 8. a, b. A 45-year-old woman with surgically proven lipomatous hemangiopericytoma of the left kidney. Unenhanced axial CT scan (a) demonstrates an irregular mass (arrows) with islets of gross macroscopic fat (arrowheads). Postcontrast axial CT image (b) shows heterogeneous enhancement of the lesion (arrows). The borders of the lesion are better delineated on contrast-enhanced CT.

(Fig. 10a). CT reveals ill-defined, hypovascular, homogeneous renal mass. Inflammatory myofibroblastic tumor of the kidney manifests with hypointense appearance on both T1- and T2-weighted MRI (Fig. 10b–10d).

Extramedullary hematopoiesis

Extramedullary hematopoiesis is most commonly seen in myelofibrosis; however,

it may also be seen in patients with thalassemia, hereditary spherocytosis, and sickle cell disease. It is most commonly detected in the reticuloendothelial system, i.e., the liver, spleen and lymph nodes, although it has also been described in the pleura, pericardium, adrenal glands, spinal cord, breast, thyroid, and kidney (13). Although extramedullary hematopoiesis is well-known in the kidney, presentation with large renal

lesions is extremely rare, around ten case reports to our knowledge (13). CT may reveal lobulated masses with mild homogeneous enhancement and pelvicalyceal areas are commonly involved (Fig. 11). Despite engulfment of the kidneys by the mass, the kidney shape is commonly preserved. They commonly appear as T2-hypointense masses on MRI.

Rosai-Dorfman disease

Rosai-Dorfman disease, also called as sinus histiocytosis with massive lymphadenopathy, is a non-neoplastic histiocytic disorder with massive lymphadenopathy due to infiltration and dilation of the lymph node sinuses by large histiocytes. The classical clinical presentation is massive, diffusely enlarged, bilateral, non-tender cervical lymphadenopathy. Kidney involvement is rare in this patient group and seen in 4% of patients (14). Radiologically the renal involvement may be seen as discrete nodal masses or infiltrative lesions around

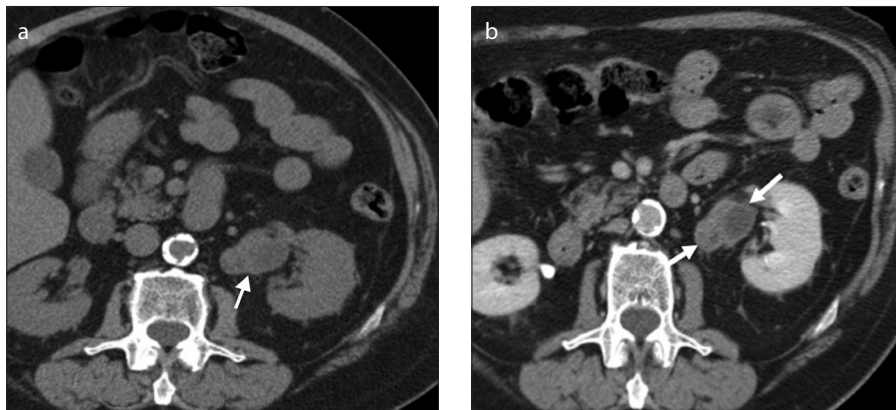


Figure 9. a, b. Surgically proven benign schwannoma of the left kidney in a 46-year-old woman. Pre- (a) and postcontrast (b) CT images show mildly enhancing lesion (arrows) with well-defined borders and no evidence of infiltration. The contrast enhancement pattern is suggestive of a cystic lesion, but the lesion was completely solid at surgery. The hilar location is typical of renal schwannoma.

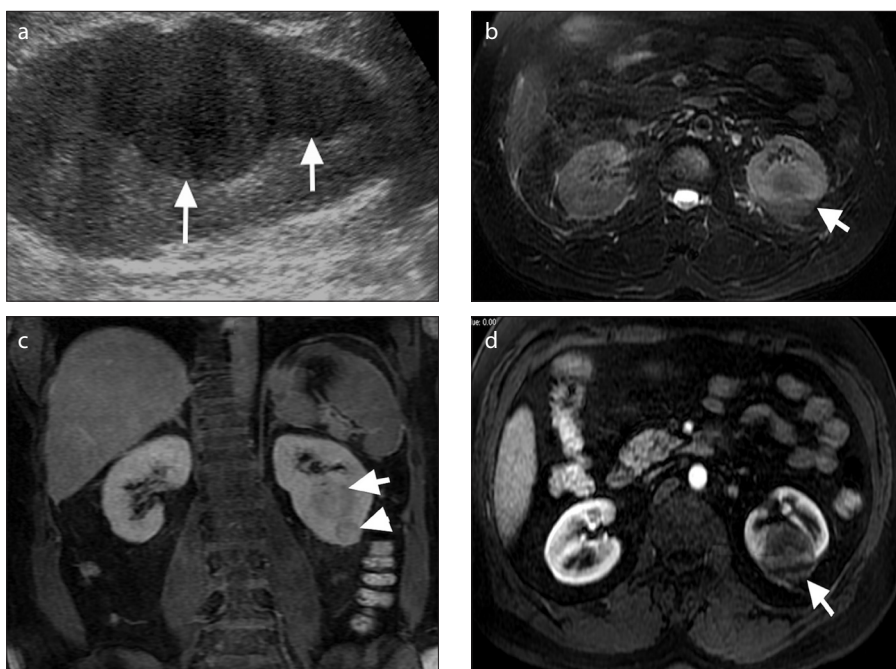


Figure 10. a–d. Inflammatory myofibroblastic pseudotumor of the left kidney. Gray-scale US (a) demonstrates two hypoechoic masses (arrows) arising from the renal parenchyma. T2-weighted fat-saturated axial MRI (b) reveals hypointense mass (arrow) without demarcating from renal parenchyma. T1-weighted fat-saturated coronal MRI (c) demonstrates hypointense masses (arrows). Contrast-enhanced T1-weighted MRI (d) reveals lower enhancement in the mass (arrow) than in the renal parenchyma.



Figure 11. Extramedullary hematopoiesis. Solid contrast enhancing tumor of the left kidney (arrows) in an 87-year-old male with known history of myelofibrosis. This lesion represents biopsy-proven extramedullary hematopoiesis.



Figure 12. A 36-year-old man with biopsy-proven Rosai-Dorfman disease in the kidney. On postcontrast axial CT scan soft tissue densities encasing both kidneys are well delineated (arrows). Also note the mass-forming soft tissue densities in both renal sinuses (arrowheads). Left kidney is atrophic due to long standing hydronephrosis.

the capsule (Fig. 12). They appear isodense on unenhanced CT with mild enhancement after contrast injection. Differential diagnosis of Rosai-Dorfman disease is not straightforward and may include lymphoma, lymphangioma, renal cell carcinoma, and metastasis depending on the imaging characteristics of the disease.

Conclusion

We present the imaging findings of rare primary benign solid renal neoplasms with an emphasis on their pertinent imaging features on several cross-sectional modalities. Imaging characteristics of renal masses on cross-sectional imaging such as size (<4 cm/>4 cm), location (parenchymal/perirenal), contour (well/ill defined), growth rate, fat content, presence of angular interface with the renal parenchyma, contrast enhancement pattern, perirenal soft tissue/renal vein invasion, presence of adjacent enlarged lymph nodes/distant metastasis can be helpful for the correct diagnosis (15). It should be kept in mind that detection of a solid renal mass necessitates histopathological evaluation which is mostly performed by surgical removal of the mass.

Conflict of interest disclosure

The authors declared no conflicts of interest.

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