How to characterise a solid renal mass: A new classification proposal for a simplified approach

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Abstract The reference method for characterising a solid renal mass is computed tomography, MRI and ultrasound can provide useful diagnostic information for characterising masses the cystic or solid nature of which it is not possible to determine from data from the CT scan. For characterising a solid mass, only MRI can replace the CT scan in most cases. Once a mass has been shown to be solid and vascularised and not occurring in a context suggesting an inflammatory pseudotumour, it can be put, using CT, into one of the four categories of the classification that we propose: pseudotumoral dysmorphisms (type 1); typical high-fat angiomyolipomas (type 2); suspect indeterminate tumours (type 3); typically malignant tumours (type 4).

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 Ninety per cent of all renal tumours come under five histological types: clear cell carcinoma (or conventional carcinoma), the most common, chromophobe carcinoma and papillary carcinoma, and two frequent benign tumours, angiomyolipoma and oncocytoma (oncocytic adenoma). The large number of other histological entities, some newly described, belong to the rare or extremely rare tumours of the kidney and altogether represent only 10% of all renal tumours. In semiological terms, solid renal tumours cover three entities in CT: typical benign angiomyolipomas with a macroscopic fatty component, benign or malignant indeterminate solid tumours with an atypical appearance and typical renal cell carcinomas (RCC), which are usually large conventional carcinomas. Solid RCC is the most common primitive tumour. Its appearance in imaging may vary considerably from one tumour to another, particularly depending on the size and macro-histological architecture of the tumour, its vascularisation and the presence of necrotic/haemorrhagic changes. Imaging can also distinguish a typical form of RCC.
and differentiate many atypical forms (small RCC, hypovascular RCC, homogeneous RCC, haemorrhagic RCC, etc.) that create problems for differential diagnosis, particularly with certain benign tumours (oncocytic adenoma, low-fat angiomylipoma) or secondaries (a metastasis, a lymphoma). Biopsy can play a role in characterising a renal tumour in the case of these atypical forms, modifying its management and sometimes even avoiding unnecessary surgery.

The reference method for characterising a solid renal mass is computed tomography (the CT scan). MRI and ultrasound can provide useful diagnostic information in addition to CT, especially in determining the solid nature of a renal mass, but in most cases only MRI can replace a CT scan for characterising a vascularised solid mass.

The first step in diagnosing a renal mass measuring a centimetre or more is to differentiate a solid mass from a cystic mass, for which the aetiological diagnosis is based on Bosniak’s classification. This step mainly depends on enhancement criteria after injecting a contrast agent. Renal masses of less than a centimetre usually remain indeterminate from imaging data alone. Once a renal mass has been clearly catalogued as being solid, it can be classified into the various categories of typically benign, malignant or indeterminate masses.

We propose to simplify this diagnostic process with CT classification into four types, inspired by Bosniak’s well-known classification of cystic renal masses. Like the Bosniak system, our classification aims to separate typically benign masses (types 1 and 2), indeterminate suspicious masses (type 3) and typically malignant masses (type 4), but it also proposes the appropriate management for each category and subcategory.

Definition of a solid renal mass in a CT scan

A renal mass is said to be ‘solid’ when it consists wholly or mainly of living tissue. It may be a ‘neoplasia’ or a formation consisting of ‘normal’ tissue. The two essential, necessary and sufficient criteria are the mass effect, indicated by localised disruption of the form or normal architecture of the kidney, and the significant uptake of contrast, reflecting the vascularised character and tissue nature of the mass. This tissue nature is defined in CT by variation in density, after contrast, of more than +15 units in a mass greater or equal to 1 cm and must be sought on an arterial phase (40 sec after the start of the injection) and/or at least on a nephrographic phase scan (90 sec after the start of the injection).

Indeterminate and unclassifiable renal masses

It is not always possible to determine the cystic or solid character of a renal mass. The mass effect may be present but the enhancement criterion cannot be interpreted. This is the case for microlesions of less than one centimetre and masses associated with an indeterminate density variation greater than +10 HU and less than or equal to +15 HU.

Microlesions (< 10 mm)

Renal masses smaller than 10 mm, in practice of about 5 mm and less, generally cannot be characterised in a CT scan [1,2]. Partial volume effects alter the quality of attenuation measurements contaminated by the density of adjacent tissue and, in particular, the density of the opacified renal parenchyma. The cystic nature of a microlesion can in some cases be recognised from examination of slices made prior to injection [3]. When the microlesion is spontaneously visible and hypodense compared with the renal cortex before injection of the contrast medium (water density < 10 HU or fat density < −20 HU), and regardless of its density after contrast as long as it remains lower than that of the cortex in arterial and nephrographic phases, microcysts (spontaneous density < +10 HU) or microangiomyolipomas (spontaneous density < −20 HU) can be diagnosed with very high probability (Fig. 1). When the density of the lesion cannot be interpreted in all examination phases (particularly with an appearance isodense with the parenchyma before injection), the description ‘indeterminate microlesion, with no suspect characteristics, probably cystic’ is used if this is observed in the general adult population, especially after the age of fifty, because based on frequency it indicates a benign microcyst and does not require special monitoring [1—3]. In the rare cases of hypervascular microtumours, enhancement of which in the arterial phase can be greater than or close to that of the renal cortex (Fig. 2), the beginnings of a small solid tumour may be diagnosed, generally permitting active surveillance to be proposed (a non-surgical lesion because of its small size).

When a microlesion is discovered in a patient at risk of a primary renal tumour (von Hippel Lindau disease, a history or the synchronous presence of a renal carcinoma, particularly of the papillary type), we talk of an ‘indeterminate microlesion’ and at least annual monitoring will be necessary, but in some cases, surgical removal (synchronous tumour surgery).

In this indication, MRI can be offered because, with its excellent T2-weighted contrast resolution, it allows better characterisation of the fluid component of a microcyst, which produces a clear homogeneous hypersignal, or, if there is no fluid component, the a priori solid character of the lesion is generally seen as a hypersignal in T2 weighting and as a clear hypersignal in diffusion-weighted imaging (b 800 to 1000) (with diffusion restriction on the ADC map) [4].

Variation in indeterminate density after contrast (from +10 to +15 HU)

Absence of significant density enhancement of a renal mass is defined by variation in the attenuation value of less than +10 HU, while significant enhancement can be asserted for values over +15 HU, the threshold below which density calculation may be influenced in vivo by certain artefacts (electronic noise and beam hardening) [5—7]. When a change in density from +10 to +15 HU is observed for a renal mass larger than one centimetre, it may be cystic or a poorly vascularised solid mass (Fig. 3), irrespective of its spontaneous density. Diagnosing the nature of the
lesion relies therefore on additional data from an ultrasound examination or from the MRI which characterises the water content or changed nature of a cyst better (a simple protein-rich cyst or a haemorrhagic cyst) or guides diagnosis towards a solid tumour.

**Inflammatory pseudotumours**

In the case of solid renal masses found in a context of chronic or acute urological sepsis (acute pyelonephritis, suspected septic emboli), the possibility of an inflammatory pseudotumour should lead to close monitoring to follow the evolution of the lesion during and after antibacterial treatment. These lesions are often accompanied, in addition to clinical data which may guide the aetiological diagnosis, by signs of perinephritis or perirenal infiltration by inflammatory processes (Fig. 4). Favourable clinical development should be accompanied in this case by gradual reduction in the mass and the perirenal inflammatory symptoms that often accompany it. In contrast, a true neoplasia will remain unchanged over this period (6–8 weeks) and can then be analysed (see below) and treated. This is also often the case with rare pseudotumoral focal xanthogranulomatous pyelonephritis, which is usually biopsied and treated surgically (excised) following the frequent failure of antibacterial treatment.

**CT classification of solid masses larger than one centimetre**

**Pseudotumours (type 1, no treatment or monitoring)**

Identification of pseudotumoral variants and dysmorphisms is the first step in diagnosis of a solid mass in the kidney (Table 1). The most frequent are hypertrophy of a renal column (interlobar dysmorphism), of the junctional accessory lobe (lobar dysmorphism) and segmental renal hypertrophy, generally paracortical. The abnormality seen, which is often misleading in ultrasound or CT, particularly on standard abdominal exploration (one or two phases), is composed of functional renal parenchyma. The
mass therefore has the same density as the healthy renal cortex in all phases on a 4-phase CT scan (Fig. 5). In lobar dysmorphism the mass is composed of cortex and medullary tissue with delayed enhancement. This mass, usually with sinus development, merges harmoniously with the renal cortex. These variants do not require monitoring or particular treatment.

Benign tumours (type 2, ‘2s’ surveillance or ‘2t’ treatment)

Only the typical form of renal angiomyolipoma meets the definition of type 2 of this classification. A benign nature can be diagnosed with certainty using CT when an intratumoral fat component (d ≤ −20 HU) is detected and if certain negative criteria are also present (see below) with, in particular, the absence of calcification or intratumoral necrosis (Fig. 6).

The ideal conditions for detecting particularly a small size fatty component are (Fig. 7): acquisition without injection of contrast medium using the most suitable field of view (FOV), exposure (mAs) and reconstruction (filter) settings giving preference to contrast resolution, thin slice (1–3 mm) reconstruction and use of a region of interest (ROI) suited to the size of the hypodense area on an image displayed with appropriate magnification for the size of the region measured.

If there are very small fatty islets in the low-fat angiomyolipomas, the size of the ROI must be taken into account in determining the level of diagnostic negative density. The threshold of −20 HU is associated with 100% specificity for ROIs with an area of at least 19 mm² [8] (Fig. 7). Some authors have also proposed correlating the density values with the number of pixels: a 100% positive predictive value is obtained when a total of at least 20 pixels have an attenuation value below −20 HU and at least 5 pixels for values below −30 HU [9].

The absence of calcification and necrosis associated with the presence of intratumoral fat are likewise obligatory negative criteria, ruling out the very rare possibility of a carcinoma with a fat component. Indeed, in most of the cases reported (just over twenty in all), the mechanisms responsible for the presence of macroscopic fat are bone metaplasia phenomena (involving fatty marrow and calcified bone tissue) or massive necrosis with the formation of amalgams of lipids of cellular origin [10] (Fig. 8). Two other less common mechanisms have been reported: cholesterol necrosis producing islets containing cholesterol crystals and foamy
Small indeterminate mass. CT scan before (a) and after contrast in the arterial (b) and nephrographic phases (c). T2-weighted MRI (d). a–c: small right renal subcapsular mass: its insignificant spontaneous density (38 HU) and maximum level of variation after contrast (+12 HU) does not establish the exact nature of the lesion (dense cyst versus tumour); d: MRI here provides the diagnosis of a solid tumour, showing moderate but significant enhancement and a T2 hyposignal. Histology after excision showed that it was a small papillary carcinoma.

Figure 4. Xanthogranulomatous pyelonephritis. Right renal heterogeneous mass with the appearance of perirenal infiltration, discovered in a woman in her fifties, in a context of recurrent episodes of fever and chronic inflammation (CRP and ESR increased, leukocytosis). Diagnosis was obtained using ultrasound-guided percutaneous biopsy (inflammatory infiltration with foamy macrophages) and confirmed by studying the tissue after partial nephrectomy (antibacterial treatment failed). Macrophages exclusively found in papillary carcinomas [11] and the inclusion of perirenal or sinus fat in an invasive carcinoma [10]. Consequently, the diagnosis of angiomyolipoma should be questioned and malignancy suspected where there is a large, solid, neoplastic lesion that is infiltrating and heterogeneous (suggesting a high-grade carcinoma), or, on the other hand, is encapsulated, homogeneous (except for the fatty islet(s)) and poorly vascularised (ratio of tumour/aorta enhancement in the arterial phase less than 25%, highly suggestive of papillary carcinoma) [12] and containing one or more small islets of fat.

An angiomyolipoma diagnosed according to the above criteria requires surveillance (type 2s) and sometimes treatment (type 2t) because of its risk of haemorrhage. Its vascular component may be more or less developed, resulting in some cases in the presence of dysplastic vessels and aneurysms, which are more frequent when the tumour is large (Fig. 7). Authors agree on the need to consider prophylactic surgery or selective embolisation from 4 cm in diameter, the size above which the risk of bleeding is significantly greater. The decision to treat must be discussed depending on various criteria affecting the risk of haemorrhage (the characteristics of the vascularisation of the tumour, the presence of intratumoral aneurysms and their size, the location and size of the tumour area), and also the nephritic risk (multifocality, tuberous sclerosis)
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Table 1 CT classification of solid renal masses larger than 1 cm and action to be taken by category.

<table>
<thead>
<tr>
<th>Category</th>
<th>CT diagnostic criteria (mass ≥ 10 mm)</th>
<th>Clinical criteria helping with the decision</th>
<th>Nature of the lesions</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type I</strong></td>
<td>Isodense with cortex (± medullary) in 4 phases (without and after contrast) + merging with cortex</td>
<td></td>
<td>Interlobar dysmorphosis Lobar dysmorphism Segmental hypertrophy</td>
<td>None</td>
</tr>
<tr>
<td><strong>Type II</strong></td>
<td>Intratumoral fat &lt; −20 HU (≥ 20 mm²) + No calcification + No necrosis + Size ≤ 4 cm + No intratumoral aneurysm + Large infiltrating cystic or compact hypovascular masses excluded</td>
<td></td>
<td>Angiomyolipoma (low haemorrhagic risk)</td>
<td>Surveillance (detection IIt)</td>
</tr>
<tr>
<td><strong>Type III</strong></td>
<td>Intratumoral fat &lt; −20 HU (≥ 20 mm²) + No calcification + No necrosis + Size &gt; 4 cm or intraT aneurysms + Large infiltrating cystic or compact hypovascular masses excluded</td>
<td>Young age Desire to become pregnant Exposure to trauma Previous history of haemorrhagic accidents</td>
<td>Angiomyolipoma (high haemorrhagic risk)</td>
<td>Treatment</td>
</tr>
<tr>
<td><strong>Type IV</strong></td>
<td>Encapsulated homogeneous T + scar Encapsulated T + 1 clinical criterion* + No calcification + No necrosis + Renal vein free or small central T or suspicion of secondary T/lymphoma</td>
<td></td>
<td>Oncocytoma Low-fat AGML RCC Rare T</td>
<td>Guided biopsy</td>
</tr>
<tr>
<td></td>
<td>Encapsulated homogeneous T (Enh &gt; +15 HU) or invasive T or small T + necrosis or calcification + Suspicion of secondary T/lymphoma excluded</td>
<td>History of CCC VHL</td>
<td>Conventional RCC Papillary RCC Chromophobe RCC Bellini or high-grade RCC Rare T</td>
<td>Treatment</td>
</tr>
<tr>
<td></td>
<td>Encapsulated T (&gt;T1a, 4 cm) + Necrosis + Hypervascular T (Enh &gt; +84 HU corticomedullary phase 40 sec) or T3b T3c stages</td>
<td>History of CCC VHL</td>
<td>Conventional RCC</td>
<td>Treatment</td>
</tr>
</tbody>
</table>

T: tumour; Enh: enhancement; RCC: renal cell carcinoma; AGML: angiomyolipoma; TS: tuberous sclerosis (Bourneville’s disease); VHL: von Hippel Lindau; T1a: Tumour limited to the kidney, less than or equal to 4 cm in its long axis; T3b and c: invasion of the renal vein or vena cava (TNM 2002 classification); M1: distant metastases.
Figure 5. Interlobar pseudotumoral dysmorphism (type 1 solid mass). CT scan (coronal oblique MPR) before (a) and after contrast injection in the arterial (b), tubular (c) and excretory (d) phases. Mediorenal mass, with sinus development, merging harmoniously with the renal cortex, and isodense with it at all acquisition times.

Pregnancy is very probably a risk factor for haemorrhagic rupture and must therefore be taken into account in deciding on prophylactic treatment in a nulliparous or primiparous young woman [15]. Surveillance of small angiomyolipomas of less than 4 cm is generally based on annual ultrasound examination, associated with a CT scan if the lesion progresses.

Indeterminate tumours (type 3, ’3b’ biopsy or ’3t’ treatment)

Renal tumours having neither the characteristics of a typical angiomyolipoma (type 2) nor of a typical renal cell carcinoma (RCC) (type 4, see below) are said to be indeterminate (Figs. 8 and 9). Tumours in this group are generally candidates for immediate surgery, given the high number of renal cell carcinomas in this group and their usually superficial and subcapsular location. Atypical RCCs are found, in fact, in approximately 85% of histological examinations of indeterminate tumours. A tumour belonging in this category is usually a small homogeneous tumour. Hypovascularity suggests a diagnosis of papillary carcinoma, in which maximum enhancement is less than or equal to 40 HU in 82% of cases [16]. An infiltrating form, often associated with invasion of the renal vein, suggests, from among the primitive carcinomas, a Bellini duct carcinoma or a high grade or sarcomatoid variant of conventional RCC.

The decision to take a biopsy (type 3b) in this group should be discussed in a multidisciplinary meeting. It depends on clinical and semiological factors, and also on
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Figure 6. Typical small angiomyolipoma (type 2s solid mass). CT scan after contrast in the arterial phase (a) and before contrast (b). High-fat solid tumour, smaller than 40 mm (28 mm). The intratumoral component has a typical fat density before injection (−54 HU).

Figure 7. Large angiomyolipoma (type 2t solid mass). Large angiomyolipoma (80 mm), fatty component limited to a few small islets. CT scan before (a) and after (b) contrast (arterial phase): a: density measurement of a hypodense islet in an enlarged slice (×3), with an ROI of about 5 mm in diameter (area: 20 mm²). The density measured under these conditions is typically fatty (−28 HU) before contrast; b: the value obtained after contrast (63 HU) should be considered as indeterminate, given the small size of the islet measured. Note the presence of aneurysmal arteries increasing the risk of haemorrhage of this large angiomyolipoma.

the risk level of the procedure and the operative strategy related to the size and location of the tumour.

A biopsy is usually decided on before percutaneous ablative treatment or when the decision to intervene surgically depends on definitive malignant histology, particularly if the nephritic risk is high, especially in a young or elderly subject and/or a patient with considerable comorbidities. In other cases, the classic indications for biopsy are renal tumours associated with a high probability of metastasis (multiple tumours, the possibility of primitive, particularly metastatic, cancer) or lymphoma (stage IV lymphoma is suspected, multiple renal tumours, infiltrating lesions, retroperitoneal lymph node involvement or concomitant extranodal involvement) and suspected nephroblastoma in a young adult (Fig. 10) which is not to be treated initially by surgery but by neoadjuvant chemotherapy.

In the case of a priori primitive tumours, certain criteria concerning the environment or characteristics of the tumour should, in selected cases, prompt a guided biopsy, to provide a histological diagnosis and possibly modify management of the patient. The two commonest benign tumours in this group are oncocytoma and low-fat angiomyolipoma. Other benign histologies are rare and have no semiological features orientating diagnosis.

Oncocytoma

A large oncocytic adenoma (≥ 3 cm) often includes a fibrous scar forming a clearly delineated, central or eccentric, hypodense area which is star-shaped or roughly triangular (63% of cases) [17]. Typically it is accompanied by pericapsular tumour tissue, enhancement of which is early,
Carcinomas

intense and above all, homogeneous (with no areas of necrosis) in the nephrographic phase (Fig. 11). Carcinomas have been reported with the same characteristics after contrast, related to necrotic changes or to an authentic fibrous scar (particularly in chromophobe carcinomas) [17,18]. The frequency of such an appearance in a population of large carcinomas was 4%, and only 1% if the two criteria, star-shaped hypodensity and otherwise homogeneous tumour tissue, were associated [17]. Consequently, when the two criteria are met the specificity is good (96%) for diagnosing an oncocyoma, with sensitivity of about 65% [17].

Such CT characteristics should only be considered as signs for guidance, which may provide an indication for a biopsy, especially in patients with a surgical or nephritic risk. Biopsies, which were long considered as of limited use, especially for differential diagnosis between oncocyoma and chromophobe carcinoma, now seem to provide a reliable diagnosis, with 100% accuracy in the diagnosis of oncocyoma in some series [19]. However, the emergence of a new entity, the sporadic form of the hybrid tumour, a chromophobe carcinoma containing oncocyotic components, challenges the diagnostic relevance of the biopsy or at least encourages cautious interpretation of its result. Nevertheless, in most cases, from a given size, the results obtained lead to excision to protect kidney function and avoid the risk of rupture of the tumour.

Small oncocyomas (≤ 3 cm) are usually a homogeneous mass which is spontaneously isodense or hypodense relative to the renal cortex, with early, intense, homogeneous enhancement after injection of contrast agent. The homogeneous character, which reflects the absence of necrotic changes, is not at all specific in a population of small renal tumours. In contrast, a hypovascular picture or the presence of necrotic or haemorrhagic changes or calcifications within a small tumour points to a carcinoma and makes the possibility of an oncocyoma unlikely. The presence of a central hypodense scar image is still possible, but much less common (10% of cases) than in large oncocyomas [17].

Low-fat angiomyolipoma

Certain clinical and radiological features can suggest the diagnosis of angiomyolipoma without macroscopic fat [10] and thus lead to biopsy being considered when the tumour is small (< 4 cm) and has no aneurysmal vessels producing a risk of haemorrhage. These features are as follows: the association in a clinical picture of tuberous sclerosis, the presence of multiple angiomyolipomas, particularly in young women (sex-ratio 1M/4F), a suggestive ultrasound appearance (a homogeneous hyperechoic lesion, at least as echogenic as the sinus), spontaneous hyperdensity in CT and the presence
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Figure 10. Indeterminate tumour (type 3b solid mass). Voluminous indeterminate tumour of the left kidney in a 25-year-old man. CT scan before (a) and after contrast in the arterial (b) and excretory (c) phases. The tumour is poorly vascularised (maximum enhancement: +45 HU), with no necrosis, and shows some cystic changes. The distinct appearance is that of a typical conventional carcinoma (type 4) and the young age of the patient led to percutaneous biopsy, suspecting in particular an adult nephroblastoma. The biopsy confirmed this diagnosis and led to neoadjuvant chemotherapy followed by nephrectomy.

of small hypodense islets within an otherwise homogeneous tumour (Fig. 12).

Typical renal cell carcinoma (type 4, malignant, surgical)

This category comprises the typical form of RCC which is the most frequently encountered carcinoma larger than 4 cm (at least stage T1b). In the vast majority of cases, it is a conventional clear cell carcinoma. The tumour is encapsulated (well circumscribed), heterogeneous and has two components: solid, hypervascularised tissue, and necrotic or haemorrhagic necrotic, avascular tissue. In the typical

Figure 11. Indeterminate tumour (type 3b solid mass). Left, upper pole, homogeneous, encapsulated renal tumour with the appearance of a central star-shaped scar suggesting an oncocytoma. Biopsy was decided to establish a virtually certain histological diagnosis, useful for planning the surgical excision which is still generally indicated in cases of oncocytoma. Histological examination of tissue after upper polar partial nephrectomy confirmed the diagnosis.
Figure 12. Indeterminate tumour (type 3 solid mass): a: ultrasound: very hyperechoic solid tumour of the left kidney in a 42-year-old woman who had several small typical angiomyolipomas; b: injected CT scan: the lesion is homogeneous, without necrosis and highly vascularised; c: CT scan before contrast: the lesion is spontaneously, discreetly, hyperdense relative to the renal cortex. All of these features strongly point towards suspecting a low-fat angiomyolipoma with a definitive diagnosis only obtainable by biopsy.

form, injection of contrast agent produces early, intense density enhancement (+106 HU ± 48), similar to that of the renal cortex in the corticomedullary vascular phase (30 to 40 sec after the start of injection) [20] (Fig. 13). The specificity of enhancement greater than the threshold of +84 HU in the early corticomedullary phase is 100% and its sensitivity 74% for the diagnosis of conventional RCC [20]. Contrast enhancement occurs in the vascularised fleshy areas of the tumour, defining areas of necrosis not enhanced by the contrast agent. These form hypodense areas of variable size and shape with irregular boundaries, generally centrally located but with no specific arrangement (e.g. stellate or like the spokes of a wheel). Eccentric areas of necrosis in the ring of tissue are frequently found and

Figure 13. Typical conventional carcinoma (type 4 solid mass). Large encapsulated, necrotic tumour, where the solid component is the site of intense enhancement (similar to that of the renal cortex, +118 HU) in the arterial phase. Histology after radical nephrectomy showed a conventional carcinoma.
usually mean that the tumour is irregularly distributed (Fig. 13).

Some very characteristic but inconsistent features can also be involved: the presence of intratumoral calcifications (about 30% of RCCs), which are typically central and irregular, and the invasion of the renal vein and inferior vena cava (23% and 7% of cases, respectively) [21]. These two features alone are almost pathognomonic of an RCC, given a solid renal tumour, irrespective of its enhancement characteristics after contrast.

Conclusion

Diagnosis by imaging of solid renal masses depends basically on CT results. MRI can replace the CT scan when there is a serious contraindication to iodinated contrast agents or exposure to ionising radiation. It does not provide any additional useful information for the aetiological diagnosis of an authentic neoplasia.

On the other hand, MRI and ultrasound are indeed useful for characterising renal masses, the cystic or solid nature of which remains indeterminate in CT scan data alone.

Once a renal mass has been shown by CT to be solid and vascularised and not in a context suggesting an inflammatory pseudotumour, it can be classified based on robust semiological data into one of the four categories of the diagnostic algorithm that we propose: pseudotumoral dysmorphisms (type 1), typical high-fat angiomyolipomas (type 2), suspect indeterminate tumours (type 3) or typically malignant tumours (type 4). The action to be taken in types 2 and 3, unlike for types 1 and 4, is not unequivocal; it depends on currently well codified criteria leading to angiomyolipomas to be treated (type 2t) being separated from those requiring only simple surveillance (type 2s), and indeterminate tumours needing to be biopsied (type 3b) being differentiated from those for immediate surgery (type 3t).

- Pseudotumoral renal dysmorphisms behave like the renal parenchyma on a 4-phase CT scan (with and without contrast).
- The presence of fat in a typical angiomyolipoma is defined by a component with a clearly negative density of less than −20 HU and sufficient volume (from 20 mm³).
- The rare possibility of a carcinoma with a fatty component must be borne in mind and suspected if there is calcification, necrosis and a poorly vascularised cystic lesion which is infiltrating or compact.
- Typical cancers are large, encapsulated tumours (>4 cm) with a solid hypervascularised (early enhancement >84 HU), necrotic component.
- Tumours that do not meet the criteria of a typical carcinoma or angiomyolipoma are said to be indeterminate.
- Indeterminate tumours are usually malignant and require immediate surgery.
- Biopsy of an indeterminate tumour is indicated in selected cases based on clinical, semiological and operability criteria discussed in a multidisciplinary meeting.

**TAKE-HOME MESSAGES**

- Negative CT enhancement is defined by a variation after contrast of less than +10 HU.
- CT enhancement is significant when it is greater than +15 HU.
- A solid tumour over 1 cm in size is defined by significant enhancement.
- A mass with contrast variation of between +10 and +15 HU is indeterminate regardless of the spontaneous density of the lesion.
- ‘Indeterminate’ masses in a CT scan are tumours or dense atypical cysts.
- Characterisation of a solid renal tumour usually leads to the lesion being classified in one of the four categories: pseudotumours; typical angiomyolipomas; indeterminate tumours; typical carcinomas.

![Figure 14. Left renal ultrasound.](image)

**Clinical Case**

This left renal mass was discovered in a 76-year-old man during an abdominal ultrasound examination. The patient has renal impairment (creatinine clearance: 40 ml/min) and lost his right kidney after a road accident. The ultrasound finding concluded that there was a possibility of interlobar dysmorphism (Fig. 14), but recommended a renal CT scan (Fig. 15).
Questions

1. Is the CT scan used here in this indication appropriate and sufficient? Give reasons for your answer.
2. How would you classify the mass?
3. What would you propose to do? Give details of the management.

Answers

1. Yes, because the tubular phase (90 sec) here would not have modified the result given the appearance of the lesion (hypodense compared with the cortex) in the excretory phase (Fig. 15c).
2. Type 3, indeterminate tumour.
3. A biopsy (type 3b), given the high nephritic risk, the non-negligible probability of a benign histology (oncocytoma in particular) and the mode of treatment (minimally invasive percutaneous) that can be offered. Management depends on the results of the biopsy: (1) a renal cell carcinoma would be treated by radiofrequency (reduced nephritic risk); (2) an oncocyto ma could be monitored in view of the patient’s age and the nephritic risk.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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