Imaging of Renal Lymphoma: Patterns of Disease with Pathologic Correlation

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Extranodal spread of lymphoma often affects the genitourinary system, with the kidneys being the most commonly involved organs. Contrast material–enhanced computed tomography (CT) remains the modality of choice for the detection, diagnosis, staging, and monitoring of renal lymphoma. Magnetic resonance (MR) imaging is particularly useful in patients in whom intravenous administration of iodinated contrast material is contraindicated. Ultrasonography (US), although very valuable for diagnosing lymphoma in the testis or epididymis, is less sensitive than CT and MR imaging for detecting renal lymphoma. Typical imaging findings of renal lymphoma include multiple poorly enhancing or hypoechogenic masses, retroperitoneal tumors directly invading the kidneys, bilateral renal enlargement, and perirenal soft-tissue masses. Cystic lesions and tumors predominantly affecting the renal sinus and collecting system are uncommon. Unless the renal lesions manifest in the setting of widespread lymphoma, percutaneous biopsy is indicated to differentiate lymphoma from metastases, hypovascular renal cell carcinoma, uroepithelial carcinoma, or atypical infection, with US routinely being used to guide the procedure. Current immunohistochemical techniques allow accurate diagnosis and characterization of renal lymphoma. Radiologists should be familiar with both typical and atypical manifestations of renal lymphoma and should recommend imaging-guided percutaneous biopsy for diagnostic confirmation to avoid unnecessary nephrectomy.

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Introduction

The genitourinary system is often affected by extranodal spread of lymphoma, being the second most commonly affected anatomic entity next to the hematopoietic and reticuloendothelial organs (1). The kidneys are most commonly involved. Reports from autopsy series of patients who have succumbed to the disease describe foci of lymphoma in the kidneys in approximately one-third of cases (1,2). In one series of 322 autopsies, lymphoma involved the kidneys in 37.6% of cases but the urinary bladder and testes in only 8.4% and 5.9% of cases, respectively (2). Despite the relatively high prevalence of renal involvement, imaging studies demonstrate renal abnormalities in only 3%–8% of patients undergoing routine evaluation for staging or during the course of therapy (3–5). This apparent discrepancy between the pathology literature and the radiology literature can be explained by several factors: Renal lymphoma is often poorly documented, since the disease is often clinically silent and renal biopsy is rarely indicated to confirm the diagnosis in the context of systemic disease. Furthermore, the statistics cited earlier were gathered before the widespread use of helical single- and multi-detector row computed tomography (CT), at a time when findings were obtained with older-generation scanners and led to underestimation of the prevalence of renal lesions. For example, in a study of 225 patients with a diagnosis of lymphoma, only 11 (4.9%) had renal abnormalities at staging examination performed on a conventional CT scanner following intravenous drip infusion of contrast material (6). In a more recently published pediatric series, renal manifestations of lymphoma were detected in 11 (8%) of 139 children (7). It is anticipated that the superior evaluation of the renal parenchyma afforded by modern imaging techniques will greatly improve the detection of renal lymphoma (5,7). When renal lymphoma occurs in the setting of disseminated disease, particularly nodal enlargement, the diagnosis is generally easily made. In a smaller number of cases, however, the kidneys are predominantly or exclusively affected. In these cases, it is essential that the radiologist be able to recognize specific patterns of involvement that can suggest the diagnosis and prevent unnecessary surgery.

In this article, we discuss the clinical manifestations of renal lymphoma and the imaging techniques used to evaluate affected patients. We also discuss radiologic-pathologic correlation and various imaging patterns (multiple lesions, solitary lesion, direct extension from retroperitoneal adenopathy, perinephric disease, nephromegaly, renal sinus involvement) seen in renal lymphoma. In addition, we briefly discuss the diagnostic role of imaging-guided renal biopsy in this setting.

Clinical Manifestations

Renal lymphoma usually occurs in the setting of widespread non-Hodgkin lymphoma, typically B-cell type intermediate- and high-grade tumors or American Burkitt lymphoma (8,9). In more than one-half of cases, renal or perirenal spread is detected at initial presentation (Fig 1) (4). Involvement by Hodgkin disease is much less common, being seen in less than 1% of patients at presentation (2,5,10). In the majority of cases, renal lymphoma is clinically asymptomatic and radiologic detection seldom influences staging and treatment. Follow-up data obtained in patients with renal lymphoma suggest that, although involvement of the kidneys at the time of presentation does not necessarily indicate a poor prognosis, recurrence in the kidney is associated with an increased mortality rate (9).

Immunocompromised patients are at significantly higher risk for developing lymphoma. In this population, lymphomas develop as a consequence of the unrestricted proliferation of B lymphocytes infected by Epstein-Barr virus. Extranodal lymphoma, including renal lymphoma—either isolated or as part of multiple organ involvement—is particularly common (11,12). In patients with HIV infection–acquired immunodeficiency syndrome, the prevalence of some types of non–Hodgkin lymphoma, particularly the immunoblastic and Burkitt subtypes, is at least 113–165 times greater than in the general population (13) and increases with the decreasing CD4 lymphocyte count at presentation (14). Recipients of
solid organ transplants also tend to develop aggressive non-Hodgkin lymphoma. One recently published large analysis of almost 200,000 organ transplant recipients by Opelz and Dohler (15) helped confirm that these patients are at higher risk than the general population. The incidence of posttransplantation lymphoproliferative disorders is highest during the 1st year following the procedure. This risk varies with the type of organ transplanted, varying from a 20-fold increase for recipients of renal transplants to a 120-fold increase for recipients of combined heart-lung and lung transplants (15). Most posttransplantation lymphomas are linked to uncontrolled Epstein-Barr proliferation caused by immunosuppressive therapy and tend to develop within or near the allograft (15). The study by Opelz and Dohler also emphasized the persistent long-term risk of developing lymphoma run by transplant recipients.

In rare cases, diffuse infiltration of both kidneys by malignant lymphocytes may be the predominant or even the sole manifestation of the disease. Patients present with flank pain, hematuria, or nonspecific symptoms of fever and night sweats (16,17). Extensive lymphomatous infiltration of the renal parenchyma and compression of the normal tubules can lead to acute renal failure.

**Figure 1.** High-grade B-cell lymphoma in a 38-year-old human immunodeficiency virus (HIV)–positive woman who presented with abdominal pain and distention. (a) Contrast material–enhanced CT scan of the midabdomen shows a very large soft-tissue mass (arrows) infiltrating the mesentery and omentum and displacing the small bowel and colon. (b) Contrast-enhanced CT scan shows hypoenhancing soft-tissue masses (arrows) in both kidneys. Note also the retroperitoneal adenopathy (arrowhead). (c) Photomicrograph (original magnification, ×200; Diff-Quik stain) of a specimen obtained at fine-needle aspiration biopsy shows hypercellularity with a uniform population of malignant lymphocytes. Numerous apoptotic cells are also seen, a finding that is compatible with a high-grade phenotype.
Primary renal lymphoma that is isolated to the renal parenchyma with no systemic manifestations is uncommon, accounting for less than 1% of cases of extranodal lymphoma (17). Its origin is somewhat uncertain. Because the renal parenchyma does not normally contain lymphoid tissue, several mechanisms have been postulated to account for the development of lymphoma in the kidney: The tumor may originate in the lymphatic-rich renal capsule or the perinephric fat and invade the parenchyma, or it can arise from lymphocytes present in areas of chronic inflammation (17,20,21). The tumor is usually a B-cell non-Hodgkin lymphoma and affects patients who are middle aged or older. The diagnosis of primary renal lymphoma is confirmed with percutaneous biopsy of the renal parenchyma. Rapid improvement in renal function and decrease in renal size follow the initiation of chemotherapy.

**Imaging Techniques**

**Computed Tomography**

Multi–detector row CT is the imaging modality of choice for the evaluation of patients with suspected renal lymphoma. This modality not only depicts the renal lesions, but also most accurately helps identify extension to adjacent anatomic structures such as the perirenal space and the retroperitoneum, thereby helping to determine the systemic spread of the disease. The administration of intravenous contrast material and image acquisition in the nephrographic (venous) phase of enhancement are essential for the detection of subtle or small lesions, particularly those in the medullary portion of the kidney (Fig 1) (22). Lymphomatous deposits tend to be hypovascular and to enhance poorly. Thus, small masses that do not deform the renal contour can be mistaken for the unenhanced normal medulla and are less conspicuous on early images obtained in the corticomedullary (late arterial) phase of enhancement. However, imaging during this phase allows optimal depiction of the renal vessels and is important for differentiating renal lymphoma from hypervascular primary renal tumors. If the tumor is predominantly central and affects the hilar region or the collecting system appears to be involved, excretory phase imaging is necessary. Excretory phase imaging also best demonstrates obstruction of the collecting system by retroperitoneal masses.

**Magnetic Resonance Imaging**

Although the role of magnetic resonance (MR) imaging in renal lymphoma is less clearly documented in the literature, small series have shown MR imaging to be as accurate as contrast-enhanced CT in demonstrating renal and perirenal disease (23). MR imaging is the optimal imaging modality in patients with iodinated contrast material allergy or renal insufficiency. In addition, MR imaging has proved superior to CT in depicting involvement of the bone marrow (24,25). Like most malignant and inflammatory renal lesions, lymphoma exhibits hypointense signal on T1-weighted MR images and is slightly hypointense or isointense relative to normal renal cortex on T2-weighted images. After the intravenous administration of gadolinium-based contrast material, lymphomatous deposits enhance less than the surrounding normal parenchyma, although some lesions demonstrate progressive enhancement on delayed images (Fig 2c, 2d) (24).

**Ultrasonography**

Both contrast-enhanced CT and MR imaging are superior to US in detecting the presence of disease as well as the number of renal lesions and the presence of extrarenal tumors (23,26,27). However, US may be the first test requested in patients who present with renal insufficiency or flank pain; consequently, it is important to recognize the relatively subtle US abnormalities caused by lymphoma (Fig 2a, 2b). US is also helpful in patients who are unable to receive intravenous iodinated contrast material. At our institution, US is the ideal guidance modality for percutaneous biopsy, which, with the refinement of immunohistochemical and flow cytometric studies, allows specific diagnosis in the majority of cases (Fig 2) (28).
Figure 2. Burkitt-like aggressive lymphoma in a 40-year-old man who presented with right flank pain and a creatinine level of 9.9. A diagnosis of HIV infection had recently been made. (a) Sagittal ultrasonographic (US) image shows an enlarged left kidney with heterogeneous echotexture of the parenchyma. No discrete mass is seen, and the normal shape of the kidney is preserved. (b) Sagittal US image of the right kidney shows similar findings. In addition, there is ill-defined infiltration of the renal sinus fat near the lower pole and a focal hypoechoic mass (arrows) in the lower pole. (c, d) Axial venous phase contrast-enhanced fat-saturated T1-weighted (c) and coronal venous phase contrast-enhanced (d) MR images of the abdomen show left renal lesions (thin arrows) with very little enhancement. The mass in the lower pole of the right kidney (thick arrows) has heterogeneous signal intensity. Note also the area of necrosis (arrowhead in c) within the mass. (e) Photomicrograph (original magnification, ×400; Diff-Quik stain) of a specimen obtained at fine-needle aspiration biopsy shows intermediate-sized atypical lymphocytes with cytoplasmic vacuolization (arrow). The nuclei lack prominent nucleoli, a finding that is compatible with Burkitt lymphoma. (f) Photomicrograph (original magnification, ×200; hematoxylin-eosin [H-E] stain) of a specimen obtained at core biopsy shows malignant cells with monotonous round nuclei and fine powdery chromatine. Note also the extensive necrosis. (g) Photomicrograph (original magnification, ×200; immunohistochemical staining for CD 20) of a specimen obtained at core biopsy shows strong positivity (brown areas), a finding that indicates a B-cell phenotype. Immunostaining for CD 45 (lymphocytic proliferation) and CD 10 was also positive, findings that helped confirm the diagnosis of Burkitt lymphoma.
Positron Emission Tomography
Positron emission tomography (PET) has emerged as a very useful technique for the staging of lymphomas and the detection of recurrent disease. Because it helps detect increased metabolic activity within lymphomatous deposits, fluorodeoxyglucose (FDG) PET is more sensitive and specific than conventional anatomic imaging in detecting additional small tumor deposits (29). Combined PET-CT is emerging as a powerful tool that demonstrates the metabolic activity of tumors as well as anatomic details, a combination that allows precise localization and potential earlier detection of additional tumor foci (Fig 3) (30).

Radiologic-Pathologic Correlation
Renal lymphoma has a variety of imaging appearances depending on the pattern of tumor proliferation at histologic analysis (31).

Malignant lymphocytes reach the renal parenchyma by means of hematogenous spread and proliferate within the interstitium, using the nephrons, collecting tubules, and blood vessels as a “scaffolding” for further growth. Alternatively, some tumors spread by means of contiguous extension from the retroperitoneum, penetrating the
renal capsule. Once the tumor reaches the kidneys, its radiologic appearance is determined by its predominant proliferation mechanism. If the tumor follows an infiltrative growth pattern and malignant cells proliferate along the scaffolding of the normal interstitial tissue, the kidneys enlarge but their normal shape is preserved (32,33). The lesions have ill-defined borders and may be quite subtle (34). In many cases, however, malignant lymphocytes proliferate focally, destroy the adjacent renal parenchyma, and form single or (more commonly) bilateral expansile lesions with well-defined margins. Small masses may coalesce and grow, thereby distorting the renal contour (31). A combination pattern is not unusual (Fig 3).

**Imaging Patterns**

Renal lymphoma has a wide variety of manifestations, including multiple lesions, a solitary lesion, direct extension from retroperitoneal adenopathy, preferential involvement of the perinephric space, and diffuse infiltration of one or both kidneys. The renal sinus and collecting system are less frequently affected, except for obstruction caused by retroperitoneal adenopathy. In a large autopsy series of 696 patients with lymphoma, Richmond et al (1) observed multiple renal masses in 61% of cases. A solitary renal nodule and direct invasion from retroperitoneal adenopathy were equally common, being found in 11 kidneys each.

**Multiple Lesions**

The most common imaging appearance of renal lymphoma is that of multiple parenchymal masses of variable size, typically 1–4.5 cm in diameter. This pattern is seen in 50%–60% of cases. The lesions are most often bilateral but may also affect only one kidney (3–5,7,26).

At unenhanced CT, these masses appear as soft-tissue lesions with slightly higher attenuation than that of the surrounding parenchyma. Calcifications within the lesions are rare. Nephrographic phase contrast-enhanced CT is essential because many lesions are small and affect the medullary portion of the kidneys, with relatively little cortical deformity (22). Lymphomatous deposits enhance less than the normal renal tissue and appear as relatively homogeneous masses with lower attenuation than that of the surrounding cortex. Large lesions tend to be more heterogeneous. The presence of retroperitoneal adenopathy is an additional clue to the diagnosis (Fig 4).

**Figure 4.** Large B-cell lymphoma in a 41-year-old HIV-positive man. (a) Unenhanced CT scan of the midabdomen shows a soft-tissue mass (arrowhead) in the region of the great vessels, a finding that is suspicious for retroperitoneal adenopathy. The kidneys do not demonstrate any abnormality in contour. (b) Contrast-enhanced CT scan of the midabdomen shows bilateral soft-tissue renal masses (arrows). Note that these masses do not deform the contour of the kidneys. The paraaortic retroperitoneal adenopathy (arrowhead) is much more clearly depicted than in a.
Figure 5. B-cell lymphoma in a 33-year-old man who presented with progressive weakness of the upper extremities. (a) Transverse US image of the right kidney shows multiple hypoechoic soft-tissue masses (arrows) in the parenchyma. Note that the normal shape of the kidney is preserved. Similar hypoechoic masses were seen in the left kidney. The patient had concomitant central nervous system involvement. (b) Sagittal color Doppler US image of the right kidney shows displacement of the renal vessels by the masses.

Figure 6. Multifocal renal cell carcinoma in a 68-year-old man with right upper quadrant pain. (a) Arterial phase contrast-enhanced CT scan of the kidneys shows bilateral hypervascular, heterogeneous masses (arrows). (b) Excretory phase contrast-enhanced CT scan of the kidneys also shows the masses (arrows). The left renal mass is centrally located and involves the collecting system. (c) Photomicrograph (original magnification, ×200; H-E stain) of a specimen obtained at core biopsy of the right renal mass shows a clear cell tumor with prominent capillary proliferation. This finding is compatible with the diagnosis of renal cell carcinoma. Biopsy of the left renal mass was also performed and demonstrated renal cell carcinoma. The patient was treated with partial right nephrectomy and total left nephrectomy.
Few reports have described the MR imaging appearance of renal lymphomas. Tumors have lower signal intensity than does normal cortex with T1-weighted sequences and are relatively iso- or hypointense with T2-weighted sequences. They enhance less than the renal parenchyma following intravenous administration of gadolinium-based contrast material (Fig 2) (24).

At US, lymphomatous masses are typically hypoechoic and homogeneous. Their US appearance reflects the underlying homogeneity of lymphoma deposits, which offer very few tissue interfaces to the insonating beam (6,23,26). Color or power Doppler US shows displacement of normal renal vessels with little vascularity within the lesions (Fig 5).

Metastatic disease to the kidneys may mimic renal lymphoma. Large autopsy series show that lung cancer is the most common primary malignancy to spread to the kidneys, followed by breast cancer, gastric cancer, and melanoma (35). These lesions are usually clinically silent and detected incidentally in patients with disseminated tumor. In the rare case in which there is no relevant clinical history, imaging-guided biopsy is indicated. Acute pyelonephritis, septic emboli to the kidneys, renal infarcts, and abscesses should also be considered in the differential diagnosis (36). Thickening of perirenal fascial planes and infiltration of perinephric fat can be present in both inflammatory processes and lymphoma. Multiple synchronous renal cell carcinomas are differentiated on the basis of their hypervascular enhancement pattern (Fig 6).

**Solitary Lesion**

Renal lymphoma manifests as a solitary mass in 10%–25% of patients (4,5,31). At contrast-enhanced CT, the mass characteristically demonstrates little enhancement following intravenous contrast material administration (Fig 7). This feature is helpful in differentiating renal lymphoma from conventional renal cell carcinoma, which usually enhances in the arterial phase. At US, renal cell carcinoma tends to appear more echogenic than lymphoma (Fig 8). In addition, the presence of associated thrombus in the renal vein or inferior vena cava is highly unusual in lymphoma. However, some primary renal tumors, such as the papillar and chromophobe variants of renal cell carcinoma, do not exhibit this classic enhancement (Fig 8). In such cases, percutaneous biopsy is required for definitive diagnosis to exclude an atypical renal cell carcinoma or a solitary metastasis.

A cystic appearance is also highly unusual in renal lymphoma. Of the 28 cystic Bosniak III lesions reviewed in one study, only one proved to be lymphoma at biopsy (37), and rare cases of lymphoma infiltrating a cyst wall have also been reported (38). Some lesions may contain large
low-attenuation areas, perhaps related to necrosis, particularly during chemotherapy (Fig 9).

Lymphoma can appear markedly hypoechoic at US and even exhibit some degree of enhanced through transmission, thereby mimicking a cystic mass (Fig 9c).

Direct Extension from Retroperitoneal Adenopathy

Contiguous extension to the kidneys or perinephric space from large retroperitoneal masses is the second most common pattern (25%–30% of cases) (3). These patients usually have widespread disease with bulky tumors, and many are immunocompromised. At imaging, large retroperitoneal masses are seen invading or displacing the adjacent kidney (Fig 10). Hydronephrosis

Figure 8. Papillary renal cell carcinoma mimicking lymphoma in a 57-year-old woman with a history of liver transplantation and a new renal mass. (a) Corticomedullary phase contrast-enhanced CT scan shows a solitary hypovascular mass (arrow) in the left kidney, a finding that is atypical for renal cell carcinoma. (b) On an early excretory phase contrast-enhanced CT scan, the mass (arrow) remains hypoattenuating relative to the renal parenchyma, despite minimal heterogeneous enhancement within the mass. (c) On a sagittal US image of the left kidney obtained at the time of biopsy, the mass (cursors) is mildly echogenic. This finding would be atypical for lymphoma, which is generally hypoechoic. (d) Photomicrograph (original magnification, ×50; Diff-Quik stain) of a specimen obtained at fine-needle aspiration biopsy shows hypercellularity with numerous tissue fragments displaying a prominent papillary architecture (arrow), a finding that is compatible with a well-differentiated papillary renal cell carcinoma. The patient underwent left nephrectomy.
Figure 9. Recurrent large B-cell lymphoma in a 61-year-old man who had been treated with high-dose chemotherapy. (a) Venous phase contrast-enhanced CT scan shows a low-attenuation mass (arrow) in the left kidney. The lesion has thick walls, and there is stranding as well as subtle nodular thickening in the perinephric space (arrowhead). (b) Contrast-enhanced CT scan of the mediastinum shows a large, subcarinal nodal mass (arrow). (c) Transverse US image of the left kidney shows a complex, partially cystic renal mass (arrow). Note the thick wall, multiple septa, and minimal through transmission (arrowheads).

Figure 10. Low-grade B-cell lymphoma in a 60-year-old man. The patient underwent abdominal CT for necrotizing pancreatitis. (a) Venous phase contrast-enhanced CT scan shows a large soft-tissue mass (arrow) infiltrating the retroperitoneum, encasing the left renal vessels, and extending into the perinephric space. Note the fluid collection (arrowhead) in the pancreatic bed, a finding that is consistent with the patient’s history of pancreatitis. (b) Excretory phase contrast-enhanced CT scan shows a pararenal mass (arrow) with soft-tissue attenuation. Note also the absence of hydronephrosis. Although pancreatitis commonly affects the perirenal and pararenal spaces, the soft-tissue attenuation of the mass in this case led to the correct diagnosis of lymphoma. The diagnosis was confirmed with US-guided biopsy.
caused by entrapment of the ureters is common; however, occlusion or thrombosis of major renal arteries and veins is rare despite extensive tumor encasement (Fig 11).

Perinephric Disease
Although perirenal spread from retroperitoneal or renal lymphoma is not uncommon, isolated perinephric lymphoma is unusual (<10% of cases) (3,4). CT scans acquired after the administration of intravenous contrast material are invaluable for demonstrating a rind of homogeneous perinephric soft tissue compressing the normal parenchyma without causing significant impairment of renal function (Fig 12). In less dramatic cases, findings are limited to thickening of the Gerota fascia or plaques and nodules in the perirenal space (Fig 13) (3,4,36). At US, hypoechoic tissue of variable thickness is seen surrounding the kidney (Fig 12c) (39).

The differential diagnosis includes sarcoma arising from the renal capsule and metastases to the perinephric space, as well as benign conditions such as perinephric hematoma, retroperitoneal fibrosis, amyloidosis, and extramedullary hematopoiesis (Fig 14) (36,40).

Figure 11. Burkitt lymphoma affecting the retroperitoneal nodes, adrenal glands, and kidneys in a 46-year-old man. (a) Sagittal US image shows a large hypoechoic mass (arrows) displacing and infiltrating the left kidney. Note also the mild left hydronephrosis (arrowheads). (b) Transverse color Doppler US image shows the mass (arrows) encasing the left renal artery and vein. Several small, subtle hypoechoic masses were seen in the right kidney. A right adrenal mass was also seen. AO = abdominal aorta.

Figure 12. Perinephric disease in a 66-year-old man with an incidental finding of a left renal mass. (a) Unenhanced CT scan shows marked enlargement of the left kidney (arrows). Left paraaortic lymph nodes (arrowhead) are seen encasing the left renal vein. (b) Corticomedullary phase contrast-enhanced CT scan shows a large hypovascular mass (arrows) located primarily in the perinephric space. The mass appears to invade the left renal parenchyma. Note that there is no significant enhancement delay in the left renal parenchyma relative to the right kidney. Arrowhead indicates paraaortic lymph nodes encasing the left renal vein. (c) Sagittal US image obtained at the time of biopsy shows a hypoechoic mass (arrows) surrounding and partially invading the left kidney. (d) Photomicrograph (original magnification, ×100; H-E stain) of a specimen obtained at core biopsy shows numerous lymphocytes with focal nuclear crush artifact infiltrating dense fibrous tissue (arrow). (e) Photomicrograph (original magnification, ×200; immunohistochemical staining) of a specimen obtained at core biopsy shows strong reactivity with CD 20, a finding that indicates a B-cell phenotype.
Nephromegaly without distortion of the normal shape of the kidneys results from diffuse infiltration of the renal interstitium by malignant lymphocytes. This appearance is more common in Burkitt lymphoma, either disseminated or limited to the kidneys (primary renal lymphoma) (8,17,18,20). Acute renal failure caused by destruction of the normal renal architecture may lead the patient to seek medical attention if both kidneys are extensively infiltrated.

Although the diagnosis can be suspected in the presence of global renal enlargement, administration of intravenous contrast material is critical for demonstrating heterogeneous enhancement of the kidneys, loss of the normal differential enhancement between the cortex and the medulla in the corticomedullary phase, and infiltration of the renal sinus fat (Fig 15). Alternatively, the renal parenchyma is replaced by poorly marginated low-attenuation lesions. The collecting system is
often encased and stretched rather than displaced. Occasionally, lymphoma infiltrates and destroys the renal parenchyma extensively and manifests as a large, nonfunctioning kidney (32,33).

The US manifestations of infiltrative renal lymphoma are often quite subtle and include globular enlargement of the kidneys with heterogeneous echotexture of the parenchyma and loss of the normal echogenic appearance of the renal sinus fat (Fig 3) (33).

In some cases, the infiltrative process is unilateral or asymmetric. Diffuse infiltration of the kidney can also be caused by transitional cell carcinoma (Fig 16), collecting duct or medullary carcinoma of the kidneys, or severe pyelonephritis (33).

**Renal Sinus Involvement**

Lymphoma can preferentially affect the renal sinus, although this is an uncommon occurrence. At CT, the normal renal sinus is replaced by a
homogeneous soft-tissue mass (Figs 17, 18) (41). Vascular encasement is common; because of the pliable nature of the tumor, however, the resulting hydronephrosis is often mild.

At US, renal sinus lymphoma appears as a hypoechoic mass infiltrating the renal sinus. This type of lymphoma may be difficult to differentiate from heterogeneous renal sinus fat, since both conditions tend to have poorly defined borders and traversing hilar vessels (Fig 19) (42).

Transitional cell carcinoma is usually associated with a greater degree of obstruction of the collecting system. Castleman disease rarely occurs in the renal hilum but cannot be identified without histologic sampling (43).

**Diagnostic Role of Imaging-guided Renal Biopsy**

Several published studies have confirmed the usefulness and safety of imaging-guided percutaneous biopsy in the diagnosis of renal masses (44–46). Generally accepted indications include the presence of a solid renal mass in a patient with known malignancy, an indeterminate cystic lesion, and suspected renal cell carcinoma that is either found to be unresectable or seen in a poor surgical candidate (45,46). Whenever renal lesions exhibit imaging characteristics suggesting renal lymphoma, imaging-guided percutaneous biopsy should be recommended. This technique has a critical impact on case management in that it makes potentially unnecessary nephrectomy unnecessary.

**Figure 17.** B-cell lymphoma in a 70-year-old woman. (a) Contrast-enhanced CT scan of the midabdomen shows a homogeneous soft-tissue mass (arrows) in the left renal sinus. Note the lack of significant hydronephrosis and the presence of mesenteric and retroperitoneal adenopathy (arrowheads) as well as splenomegaly. (b) Sagittal US image of the left kidney shows a poorly defined infiltrating mass (arrows) in the region of the renal pelvis, a finding that helps confirm the absence of hydronephrosis. (c) On a color Doppler US image, the kidney is well vascularized and the mass (arrows) is hypovascular. The diagnosis was established with US-guided biopsy of the mass.

**Figure 18.** Large B-cell lymphoma in a 52-year-old man with a history of chronic lymphocytic leukemia. Contrast-enhanced CT scan shows bulky retroperitoneal adenopathy (black arrows). A soft-tissue mass (white arrow) is seen in the right renal sinus fat and the perinephric space. Note the delayed enhancement of the right kidney.
avoidable. Both CT- and US-guided procedures have a reported accuracy of 89%–92% (47–49). We strongly favor US guidance because it offers real-time needle guidance and does not involve radiation. Core biopsy as well as flow cytometric and immunohistochemical studies are essential in confirming the diagnosis and classifying the tumor prior to therapy, with satisfactory specimens being reported in 69%–82% of cases. The diagnostic yield is higher in cases of non-Hodgkin lymphoma than in cases of Hodgkin disease (47–49). Immunohistochemical stains are routinely used employing conventional methodology and include leukocyte common antigen, CD20 (B-cell marker), CD3 (T-cell marker), kappa and lambda light chains (to demonstrate clonality in B lymphocytes) and, CD15 and CD30 (Reed-Sternberg cell markers). For immunostaining, cell block sections of the fine-needle aspirate or sections from the tissue obtained at core biopsy are used. Flow cytometric analyses performed on needle rinses from the fine-needle aspiration biopsy make use of antibodies against CD45, CD71, CD33, CD22, CD19, CD20, kappa and lambda light chains, CD5, CD3, and CD56. Additional antibodies are used in cases of lymphoma with a previously diagnosed unusual immunophenotype.

Conclusions
The urinary tract is a common site for extranodal spread of lymphoma, particularly non-Hodgkin lymphoma. CT remains the modality of choice for initial diagnosis, staging, and monitoring of the disease. MR imaging is useful in selected cases, particularly in patients in whom intravenous administration of iodinated contrast mate-

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