Ablative Therapy for Small Renal Masses

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KEYWORDS

• Renal cell carcinoma • Thermal ablation • Cryoablation • Radiofrequency ablation
• Ablation techniques

KEY POINTS

- Optimal conditions for cryoablation include achieving treatment temperatures less than −40°C, treating 5 mm to 10 mm beyond tumor margin, and performing a double freeze-thaw cycle of 8-minute to 10-minute duration.
- Radiofrequency ablation temperatures should exceed 70°C but avoid high temperatures that cause charring, and treatments can be thermal based or impedance based.
- Treatment success is defined as lack of tumor enhancement and absence of tumor enlargement on intravenous contrast enhanced CT or MRI.
- Ablation techniques seem to have higher rates of local recurrence than surgery, but caution should be taken when comparing outcomes between ablation modalities and surgical extirpation in non-randomized, heterogenous case studies.
- Complication rates are lowest with percutaneous approaches and increase with laparoscopic or open procedures.

INTRODUCTION

With increased use of cross-sectional imaging, there has been a trend toward earlier diagnosis of stage 1 renal tumors.[1] Pathologically, up to 20% of small renal masses after extirpative surgery are benign.[2] In the past several decades, there has been a drive to discover minimally invasive treatments that aim to decrease treatment-related morbidity while respecting oncologic principles. However, 10-year trends from the American Nationwide Inpatient Sample showed that cryoablation and radiofrequency ablation (RFA) were used less compared with partial nephrectomy or radical nephrectomy.[3] Although partial nephrectomy is the gold standard treatment of T1a renal masses per the American Urological Association (AUA) guidelines, ablation therapy is a reasonable therapeutic option due to its ease of use, fewer complication rates, and shorter convalescence.[4] As with partial nephrectomy and active surveillance, patient selection plays a key role when weighing the risks and benefits while long-term data begin to mature.

PATIENT SELECTION

Thermal ablation is an appealing option for patients who have contraindications to surgical extirpative therapy (ie, comorbidities or advanced age) or have strong preference for nonsurgical management. Additionally, patients who have underlying renal insufficiency, solitary kidney, transplant kidney, multifocal tumors, or recurrent tumors in the nephrectomy bed may be considered for ablative therapies.[5]

Conflict of Interest/Disclosure: None.

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Urol Clin N Am 44 (2017) 223–231
http://dx.doi.org/10.1016/j.ucl.2016.12.008

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EVOLUTION AND TECHNICAL CONSIDERATIONS FOR ABLATION TECHNIQUES

Cryoablation

The first modern cryoprobe using liquid nitrogen was developed in the mid-1960s, thus allowing for treatment of intra-abdominal lesions.[6] It was not until the 1980s when ultrasound (US) was used to identify the highly echogenic ice-tissue interface.[7] Argon gas–based probes became available in the 1990s, and these provided more consistent temperatures and more efficient delivery to target tissues.[8] Animal models showed that cryoablation destroys normal tissue and cancerous tissue at temperatures between −19.4°C and −50°C, respectively. Therefore, to account for the more fibrous quality of the cancerous tissue, the preferred target temperature to ensure cellular death is −40°C.[9] It was also shown that the ice ball treatment zone should extend 5 mm to 10 mm beyond the edge of the lesion because consistent temperatures below −20°C could not be reached until 3.1 mm within the ice-tissue interface.[10] Animal studies showed larger areas of tissue necrosis with multiple freeze-thaw cycles; therefore, to increase cure rates it is recommended to perform a double freeze-thaw cycle.[11] Thawing can be done by either a more time-consuming passive process or via an active process where helium gas is used to create a warming effect through the probe. There is increased risk for bleeding if the duration of the freeze cycle is 5 minutes, and there is increased risk for tumor fracture if treatment lasts for 15 minutes.[12] Therefore, freeze cycle lengths of 8 minutes to 10 minutes are commonplace in the literature.[13]

Radiofrequency Ablation

RFA requires the use of monopolar alternating electric current at different frequencies, which stimulates ion vibration, leading to molecular friction and heat production. The increased temperatures desiccate tissue.[14] Modern-day probes were developed in 1990 and contain insulation down to an exposed tip.[15] The 2 main types of RFA generators are either temperature based or impedance based. Impedance occurs with rapid increase in temperatures, thus causing charring and dehydration of the tissues, which prevent desiccation of larger circumferential areas.[16] Target temperatures should be kept at or below 105°C to minimize incomplete ablation; however, tissues should reach a temperature of at least 70°C to ensure cellular death.[17] Larger tumors, greater than 2 cm, can be treated using multitine electrodes to disperse current in a larger spherical area.[18] Similar to cryoablation, improved cellular death occurs with 2 treatment cycles and a brief cool-down between active treatments.[19] Unlike cryotherapy where intraoperative US can easily visualize the ice ball, success during RFA relies on generator feedback and accurate placement of probes.[20]

SURGICAL TECHNIQUE

Percutaneous Cryoablation

The surgical technique for percutaneous cryoablation is shown in (**Box 1**, **Fig. 1**).

Percutaneous Radiofrequency Ablation

The surgical technique for RFA is shown in **Box 2**.

Laparoscopic Approach

Although percutaneous treatment of small renal masses has decreased morbidity, some patients

Box 1
Technique for percutaneous cryoablation

1. Position in prone or modified flank depending on tumor location.
2. Mark and clean site where probe will be inserted.
3. Give local anesthetic and conscious sedation.
4. Under CT, US, or MRI guidance, place ablation probe(s) in the target lesion.
5. Displace vital structures with use of balloons or saline hydrodissection if needed.
6. Can perform tumor biopsy using 18-gauge core biopsy needle after probes have been placed.
7. Ablate with a 5-mm to 10-mm margin of normal parenchyma ensuring the ice ball extends at least 3.1 mm beyond tumor margin.
8. The preferred target tissue temperature is at or below −40°C.
9. Apply double freeze-thaw cycle for complete cellular death.
10. Freeze cycles should be approximately 10 minutes.
11. Thaw can be active or passive.
12. Twist and remove probe atraumatically.
13. Perform CT to assess for completion and complications.

Data from Campbell SC, Krishnamurthi V, Chow G, et al. Renal cryosurgery: experimental evaluation of treatment parameters. Urology 1998;52(1):29–33. [discussion: 33–4].