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Radiologically-guided thermal ablation of renal tumours

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Abstract Thermal ablation techniques for renal tumours have become the norm in surgically at-risk patients. These percutaneous treatments are locally effective, particularly for tumours measuring less than 4 cm. Larger tumours may be treated by adapting the technique and strategy. Multidisciplinary discussion is essential before any decision, in order to decide on the most appropriate technique. Radiofrequency is simple, effective and inexpensive. Cryotherapy is more complex and should be preferred when the tumour is large or there is vascular or urinary tract contact. Microwaves can be used to treat larger tumours. Morbidity is low, but good knowledge of these techniques and of dissection is required to avoid injury to neighbouring digestive or urinary structures.

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Over the last few decades, the increasing use of imaging in many diseases has profoundly altered the natural history of kidney cancer. Nearly 50% of kidney cancers diagnosed are currently discovered by chance [1]. This has meant earlier detection of often small, renal tumours, and in 70 to 80% of cases, while they are still in a non-metastatic stage [2,3]. These changes in presentation and prognosis have considerably modified the management of renal cell carcinomas (RCC), particularly over the last ten years, with the development of nephron-sparing techniques replacing open surgery. The initial technique of laparoscopic partial nephrectomy has been supplemented by the techniques of laparoscopic thermal ablation, including the use of radiofrequency (RF) and cryoablation. However, some patients with small kidney cancers cannot tolerate a surgical procedure, because of advanced physiological age, comorbidities, or already precarious renal function. For these patients, a percutaneous approach using thermal ablation is gradually predominating.

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particularly because the equipment and techniques have developed to be ever more efficient in terms of sparing renal function and being less invasive for these fragile patients. This review does not set out to explain the principles of the various thermal ablation techniques (RF, cryoablation, microwaves, laser and focused ultrasound), already widely described in the literature, but aims rather to give the benefits, limitations, complications and performance reported, and the principles of post-treatment monitoring.

Guidance methods
A percutaneous approach is required in the majority of thermal ablation indications and techniques. However, the laparoscopic route, which is effective in oncological terms [4], is still suggested for tumours at risk due to their topography, particularly in an anterior position and therefore difficult to access via a posterior approach, justifying direct visual control during thermal ablation. Apart from its less invasive character, the advantages of the percutaneous approach are less pain, immediate verification, which is possible using CT, MRI or ultrasound, a shorter period of hospitalisation [5] and reduced overall cost [6]. In his meta-analysis of 46 studies from 1996 to 2006, Hui et al. [5] concluded that percutaneous radiofrequency is safer and as effective as laparoscopic radiofrequency, with complication rates of 3.1% and 7.4% respectively, for identical secondary efficacy of 92% at 5 years.

CT guidance is currently best for localising the tumour and controlling the procedure. The limits and relationships of the tumour to be treated can be precisely determined, but nevertheless it can be adversely affected by the patient's breathing movements, which justifies positioning the applicators during anaesthesia. At the end of the procedure, it can help in looking for immediate complications before the patient is transferred to the recovery room. However, because of the risks of using iodinated contrast agents and the frequent need for an injection of contrast agent before thermal ablation, to identify the relationships of the lesion, identifying enhancement of tumour remnants at the end of the session can be difficult. This may prevent any further treatment during the same period of anaesthesia. As an alternative, or associated with CT, ultrasound guidance has proved to be feasible and to provide good procedural safety [7,8] and can be an effective aid for fast and accurate positioning of the applicators. It is nevertheless limited by the generally narrow acoustic window; in the same way, the formation of hyperechoic gas microbubbles at the treatment site alters the ultrasound window [9] in radiofrequency therapy, and the formation of ice is a source of reflection during cryotherapy. Finally, MRI guidance provides real-time monitoring of the ablation site, either by conventional T1-weighted sequences or without contrast, by T2 sequences or by thermometry sequences [9]. This technique is however limited by restricted accessibility and MRI compatible equipment.

Performing biopsies
At the time when surgery was the only therapeutic option for a solid renal mass, biopsies were limited to lesions suspected of being renal metastases, lymphomas or abscesses, or when histological analysis was needed because of metastatic development of a cancer or tumour which could not be immediately resected [10]. Heilbrun argued that pre-operative biopsies did not provide additional information for confirming the malignancy of lesions when the characteristics of malignancy were typical in pre-operative imaging [11].

When thermal ablation treatment is to be undertaken, on the other hand, pre-treatment biopsy seems to be justified, firstly because there will be no postoperative surgical specimen, secondly because nearly 20% of T1 tumours are estimated to be benign (particularly when less than 3 cm [12], with up to 44% of tumours less than 1 cm being benign [13]) and thirdly because of the value of grading the lesion and obtaining a molecular analysis for determining a prognosis. This is all the more justified now that the rate of false-negative biopsies is in the order of 1%, with an incidence of symptomatic complications of less than 2% [14]. In certain special cases (e.g. von Hippel Lindau disease, a recent history of RCC), a biopsy is not essential. Similarly, for cystic tumours, the risk of malignancy can currently be evaluated using Bosniak’s classification and the resulting therapeutic choices assessed [2].

Two approaches should be discussed if it is decided that a biopsy is indicated. A biopsy performed during the same session as the ablation certainly has the advantage of saving time and being more comfortable for the patient. However, due to the significant proportion of biopsies that have proved negative or shown a benign lesion and have led to treatment without any histological evidence or even treatment that was unnecessary, biopsy is now proposed during a procedure prior to thermal ablation. This provides a sample contributing to the decision before treatment [15] but can put constraints on patients who may require adjustment to their anticoagulant or antiplatelet medication.

Clinical results
Thermal ablation using radiofrequency
Since Zlotta et al. [16], many studies have reported the efficacy of radiofrequency ablation (Fig. 1) on RCC, even though long-term studies are not yet available. Local recurrence-free survival at 5 years is in the order of 89 to 92% [17,18] and most authors agree on the fact that most recurrences appear during the first year [19]. However, recurrences can occur several years after what was considered to have been complete treatment of the lesion [20], although after three years they are still rare [21]. In a long-term follow-up of a mean of 61.6 months in a population of 31 patients, Levinson describes only three in situ recurrences, all occurring before 31 months, and no metastatic development [22]. Primary efficacy is 67 to 100% [17–19,23]. This wide heterogeneity of results can be explained particularly by very variable follow-up times and tumour sizes. Nevertheless, the proportion of conversions to surgery is low, with a mean of 1.6% in the literature, because repeating radiofrequency procedures is not described as a technical challenge; it is used in a mean of 8.5% of cases [24]. The secondary efficacy of radiofrequency treatment seems much more
informative and representative of the contribution of the technique to oncological control, with values between 90 and 100% [17,21,22,25,26]. In a small series, comparing 37 patients treated by partial nephrectomy with 40 patients treated by percutaneous or laparoscopic radiofrequency, Stern found no significant difference in recurrence-free survival at 3 years for T1a tumours, with respective levels of 95.8% and 93.4% [27]. In radiofrequency thermal ablation, the size and sinus extension of the tumour to be treated can increase the risk of technical failure [25]. In a series of 104 patients and 125 tumours, Zagoria was able to treat all cancers measuring less than 3.7 cm completely. The survival rate without recurrence fell to only 47% for tumours over 3.7 cm in size. For tumours larger than 3.6 cm, this author described a risk of recurrence increased by a factor of 2.19 for each additional centimetre. The recurrence-free survival rate was not however influenced by sex, the side or cranio-caudal topography of the tumour. Zagoria found no significant difference whether the site of the lesion was exophytic, parenchymal, central or mixed [19]. Gervais, in a series of 85 patients and 100 tumours, identified tumour size of less than 3 cm and a non-central location as independent factors of primary efficacy. Only the non-central site of lesions is described as an independent factor of secondary efficacy. Gervais emphasised that the choice of a size limit for treatment is not unequivocal. In his series, a cut-off at 4 cm produced treatment that was 90% complete, while excluding 15% of patients who could have benefited from effective treatment. A cut-off at 5.8 cm would mean 99% of patients could be treated completely, but with a short-term success rate of 63% [17]. At present, these results need to be confirmed in series with long-term follow-up.

**Cryotherapy**

The first use of cryoablation to treat renal tumours (Fig. 2) was reported in 1995 [28] and was initially performed by laparoscopy (65%) [29]. The percutaneous approach has only developed recently owing to a reduction in the size of cryoprobes. The basis of this ablation technique is the destruction of tumour cells using freeze/thaw cycles. During the freeze part of the cycle, the formation of ice crystals denatures the intracellular proteins, breaks up cell structures and modifies cell membrane function. Subsequently, after increasing the intracellular osmotic pressure, an inflow of water occurs during thawing resulting in the tumour cells bursting [30]. A major advantage of cryoablation is the ability to monitor the ablation zone in real time [31,32] by
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Figure 2. Cryoablation of a left renal papillary tumour in an anterior exophytic location, near the tail of the pancreas, in a patient with a history of contralateral nephrectomy: a: left anterior renal tumour in a CT axial slice with injection (arterial phase); b: renal mass in a sagittal slice with injection (cortical phase); c: cryotherapy with visualisation of a needle and dissection with CO2 to displace the digestive structures: axial CT without injection; d: cryotherapy: the 3 cryoprobes and the CO2 dissection are visible on this oblique coronal CT scan; e: control after the procedure, in an axial slice comparable to figure c; f: control in an oblique coronal slice showing the hypodense extension of the ice after removal of the cryoprobes, comparable to figure d; g: MRI control at 6 months showing the post-ablation necrotic-haemorrhagic changes, with a typical T2 hyposignal halo in this axial slice; h: absence of enhancement on this T1-weighted axial MRI with injection.
Figure 2.  (Continued).

Figure 3. Microwave thermal ablation of an upper polar tumour (clear cell carcinoma) of the left kidney: a: CT axial slice with injection of contrast agent in the arterial phase; b: comparative coronal slice with injection of contrast agent in the arterial phase; c: comparative sagittal slice, with injection of contrast agent in the arterial phase; d: treatment with microwaves, with an applicator positioned in the mass: CT axial scan without injection; e: applicator positioned in the centre of the lesion on this coronal scan; f: control CT axial scan, with injection (arterial phase) at 6 months, showing neither recurrence nor any remnant; g: control CT scan with injection: comparative coronal slice. (Acknowledgements to Dr Régis Hubrecht, centre hospitalier de Pau, France.)
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visualising the physical changes caused by freezing, whether using CT, MRI or ultrasound. This is particularly useful when the lesion to be treated is close to sensitive organs or structures. Another advantage is that there is no denaturing of protein, as in hyperthermic treatment, in the architecture of supporting tissues, particularly urothelial tissue, which is therefore conserved. In Kunkle’s meta-analysis [29], the primary efficacy of cryotherapy was better than that of RF treatment, with a reoperation rate of 8.5% for RF versus 1.3% for cryotherapy ($P < 0.0001$). The local tumour progression rate was significantly higher for RF (12.9% as against 5.2% ($P < 0.0001$)) for cryoablation. Moreover, the frequency of metastases was reported to be lower for cryoablation (1.0%) than for RF (2.5%, $P = 0.06$) during monitoring.

**Microwave thermal ablation**

Microwave ablation is a thermal ablation technique that is currently used for the treatment of hepatocellular carcinoma or lung carcinoma [33], but its use in kidney cancer is still being evaluated (Fig. 3). The potential benefit of this technique [34] is ablation that is not limited by desiccation, carbonisation or thermal convection [35]. As a consequence, the temperature obtained is high, and can result in a larger ablation zone being treated in less time.

After adjusting the technique, Clark et al. [36] gave 10 patients microwave treatment before nephrectomy. Histological analysis showed uniform cell death in the ablation zone. Liang et al. [33] recently reported the results of a feasibility study in which 12 patients were treated with no remnant or recurrence at a mean follow-up of 11 months. Carrafiello et al. [37] also performed 12 successful procedures, with a mean follow-up of 6 months [3–14]. It is however necessary to analyse complications, tolerance and efficacy in the medium term.

**Focused ultrasound ablation**

Many experimental studies have been performed on the kidney in animals (Fig. 4). In contrast, clinical applications are still in the very early stages and no recent review of clinical studies has been published. Nevertheless, such applications were initiated very early on because of the totally non-invasive character of this technique. In the 1990s, a study [38] including eight patients treated pre-operatively showed thermal ablation lesions. More recently, Marberger et al. [39] treated 16 patients, again pre-operatively, but considerably underestimating the volume of the lesion induced (only 15 to 35% of the target volume). The results were only analysed for the 10 of the 13 patients treated by
Figure 4. Focused ultrasound thermal ablation performed during a large animal experimental procedure: a: positioning the transducer, with the red triangle showing the focusing cone. The transducer is visible at the bottom of the image (arrow), on a T1-weighted axial MR image; b: determination of the focal point (arrow) on the T1-weighted sagittal MR image; c: temperature MRI (proton resonance frequency (PRF) method) controlling heating at the focal point in real time, merged with a sagittal T1-weighted gradient echo MR image; d: thermal dose mapping merged with a sagittal T1 gradient echo MR image; e: control following ablation at the same level by T1-weighted MRI (sagittal slice) after injection, showing the ablation area which is not enhanced; f: control T2-weighted TSE MRI (sagittal slice) showing necrotic-haemorrhagic changes as a T2 hyposignal; g: apparent diffusion coefficient (ADC) mapping in a sagittal slice showing diffusion restriction of the treated area.
Wu et al. [40] who were being given palliative treatment. In the Oxford group series, complete treatment was demonstrated, in five cases out of 10 [41], only when the tumour was completely accessible via the subcostal route, which further emphasises the problem of acoustic interfaces. These issues have been discussed in a recent general review [42]. This author also highlights the problems of positioning the focus during respiration, since, even if the shots are made during apnoea, each shot must be repositioned relative to the others to the nearest millimetre, to avoid leaving intervals of untreated tissue. Technical solutions have nevertheless recently been proposed [43–45] to improve control of the energy applied, thus opening up new prospects.

Complications

In addition to its oncological efficacy, the low morbidity of percutaneous thermal ablation is a major asset for the treatment of kidney cancer in patients who are poor candidates for surgery because of their comorbidities [46]. The rates of complications for thermal ablations reported in the literature are very variable, between 4 and 37%, because of an absence of standardisation in grading the side effects [47], which have mainly been described for radiofrequency and cryotherapy techniques.

Bleeding

A perirenal haematoma is the most common complication, in 0 to 30% of cases depending on the series [17,48,49], and particularly concerns procedures performed using cryotherapy, even if more evidence must be obtained from large series. These haemorrhages are usually minor and asymptomatic and do not justify special monitoring. The risk of major bleeding with a fall in erythrocyte count and the need for transfusion is rare, in the order of 0 to 2% in the literature [17,19]. The risk of bleeding is increased in patients receiving non-interrupted antiplatelet therapy or if the lesion is close to a vascular pedicle. It can be prevented by good vascular screening before the procedure and with rapid, optimal positioning of the electrode. Gross haematuria, at the end of the procedure, is a rare event occurring in 0 to 2.5% of cases [50]. This should not be considered an alarm signal, especially if the urine gradually clears within 12 hours [51]; this risk will be greater in the case of a central tumour [51,52].

Figure 5. Digestive complications of the ablation procedures: a: left renal mass on the only kidney (arrow) in a patient with a history of ipsilateral ablation (dotted arrow); b: radiofrequency with deployable needle: CT axial scan without injection; c: enhancement within the ablation zone (hyposignal), corresponding to leakage of excreted contrast medium on this T1-weighted MRI with injection and subtraction; d: fistulation of the colon shown by a hypersignal in the intestinal tract in the later phases after injection, in T1-weighting with subtraction. Secondary infection of the ablation zone led to nephrectomy and dialysis for this patient.
Pain and neuromuscular weakness

This is usually temporary [19] and uncommon, being described in 4.5% of cases [20,26], and results from lesions of the lumbar plexus, subcostal or genitofemoral nerves, which pass close to the lower pole of the kidney and the psoas muscle [9,51,53]. Posterior approaches passing close to the anterior surface of the psoas muscle are most at risk.

Pneumothorax

The incidence of pneumothorax is 1 to 2% [19,50]. In most cases, these pneumothorax are minor, well tolerated and do not justify drainage [54]. Approach through a pleural recess is sometimes anticipated and unavoidable for tumours which are difficult to access [54].

Risk factors

The rate of major complications is generally in the range of 0 to 6% [7,17–19,25]. In a meta-analysis of minimally invasive radiofrequency and percutaneous cryotherapy procedures, Hui et al. reported 3.1% of serious complications [5]. The various studies in the literature describe variable statistical ratios between the different tumour parameters and the risk of major complications, which can be explained by their low incidence. In a series of 71 patients with 87 tumours and a rate of major complications of 4.6%, Velti et al. found that an exophytic location played a protective role [25]. Zagoria et al., in a series of 104 patients with 125 tumours and a rate of major complications of 2.9%, did not report any changes in the rate of complications related to the location of the tumour, the patient’s sex or even the size of the lesion [19]. In a series of 24 patients with 32 tumours and a rate of major complications of 16.6%, Weizer found that this rate increased when several tumours were treated during the same session [55].

Thermal lesions of the digestive tract

A major complication to be feared, and specific to hyperthermic ablation treatments, is the result of thermal injury to adjacent organs, including the digestive tract. It is rare, with a mean of between 0 and 1% in the series [17,20,48], and can appear with a free interval of several days, threatening the life of the patient and requiring emergency surgical management because of the risk of perforation and septic complications. The colon, particularly exposed in the case of upper pole and anterior tumours [55], seems to be most at risk of thermal injury (Fig. 5). The stomach, probably
Lesions of the urinary tract

The upper urinary tract is particularly exposed during treatment of central tumours by hyperthermic ablation techniques (Fig. 6), in contrast to cryotherapy, but these complications are rare [51], less than 4% in the literature [17,19,50,55]. In the acute phase, a ureteral injury may appear as a perforation with formation of a urinoma. The symptoms may appear several months later as ureteral stenosis, with the risk of recurrent urinary tract infections, hydronephrosis and impaired renal function, necessitating fitting of a double J stent, a nephrostomy or a ureteral stent [58]. It is necessary to prevent these complications, particularly for central and lower pole tumours, where the minimum safety distance from the ureter is less than 15 mm, and often requires the use of cryotherapy. However, pre-operative fitting of a ureteral catheter with per-operative pyelocaliceal irrigation using a non-ionic 5% glucose/sterile water mixture [58] which is not modified by the RF waves can be discussed. The corollary to preventing pyeloureteral thermal injury by this way is the possible decrease in the efficacy of the thermal ablation by the ’’heat-sink effect’’.

Infection

Despite taking aseptic measures, the risk of infection (Fig. 7) is not negligible, being in the order of 0 to 2% in the series [7,25]. Diabetes increases the risk of sepsis [51].

Figure 7. Infectious complications of thermal ablation: a: radiofrequency ablation of a left lower pole renal mass: pre-treatment coronal T1-weighted MRI with injection; b: secondary infection of the ablation zone: CT coronal slice with injection; c: control examination 2 months after antibiotic treatment: T2-weighted MRI (axial slice); d: control examination 2 months after antibiotic treatment: T1-weighted MRI with injection of contrast agent (comparative axial slice); e: control examination 6 months after antibiotic treatment: T2-weighted MRI (axial slice) showing regression of the infected ablation zone; f: control examination 6 months after antibiotic treatment: T1-weighted MRI with injection of contrast agent (comparative axial slice).
Tumour dissemination

Studied in radiofrequency ablation, tumour dissemination along the applicator path is exceptional, as only two cases have been reported in the literature [59]. To minimise this risk, the electrode must be positioned optimally in a direct path, and the path of the needle should be treated at the end of the procedure; this can also reduce the risk of bleeding [51].

Surveillance and follow-up imaging

It is essential for patients to be monitored for remnants or recurrences. Although a biopsy is the gold standard, it is an invasive procedure, the usefulness of which is controversial.

Normal appearance in imaging

Monitoring by imaging is nowadays essential. The appearance of an ablation site evolves with time in a normal and relatively predictable way. Several changes occur, particularly the size of the site: a clear increase in the volume of the site treated by heat ablation appears early in the following week and the first 2 months after the procedure, particularly for small tumours of less than 3 cm³ [60]. Then, the scar volume gradually decreases over 1 to 2 years.

In a CT scan, the density of the treated area, the site of coagulation necrosis, is and remains spontaneously denser than the adjacent renal parenchyma. No contrast uptake can be identified. However, in a series of 36 radiofrequency-treated tumours, Javadi described significant homogeneous enhancement, greater than 10 HU, visible in the
parenchymal phase, on a control on D0 of the radiofrequency sites, which improved over time in 78% cases [61].

In MRI, the treated site is heterogeneous, generally with a T1 hypersignal and a T2 hyposignal without contrast uptake (Figs. 8 and 9). A thin ring of peripheral enhancement can be seen on late acquisitions throughout follow-up, with no suspicious character, probably related to inflammatory changes.

In both CT and MRI, infiltration of peripheral fat is almost systematic, especially with exophytic tumours [53]. A spontaneously dense peripheral halo with a T1 hyposignal has been reported in nearly 75% of cases; it appears during the first months and often persists [62]. Fat invagination into the scar is less common and occurs later [60]. MRI has no particular advantage over CT apart from not requiring injection of an iodinated contrast agent; it should therefore be preferred in cases of renal impairment.

As for cryotherapy, there is no precise description of the ablation zone, the volume of which tends to decrease over time; MRI shows a clear T2 hyposignal ring [63].

**Tumour residue and local recurrence**

The presence of focal nodular contrast enhancement is still the only validated marker of living residual or recurrent tumour tissue and involves acquisition first without injection of contrast agent and then with this injection.

In the CT scan, enhancement is evaluated qualitatively and quantitatively. Any contrast enhancement of the radiofrequency site of more than 10HU [19] or 15HU [64] must be considered significant, suggestive of a residual or recurrent local tumour. Any complication due to local infection may make this analysis difficult.

In MRI, because of the T1 hypersignal from the ablation site, subtraction techniques must be widely used to detect or eliminate focal enhancement. Quantitatively, enhancement is considered significant if it exceeds 15% on the dynamic sequence [19,65].

Some authors have evaluated the feasibility of contrast-enhanced ultrasound (SonoVue®, Bracco, Milan, Italy) during monitoring, instead of CT or MRI [66], with a possible limit for hypovascularised and/or deep tumours for which this examination may be found wanting as regards detecting living tumour tissue. This technique is to be preferred in patients with severe renal impairment, in whom injection of iodinated or gadolinium chelate contrast agent is contraindicated.

There is no recommendation on follow-up in terms of examination dates, but there is some consensus in the literature. Follow-up is generally frequent during the first year.
following the ablation [67], with three to four examinations gradually more widely spaced: at 2, 6 and 12 months or at 1, 3, 6 and 12 months. An annual follow-up is then recommended for 5 years or even longer.

Nephron-sparing measures

Sparing the kidney is the objective at the forefront of RCC management. Besides in familial diseases, such as von Hippel Lindau disease, in which the high frequency of synchronous and metachronous cancer sites requires multiple treatment with progressive reduction in kidney reserves, it has been shown that progression towards chronic renal disease is associated with increased mortality [68].

Many studies agree in demonstrating the absence of significant impairment of renal function at 1 month and 1 year for patients treated for a single tumour [22,25,69]. In a series of 242 patients, Lucas observed preservation of renal function after radiofrequency and partial nephrectomy which was significantly higher than for total nephrectomy surgical techniques, with a rate without appearance of chronic renal impairment after 3 years of 95.2%, 70.7% and 39.9% respectively [70].

Raman compared 47 patients who had had a solitary kidney treated by radiofrequency with 42 treated by open partial nephrectomy, with mean tumour sizes of 2.8 and 3.9 cm respectively, mean renal function of 46.5 mL/min and 55.9 mL/min respectively and mean follow-up of 18.1 and 30 months. Decline in renal function was significantly higher in patients treated with conservative surgery than in patients treated by radiofrequency, both soon after the procedure (15.8% versus 7.1%), at 12 months (24.5% versus 10.4%) and at the last follow-up (28.6% versus 11.4%; P < 0.001). The proportion of patients who, during follow-up, developed moderate (CrCl < 60 mL/min) and severe (CrCl < 30 mL/min) renal impairment was 0% and 7% respectively for patients treated with radiofrequency as against 35% and 17% where treatment had been surgical [71].

A recent study [53], reviewing 24 thermal ablations (radiofrequency and cryoablation) on kidney, transplants showed no change in renal function following the procedures.

Conclusion

Apart from the need for large-scale validation of newly developing techniques such as microwaves and focused ultrasound, the long-term results of radiofrequency and cryotherapy ablations need to be confirmed. Nevertheless,
given the low morbidity of these techniques and the excellent oncological efficacy reported in the management of kidney tumours of less than 4 cm, enlarging the indications to a wider population can be envisaged. Prospective studies comparing thermal ablation with the reference treatment, which is still surgery, must now be undertaken.

**TAKE-HOME MESSAGES**

- General points on the thermal ablation of renal tumours
  - Thermal ablation techniques can be proposed for renal tumours as an alternative to surgery.
  - These techniques are effective, with results comparable to those of partial nephrectomy, and they preserve kidney capital.
  - Morbidity is low if precautionary rules are followed, particularly concerning adjacent organs (the digestive or urinary tract).
  - Radiofrequency thermal ablation is simple, effective and economical.
  - Cryotherapy allows the ablation zone to be controlled and appears to be particularly useful for treating central tumours, as it does not damage the supporting urothelial tissue.
  - Microwave ablation allows larger ablation zones to be treated.
  - The use of focused ultrasound is still to be defined.

Follow-up after thermal ablation
- Regular follow-up is necessary (at 2, 6 and 12 months during the first year).
- This may be with ultrasound, CT or MRI.
- Injection of a contrast agent is required to detect remnants or recurrences that are hypervascularised.
- Interpretation may be hindered by necrotic-haemorrhagic changes that give a T1 hypointense and T2 hypointense in MRI, and are spontaneously dense in a CT scan. The T1 hypointense signal requires subtraction sequences to be undertaken after injection of a contrast agent in order to detect early contrast uptake.

**Clinical case**

This 86-year-old woman presented a 32 mm left renal tumour (Fuhrman 2 clear cell carcinoma) (Fig. 10a). Considering the age and general condition of the patient, radiofrequency thermal ablation was decided in a multidisciplinary meeting.

The procedure was performed under CT guidance and general anaesthesia (Fig. 10b) without complication. The patient was reassessed by MRI some time after the procedure (Fig. 10c: 1, 2).

**Questions**

1. What follow-up should be proposed after this thermal treatment?
2. Is an injection at the time of the examination needed for this surveillance?
3. What is your diagnosis and what management, if necessary, do you recommend?

**Answers**

1. Follow-up using imaging should be offered systematically. The technique used must be adapted to each case, using ultrasound, CT or MRI particularly depending on the contraindications (especially renal impairment). Ideally, the examinations will be performed at 2, 6 and 12 months during the first year, then annually if there is no recurrence.
2. Injection of a contrast agent is essential for identifying a residual tumour or an in situ recurrence, because images contain artefacts due to necrotic-haemorrhagic changes secondary to thermal ablation.
3. The control MRI shows a T2 hypersignal and above all peripheral uptake of contrast, corresponding to tumour remnants, and not recurrence, for this was detected during the first follow-up examination and was secondary to incomplete treatment (due to the size of the lesion or the technique used). Primary efficacy was not good, therefore, in this case. A new procedure had to be proposed as a first course of action, in order to complete the treatment, taking into account the limits of the first technique used. Cryotherapy treatment was proposed and performed in this patient. Given the efficacy of this second procedure on the control examinations, the secondary efficacy of the thermal treatment overall (radiofrequency then cryotherapy) was, in the end, good.

**Disclosure of interest**

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

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