CHAPTER 36

Renal Masses: Imaging and Biopsy

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CHAPTER OUTLINE

METHODS OF ANALYSIS

Plain Abdominal Radiography

The plain abdominal radiograph (KUB—kidneys, ureters, bladder) is rarely used to diagnose a renal mass. Loss of the psoas margin or displacement of retroperitoneal fat may suggest the presence of one, as may an opacity projected over the renal outline, or a loss of the renal outline. Central calcification within a renal mass is more suggestive of malignancy than peripheral calcification (87 vs 20–30%).

Intravenous Urography

Intravenous urography (IVU) is a relatively insensitive method for detecting renal masses, particularly if they occur centrally rather than peripherally; cross-sectional techniques are a more appropriate method for investigating a patient with a suspected renal mass.

Radionuclide Imaging

Differentiation between a definite mass and an anatomical variant that simulates a mass (pseudotumour) can be made using radionuclide imaging, although this is rarely useful in practice.

Ultrasound

Ultrasound (US) is usually the first method for evaluating a patient for a renal mass and is the most appropriate technique for evaluating an abnormal IVU. Ultrasound is ideally suited for children, pregnant women and patients with renal impairment. Ultrasound can reliably differentiate solid masses from simple cysts, which are the most common space-occupying lesions in the kidney. A lesion that appears solid on ultrasound, or demonstrates any suspicious features, merits further analysis with CT or MRI.

Ultrasound is less accurate in staging renal cell carcinoma than computed tomography (CT) or MRI. It is poor at demonstrating lymph node disease, skeletal or lung metastases.

Computed Tomography

Computed tomography (CT) is still the Investigation of choice for evaluating and characterising solid renal masses. It can accurately assess 'pseudomasses' (see Fig. 36-1) and other anatomical variants and can provide attenuation values that can confirm the presence of fluid in cysts or fat in angiomyolipomas. As CT can delineate accurately the perinephric space and the retroperitoneum, it is useful in the diagnosis of complicated renal sepsis and the assessment of the extent of haemorrhage; it can also identify tumour recurrence after radical nephrectomy. Accurate analysis of renal masses requires the use of intravenous contrast medium.

The continued development of multislice CT has improved the detection, characterisation and staging of renal tumours and allows high-quality multiplanar imaging of the kidneys, which is useful for evaluating small areas of enhancement and for presurgical planning. With the increased use of laparoscopic, robotic and nephron-sparing surgery, it is vitally important to be able to review the coronal and sagittal images with surgical colleagues to decide upon appropriate management.

Unenhanced CT images are essential for identifying calcification and allow true evaluation of enhancement following IV contrast. Corticomedullary phase (25–40 s post-IV contrast administration) imaging is helpful in demonstrating normal variants, pseudotumours, tumour vascularity and the renal vein. The nephrographic phase (90–100 s post-IV contrast administration) is best for the detection of central renal masses, as the medulla is optimally enhanced and small medullary lesions are better visualised.[1,2] For optimal lesion detection and characterisation, images should be obtained in both phases; however, if only one phase is to be used, to reduce radiation dose, it should be the nephrographic phase. If surveillance imaging of a lesion is to be undertaken, the single optimal phase for detection of the mass can be used rather than repeating a three-phase examination.

MRI

The ability of MRI to characterise renal masses has improved with the development of phased-array multicoils, fast breath-hold imaging and the use of Gd-DTPA contrast enhancement. Protocols vary widely but usually

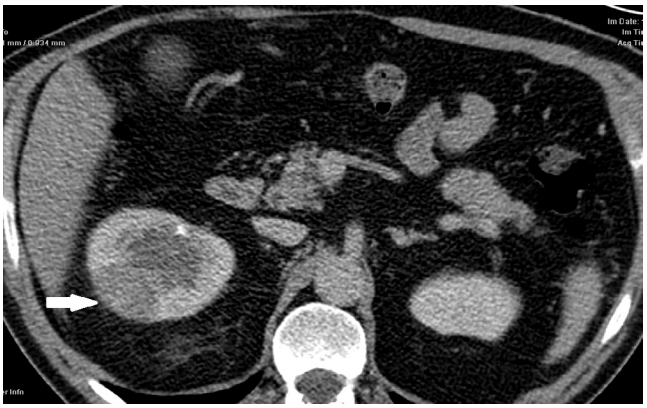

FIGURE 36-1 ■ Pseudomass of the kidney secondary to renal obstruction. Post-contrast CT performed in a patient with an obstructed kidney reveals an apparent soft-tissue mass in the upper pole of the kidney which was initially misinterpreted as a probable incidental renal cell carcinoma (see arrow). Follow-up imaging demonstrated near-complete resolution of these changes with the development of a small focal scar.

include pre- and post-contrast T1-weighted images with and without fat suppression. The coronal and sagittal planes are helpful for evaluating the extent of lesions. MR angiography can demonstrate the renal arteries and veins, and the inferior vena cava. MRI can be used as an alternative to CT for detection and surveillance of masses, although this depends upon local resources, and availability of equipment. Many radiologists prefer to use CT for the initial evaluation of renal masses as it is such a reliable technique, and easier to interpret than MRI. There has been recent interest in the use of diffusion-weighted imaging for the characterisation of renal masses. Malignant tumours are associated with a significantly reduced analog-to-digital converter (ADC) value[3,4] compared to benign lesions, although the utility of this technique is not definitively confirmed at present and not widely practised outside the research setting.

Simple renal cysts and angiomyolipomas have characteristic appearances, but the signal from most other masses is nonspecific.

MRI is an alternative to CT in patients with renal insufficiency or severe previous reactions to contrast medium. MRI is superior to CT in differentiating benign thrombus from tumour thrombus and in identifying its extent. MRI is ideally suited for monitoring patients who have a genetically increased risk of renal malignancy, such as von Hippel–Lindau disease, who require repeated imaging for surveillance.

MRI is no more specific than CT at differentiating malignant from reactive lymphadenopathy, although the development of tissue-specific agents might alter this in the future. MRI is a more lengthy and complex investigation than CT. The role of MRI has reduced with the development of multislice CT, which allows the production of reliable and high-quality multiplanar reconstructions.

Renal Arteriography

Renal arteriography is seldom used to diagnose or characterise a renal mass as the necessary information is usually provided by cross-sectional imaging. Angiography can play a role in preoperative embolisation of very vascular tumours immediately before partial nephrectomy. CT or MR angiography is usually sufficient to provide a road map for surgery, and to identify the size, number and position of renal vessels.

Needle Aspiration and Biopsy

Percutaneous aspiration of renal cysts is indicated in the investigation of an indeterminate cystic renal mass to diagnose an abscess or an infected cyst.

Fluid obtained at aspiration should be sent for cytological examination, although negative cytology does not exclude malignancy; this applies particularly in some cystic renal cell carcinomas, in which malignant disease is confined to the wall of the lesion. If the fluid is found to be turbid, microbiological examination should also be performed. Needle biopsy of a cyst wall can be performed to improve the diagnostic yield although there are small but potential risks in this setting including seeding of tumour and false-negative diagnosis.[5]

Biopsy is used to confirm the histology of a renal mass in patients with underlying non-renal malignancy or radiological features suggestive of lymphoma. Biopsy is also used to confirm the presence of malignancy before radiofrequency or cryoablation of a renal mass. Histological techniques have improved over the past 10 years and are more reliable at classifying a renal mass and differentiating between oncocytoma and renal cell carcinoma. In patients with significant other comorbidity, this may significantly alter the management of an asymptomatic renal mass. Biopsy should also be considered in bilateral masses to characterise whether the lesions represent multifocal oncocytoma or papillary tumour. This information may make such lesions suitable for attempted nephron-sparing surgery even if potentially suboptimal for this approach.

NON-NEOPLASTIC RENAL MASSES

A number of non-neoplastic tumours must be differentiated from renal cell carcinoma. Fetal lobulation occurs as a result of incomplete fusion of the fetal lobules, which results in a lobulated contour to the lateral border of the kidney occurring between the underlying calices. Dromedary humps are bulges occurring on the lateral side of the left kidney. Many of these pseudomasses can be identified with ultrasound but occasionally further imaging is required. This is usually achieved with CT or MRI, although scintigraphic techniques can be used.

PATHOLOGICAL RENAL MASSES

Renal Cysts

Serous Renal Cyst

This is the commonest form of cystic disease and is seen with increasing frequency with advancing age. Autopsy studies have demonstrated a prevalence of almost 50%.

The cysts are frequently multiple and occur in various sizes. On ultrasound examination renal cysts appear as anechoic, well-defined masses, with thin walls and good through transmission of sound. On CT, a simple cyst usually appears as a well-defined rounded mass with an attenuation value of 0–20 HU, with an imperceptible wall and no enhancement after injection of contrast medium. The MRI appearance of a simple renal cyst is characterised by a sharply demarcated, homogeneous, hypointense mass on T1-weighted images, which becomes uniformly hyperintense on T2-weighted images and shows no enhancement following contrast medium administration on T1-weighted images.

'Complicated Cysts'[6,7]

A classification of cystic lesions was suggested in 1986 by Bosniak, based upon CT characteristics, and is used to guide management.[7] Class I is a simple benign cyst. Class II cysts have one or more thin septa running through them (<1 mm), thin areas of mural calcification or fluid contents of increased attenuation; they do not enhance following injection of contrast medium and are benign (see Figs. 36-2–36-4). These two categories of cysts are benign, and do not require surgery or radiological follow-up.

Class III cysts are more complicated and contain thickened septa, nodular areas of calcification or solid non-enhancing areas. Mural enhancement can be seen in class III lesions, which are indeterminate for malignancy and should be biopsied or surgically explored. Less than 50% of these will turn out to be malignant, although there can be significant interobserver variation in how such cysts are classified.

Class IV cystic masses are clearly malignant, with solid enhancing nodules and should be treated accordingly.

A subcategory, IIF, has been suggested for lesions with multiple class II features, and these require follow-up for up to 5 years to exclude malignancy (see Fig. 36-5). Surveillance of these lesions may demonstrate growth or change in calcification, but it is the development of enhancing soft tissue that should upgrade the cystic lesion and result in surgical treatment. Category IIF lesions are large (>3 cm) hyperdense cysts or hyperdense cysts that are totally intrarenal.

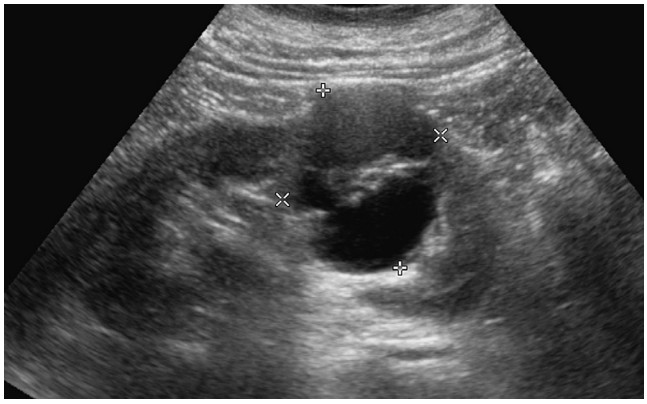

FIGURE 36-2 ■ US of a Bosniak II cyst. Ultrasound demonstrates a large cyst in the mid pole of the kidney with thick internal septation. No abnormal colour flow was seen on US, and CT confirmed the absence of solid enhancement. The lesion was classified as a IIF cyst and did not demonstrate significant change over the subsequent 5 years.

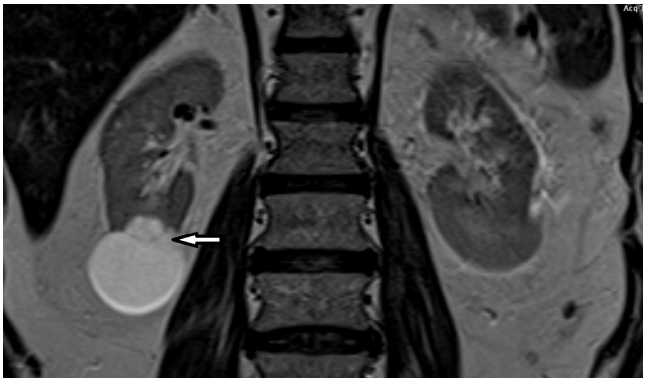

FIGURE 36-3 ■ MRI of a Bosniak II cyst. Coronal T2 MRI demonstrates a large right lower pole renal cyst with internal septation, categorised as a Bosniak II cyst (see arrow). MRI usually shows greater detail of internal cyst architecture than CT.

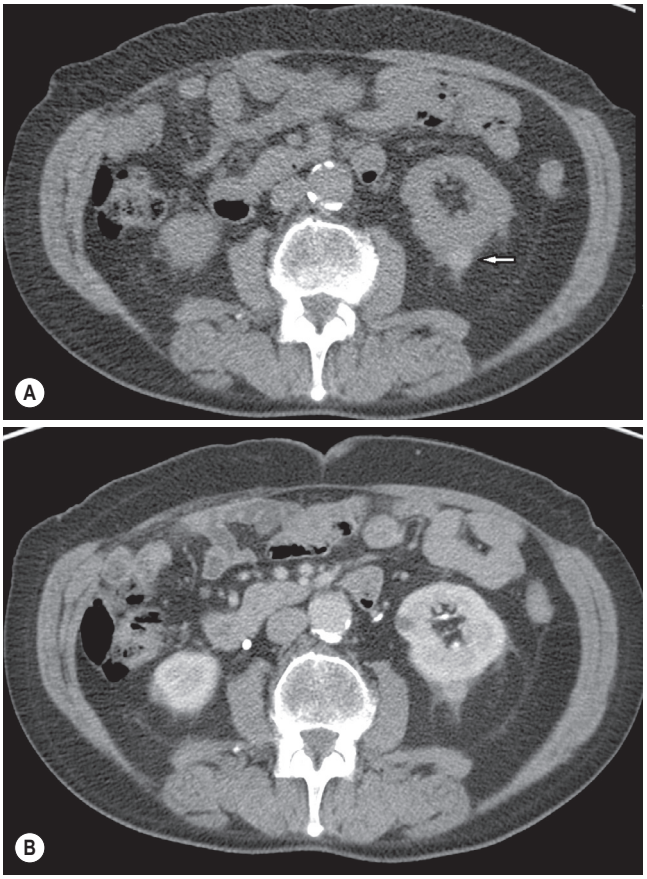

FIGURE 36-4 ■ Haemorrhagic cyst of the kidney. Pre-contrast (A) image reveals high-density, round, smooth mass in the right kidney (see arrow). There is minor inflammatory change surrounding the lesion which may be due to recent trauma, or infection. (B) Following contrast medium there is no significant change in the appearance or density of the mass. It is easy to misdiagnose a haemorrhagic cyst as a solid renal mass, and review of a non-contrast CT is vital to evaluate the presence of enhancement.

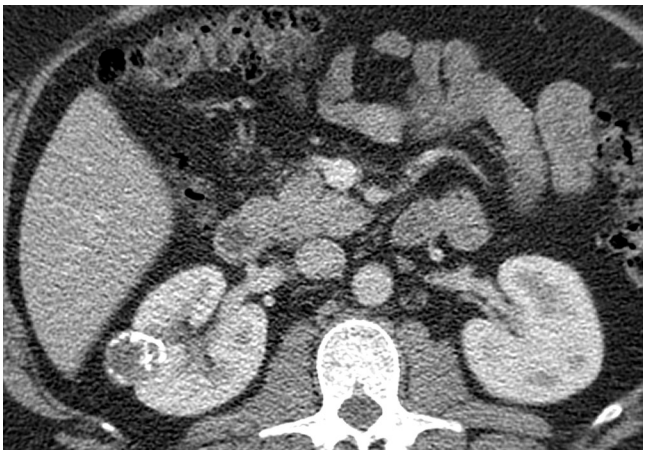

FIGURE 36-5 ■ Bosniak IIF renal cyst. CT demonstrates heavy calcification in a small cyst which was difficult to evaluate at US. Despite the absence of enhancement on CT, the lesion was considered too atypical to be a Bosniak II lesion, and was classified as a 2F cyst for observation.

A simple benign cyst on ultrasound or CT requires no further investigation or follow-up. If there is wall thickening or the contents of the cyst are not of water density, the lesion is indeterminate. Haemorrhage or infection may result in cyst fluid of high attenuation but, unlike tumours, such lesions do not enhance following the administration of contrast medium. It is usually necessary to obtain a pre-contrast CT to adequately assess a rounded homogeneous lesion on a post-contrast CT that is not of water density to exclude low-grade enhancement signifying a renal mass, e.g. papillary tumour, rather than a benign cyst. Ultrasound is helpful if the hyperdense mass satisfies the sonographic criteria of a benign simple cyst.

Thick and irregular mural calcification can be seen with both cystic renal cell carcinomas and complicated renal cysts.[8] CT attenuation values in both lesions may be identical. Cystic renal cell carcinomas (especially papillary cystadenocarcinomas) may have fluid-range densities, while benign haemorrhagic cysts may have attenuation values much higher than those acceptable for benign cysts.

Parapelvic and Peripelvic Cysts

These occur in the renal sinus and frequently cause distortion, but rarely obstruction, of the renal collecting system. Peripelvic cysts are of lymphatic origin, whereas parapelvic cysts are renal serous cysts arising from the renal parenchyma that is present in the sinus. Although parapelvic cysts may be evaluated satisfactorily using ultrasound, peripelvic cysts can occasionally lead to confusion with hydronephrosis, as they track along the renal infundibula. Careful examination should demonstrate that the apparently dilated infundibula do not connect to a dilated renal pelvis. If necessary, urography or CT in the pyelographic phase is usually confirmatory.

Adult Polycystic Kidney Disease (ADPKD)

This is an autosomal dominant hereditary condition which affects many organs in addition to the kidneys. Although it has 100% penetrance, it has variable expression and does not generally produce symptoms until adult life. Renal cysts are seen in addition to cysts within the liver, pancreas and spleen, although hepatic failure does not tend to occur despite extensive infiltration. Coexisting aneurysms of the circle of Willis are seen in 10–16% of patients in autopsy series and as many as 41% of patients undergoing cerebral angiography.

The imaging appearances vary with the severity of the disease. Ultrasound demonstrates cysts in the adolescent or young adult, who is usually not yet clinically symptomatic. CT and MRI are more sensitive and frequently show more cysts than US. Adults presenting with ADPKD usually have enlarged kidneys with numerous cysts of varying sizes.

Occasionally, an infected cyst, a hyperdense cyst and, less commonly, a renal neoplasm may coexist with adult polycystic renal disease and the diagnosis becomes somewhat difficult in these cases. MRI may prove to be a useful technique in differentiating between simple cysts, haemorrhagic cysts and neoplasms when the findings on CT and ultrasound are equivocal. Infected cysts can be difficult to diagnose, and aspiration of a dominant or hyperdense cyst may be required for definitive evaluation. Fluorodeoxyglucose positron emission tomography (FDG PET) can be helpful in evaluating for the presence of an infected cyst, and has logistical advantages over white cell scintigraphy in such cases.

Multicystic Renal Dysplasia

This is a non-hereditary, congenital, usually unilateral form of renal cystic disease and is one of the commonest causes of an abdominal mass in the newborn.

Localised Cystic Disease of the Kidney

Localised cystic disease is characterised by the presence of multiple cysts seen throughout part, or all, of one kidney (see Fig. 36-6). The aetiology of this disorder is not known. Normal cortex is seen between the individual cysts, which helps distinguish the disease from multicystic dysplastic kidney. The contralateral kidney is usually entirely normal or contains several small cysts, which can help distinguish it from ADPKD, in which multiple cysts of varying size are seen in enlarged kidneys bilaterally. It is equally important to distinguish localised cystic disease of the kidney from multilocular cystic nephroma, which is achieved by the demonstration of normal parenchyma between the cysts.

Hydatid (Echinococcal) Cysts of the Kidney

These are rare in most parts of the world and uncommon even in endemic areas. They are thick-walled, mainly intrarenal, and sometimes calcified. Hydatid cysts may present as flank or perinephric masses, which rupture into the collecting system, giving rise to acute flank pain followed by the voiding of hydatid scolices, with or without haematuria. Ultrasound demonstrates a multicystic lesion of mixed reflectivity.

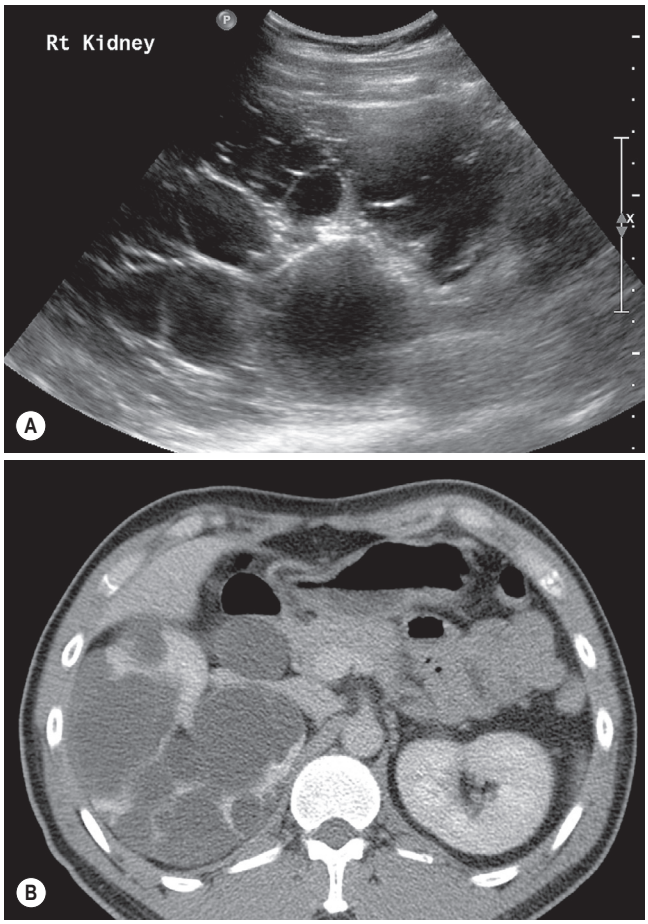

FIGURE 36-6 ■ Localised cystic kidney disease. Ultrasound (A) and CT (B) demonstrate multiple cysts throughout both kidneys with no solid elements. The initial US was interpreted as a probable multicystic dysplastic kidney (contralateral kidney was normal), although the CT demonstrates the presence of some normal renal parenchyma surrounding the kidney in keeping with localised cystic kidney disease.

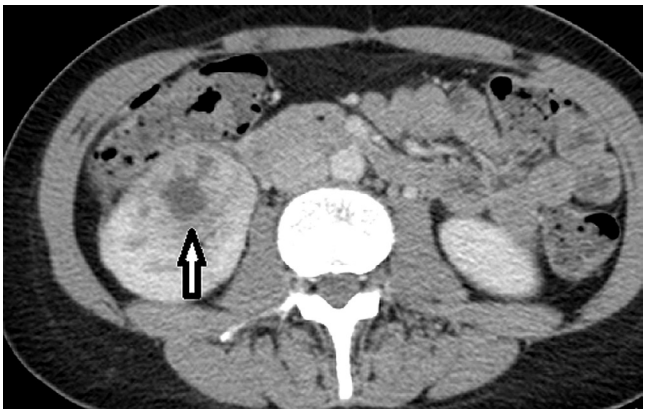

FIGURE 36-7 ■ Renal abscess. A 30-year-old woman presents with symptoms of urinary infection with loin pain. CT demonstrates a thick-walled cystic lesion in the right kidney (see arrow) in keeping with an abscess. CT is particularly helpful for infections that involve the perinephric space which are not well demonstrated with US.

Inflammatory Masses

Renal Abscesses

Renal abscesses are increasingly uncommon, as urinary tract infection is usually treated early. Most abscesses are due to ascending infection, commonly by *Escherichia coli* (see Fig. 36-7). Immunocompromised and diabetic patients, as well as those with infected renal stones, are at a higher risk of developing renal infection. Haematogenous infection is usually secondary to *Staphylococcus*. Although renal abscess formation is generally associated with symptomatic urinary tract infection, it can present with vague symptoms such as flank pain and weight loss. Rupture of a renal abscess can lead to spread of infection into the perinephric space.

CT is the best technique for the diagnosis and staging of renal and perinephric abscesses. The central portion of an abscess is of near-fluid density and does not demonstrate contrast enhancement, making it more obvious following contrast administration. There is often a thick irregular wall, which enhances together with inflammatory changes in the perinephric space. The presence of gas within a lesion is diagnostic of an abscess but is very rarely seen. The differential diagnosis of these appearances includes renal lymphoma, metastatic disease, renal infarction and complicated cystic disease.

Acute Focal Pyelonephritis

A renal mass may be caused by acute focal pyelonephritis with localised swelling of the kidney but without liquefaction. Focal pyelonephritis appears as a round or wedge-shaped focal mass without a defined wall, which tends to extend from the papilla to the outer cortex. Contrast administration demonstrates heterogeneous enhancement of the affected area, which can often be greater than that of the normal parenchyma on delayed images. Perinephric inflammation is frequently seen. CT may demonstrate persistent renal abnormality for several weeks after infection and a focal mass may persist for several months.

Malacoplakia

This is a rare disease of the renal parenchyma caused by granulomatous inflammation. Malacoplakia is most commonly seen in middle-aged women and is more prevalent in individuals who are immunosuppressed. Renal involvement is usually associated with disease in the lower urinary tract. Focal hypoechoic renal masses may simulate renal abscesses, and heterogeneous masses that undergo calcification may be mistaken for renal carcinoma. Renal malacoplakia can extend outside the kidney into the perinephric space and can also undergo spontaneous haemorrhage.

Vascular Masses

Haematomas

These may present as masses following trauma or as a result of spontaneous intrarenal bleeding. It may be

difficult to determine whether there is underlying renal pathology, such as a tumour that has bled because of anticoagulation, or whether the kidney is otherwise healthy. Follow-up examination will be required to clarify whether there is an underlying mass.

The ultrasound appearance of a haematoma varies according to its age. Fresh haematomas behave primarily as fluid collections, whereas organised haematomas may be highly reflective because they contain fragments of clot. CT during the acute phase will demonstrate an area of high attenuation, which is diagnostic of haematoma.

Intrarenal Vascular Masses

Two uncommon vascular lesions that may present as intrarenal masses are aneurysms and arteriovenous malformations (or fistulas). Aneurysms are usually caused by atherosclerosis, but may be congenital, post-traumatic or secondary to vasculitis. Rim calcification is common. Arteriovenous communications are usually congenital, but may be caused by trauma (particularly renal biopsy) or atherosclerosis.

Angiomyolipomas[9]

Angiomyolipomas are benign lesions composed of variable amounts of fat, smooth muscle and abnormal blood vessels (see Figs. 36-8–36-10). They occur spontaneously in the general population, mainly in women during their fifth decade; they occur at a much younger age and are frequently multiple in patients with tuberous sclerosis, with an incidence of 50–80%. They are rarely seen in neurofibromatosis and in autosomal dominant polycystic kidney disease. Angiomyolipomas are composed of thick-walled, inelastic blood vessels. The risk of haemorrhage is related to the size of the tumour, and is significantly higher in lesions greater than 4 cm in diameter.

The appearance on ultrasound depends on the proportions of fat, smooth muscle and vascular elements, and on the presence of haemorrhage. Typically, angiomyolipoma appears as a circumscribed, highly reflective mass, more echogenic than the central sinus fat. Because of this high reflectivity, very tiny lesions can be detected with ultrasound. Tumours with a greater proportion of muscle, and those which have undergone haemorrhage or necrosis, may not be echogenic. Recent work has indicated that 32% of renal carcinomas smaller than 3 cm in diameter are also highly reflective, although there will often be other suspicious features, such as a hyporeflective rim or small focal spotty areas of reduced central reflectivity.[8] A further feature that may be of help in distinguishing an angiomyolipoma from a small renal cell carcinoma is

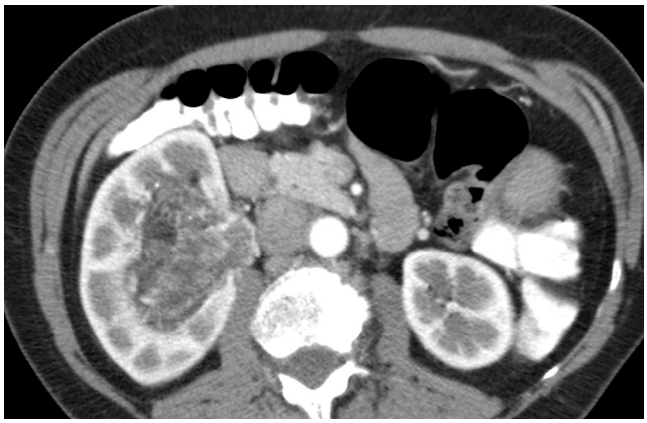

FIGURE 36-9 ■ Central angiomyolipoma of the kidney. There is a large predominantly fat-containing lesion in the right mid pole of the kidney involving the renal pelvis in keeping with an AML. The presence of macroscopic fat is strongly suggestive of the diagnosis. Large renal cancers can engulf perinephric fat, and mimic an AML. The patient in this case actually had a tumour extending into the vena cava, which was confirmed as benign AML at surgery.

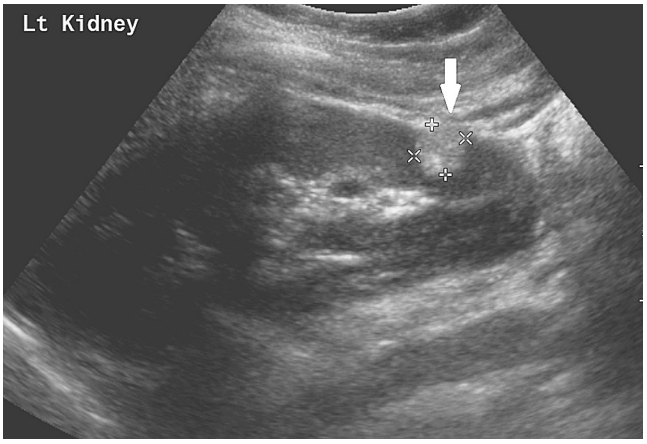

FIGURE 36-8 ■ US of an angiomyolipoma. There is a small hyperechoic mass in the lower pole of the kidney characteristic of an AML (see arrow). Confirmation of the diagnosis can be made with CT or MRI as small renal cell cancers may occasionally mimic the hyperechoic appearance of an AML.

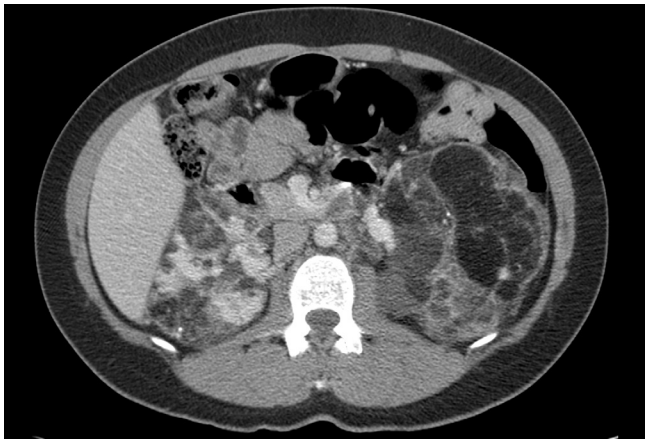

FIGURE 36-10 ■ Multifocal angiomyolipoma of the kidneys. CT of the kidneys demonstrates extensive infiltration of both kidneys with multiple fat-containing lesions in a patient with tuberous sclerosis. Angiography should be considered in patients with such large tumours with a view to prophylactic embolisation as the risk of bleeding is high.

posterior shadowing, which is seen in approximately 30% of angiomyolipomas but not seen in the small hyperreflective renal carcinoma.

CT usually demonstrates a fatty mass intermixed with areas of increased tissue density, although the amount of fat present is variable and it can even be absent.[9] Generally, the detection by CT of even a small amount of fat within a renal mass establishes the diagnosis of angiomyolipoma. An attenuation value of –15 HU is considered diagnostic of fat, although some authors specify a lower level, such as –20 HU. If there is coexistent haemorrhage, CT and other techniques may not provide an accurate preoperative diagnosis.[9] It is important to assess the relationship of the fat to the remainder of the tumour to be certain that the fat is intratumoral, and not perirenal fat that has been engulfed by an expanding renal cell carcinoma.

Angiography can demonstrate multiple aneurysms and an 'onion layer' appearance. Embolisation can control bleeding tumours, and can also be used to treat enlarging tumours to reduce the risk of haemorrhage.

Focal Hydronephrosis

Hydronephrosis confined to one part of the kidney can simulate a mass on urography. This most commonly occurs in patients with an obstructed upper segment of a duplex system. Obstruction to an infundibulum may be caused by a variety of conditions, such as tuberculosis and tumour.

Renal Sinus Lipomatosis

Sinus lipomatosis is an overabundance of normal renal sinus fat, which may produce stretching of the infundibula and compression of the renal pelvis, simulating a parapelvic cyst or other hilar renal mass. The diagnosis is generally clarified by CT or ultrasound. On ultrasound examination the area in question is usually echogenic.

Non-Renal Masses

Occasionally an extrarenal mass may extend into the kidney and appear to be intrarenal, e.g. pancreatic pseudocysts, tumours of the colon, spleen and adrenal gland.

NEOPLASTIC RENAL MASSES

Benign

Adenoma and Oncocytoma

Small renal tumours (<3 cm) have been regarded in the past as adenomas rather than carcinomas. Unfortunately the size of a renal mass is not a valid criterion for differentiating a benign from a malignant mass. There are reports of tumours that have produced metastases when less than 3 cm, although this is uncommon.

Oncocytomas are tubular adenomas with a specific histological appearance characterised by the oncocyte.[10] They have previously been considered benign, but it is now recognised that they can metastasise. Oncocytomas can occur at any age and are often asymptomatic at presentation. They can vary in size from 1 to 20 cm in diameter, but tend to be large. Although they are usually solitary and unilateral, they can be multiple (5%) and bilateral (3%). Ultrasound demonstrates a solid mass with internal echoes, which occasionally has a stellate hypoechoic centre. However, the echogenicity of the mass can be variable. Contrast-enhanced CT demonstrates a well-defined solid mass which, when large, can contain a low-attenuation central scar. Large lesions can extend into and engulf the perinephric fat, and can be mistaken for angiomyolipomas. There are no features on MRI that will differentiate an oncocytoma from renal carcinoma. Arteriography is also of limited value in discriminating between an oncocytoma and renal cell carcinoma.

Haemangioma

Haemangiomas of the kidney are rare lesions, which are generally cavernous rather than capillary. The most common symptom is haematuria. They are most commonly symptomatic in the middle years and are equally distributed between the sexes.

Excretory urography may demonstrate a renal mass, or more commonly pyelocalyceal distortion or a filling defect, attributable to the haemangioma or associated clot. Selective arteriography is often unhelpful, although occasionally will suggest the diagnosis.

Multilocular Cystic Nephroma

This is a rare benign neoplasm which presents as a unilateral septated encysted mass. It usually presents in young children but can be seen in adulthood, particularly in women. There are frequently septae which demonstrate enhancement. The cystic portion is usually of water density or slightly higher density with no enhancement. The best clue to the diagnosis is the presence of herniation of the mass into the renal hilum.

Malignant

Parenchymal

Renal Cell Carcinoma. Most cases arise spontaneously in the fifth to seventh decade, although an increasing number of cases are discovered in younger patients, some of whom have hereditary cancer syndromes.[11]

There are several main types of renal cancer, as well as a larger number of rarer subtypes. It occurs bilaterally in 3–5% of cases, and is the eighth most common malignancy, accounting for 3% of newly diagnosed neoplasms.

Clear cell carcinoma is the commonest renal malignancy, comprising 85% of all malignant renal tumours (see Figs. 36-11–36-13). Clear cell carcinoma is seen in about 36% of patients with von Hippel–Lindau disease[12] and is characterised by significant enhancement following contrast administration (see Fig. 36-14).

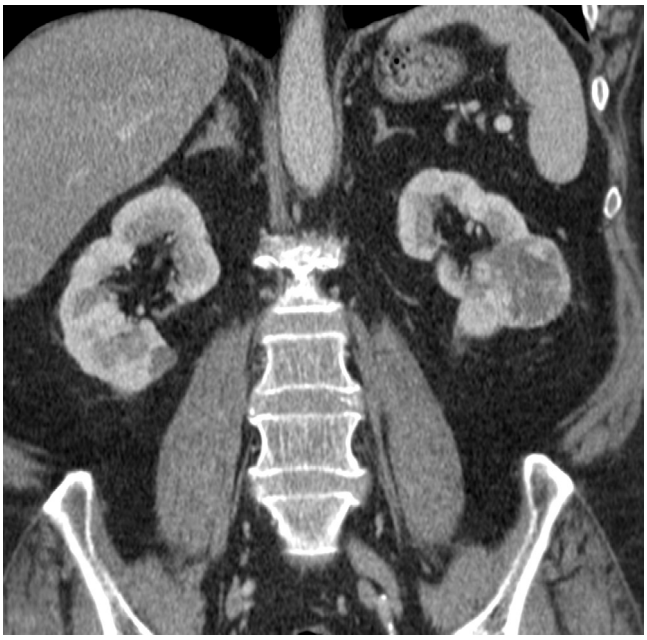

FIGURE 36-11 ■ Clear cell carcinoma of the kidney. Post-contrast CT demonstrates an enhancing soft-tissue mass in the lower pole of the left kidney, histologically confirmed as a clear cell cancer. Coronal reconstructions are critical in planning surgery and deciding upon the feasibility of nephron-sparing surgery.

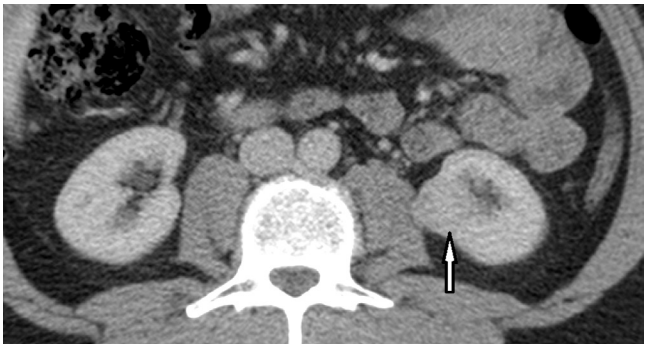

FIGURE 36-12 ■ Isodense renal cell carcinoma. There is a partially exophytic mass on the medial aspect of the mid pole of the left kidney (see arrow) which demonstrates isoenhancement compared with the rest of the renal parenchyma. Partial nephrectomy confirmed a T1 renal cell carcinoma.

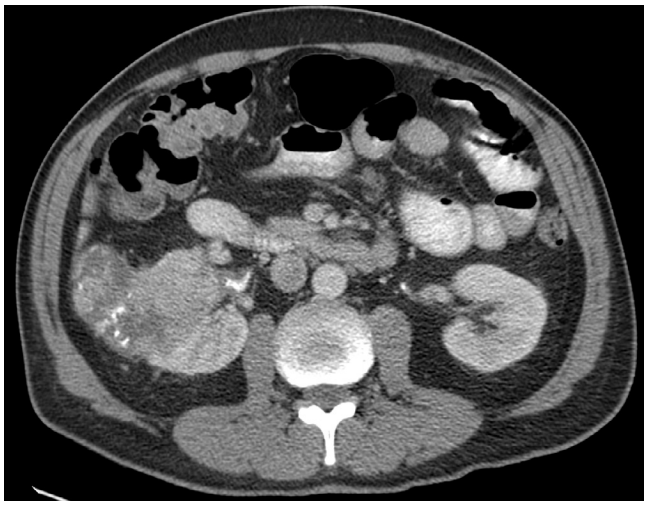

FIGURE 36-13 ■ Calcified renal cell carcinoma. Post-contrast CT demonstrates a large soft-tissue mass in the right kidney with central calcification. Whilst peripheral calcification is commonly seen in cysts and benign lesions, central calcification is usually seen with malignant lesions.

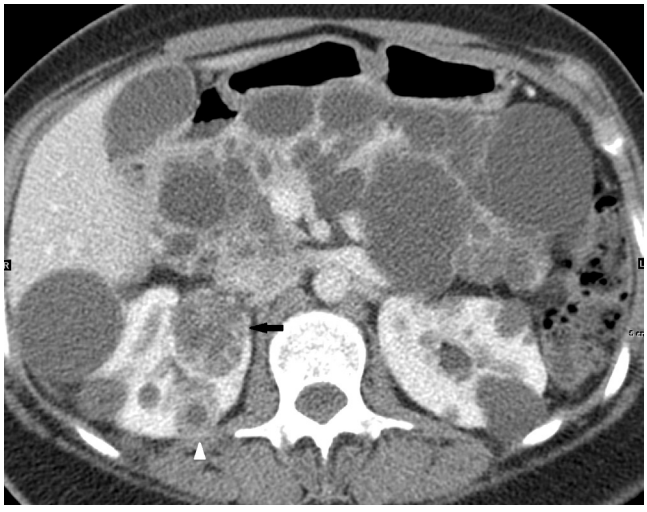

FIGURE 36-14 ■ Von Hippel–Lindau and renal tumours. Single-phase post-contrast CT demonstrates multiple renal and pancreatic cysts in a patient with known von Hippel–Lindau. There is a cystic RCC in the mid pole of the right kidney (see arrow), which was subsequently removed at open partial nephrectomy. There is a further smaller mass in the posterior aspect of the right kidney (see arrowhead).

Papillary tumours are the next most common subtype of tumour, occurring in 10–15% of cancers (see Figs. 36-15 and 36-16) These tumours are commonly seen in failing kidneys, and in some hereditary syndromes, and are not infrequently multiple. They have a characteristic appearance on CT and are associated with minimal contrast enhancement. They can be easily misinterpreted as a hyperdense cyst on CT if an unenhanced examination has not been performed.

There are two types of papillary tumour—type 1 and 2, the latter of which is less common and associated with a worse prognosis.

Chromophobe tumours (see Fig. 36-17) are the third most common tumour (5%). They have a similar appearance to oncocytomas with homogeneous enhancement and presence of a central scar. Ultrasound frequently demonstrates a hyperechoic mass.

Less common pathological subtypes include collecting duct tumours, which are associated with a poor prognosis.

Renal cancers can appear hyperechoic, hypoechoic or isoechoic on ultrasound. Most small renal carcinomas are hyperechoic compared with normal parenchyma, whereas up to 86% of large tumours are isoechoic. Central necrosis can produce a central hypoechoic region that is associated with posterior acoustic enhancement. Cystic

tumours may have thick or irregular walls, together with small or large intracystic nodules of tumour. Ultrasound with colour Doppler is useful for detecting inferior vena cava thrombus and extension of tumour thrombus into the intrahepatic vena cava.

Renal cell carcinomas are often heterogeneous on unenhanced CT, with one or more low-density central areas. An extensively necrotic tumour may have a pseudocapsule. Unusually high- or low-density tumours have been described. CT is the most sensitive technique for the depiction of parenchymal calcification associated with renal malignancy. Most renal cell cancers are solid, with attenuation values of more than 20 HU on pre-contrast CT. An increase in attenuation of more than 10 HU after IV contrast administration suggests a solid mass, and enhancement of more than 20 HU indicates malignancy. Tumours occurring in non-functioning kidneys may show little enhancement due to papillary subtype or poor renal arterial blood flow (see Fig. 36-18).

Attention should always be made when fully evaluating the contralateral kidney for a renal mass, as bilateral tumours are not infrequently seen. When tumours are seen bilaterally, they can have similar histological subtypes, although if the morphology is different, there may be two different pathological renal masses present (see Fig. 36-19).

MRI can be used to detect and stage renal cell carcinoma, with a sensitivity similar to that of CT. However, CT is better at detecting small foci of calcification. The signal characteristics of renal carcinoma are variable, with tumours appearing isointense or hypointense compared with the renal cortex on T1-weighted sequences, and slightly hyperintense on T2W sequences. Following administration of gadolinium intravenously, heterogeneous enhancement occurs immediately, decreasing on delayed images. Homogeneous enhancement is more likely in small, low-grade tumours. MRI is not significantly better at detecting lymph node disease. Although in most institutions CT is the technique of choice for the diagnosis and staging of renal cell cancer, MRI can play a role when contrast-enhanced CT is contraindicated, or if frequent follow-up is required in high-risk patients.

Angiography is no longer required for the diagnosis of renal cell carcinoma but is occasionally performed for embolisation of large tumours before surgery in order to reduce the risk of perioperative haemorrhage.

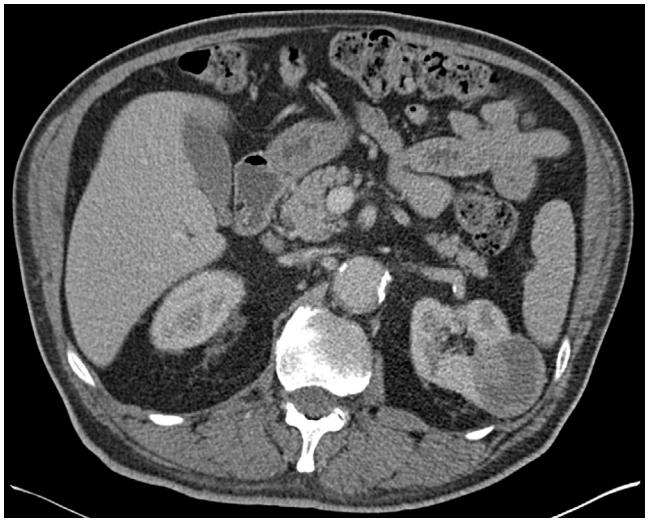

FIGURE 36-15 ■ Papillary tumour of the kidney. Post-contrast CT demonstrates a partially cystic, and partially solid, left renal mass, with a histologically proven papillary cell carcinoma type 1. These tumours often have characteristic appearances at CT or MRI, as they are often homogeneous in density and demonstrate minor enhancement only (see Fig. 36-16). Some lesions, as seen in this example, have a partially cystic component.

Staging of Renal Cancer. The TNM staging system is the most widely used system and is shown in Table 36-1. CT is the most frequently used staging technique, with accuracy ranging between 72 and 90%. CT is not very accurate in differentiating T2 from early T3a disease; however, this is not particularly important clinically, except in the context of nephron-sparing surgery. The

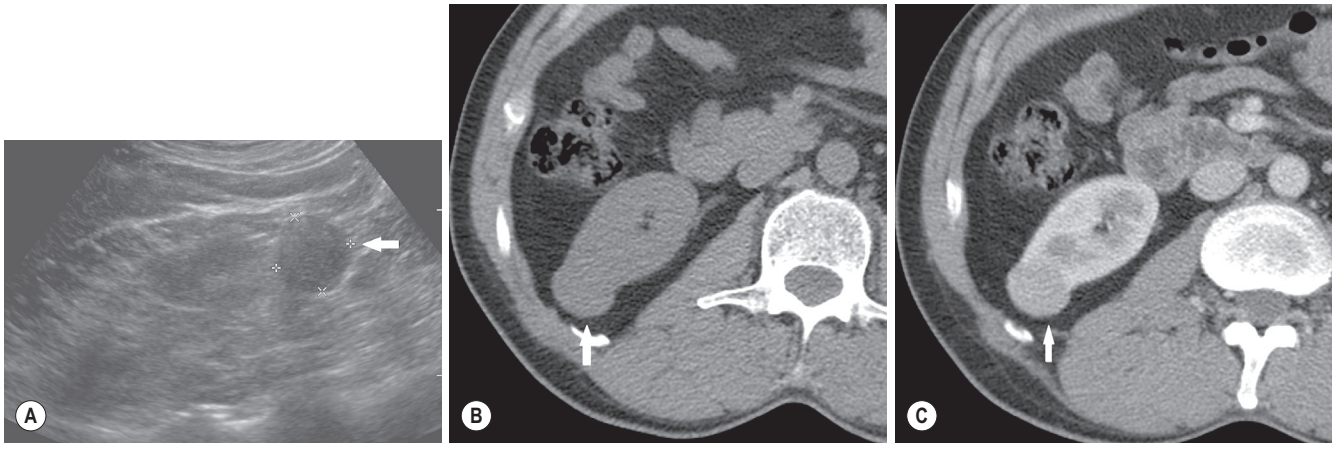

FIGURE 36-16 ■ Papillary carcinoma of the kidney. (A) US and (B) pre- and (C) post-contrast CT demonstrate an incidental solid mass detected on US which demonstrates low-grade enhancement (25 HU) post-contrast (see arrow). This appearance is typical for a papillary tumour. These can be multifocal, and close scrutiny of the ipsi- and contralateral kidney is recommended.

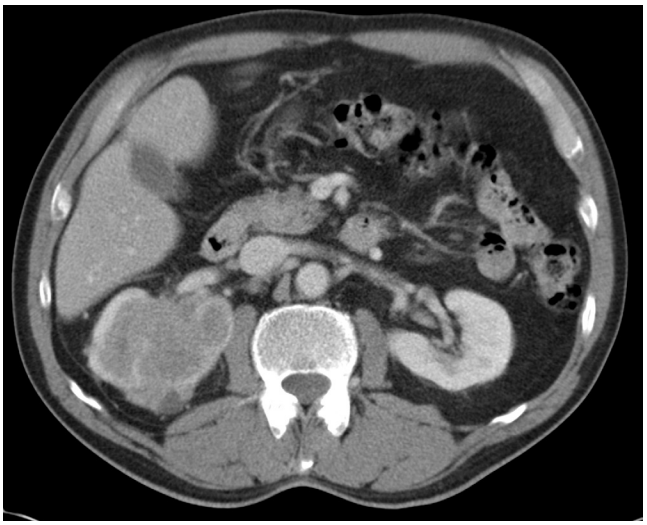

FIGURE 36-17 ■ Chromophobe tumour. Post-contrast CT demonstrates a large enhancing right renal mass which was confirmed following nephrectomy as a chromophobe renal cancer. The appearances are indistinguishable from that of a clear cell cancer. Chromophobe tumours have a better prognosis than clear cell carcinoma.

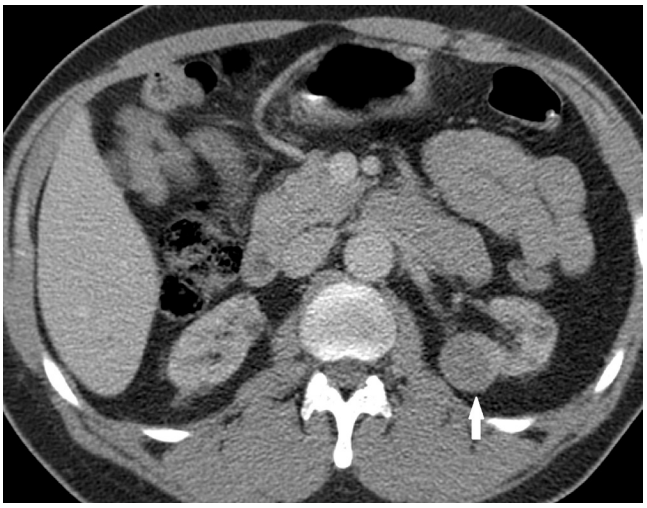

FIGURE 36-18 ■ Renal cell carcinoma in the non-functioning kidney. Single-phase post-contrast CT through the native kidneys in a patient with a renal transplant demonstrates a small left-sided renal mass which was confirmed as a solid lesion on US and subsequently resected and confirmed as a renal cell carcinoma. Native non-functioning kidneys demonstrate poor enhancement post-contrast and it can be difficult to differentiate a complex cyst from a poorly enhancing tumour.

presence of a discrete soft-tissue tumour mass in the perinephric space is a specific sign of T3a disease (98%) but has a sensitivity of only 46%. Perinephric stranding is found in most patients with T3 disease but is also detected in a significant number of patients with T1 or T2 disease, when it is caused not by tumour but by oedema, vascular engorgement or fibrosis.

CT has a limited ability to identify lymph node involvement, which is based entirely on size. Using 1 cm as the upper limit of normal, nodal micro-metastases will be missed in 4% of patients. There is also a variable

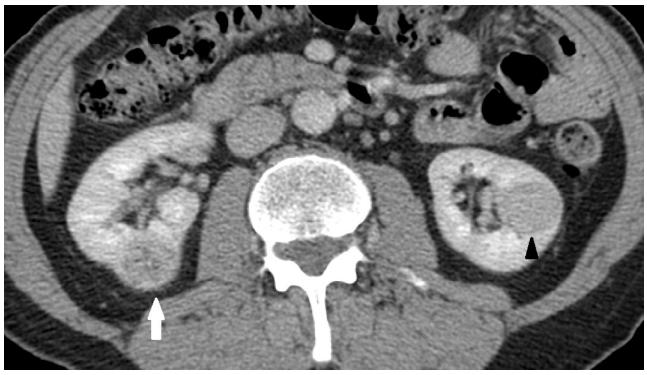

FIGURE 36-19 ■ Bilateral renal tumours. Post-contrast CT demonstrates a typical small right renal cell carcinoma (see arrow). The contralateral kidney contains a mass with different morphology (see arrowhead), which is more in keeping with a papillary tumour, although a haemorrhagic cyst could cause a similar appearance, and comparison with a pre-contrast image would be required to confirm that there is enhancement. Partial nephrectomy was performed bilaterally as a staged procedure.

TABLE 36-1 Staging of Renal Cell Carcinoma: TNM System 2010 Modification

Tumour confined to kidney, small <4 cm	**T1a**
Tumour confined to kidney >4 cm, <7 cm	**T1b**
Tumour confined to kidney >7 cm, <10 cm	**T2a**
Tumour confined to kidney >10 cm	**T2b**
Tumour spread to perinephric fat, or renal vein	**T3a**
Tumour spread to cava below diaphragm	**T3b**
Tumour spread to cava above diaphragm, or invades the wall of the cava	**T3c**
Tumour spread outside Gerota's fascia, or ipsilateral adrenal gland	**T4**
Metastasis in single lymph node	**N1**
Metastasis in more than one lymph node	**N2**
Distant metastasis	**M1**

false-positive rate due to nodal enlargement caused by reactive hyperplasia. This is more common when tumour necrosis or tumour thrombus is present. The overall accuracy for lymph node staging is reported to be between 83 and 89%.

Accurate identification of involvement of the renal vein and inferior vena cava is very important for correct patient management (see Figs. 36-20 and 36-21). The reported accuracy for detecting renal vein involvement using CT is approximately 96%. Optimal enhancement of the renal vein is seen during the corticomedullary phase of enhancement. Thrombus is seen as a filling defect within the vein. Isolated renal vein enlargement is an unreliable sign because it can be caused by increased blood flow secondary to tumour hypervascularity. It is usually difficult to differentiate tumour thrombus from bland thrombus unless enhancement can be seen within the thrombus. CT is a sensitive method for detecting lung metastases but is often reserved for patients with extensive regional disease or an abnormal chest radiograph. MRI has been reported as being the best technique for defining the extent of venous invasion. MRI is superior to CT in differentiating benign from malignant

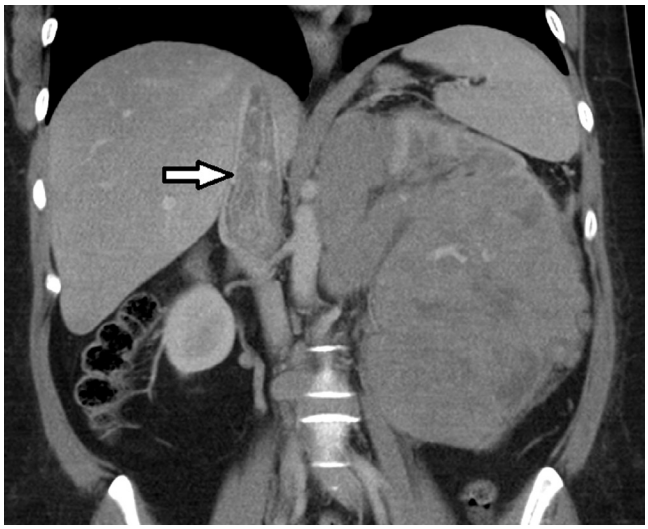

FIGURE 36-20 ■ T3b Renal cell carcinoma. Coronal post-contrast CT demonstrates tumour thrombus extending into the right renal vein and the cava (see arrow) (radiological stage T3b).

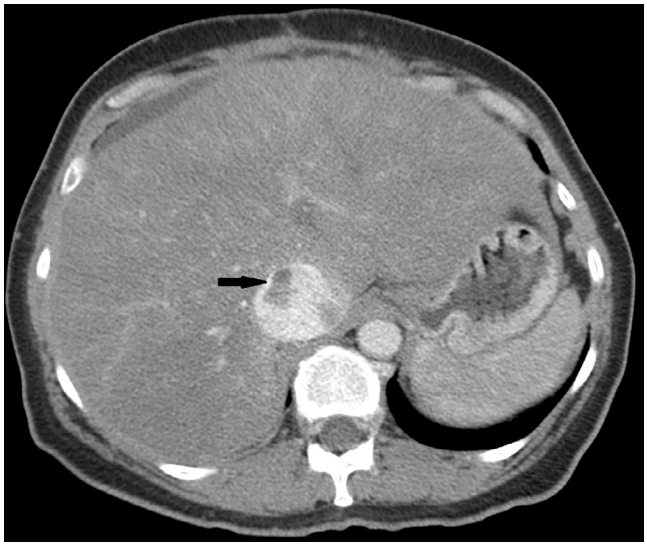

FIGURE 36-21 ■ Recurrent renal cell carcinoma in the vena cava. Post-contrast CT performed during follow-up for a previously resected renal cell carcinoma demonstrates a soft-tissue mass in the vena cava (see arrow) consistent with recurrent tumour.

thrombus, but offers no advantage in staging nodal disease.

Wilms' Tumour in the Adolescent and Adult. Approximately 90% of Wilms' tumours are diagnosed before 7 years of age. Presentation in adolescence is uncommon and it is very occasionally seen in adulthood. In adults, it generally presents as a palpable abdominal mass, although hypertension, abdominal pain and, less frequently, gross haematuria may be seen. Wilms' tumours are usually large at presentation and can occasionally be identified on plain abdominal radiographs.

As with renal cell carcinoma, invasion and obstruction of the renal vein or inferior vena cava may occur, as well as invasion of the renal pelvis and ureter.

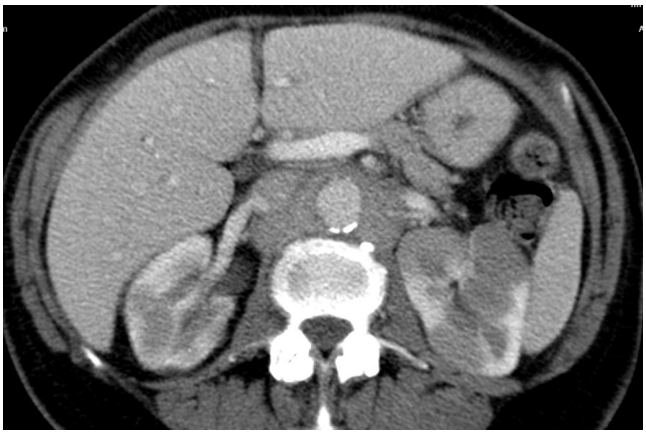

FIGURE 36-22 ■ Lymphoma of the kidney. Post-contrast CT demonstrates multifocal solid masses in both kidneys with paraaortic nodal disease highly suggestive of lymphoma. Biopsy of the renal mass is required to confirm and characterise before treatment, which will not be surgical.

Sarcoma. Sarcomas of the kidney are rare, solid, malignant tumours which develop from mesenchymal cells. Many of these tumours arise in close proximity to the renal capsule, making it difficult to distinguish whether they originate in the renal or perinephric tissues. Others arise from the wall of intrarenal blood vessels within the kidney, or close to the renal pelvis. The imaging characteristics are non-specific, making it difficult to distinguish a renal sarcoma from a renal cell carcinoma. The tumours are frequently large at presentation and tend to present with abdominal pain and discomfort. Renal vein and inferior vena cava invasion is seen, and metastases are common at initial diagnosis.

Lymphoma and Leukaemia.[13] Primary lymphoma of the kidney is very rare, as there is no lymphatic tissue within the kidneys. Renal involvement may be due to haematogenous spread or contiguous invasion from adjacent retroperitoneal lymphadenopathy (see Figs. 36-22 and 36-23). The kidneys are much more frequently involved in patients with non-Hodgkin's lymphoma, particularly when the disease has relapsed. Although clinically apparent renal involvement is seen in 5% of patients, and autopsy post mortem studies have shown that 30–50% of patients have involvement of the urinary tract.

CT may demonstrate sheet-like diffuse infiltration of the perirenal tissues or multiple focal nodules. Following intravenous injection of contrast medium, focal lesions are usually of low attenuation. Contrast enhancement may also be useful in demonstrating the presence of discrete focal abnormalities in diffusely enlarged kidneys. Lymph node enlargement is often seen surrounding the vessels and can lead to bilateral hydronephrosis.

^{67}Ga citrate radionuclide imaging may also identify lymphomatous involvement of the kidney. CT- or ultrasound-guided biopsy may be helpful if lymphoma is suspected. Leukaemic renal infiltration is frequently seen at postmortem examination and can be associated with renal impairment. CT can demonstrate unilateral or bilateral renal enlargement or the presence of a focal mass or masses.

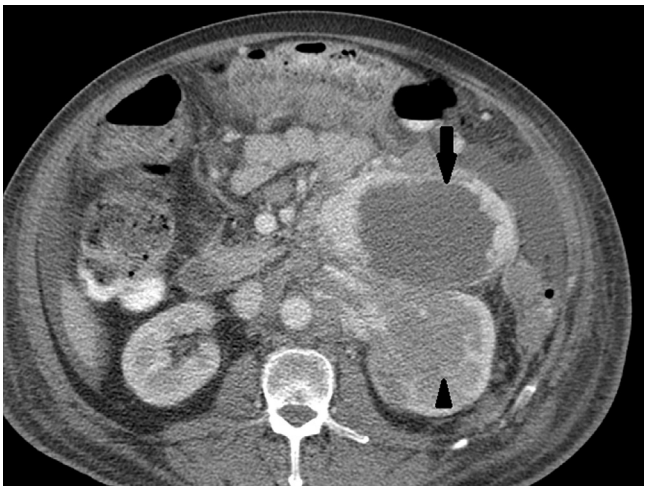

FIGURE 36-23 ■ RCC and lymphoma. Post-contrast CT demonstrates a complex left renal mass. There is an irregular hypervascular mass in the upper pole of the left kidney (see arrow), as well as a poorly enhancing soft-tissue mass in the lower pole (see arrowhead). Incidental para-aortic nodes were seen. Biopsy of both components was performed, confirming the presence of a clear cell carcinoma in the upper pole and a lymphoma of the lower pole. There was no previous history of lymphoma. Following chemotherapy, the lower pole renal mass responded, as did the nodal disease. Nephrectomy was performed for the clear cell carcinoma of the upper pole.

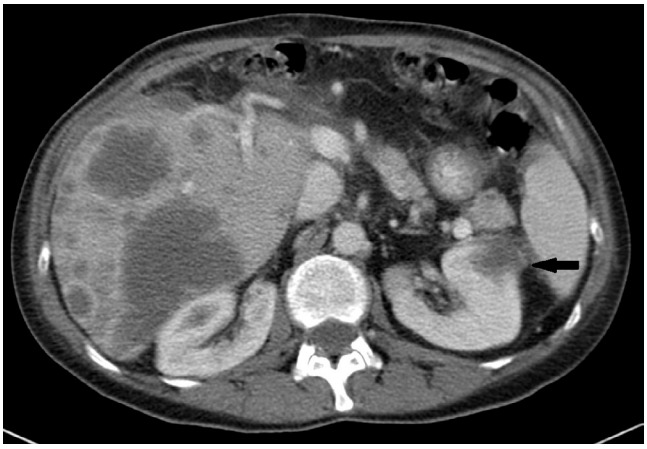

FIGURE 36-24 ■ Metastatic disease to the kidney. Post-contrast CT in a patient with advanced metastatic cholangiocarcinoma demonstrates multiple metastases to the liver with a similar metastatic deposit in the left kidney (see arrow). Renal metastases in advanced metastatic disease are not uncommon, but are rarely clinically significant.

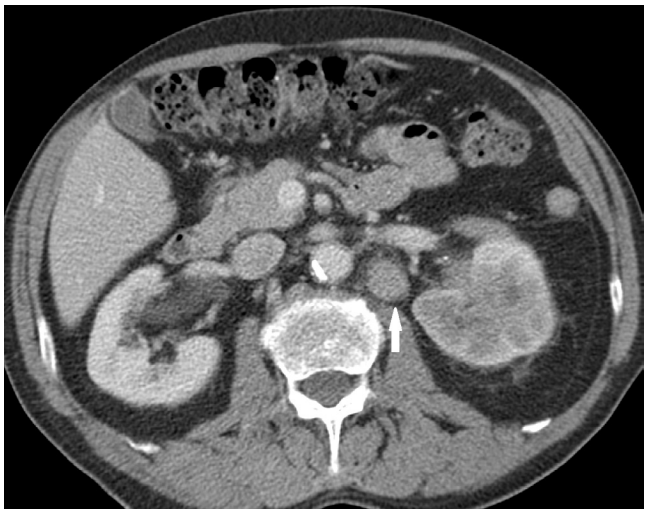

FIGURE 36-25 ■ Transitional cell carcinoma of the kidney presenting as a solid renal mass. CT performed with contrast demonstrates a large centrally placed and poorly vascular mass in the middle of the left kidney confirmed histologically as a TCC. There is an enlarged left para-aortic lymph node (see arrow), which is also metastatic.

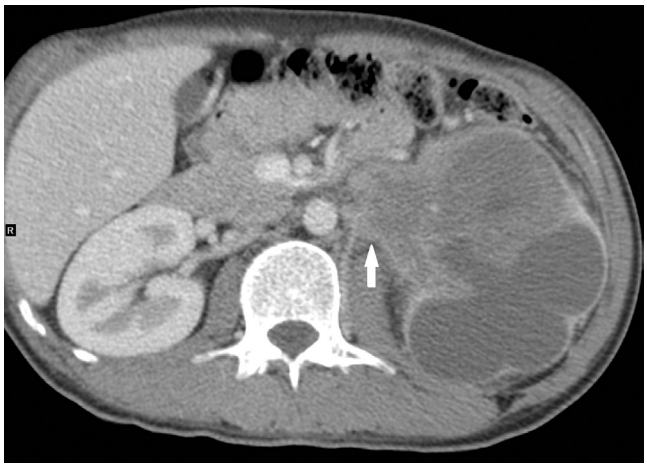

FIGURE 36-26 ■ Urothelial cell cancer of the kidney. Post-contrast CT performed in a 22-year-old with haematuria demonstrates a large central soft-tissue mass invading the renal pelvis, and causing hydronephrosis (see arrow). Resection was performed, confirming a transitional cell tumour. These can sometimes be difficult to differentiate from an RCC, and should always be considered in a poorly enhancing central endophytic mass. Surgical treatment for TCC includes ureterectomy, so preoperative differentiation is important.

Tumours Metastatic to the Kidney.[14] These tumours rarely cause symptoms during life but are frequently found in autopsy studies. They are increasingly detected as a result of the widespread use of CT in monitoring the response of extrarenal tumours to chemotherapy (see Fig. 36-24). Most renal metastases are haematogenous, although a few occur by direct invasion or from lymphatic spread. The commonest primary tumours are bronchial, colorectal, breast, testicular and gynaecological malignancies and malignant melanoma. Haematogenous metastases are usually small (<3 cm), multiple and confined to the cortex. They tend to present late in the course of the disease and are associated with other evidence of metastatic disease. They are usually hypovascular on CT and do not tend to demonstrate calcification or renal vein invasion. Most metastases are more infiltrative and less exophytic than renal cell carcinoma. Fine-needle aspiration can confirm malignant disease if there is clinical doubt.

Non-Parenchymal

Urothelial Tumours

Transitional Cell Carcinoma (see Figs. 36-25 and 36-26). Transitional cell carcinoma of the renal pelvis

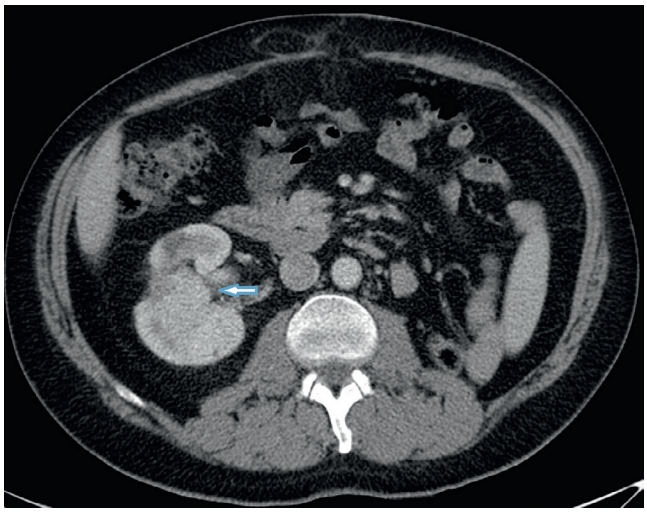

FIGURE 36-27 ■ Local recurrence of renal cell carcinoma following cryotherapy. Dynamic post-contrast CT demonstrates a soft-tissue mass in the mid pole of the right kidney (see arrow) with overlying cortical atrophy. The patient had received previous cryotherapy to a 3-cm mass, but follow-up imaging demonstrated a progressive mass. Biopsy confirmed recurrence, and under intraoperative US guidance, a successful open partial nephrectomy was performed.

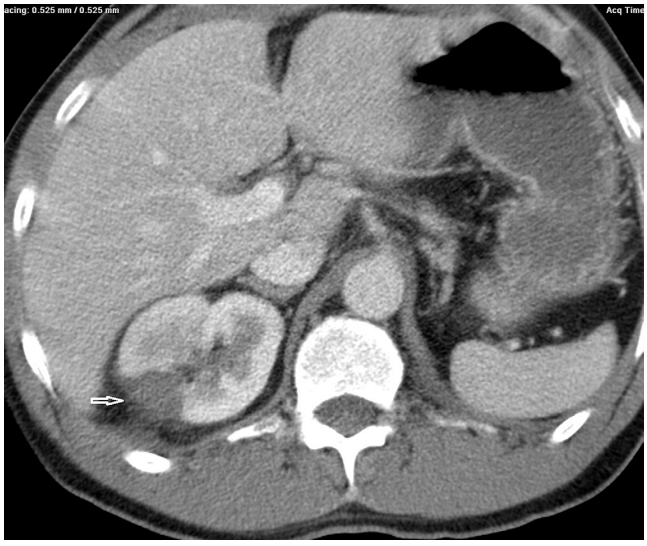

FIGURE 36-28 ■ Post-treatment appearances following radiofrequency ablation of the kidney. Recent radiofrequency (RF) treatment to a small right renal mass (see arrow) is seen as a wedge-shaped area of reduced attenuation. Increased use of local ablation with RF or cryotherapy produces a cohort of patients requiring follow-up for assessment of local disease, as well as detecting metachronous lesions in the same or contralateral kidney.

and calyceal system presents as a renal mass when it infiltrates into the renal substance, although most urothelial tumours present as filling defects within the renal pelvis or ureter. The infiltrative form may be mistaken for a primary renal cell carcinoma that has breached the renal pelvis. Renal cell carcinoma may, on occasion, invade the calyceal system.

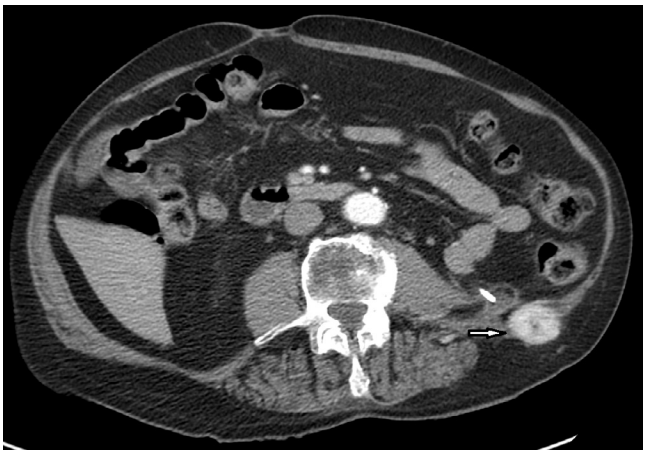

FIGURE 36-29 ■ Local recurrence of renal cell carcinoma. Post-contrast axial CT performed 5 years after radical nephrectomy demonstrates a focal enhancing mass (see arrow) in the posterior abdominal wall. No other metastatic disease was evident. Originally the tumour had been treated with focal percutaneous therapy and the local recurrence was considered to be secondary to this. In view of the solitary nature of the lesion, and absence of metastatic disease, local excision was performed.

Squamous Cell Carcinoma. Squamous cell carcinoma of the renal pelvis is a relatively rare tumour, representing only a few per cent of all renal neoplasms. It is a highly aggressive tumour and carries a poor clinical prognosis. Chronic infection and calculi play an important aetiological role in this malignancy, with stones being present in 57% of patients. It often involves the renal parenchyma and perinephric tissues, and may present with metastases.

There has been an increased use of localised or minimally invasive treatments with radiofrequency and cryotherapy for small renal masses over the past 10 years. Although local treatment is an attractive approach, it requires a relatively higher intensity of follow-up to ensure treatment is adequate and that there is no local recurrence (Figs. 36-27 and 36-28).

A soft-tissue mass is usually seen around the site of local treatment which demonstrates involution over time, often leaving some residual soft tissue (Fig. 36-29). The development of new enhancing tissue on the lateral or medial surface of the kidney suggests local recurrence. It is important to scrutinise both these areas for disease, as well as for metachronous tumours or metastatic nodes.

For a full list of references, please see ExpertConsult.

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