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Subtotal Nephrectomy and Tumour Ablation

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Introduction

With the use of cross-sectional imaging, small renal tumours have been increasingly diagnosed over the past 20 years [1]. During this period, management has become more conservative with a progressive decline in the utilisation of radical nephrectomy. Nephron-sparing approaches have been widely adopted with the objectives of preserving renal function and reducing long-term morbidity. Partial nephrectomy with excision or enucleation of the tumour appears to have equivalent oncological outcomes to more radical surgery. The availability of robotically assisted surgery allows a minimally invasive procedure for partial nephrectomy that many now suggest is the surgical procedure of choice when feasible. Ablative therapies such as radiofrequency ablation (RFA) and cryoablation (CA) are alternatives to partial and radical nephrectomy, particularly for patients who are not suitable surgical candidates. Small renal masses in the short to intermediate term frequently exhibit slow growth and minimal metastatic risk and consequently surveillance is now adopted in patients who are elderly or have significant co-morbidities.

Postoperative and follow-up imaging after radical nephrectomy for small renal tumours is essentially to detect early postoperative complications and the relatively rare events of local recurrence and metastatic disease. The increasingly utilised nephron-sparing approaches have introduced challenges associated with the repeated imaging that is required for these various options. These include investigations of the tumour-bearing kidney for a range of specific complications of the various strategies as well as the possibility of incomplete eradication, tumour recurrence within the remaining parenchyma as well as disease progression. Anatomical distortion of the kidney and evolving changes to masses subjected to ablative treatment or undergoing surveillance management represent specific challenges for the nephron-sparing approaches.

Procedures

Partial Nephrectomy

Surgical excision of small renal tumours is undertaken as either an open operation or, increasingly, with a robotically assisted or laparoscopic approach. Tumours can be enucleated or excised with a margin of surrounding renal parenchyma. Components of the operation include mobilisation of the kidney and identification of the renal mass, isolation of the renal artery, with temporary occlusion/clamping if required, tumour excision and renal repair. The last may, in some cases, require closure of the collecting system in addition to oversewing of the incised parenchyma including divided blood

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vessels required for haemostasis. A ureteric stent can be inserted as a preliminary or during surgery if collecting system repair is required.

Follow-up imaging is required to assess and guide management of early postoperative complications, most often haemorrhage or urinary leakage. Longer term imaging is also required as routine to detect local recurrence either at the site of resection or within the remaining parenchyma.

Early Imaging

This is principally indicated for assessment of clinically recognised or suspected complications of the surgical procedure and to direct their management. Haemorrhage and urinary leakage comprise the principal surgical complications that require imaging.

Haemorrhage Bleeding can arise in the initial postoperative period, usually reflecting an unsecured artery, or days to weeks later as a result of rupture of a pseudo-aneurysm of an intrarenal artery. The events alerting the clinician are signs of blood loss or falling haematocrit as well as flank pain or mass and at times, heavy haematuria. Subtle unexplained drops in haematocrit, which may precede signs of significant bleeding, can also prompt radiological investigation. The principal investigations used are computerised tomographic angiography (CTA) and invasive angiography [2].

CTA – may be required initially to determine the source of blood loss. Intravenous contrast should be employed as this will assist localisation of bleeding. Recommended imaging entails an initial arterial phase after bolus contrast injection with a subsequent portal venous phase approximately 1 minute later [3]. Visualisation of active bleeding based on contrast extravasation is an indication for urgent embolisation (Figure 1.1). Whether CTA is a necessary preliminary to standard angiography, required for embolisation, is debatable. In the context of bleeding following partial nephrectomy from the kidney, CTA may be a redundant investigation increasing contrast media exposure as angiography and embolisation is highly likely to be required. When CTA fails to detect an active source, angiography may also be deemed necessary based on clinical concern and heightened suspicion. In practice it is often used as a rapidly accessible investigation and to confirm whether bleeding is from the kidney itself, from non-renal vessels such as lumbar or intercostal or reflects damage to other organs such as the spleen or liver which may not be evident on selective angiography.

In cases where there are significant concerns regarding contrast and specifically renal dysfunction, ultrasound (US) and magnetic resonance angiography (MRA) are alternative options. Of these, MRA, if available, is the best alternative to CTA in providing detail of the intrarenal circulation

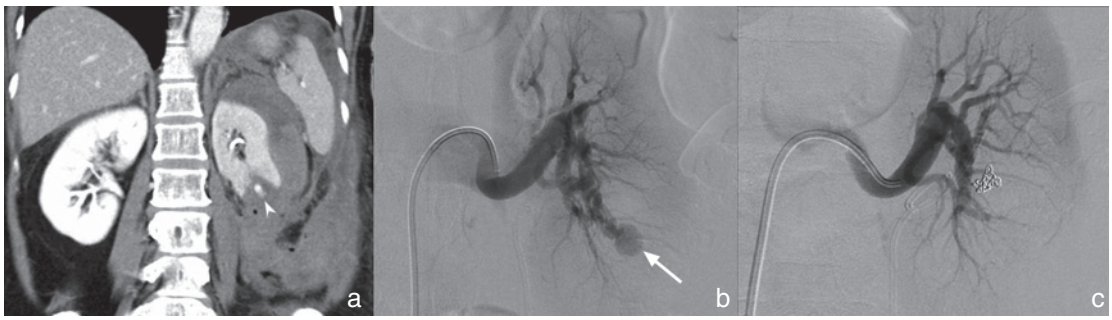

Figure 1.1 Haemorrhage 7 days following left partial nephrectomy with large perinephric haematoma and contrast extravasation on computerised tomography (CT) (a). On subsequent angiography, no sign of active bleeding persisted but a contained lower pole aneurysm was demonstrated (arrow, b) which was successfully treated with gel embolisation (c).

as well as assessment of non-renal bleeding sources. US can exclude other bleeding sites, such as the liver or spleen, but apart from this and the presence of a perinephric haematoma provides little additional information. Therefore its use may be of little value if there is clinical evidence of bleeding.

Angiography is used both diagnostically and for selective embolisation as the preferred management of the bleeding source [4]. To minimise contrast exposure, this is performed selectively with initial study of the renal artery to localise the source of bleeding. This may demonstrate an obvious pseudo-aneurysm or outline extravasation of contrast from an involved vessel. Manipulation of the angiographic catheter into the involved vessel is then undertaken, with coils being deployed to occlude the lumen and control bleeding. Multiple coils may be required to achieve occlusion and on occasions repeat procedures are required – as intrarenal vasospasm may masquerade as adequate control with subsequent further bleeding. Whilst super selective embolisation is preferred, this may not prove feasible or successful. In this circumstance, larger vessels may need to be occluded resulting in loss of some of the remaining renal parenchyma.

Urinary Leakage Urinary leakage arises from either the collecting system or the ureter or renal pelvis if these were damaged at the time of the procedure [5]. These problems present as urine leakage from a drain, renal dysfunction or flank mass/pain in the absence of bleeding. US may demonstrate a fluid collection around the kidney prompting formal assessment with a CT urogram (Figure 1.2). This will confirm the presence of urinoma and outline the site and nature of leakage with extravasation of contrast from the collecting system or ureter. Hydronephrosis may also be seen on US and CT – which may relate to distal obstruction resulting from luminal clot, ureteric compression by the urinoma or a consequence of ureteric injury.

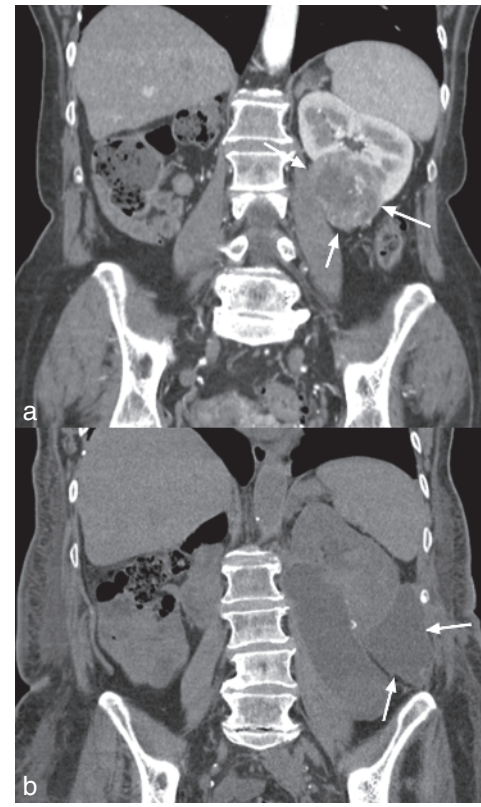

Figure 1.2 A large urinoma presenting 4 months after a partial nephrectomy. The arrows in (a) show the tumour. A ureteric stent was placed at time of surgery in view of the major collecting system repair. The stent had been removed electively 4 weeks prior to representation with left flank discomfort; the urinoma is shown by the arrows in (b).

Late Imaging

Tumour recurrence is the principal goal of longer term imaging. Currently, there are no standardised guidelines regarding the preferred imaging modality or the frequency with which it should be performed. US, CT and magnetic resonance imaging (MRI) are all used. Anatomical and functional changes can also be seen in the course of planned follow-up imaging.

Anatomical Changes Distortion of the renal parenchyma may complicate the interpretation of studies. Imaging is thus recommended 3–6 months following surgery to redefine

the anatomical appearances of the kidney as a baseline for longer term follow-up. A resection defect will usually be apparent, reflecting the excised segment of kidney – often more complex if the initial tumour was central or hilar.

Techniques used to secure haemostasis and close the excision defect can also confound the interpretation of imaging [6]. These include portions of revascularised perinephric fat (Figure 1.3) and haemostatic agents (e.g. oxidised cellulose; Figure 1.4) [7]. Inflammatory reactions including foreign body granulomas reported with the latter may result in pseudo-tumour formation resulting in a diagnostic dilemma [8]. With surveillance, these remain stable or gradually involute although complete regression may not occur. Similar reactions have been reported with other biomaterials used to secure haemostasis [8]. Perinephric haematomas or urine collection at the site of resection can also result in abscess formation (Figures 1.5 and 1.6) and can develop weeks to months following surgery [7].

Haematomas and small urinomas at the site of resection can also create effects that may masquerade as recurrent disease. These may appear complex with solid and cystic elements as a consequence of inflammation and clot organisation. These may be evident on imaging at 3–6 months but resolve gradually over time (Figure 1.7).

Functional Changes The following types of late complications can be observed as a consequence of surgery:

- *Vascular* Renal artery pseudo-aneurysm may present asymptomatically as an incidental finding as a complex vascularised mass (Figure 1.8). Systematic radiological evaluation suggests that these occur in up to 20% of cases during the early postoperative period after partial nephrectomy [2]. They usually resolve spontaneously but may leave a persistent residual mass which may be difficult to distinguish from recurrent disease [9].

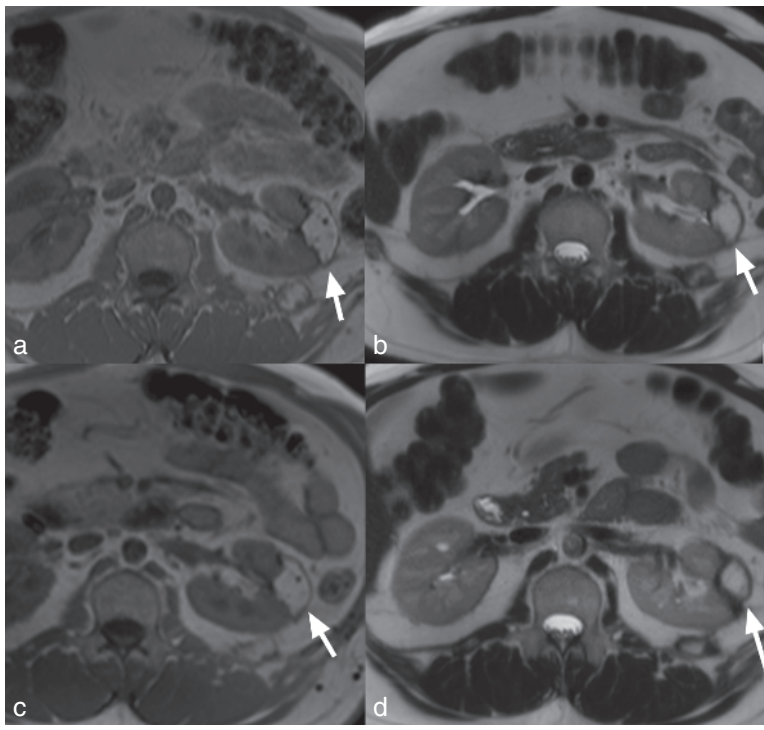

Figure 1.3 Magnetic resonance imaging (MRI) of a patient who underwent left partial nephrectomy with placement of perinephric fat into the defect (arrow) at 3 months on (a) T1 and (b) T2 axial images. (c,d) T1 and T2 images at 15 months. No changes were observed over this time.

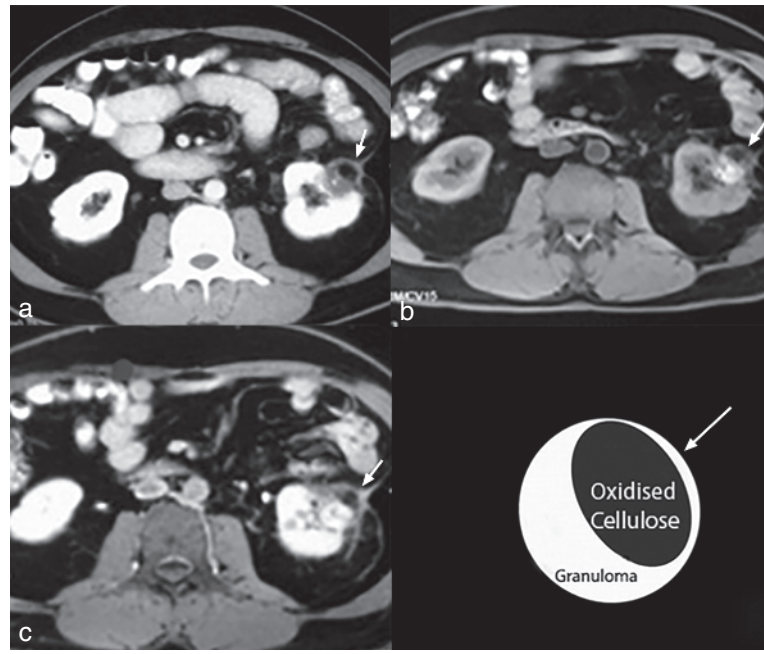

Figure 1.4 Contrast-enhanced CT: (a) 3 months after partial nephrectomy demonstrating a lesion with a hypodense non-enhancing outer portion where oxidised cellulose had been placed and an inner isodense enhancing area representing granuloma formation; (b) T2 MRI showing hypointense outer and hyperintense inner; and (c) contrast-enhanced MRI showing enhancement only in the inner portion.

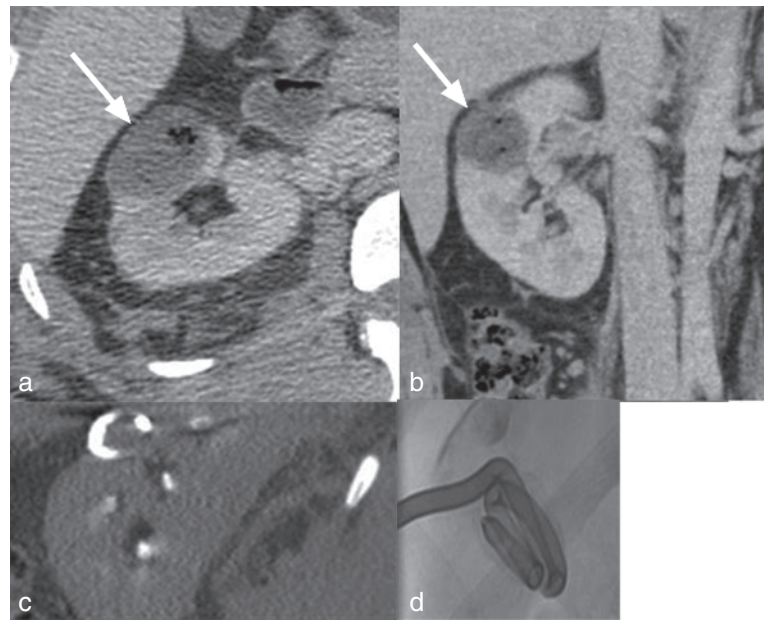

Figure 1.5 (a) Axial and (b) coronal CT images demonstrated a rim enhancing collection (arrow) containing locules of gas at the site of recent partial nephrectomy. (c) The abscess was managed with CT-guided drainage. (d) The drain was subsequently up-sized under fluoroscopic guidance to ensure complete drainage.

- *Ischaemia* Ischaemic injury can occur to the kidney reflecting parenchymal effects of prolonged renal artery clamping. Renal ischaemia can also evolve from the effects of renal artery manipulation. Thrombosis of the renal artery may occur in the postoperative period with complete infarction of the kidney which subsequently undergoes global atrophy. Renal artery stenosis can also occur although this may be

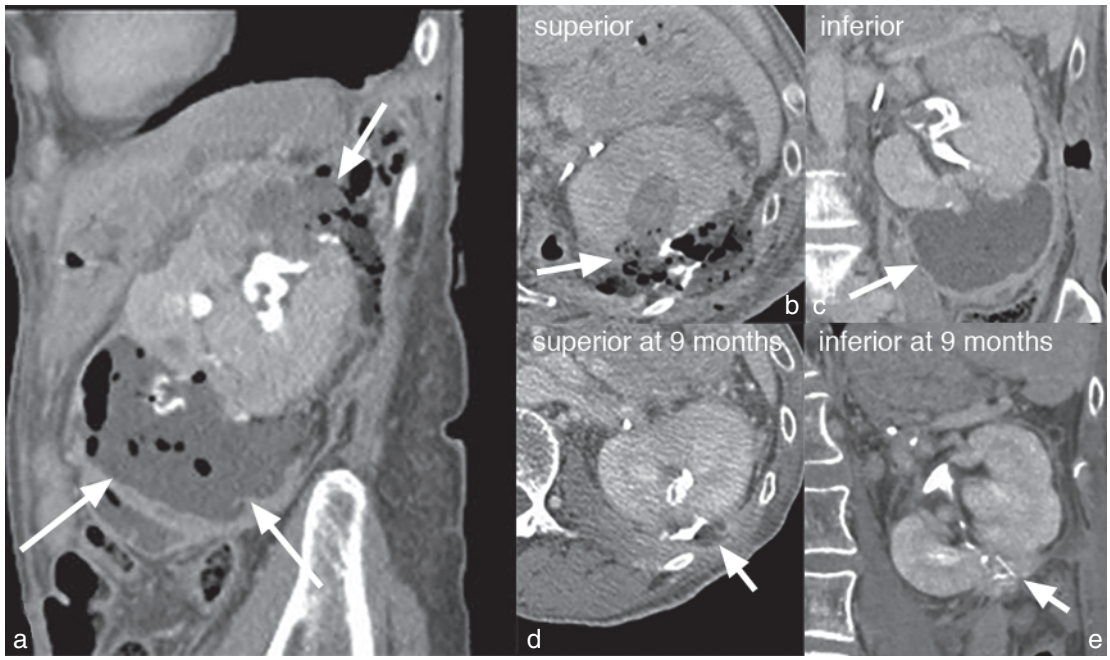

Figure 1.6 Following a two-site left partial nephrectomy: (a) sagittal CT imaging demonstrated two discrete enhancing collections (superior b, inferior c) consistent with infected urinomas. (d,e) Interval CT imaging at 9 months following percutaneous drainage and decompression with retrograde stenting showed resolution.

difficult to distinguish from the effects of intraoperative ischaemia. Severe hypertension prompts angiographic assessment and consideration of renal vein renin sampling.

- *Obstruction* Ureteric stenosis can result in proximal ureteric and collecting system dilatation, reflecting direct ureteric injury or ischaemia as a result of cautery or other trauma to its blood supply if aggressively mobilised or retracted during the surgical event (Figure 1.9). Intrarenal obstruction to one or more calyces may also arise insidiously, reflecting infundibular damage related to ischaemia or an effect of collecting system repair or closure of the parenchymal defect.

Recurrent Tumour Tumour recurrence occurs in a small proportion of cases following partial nephrectomy [10]. This may occur at the margins of the resection and reflects either incomplete excision or a separate satellite lesion that has progressed. Further tumours may also occur remotely within the remaining parenchyma, with patients with hereditary disorders at highest risk. From the imaging point of view they have the same characteristics as the original tumour.

Ablative Therapies

Image-guided ablation with use of thermal energy is now frequently used as an alternative to surgical excision of small renal tumours. The currently employed modalities are RFA and CA [11]. RFA results in coagulation of tissue as radiofrequency waves delivered continuously via a probe are converted to heat producing thermal tissue damage. In contrast, CA involves rapid freeze–thaw cycles delivered through probes inserted into the tumour producing ice formation and disrupting cellular membranes resulting in tissue necrosis and injury to local microvasculature. The volume of treatment has to be slightly larger than the tumour area to ensure adequate ablation.

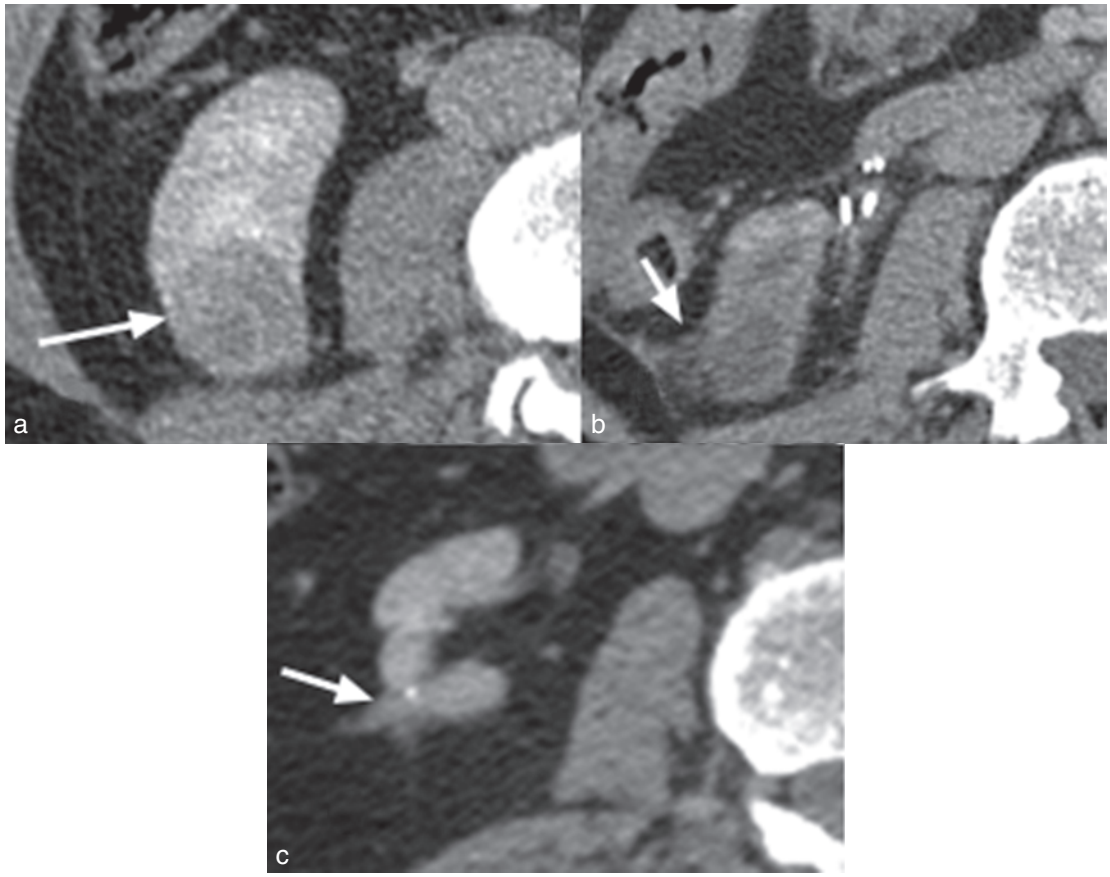

Figure 1.7 (a) Right lower pole tumour at presentation. (b) At 6 months post partial nephrectomy. (c) At 6 years post partial nephrectomy.

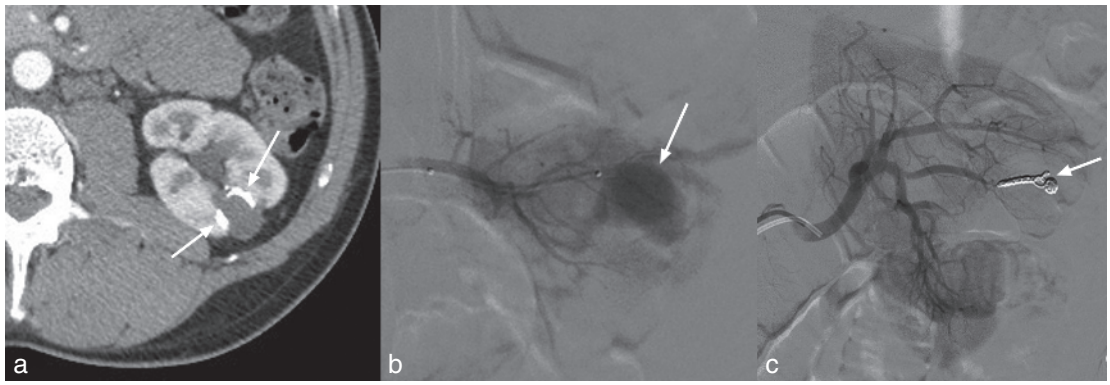

Figure 1.8 Asymptomatic pseudo-aneurysm identified 18 months after partial nephrectomy. Curvilinear calcification seen on CT (arrows, a) with pseudo-aneurysm demonstrated on angiography (b). This was treated with coil embolisation (c).

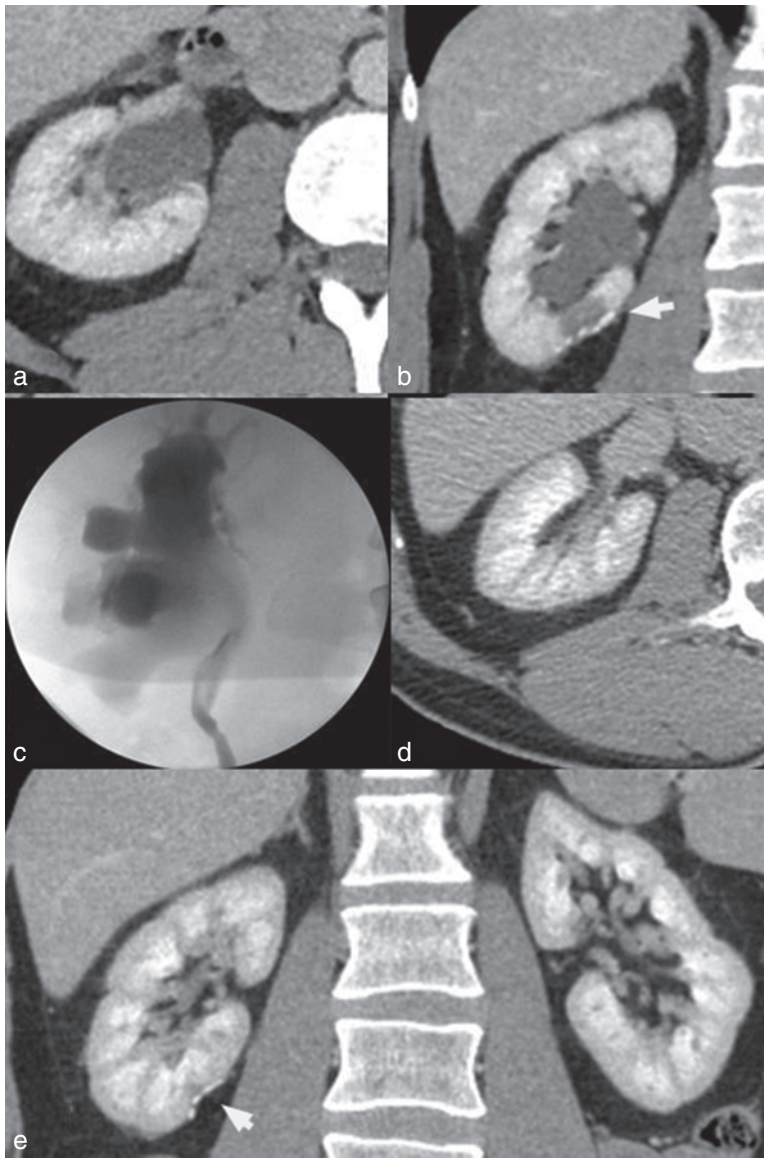

Figure 1.9 (a) Axial and (b) coronal CT images demonstrated new hydronephrosis at 6 months post partial nephrectomy for a right lower pole lesion. (c) Retrograde pyelogram obtained at the time of retrograde dilatation and stenting. (d,e) Subsequent CT at 12 months demonstrated resolution of the hydronephrosis without further intervention. Non-absorbable polymer sutures (arrows) used to secure haemostasis are seen on (b) and (e).

Whilst there are variations in technical issues, neither modality is clearly superior and preference is largely based on institutional facilities and clinician experience [11]. Currently, both are delivered as CT-guided techniques using a percutaneous approach, although some centres continue to use a laparoscopically guided approach with CA in selected cases.

As the tumour remains in situ following ablative therapies it is imperative that radiological surveillance with cross-sectional imaging is undertaken to exclude residual or recurrent malignancy. There is no consensus regarding frequency or duration of imaging studies [12]. Both MRI and CT can be used and require contrast studies to assess for incomplete ablation and recurrent tumour formation. As the radiological appearances of ablative therapies may evolve over time, serial studies are critical to determine successful treatment. Interpretation of changes

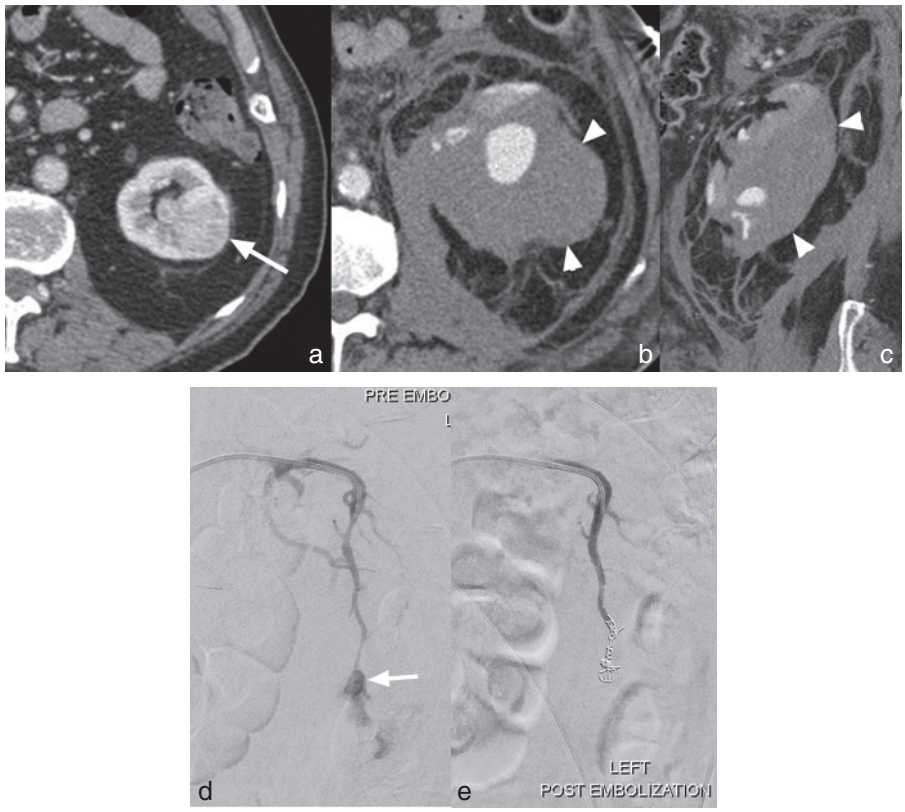

Figure 1.10 Enhancing endophytic renal mass pre-cryoablation (arrow, a). (b) Axial and (c) sagittal post contrast CT images demonstrate acute haemorrhage (arrowheads) at 6 hours post cryoablation. (d) Subsequent angiogram demonstrates acute extravasation from a lower pole segmental artery. (e) Haemostasis was achieved following successful super selective embolisation with micro coils.

to the treated and surrounding areas creates challenges in addition to the long-term burden of follow-up imaging.

Complications

Early Complications Despite its minimally invasive nature both RFA and CA are associated with complications requiring imaging in the early period following the procedure. Some degree of haemorrhage is an expected outcome following percutaneous ablation. If contrast is administered immediately after CA bleeding may be seen along the applicator tracts [13]. Most scans during or immediately following renal ablation procedures will show some evidence of perinephric haematoma, regardless of the technology used [13]. Whilst the vast majority are subclinical, significant haemorrhage can occur and may be both perinephric (Figure 1.10) and subcapsular (Figure 1.11) [14]. Collecting system and ureteric damage can occur when these structures are adjacent to the treated lesion, resulting in urinoma formation and obstruction [13].

Late Complications As with partial nephrectomy, both RFA and CA may be associated with late complications which may be demonstrated on imaging performed for clinical indications or become apparent with follow-up surveillance studies. Subcapsular haematoma may also occur insidiously with compromise to renal function [14]. Ureteric

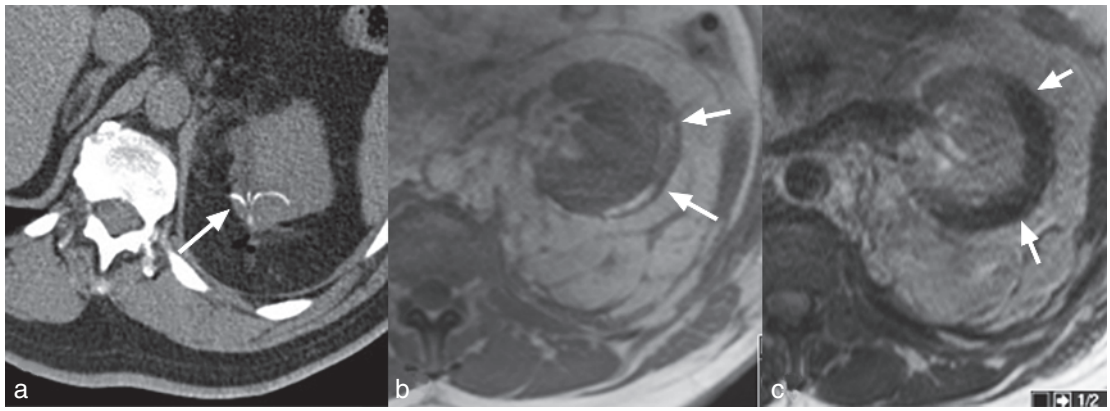

Figure 1.11 Following radiofrequency ablation (RFA) for an upper pole renal mass measuring 3 cm (arrow, a), a patient represented at 4 days with persistent left flank pain related to subcapsular haematoma (arrows), seen on (b) T1 and (c) T2-weighted MRI.

stenosis may also be seen on follow-up imaging – typically associated with treatment of medial lower pole masses.

Successful Tumour Ablation

With successful ablation, renal tumours will ultimately appear as focal lesions with no evidence of contrast enhancement on MRI (Figure 1.12) and CT [15]. Whilst there may be a zone of ablation, which can increase in the days following treatment, involution and residual scar formation subsequently occurs if tumour eradication has been successful (Figure 1.13). This can be a relatively slow process, with 30% reduction in the first 6 months. By 3 years the ablation zone size has decreased by an average of 75%. At this point only 40% of cases have undetectable treatment zones on CT or MRI [15]. Consequently, lack of involution of the treated zone is not indicative of treatment failure.

On CT scanning, the treated areas appear as low attenuation regions following both RFA and CA. On MRI, tumours appear isointense to hyperintense on T1-weighted images and hypointense on T2-weighted MRI compared with normal renal parenchyma [15]. Within the treated tumours, necrotic debris and areas of haemorrhage may demonstrate

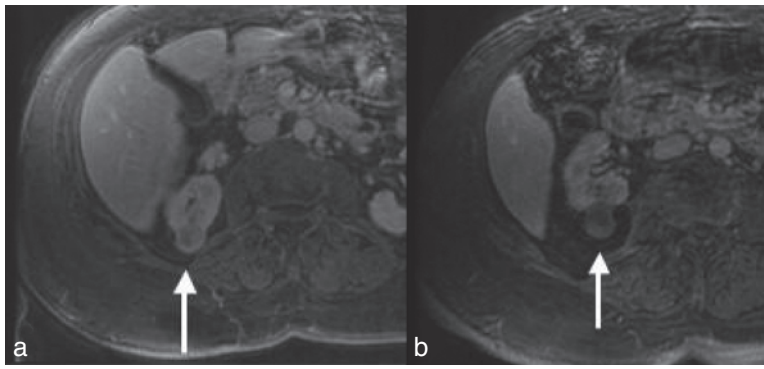

Figure 1.12 Contrast-enhanced T1-weighted MRI (a) before treatment with the renal tumour seen as an avidly enhancing exophytic mass arising from the posterior aspect of the right kidney and (b) immediately following successful radiofrequency ablation where the lesion is now devascularised and does not enhance post contrast.

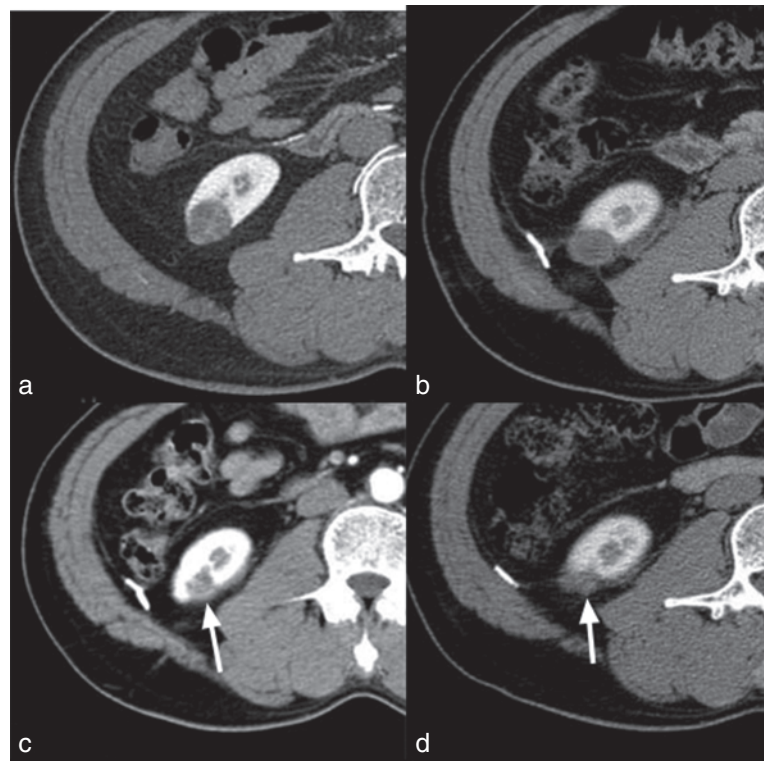

Figure 1.13 Progressive involution following cryoablation. (a) CT image of a 2.0-cm tumour with changes: (b) at 3 months, (c) 1 year and (d) 2 years following treatment.

increased signal intensity on MRI. On CT, these appear as areas of increased attenuation. These changes are most apparent during the first few months following treatment.

Following ablative therapies a thin rim of enhancement peripheral to the treated parenchyma can be seen on CT and MRI. This periablational enhancement reflects the physiological response to tissue injury comprising early reactive hyperaemia with subsequent inflammatory cell response and fibrosis [12]. The enhancing component gradually resolves and is often barely visible after 3–6 months. An area or halo of curvilinear hyperattentuation, however, may persist to some extent for years after treatment (Figure 1.14). This benign process appears as an essentially concentric, symmetric and largely uniform process. Its smooth margins need to be distinguished from the irregular peripheral enhancement associated with residual tumour.

Treatment Failure

Contrast enhancement within ablated lesions is generally indicative of the presence of residual tumour. This is typically seen as a nodular (Figure 1.15) or crescentic region peripherally located within the ablated lesion (Figure 1.16). The latter needs to be differentiated from the thin peripheral rim of enhancement that can persist for several months following successful ablation.

Failure of ablative therapy must be suspected with tumour, or parts thereof, that demonstrate increased post-contrast signal intensity on MRI or enhances more than 10 HU with contrast-enhanced CT imaging [12, 15]. Similarly, serial increase in tumour size following treatment should be regarded with suspicion.

Both RFA and CA result in a spherical treatment effect and thus residual tumour generally manifests as enhancing tissue that is nodular or crescentic in shape at the periphery of the ablated tumour. Within

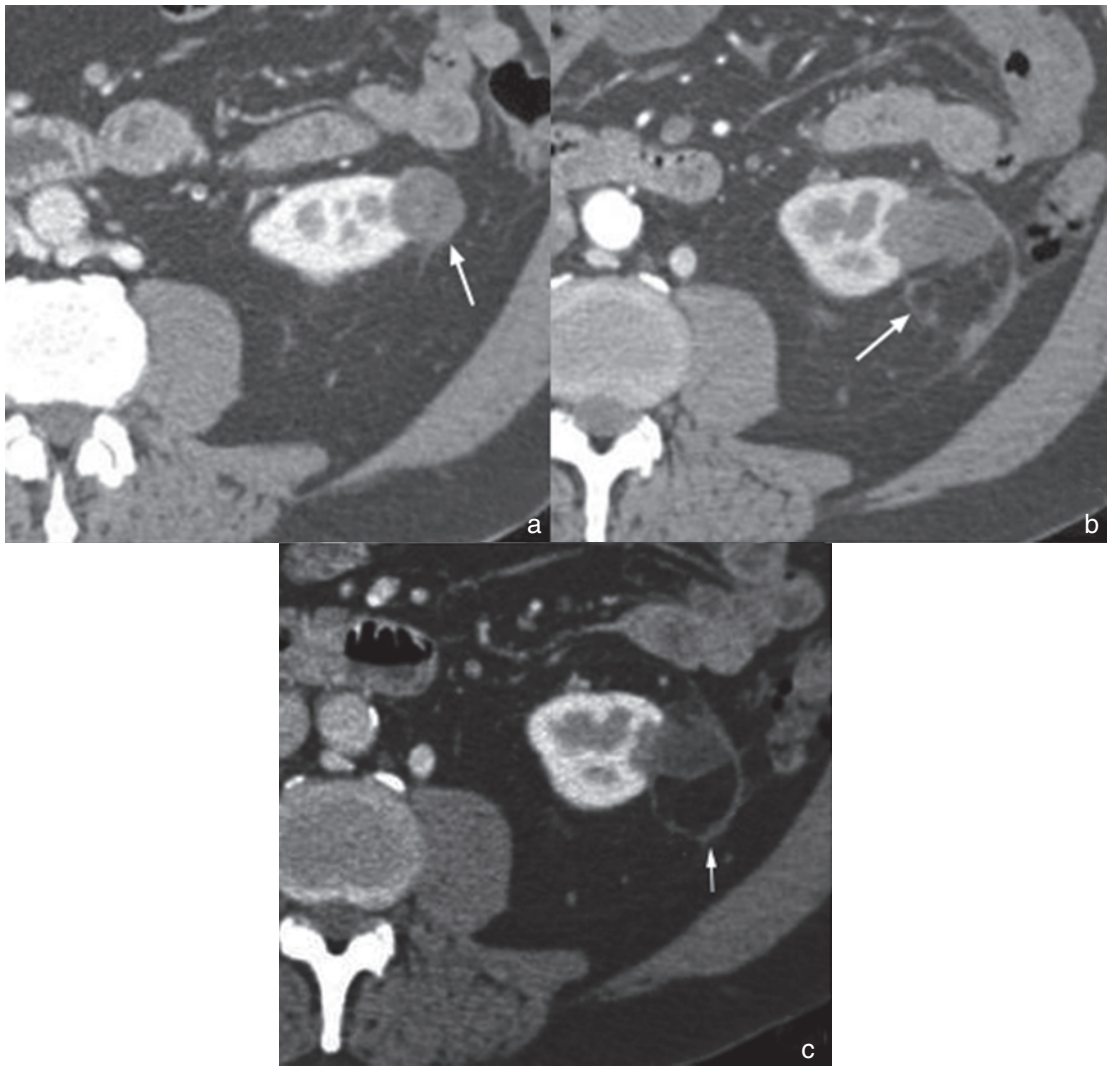

Figure 1.14 (a) Exophytic tumour prior to cryoablation. (b) Venous phase CT scan at 3 months demonstrates a heterogeneous hypodense area in the ablation zone with a curvilinear hyperattentuation area, or'halo'. (c) At 12 months, ablated lesion shows non-enhancement but persistence of the curvilinear hyperattentuation in the surrounding perinephric fat.

treated lesions, haemorrhage or calcification can produce relatively high attenuation on CT which obviously do not enhance (Figure 1.17). With MRI, subtraction or quantitative assessment is used to assess contrast enhancement, as high signal intensity on T1 images in treated tumours.

Residual hypervascular tumours show avid enhancement with late arterial phase images. Less vascular tumours may demonstrate more delayed contrast enhancement requiring delayed venous images to appreciate [12]. At times, findings may be subtle or equivocal in nature and may prompt early repeat CT or MRI and possible consideration of biopsy – although sampling error may limit its utility [16].

Unfortunately, with ablative therapies residual microscopic foci of tumour may not be identified with current imaging

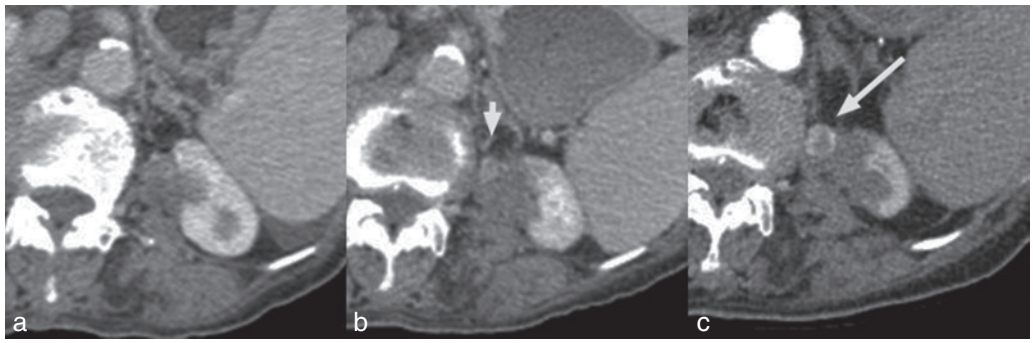

Figure 1.15 Contrast-enhanced axial CT images post percutaneous cryotherapy at 24 months demonstrated a new enhancing 9-mm nodule (arrow, b) in comparison with the 12-month post-treatment scan (a). The nodule demonstrated further growth to 12 mm on the 27-month CT (arrow, c).

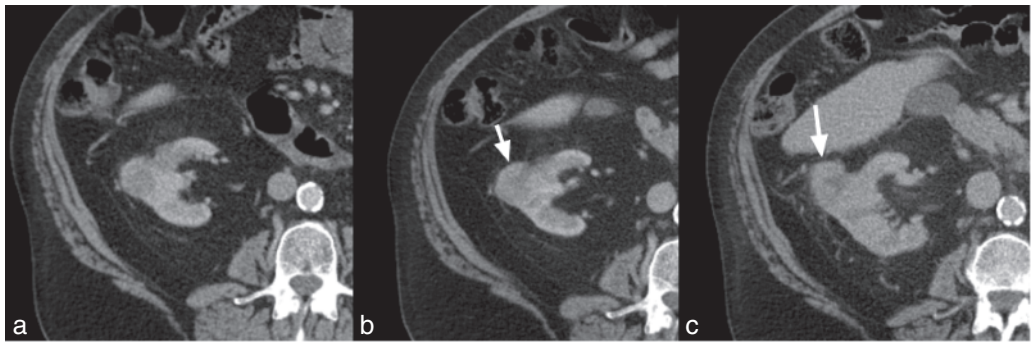

Figure 1.16 Patient who underwent RFA to a 3-cm right renal lesion initially had a favourable CT response at 3 months (a) but on subsequent imaging 6 months later demonstrated enhancing soft tissue nodularity in the periphery of the lesion (arrow, b). This progressed further over a 6-month period with clear tumour recurrence in the anterior aspect of the lesion (c), arrow.

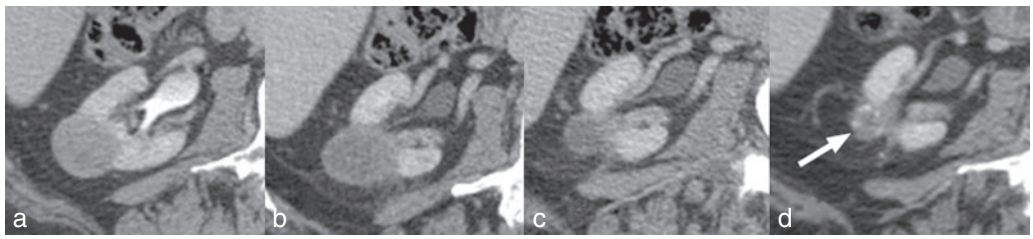

Figure 1.17 (a) An enhancing right renal lesion was treated with percutaneous cryoablation. (b) At 3 months post cryoablation, the lesion no longer demonstrated significant post-contrast enhancement. (c) At 18 months, the lesion had reduced in attenuation and in size. (d) At 4 years, the treated lesion had reduced further in size and was non-enhancing containing areas of peripheral calcification (arrowed) as well as a surrounding halo.

techniques and, consequently, even with apparent radiological success, long-term surveillance imaging is required.

Treatment failure may only become radiologically apparent over time reflecting progression of viable elements of the tumour. Enlargement or subsequent appearance of enhancement within the ablated region following an initially favourable radiological response should be regarded with a

high level of suspicion and either closely monitored or considered for investigation and treatment [16].

Surveillance

Small renal tumours are often detected in elderly patients with significant co-morbidities. Many of these tumours have a lower malignant potential, with 20% or more, in fact, being benign lesions such as oncocytomas. Based on series reports, active surveillance (AS) of small renal tumours may be appropriate in elderly patients and even younger patients with co-morbidities. Data from retrospective studies demonstrate that the growth rate for these tumours is slow, with very few progressing to metastatic disease [17]. Consequently, AS with treatment only with evidence of progression is now increasingly practised and is the initial strategy in up to 10% of patients presenting with small renal masses [18]. Radiological studies, employing one or more of US, CT or MRI, do not reliably distinguish between benign and malignant masses <4 cm in diameter. Tumour growth, features or multifocality do not appear particularly useful. An analysis of multiple retrospective AS series suggested only lesions that demonstrated growth developed metastases, with the obvious uncertainty that intervention at presentation would have prevented this [19].

Thus, whilst growth rate of small renal tumours may be a predictor of aggressive disease, this has not been validated in a controlled or prospective fashion. Studies use a range of modalities to assess lesions, with a broad range of clinicians assessing potential changes. Linear dimensions based on diameter is the principal technique used for measuring and reporting tumour size and growth in studies and is the standard in clinical practice. Whilst this is the easiest and most reproducible mechanism to assess and follow masses, it may not be as representative of clinical significance as volumetric assessment – although the latter is not yet a widely used tool.

Follow-up Imaging

Nephron-sparing approaches to renal tumours introduce a requirement for follow-up imaging significantly greater than with nephrectomy. All guidelines, even following nephrectomy, have been generated from retrospective series without prospective evaluation either oncologically or financially [20]. Nor surprisingly, whilst imaging following nephron-sparing approaches is the topic of many publications, there is no consensus or evidence-based guidelines with respect to frequency, duration or modality of imaging [21].

Surveillance studies have highlighted the slow growth of small renal masses, and consequently local recurrence may take considerable time to be radiologically apparent. Follow-up imaging therefore would appear a necessary requirement for nephron-sparing approaches to small renal masses unless final histology has confirmed a benign lesion such as an oncocytoma. Cost considerations and avoidance of repeated contrast exposure would favour the use of US where feasible in the longer term, reserving MRI and CT for when size or features change. As tumour recurrence may have subtle features, which may be slow to become apparent, imaging should always be performed with access to prior studies to characterise accurately the features of any abnormality as well as size of residual lesions over time.

Partial Nephrectomy

Cross-sectional imaging, with either CT or MRI, as well as a US examination of the kidneys at 3–6 months following surgery would seem a sensible approach. This is fundamentally to establish a baseline to enable interpretation of longer term studies and identify unrecognised complications of surgery. With this any changes seen can be reasonably attributed to the procedure as recurrence, particularly in the absence of positive surgical margins, at this time point is extremely unlikely. Subsequent imaging can comprise annual US alone, provided

it is a technically satisfactory evaluation, to minimise cost and radiation exposure. Patients with positive surgical margins, larger size (pT1b), adverse histological features, hereditary and multifocal tumours may also warrant more frequent imaging including contrast studies because of heightened concerns regarding local recurrence.

Ablative Therapies

Follow-up imaging is more burdensome with both RFA and CA as residual lesions can remain after apparently successful ablation. The complex features of the residual mass that frequently remains requires contrast-enhanced evaluation to verify treatment success. As with partial nephrectomy, baseline imaging with CT or MRI should be undertaken at 3 months. The intervals between subsequent studies will be dependent on findings, particularly if the ablated mass demonstrates any suspicious features. With complete resolution of the mass or a stable residuum/scar without contrast enhancement, US examination could be substituted after several years to reduce both the cost and other implications of contrast-based studies. This should be continued as recurrence can occur after even complete resolution of a post-treatment mass (Figure 1.18).

Surveillance

To date, there are no consistent criteria for either consideration of AS or follow-up imaging. Clinical judgement and patient preference favour this in selected cases where age or co-morbidities are relevant factors [22]. With solid lesions there is little need for follow-up imaging to be dictated by the need to characterise the mass as the essential trigger for intervention is size. When technically feasible, US is quite adequate to provide linear measurements in several axes. Frequency of imaging is also undetermined although initial reassessments at 3–6 month intervals may be useful for clinician and patient reassurance. Frequency can be reduced if stability of the mass is demonstrated and both the clinician and patient remain comfortable. Complex cystic lesions are more problematic and may require more detailed characterisation with contrast studies [23].

Conclusions

The increased utilisation of nephron-sparing approaches in the management of small renal masses has increased the need for follow-up imaging compared with nephrectomy. The interpretation of radiological findings has also become more challenging.

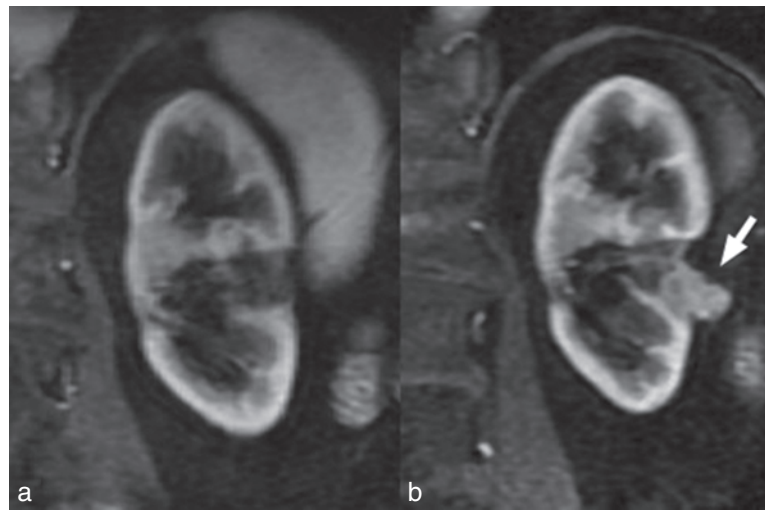

Figure 1.18 (a) No residual abnormality demonstrated at the site of laparoscopic cryotherapy at 3 years post treatment. (b) Further MRI at 4 years post treatment demonstrated an enhancing 2.3-cm mass in the mid pole of the left kidney consistent with recurrence. This was subsequently treated with percutaneous cryotherapy.

This relates to the complications and local effects of treatment as well as the risks of local recurrence and tumour progression. Serial imaging studies are frequently required which may need to be tailored to the individual patient and circumstance. It is also critical that urologists and radiologists work closely in interpreting images in longitudinal sequence because of the evolutionary nature of the changes that may occur.

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