Radiofrequency ablation of renal tumours

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The widespread use of cross-sectional imaging has led to a dramatic increase in the detection of small (<4cm) solid renal masses. The majority (65-80%) of these tumours are renal cell carcinomas (RCCs) when pathologically analysed. Therefore, patients presenting with these lesions are counselled on all available treatment options, including active surveillance, radical nephrectomy, nephron sparing surgery and needle ablative techniques.

Although radical nephrectomy still remains the standard of care for localised renal tumours, their relatively benign clinical course has generated an increase demand for nephron-sparing approaches. Open partial nephrectomy preserves renal mass but is associated with prolonged convalescence and a complication rate of approximately 30%. Laparoscopic partial nephrectomy is a less invasive approach with more rapid recovery than open surgery but, unfortunately, is associated with even more complications and more adverse effect on renal function.

On the other hand, in situ ablation methods such as radiofrequency ablation (RFA) have clear potential benefits compared with the extirpative approach. They include a decreased complication rate, shorter convalescence, absence of an ischemic period for the kidney and the use of conscious sedation instead of general anaesthesia. These potential benefits are clearly desirable in the increasingly older, sicker patients who represent a growing proportion of patients with incidental renal tumours.

This article will briefly discuss RF technology and the indications, various approaches, results and current limitations of RFA in the management of RCCs.

Radiofrequency ablation technology
Radiofrequency ablation is the application of electrical current in the radiofrequency range to produce cell death. The energy is applied via needle electrodes designed for this purpose. In general, grounding pads are placed on patients’ thighs or back and the RF probe is inserted and deployed under imaging guidance in the ablation zone. A radiofrequency generator provides an alternating current which causes ion agitation in the vicinity of the electrode tip. This ion agitation in turn results in tissue heating. Once the temperature exceeds 45°C cell death occurs, although not at levels sufficient for complete tumour necrosis. Ideal temperatures for RFA of soft tissue tumours ranges from 60°C to 100°C. Further temperature increases can be counterproductive, as vaporisation and carbonisation of tissue occur at temperatures from 100 to 105°C.

Vaporisation and carbonisation increase the impedance of the thermal lesion produced. Commercially available RFA units are broadly classified into temperature-based (eg Talon and Starburst Electrodes, RITA Medical Systems, Mountain View, CA, USA) and impedance-based systems (eg Leveen electrode, Radiotherapeutics-Boston Scientific, Watertown, MA, USA). This means that the generator provides energy to the probe based on either the average temperature achieved at the tissue or the measured impedance of the soft tissue during ablation.

Indications for RFA of renal tumours
According to NICE, the procedure should be offered to patients with small (<4cm) renal tumours who are unsuitable for surgery or who refused surgery. Other indications include patients with a solitary kidney, multiple RCC, von Hippel Lindau disease, familial RCC or limited renal function.

Treatment planning begins with a multidisciplinary evaluation involving urologists, oncologists and interventional radiologists. This multidisciplinary team is well suited to evaluate the medical history and preprocedural imaging, inform the patient and guide them through the various treatment options. Risk assessment and treatment goals must be defined before selection of RFA as a treatment choice. Patients are informed that, while cancer control data are encouraging, after renal RFA long-term follow-up beyond five years is not available to date. Patients also agree to a protocol of imaging follow-up and they understand that recurrence may require repeat RFA or even radical nephrectomy.

Anatomical factors which influence the success of RF ablation is tumour size and location. RFA is suitable for small (<4cm) and exophytic tumours. A central location with tumour adjacent to large hilar blood vessels is more challenging to treat with RF ablation because of the perfusion mediated tissue cooling. In essence, blood flow through large vessels acts as a “heat sink” thereby limiting the temperatures that can be reached and maintained.

RFA technique and clinical practice
In most cases, RFA of renal tumours can be performed with intravenous sedation and analgesia with overnight inpatient observation or as an outpatient procedure. Some radiologists prefer to perform RFA with the patient under general anaesthesia (GA). GA optimises patient tolerance, allows for greater control of respiratory motion during probe placement and potentially improves accuracy of targeting the lesion but is associated with higher cost and morbidity.

It is recommended that an 18G biopsy is performed immediately before the RFA procedure, since ablation allows for adequate coagulation of the biopsy sites to minimise post-biopsy bleeding. The biopsy results affect the subsequent management of the patient, since frequent follow-up is needed for patients with RCC but not with oncocytomas.

Percutaneous renal RFA can be performed either under ultrasound or CT guidance. Ultrasound provides real-time visualisation of the needle electrode as it is positioned into the tumour. However, the formation of bubbles of water vapour creates an echogenic area that may obscure the tumour and render difficult any necessary repositioning of the electrode for subsequent overlapping ablations. In addition, some tumours may be difficult to see with ultrasound. CT may provide better delineation of tumours not suited for ultrasound guidance. Furthermore, when using CT, rapid two-dimensional reconstructions along the plane of insertion of the needle can determine accurately the position of the tip of the needle in relation to the tumour and adjacent tissues (figure 1).

When planning the procedure, the radiologist must pay close attention to the proximity of structures such as bowel and ureter and consider using air or dextrose 5% to displace them for protection from thermal injury when they are contiguous with the renal mass (figure 2). Finally, when completing the percutaneous procedure, ablation of the electrode...
track upon withdrawal of the electrode may protect against haemorrhage and tumour seeding.

**Follow-up and definitions of success**

Because RF ablation treats the tumour in situ without surgical removal or assessment of surgical margins, imaging is vital to the assessment of the results of RF ablation. Areas of complete necrosis show no enhancement at CT or MR, whereas areas of viable tumour show persistent enhancement. Incomplete ablation is defined as any enhancement within the tumour ablation zone on CT or MR on initial six-week imaging after RFA. Recurrence is defined as any enhancement or increase in size of the tumour ablation zone, after an initial non-enhancing six-weeks CT or MRI. These patients are given the option of a repeat ablation or extirpative surgery.

**Oncologic and renal function outcomes**

As clinical experience with renal RFA continues to grow, there is an increasing body of literature composed of case series with promising early oncologic outcomes. In 2006, Park et al reported intermediate-term data on percutaneous and laparoscopic RFA performed in 78 patients for 94 tumours with a mean tumour size of 2.4 cm (range: 1-4.2). Approximately 75% of lesions were biopsy-proven RCC. Only patients with at least 12 months of follow-up were included and the mean follow-up for this cohort was 25 months. These authors reported a recurrence-free survival rate of 96.8%, cancer-specific survival rate of 98.5% and an overall survival rate of 92.3%. The authors concluded that RFA is comparable with traditional extirpative treatments for small renal tumours. Most recently, in 2008, Levinson et al presented outcomes on 31 patients who underwent a total of 34 RFA procedures for solitary renal masses (median size 2.0 cm, range: 1.0-4.0). The mean follow-up in this cohort was 61.6 months, which is one of the longest follow-up intervals in the ablation literature. In this cohort, the recurrence-free survival rate was 90.5%, cancer-specific survival rate was 100% and overall survival rate was 71%. The authors reported one incomplete ablation and three recurrences with no deaths attributable to RCC. They concluded from their long-term data that RFA is reasonable for poor surgical candidates with small renal tumours, but emphasised that vigilant follow-up is essential.

In 2008, Lucas et al compared the effect on renal function of patients with small renal tumours (<4 cm) who underwent RFA, partial nephrectomy or radical nephrectomy. Just over 25% of each cohort preoperatively had stage 3 CKD (GFR <60 ml/min/1.73 m²). The mean pretreatment GFR was 73.4, 70.9, and 74.8 ml/min/1.73 m² in the RFA, partial nephrectomy, and radical nephrectomy groups, respectively (P < 0.59). Following intervention, the three-year freedom from stage 3 CKD was 95.2% for RFA, 70.7% for partial nephrectomy and 39.9% for radical nephrectomy. Furthermore, patients undergoing radical and partial nephrectomy were 34.3 and 10.9 times more likely, respectively, to develop stage 3 CKD compared with their RFA counterparts. This study emphasises that, even in the setting of a normal contralateral kidney, ablative procedures may confer 'renal protection' compared with surgical extirpation.

**Complications**

RF ablation has proven to be a safe procedure for small RCCs with a safety profile that is favourable when compared with surgical alternatives. The overall complication rates in the literature ranges between 2.8 and 12.6%, with the majority being minor complications. Major reported complications include haemorrhage requiring transfusion or ureteral stent placement, ureteral strictures, tumour seeding of the electrode track and urine leak. Minor complications include self-limited paresthesias and transient hematuria. Central tumours have shown a higher risk of bleeding complications. The central location predisposes to injury of larger vessels and bleeding into the collecting system. Furthermore, central tumours are often closer to the ureter and ureteropelvic junction, both of which are susceptible to thermal injury that can result in stricture formation.

**Conclusion**

As the ablation experience continues to mature, longer term outcomes for renal RFA are increasingly available. Collectively, these data build upon observations from intermediate-term studies, which demonstrate that cancer-control for appropriately selected lesions is excellent and comparable with extirpative techniques. Furthermore, global renal function is well maintained even in high-risk patients with chronic kidney disease or solitary renal units. As more renal masses are diagnosed in the elderly or comorbid patients, RFA will assume an increasingly central role in management strategies of renal tumours.

**References**


