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Ablative Therapies for Renal Masses: Current Treatment Indications, Types and Outcomes*

Learning Objective: At the conclusion of this continuing medical education activity, the participant will be able to describe the indications, types of therapies, their mechanism of action and outcomes for renal masses treated with ablative therapies.

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BACKGROUND

Currently there are 4 types of ablative therapies used for treating cT1a renal masses: radiofrequency ablation, cryoablation, microwave ablation and irreversible electroporation. Initially only recommended for patients who were frail and/or elderly, the use of ablative therapies has expanded to younger and healthier patients as high quality data have been published reporting excellent 5 and 10-year outcomes (RFA, CRA). While local recurrence rates are slightly higher than for surgery, this is offset by the ability to re-treat, the lower cost, lower complication rates and comparable cancer-free survival rate to surgery. As IRE is a newer technology, long-term data are still lacking. Clinicians should discuss percutaneous ablation as a first line option in the treatment of T1a (especially smaller than 3 cm) renal masses with patients.

HISTORY OF RENAL ABLATION

With the rise in the discovery of incidental small renal masses (less than 4 cm) due to the increased use of cross-sectional imaging, urologists are diagnosing and treating renal masses more commonly than before.[1] While most of these masses will be malignant (69%–80%), they are treatable with high success rates (greater than 95% 5-year survival).[2] The current gold standard for the treatment of small renal masses (less than 4 cm, cT1a) is surgical resection consisting of partial nephrectomy (nephron sparing surgery). As physicians continue to pursue treatment options that decrease morbidity and cost for the patient, percutaneous ablative therapies have been developed and are an option for many patients with cT1a renal masses.

The origins of ablative therapies are spaced throughout history. Both radiofrequency ablation and cryoablation can be traced back to the 1800s and beyond, while microwave ablation and now irreversible electroporation are newer technologies developed within the last 25 years. In this Update we will briefly review the historical context of the 4 most commonly used ablative therapies: radiofrequency ablation, cryoablation, microwave ablation and irreversible electroporation.

Radiofrequency ablation. With the advent of reliable electricity at the end of the 19th century it was not long before it was used in medicine to treat a wide array of ailments, from circulatory diseases to insomnia to skin malignancies.[3] The most famous application of electricity in medicine was the birth of the electrocautery by Harvey Cushing and William Bovie in 1926. Since then, medicine has expanded the use of alternating high frequency currents to treat solid masses. The first use of RFA was performed in hepatic masses in 1990.[4] The first renal mass was treated with RFA in 1997 by Zlotta et al.[5]

Cryoablation. Cryoablation can trace its roots back to James Arnott, who in the 19th century used ice and salt to treat pain from breast and cervical tumors.[6] Lutzeyer and Lymberopoulos were the first to report the use of cryosurgery in the treatment of renal masses in 1968.[7] However, the first application of nitrogen based percutaneous cryoablation did not occur until 1995, when it was used in a canine model. This was followed by the modern day argon based CRA in the late 1990s.[8]

Microwave ablation and irreversible electroporation. MWA and IRE are newer technologies tracing their origins back to the 1990s and 2000s, respectively.[9] MWA was first used in Japan to treat unresectable hepatocellular carcinomas. IRE is the newest treatment and was first described in 2005 by Miller et al, who performed in vitro studies using hepatocellular carcinoma cells.[10] It began being used in the clinical setting in 2007 using a percutaneous technique.[1]

PATIENT SELECTION

Guideline recommendations. As the use of ablative therapies in the management of small renal masses is a relatively newer treatment option, guideline recommendations can be helpful in discussing treatment with patients. The use of ablative therapies, specifically RFA and CRA, is discussed within all major guidelines. However, their recommendations vary depending on the association. **All major guideline recommendations are summarized in Appendix 1.** Briefly the European Association of Urology has the most restrictive recommendation, that ablation should be considered in the elderly or comorbid only.[12] The National Comprehensive Cancer Network has the newest guidelines and recommends ablation as an option in patients with cT1 renal masses.

Indications for treatment—patient characteristics. Traditionally ablative therapies have been reserved for patients with multiple comorbidities, those with advanced age, poor surgical candidates and patients with poor renal function. Furthermore, in certain cases nephron sparing is of utmost importance (solidary kidney, renal disease and genetic conditions such as von Hippel-Lindau).[13] As robust long-term data continue to be published,[14] ablation treatment recommendations are being extended to younger and healthier patients.

The only absolute contraindication to ablation is uncontrolled coagulopathy. Relative contraindications include tumor size (most recommend treatment in tumors 3 cm or less in diameter), tumor location (if treating with thermal ablative therapies), and patient unable to tolerate appropriate positioning or unable to tolerate anesthesia or sedation.[15, 16] Patients who are on anticoagulation therapy are usually asked to stop anticoagulation (if safe to do so) 2–5 days prior to surgery, and most clinicians recommend an internal normalized ratio less than 1.5 and platelet count to be greater than 50,000/μl.[16]

Tumor characteristics. When considering treatment of a renal mass with ablative therapy, the characteristics of the tumor will largely dictate treatment options. **Schmit et al developed the acronym ABLATE, axial tumor diameter, bowel proximity, location within kidney, adjacency to collecting system, touching sinus fat and endophytic or exophytic, to aid in determining eligibility for ablative treatment.[17]**

Axial tumor diameter is the most important tumor characteristic to consider, as all ablative therapies show worse oncologic outcomes and higher complication rates with an increase in tumor diameter. For example in RFA Best et al reported a 5-year cancer-free survival rate of 95% for renal masses less

ABBREVIATIONS: AUA (American Urological Association), CRA (cryoablation), CT (computerized tomography), IRE (irreversible electroporation), MRI (magnetic resonance imaging), MWA (microwave ablation), NCCN (National Comprehensive Cancer Network), PN (partial nephrectomy), RFA (radiofrequency ablation)

than 3 cm.[18] This rate dropped to 79% for renal masses measuring 3 cm or more. For CRA similar experiences of diminishing success with increased tumor size have been reported.[19] Some studies have reported sustained success with tumors up to 4 cm.[20] Furthermore, cystic lesions have been successfully treated with RFA[21] and it is recommended as a treatment option in international guidelines for the treatment of Bosniak III and IV cysts.[22]

When treating tumors with thermal ablation (heat or cold based), the tumor's proximity to other structures must be carefully assessed. If the tumor is located too close to the bowel, liver, spleen or body wall, simple patient positional changes (i.e. turning or rolling patient) can be successful. **Hydrodissection with 5% dextrose in sterile water can also be utilized to displace organs out of the treatment area prior to commencing treatment.[23, 24]** If there is any concern of a ureteral injury, an internalized stent can be placed for 2 months.

Historically only tumors located laterally and posteriorly were considered for ablation. However, as technique and experience have improved, anterior tumors have been treated successfully.[26] If treating anterior tumors, one must consider proximity to bowel and adrenal gland, and a transhepatic approach may be required.[17] **Finally, central tumor location (abutting sinus fat) is associated with treatment failures as high as 22% due to "sink effects" of the nearby vasculature.[27]** Furthermore, central tumors carry a higher risk of injury to the vasculature and the renal pelvis.[28] This can lead to collecting system stenosis and higher risk of bleeding. Finally, for reasons previously described, exophytic tumors have higher treatment success rates than tumors that are completely endophytic.[29]

ABLATIVE TECHNOLOGIES AND TECHNIQUES

It is generally recommended that percutaneous ablative therapies be performed with CT guidance. CT guidance allows for immediate measurements of the probe in relation to the tumor and surrounding structures. Furthermore, a post-procedure contrast enhanced scan can be performed to exclude bleeding or any injury to surrounding structures.[30] MRI can also be used but is limited to specialized centers.

A common goal of ablative therapies is to achieve a negative margin of at least 5–10 mm by achieving a continuous and predictable lethal cell ablation zone. This is achieved differently depending on the technology used, and we review the mechanisms of each below.

Cryoablation. **With all modern systems utilizing argon gas, CRA of tumors utilizes freezing and thawing cycles. Tissue cooling should be as rapid as possible, and thawing slow and complete.** Then this cycle is repeated. Most clinicians will treat with an initial freeze cycle of 8–10 minutes, followed by a second cycle of 6–8 minutes.[31] Lethal temperatures of between –20C and –40C beyond the tumor margin must be achieved.[32] Both cycles induce cell death, albeit through different mechanisms. The use of freezing results in cell death through 2 main processes. First, intracellular ice crystal formation causes damage to cell membranes and organelles, causing apoptosis. Second, slower freezing results in extracellular ice crystal formation, causing an increase in osmolarity within the extracellular space, resulting in dehydration of cells.[33] During the thawing phase, as the ice crystals melt, the osmolarity of the extracellular space decreases relative to the intracellular space. This causes an influx of water into cells, resulting in cellular edema, cell membrane disruption and cell death.[34] Finally, cryoablation causes damage to the surrounding vascular endothelium, causing edema and local tissue ischemia. This activates the inflammatory pathways, resulting in further cell death.[33]

CRA efficacy can be influenced by thawing and cooling rates, treatment time and ablation zone temperature. Areas in closest proximity to the cryoprobe will have the lowest temperature, while the periphery of the ice ball will have the highest temperature. Therefore, treatment planning must ensure that the periphery of tumor (i.e. ice ball) is within the lethal ablation zone (less than –20C).[35]

Depending on the treatment area required, cryoprobes can produce different shapes and/or sized ice balls by using different probe types or multiple probes. **Each cryoprobe acts independently, thereby allowing for multiple probes to be used simultaneously. This creates ablation zones that can conform to tumors with unique shapes (not just round). Another advantage to CRA is that the ablation zone can be monitored in real time using CT.** During CT the ablation zone will hypoattenuate compared to the surrounding renal tissue with a sharp demarcation zone, making it easy to identify.[34] Due to anesthetic effect of cooling, CRA is less painful than heat based ablation techniques such as RFA and MWA.

While there are many benefits to CRA, there are drawbacks to its use as well. Without the coagulative and cautery effects of heat, bleeding complications are more common with CRA.[15] Furthermore, paresthesia has been reported as a complication. While inserting the cryoprobe and during treatment, excessive torque and/or force must be avoided, as the ice ball may fracture, resulting in bleeding and renal laceration.[36] There have been rare reports of a systemic inflammatory response, called cryoshock, occurring after CRA. This is due to the inflammatory response and can result in shock, disseminated intravascular coagulation and multiorgan failure.[37] Finally, cryoablation systems have higher costs than RFA and MWA as they must use argon and helium gas.[38]

Percutaneous vs laparoscopic approaches. CRA can be performed either percutaneously or laparoscopically. Laparoscopic technique involves general anesthetic, lateral positioning of the patient, obtaining pneumoperitoneum and placing laparoscopic ports, similar to that of laparoscopic nephrectomy. Bowel is mobilized off the kidney and the tumor is exposed.[15] After the procedure is completed, the needles are removed and the site is monitored for any bleeding. Patients are usually admitted to hospital for observation.

The percutaneous technique is an outpatient procedure that requires either local or general anesthetic and prone positioning of the patient. In general, laparoscopic CRA has been favored for anterior tumors and hilar tumors, which can be challenging to perform using traditional surgery (PN) or percutaneous CRA.[39] The percutaneous technique is traditionally favored for posterior tumors and frail/elderly patients and/or patients with multiple comorbidities.

Radiofrequency ablation. Radiofrequency energy (450 to 1200 kHz) is part of the electromagnetic spectrum. In simple terms an RFA system is an electrical circuit, where the patient is part of the circuit. The electrode (probe) acts as the cathode and the grounding pads are the anode in a monopolar system. Due to the small cross-sectional area of the probe (cathode), there is a high energy flux surrounding it. The grounding pads

have a large cross-sectional area, allowing for minimal energy flux and resulting in tissue damage being limited to the area around the probe tip.[16, 25] **Molecules (primarily water) become heated due to the rapidly alternating current from the electrode, a process called dielectric hysteresis.** This causes heat and intense vibration. **It should be noted that the electrode itself is not the source of heat; rather, it's the adjacent molecules that become heated and through conductivity transmit heat farther to surrounding tissue**.[40] Therefore, as molecules become farther from the probe, the vibrational energy, and hence temperature, drops drastically.

When performing RFA, target tissues must be slowly heated to 50C– 100C (ideally 70C–100C), and this temperature maintained for 5–8 minutes. Tissue destruction occurs in 3 phases: first, molecular friction results in protein denaturation, cellular vaporization, destruction of cellular structure and lipid melting.[41] This process occurs immediately. Days after treatment, coagulative necrosis, cellular edema and inflammation occur. The final stage is reabsorption of necrotic tissue, resulting in a fibrotic scar that is non-enhancing on contrast enhanced imaging.[42]

The gradual heating during RFA results in cell death without charring or vaporization. **Charring and/or vaporization must be avoided in RFA as they have an insulating effect, resulting in decreased energy transmission to tissue, decreased ablation size and suboptimal treatment.** RFA systems use impedance or temperature measurements to avoid charring.

RFA has long-term outcome data, is cheaper and is more widely available compared to other technologies. The RFA probe is small (14–17 gauge) and typically only 1 treatment with 1 probe is required. Furthermore, RFA has hemostatic effects on tissue that help minimize bleeding and provide an acceptable safety profile.[16, 25] Disadvantages of RFA are size restrictions (efficacy decreases over 3 cm), required image guidance and its susceptibility to "heat sinks," and in monopolar systems patients can receive skin burns if the grounding pads are malpositioned.

Microwave ablation. MWA uses heat in a mechanism similar to RFA to result in cellular death. MWA uses EM radiation within the microwave spectrum (3 MHz–3 GHz), with 915 MHz and 2.45 GHz being the most popular.[43] MWA heats tissues at higher temperatures and more rapidly than RFA, having the ability to ablate larger tumors in shorter times.[44] **However, an important difference from RFA is that that the probe (often called antenna) causes direct heating by emitting microwave energy that radiates into the surrounding tissue.[45]** This difference allows microwave energy to be delivered through charred or desiccated tissue. Furthermore, thermal synergy can be achieved by placing multiple microwave probes in close proximity to each other. If there are multiple tumors, they can all be treated at once with multiple antennae.[46] Furthermore, no grounding pads are needed and, compared to RFA, MWA is more resistant to "heat sinks."[47]

While MWA offers many potential benefits, it does have limitations. It is more difficult to safely deliver and generate energy efficiently within the ablation zone compared to RFA, as coaxial cables must be used. Coaxial cables are more prone to heating and are larger in diameter than traditional wires used for RFA. The resulting cable and shaft heating can impede energy delivery to tissue.[48] Furthermore, an undesired ablation "tail" of proximal tissue (outside the ablation zone) can be created due to the heating effect of the probe. This can result in damage to the body wall or other, more proximal structures.[45] Shaft cooling systems have been developed to help prevent this undesired effect.[49] Currently available microwave probes and systems differ in their design, frequency, wavelength and power, resulting in a variety of ablation zone sizes and shapes. This can make it difficult to predict treatment zones successfully. Compared to other ablative technologies, clinicians have reported a steeper learning curve with MWA.[44]

Irreversible electroporation. **IRE is the only ablative treatment that does not use thermal energy for cell death.** Irreversible electroporation was initially seen as an unwanted byproduct of reversible electroporation. However, in the mid 2000s IRE began being investigated as a treatment for hepatocellular carcinoma.[10] IRE has been available commercially in the U.S. since 2007 for soft tissue ablation. Using an electric current of 30–40 A, IRE uses multiple probes placed across the ablative zone to pass an electric current between them. **This current increases the permeability of the cell membrane by creating nanopores (small holes in the membrane), resulting in cell death through apoptosis.[10, 11]** As the electric current only affects living cells, the blood vessels, collecting system, biliary system and other connective tissues surrounding cells are spared. **Due to its non-thermal mechanism of action, IRE may be able to treat tumors not amenable to thermal based ablative technologies.** This includes tumors close to vital structures (bowel, collecting system), central tumors and tumors near larger vessels (also known as "heat sinks").[11] IRE could allow for faster tissue regeneration than other ablative techniques as it causes cell death through apoptosis, not necrosis, and preserves extracellular structures.

As IRE is the newest technology to be adopted for renal ablation, long-term data on efficacy and outcomes are lacking.[50] Furthermore, it is the most expensive of ablative therapies currently approved and the insertion of multiple probes per treatment is time-consuming. **As IRE uses an electric current, it requires electrocardiographic synchronization (to avoid arrhythmias) and full muscle paralysis (electric current causes muscle contractions).**[51] Usually 2 ablation cycles are used for treatment. Appendix 2 outlines the major advantages and disadvantages and oncologic outcomes of the 4 ablative therapies listed above.

TREATMENT OUTCOMES

Oncologic outcomes for T1a tumors. Surgical treatment is considered the gold standard to which all ablative therapy outcomes are compared. Currently there are no randomized controlled studies directly comparing surgery to ablative therapies. Long-term oncologic outcomes for T1a renal cell carcinoma are available for CRA and RFA, while long-term data are still lacking for MWA and IRE. Traditionally ablative therapies have only been offered to patients who are older, comorbid with limited life expectancy or are medically unfit for surgery. As a result, overall survival has traditionally been lower than surgery.[52–54] Five to 10-year cancer specific survival for both CRA and RFA are reported in the literature to be 95%–100%, which is similar to PN.[5] A recent study comparing 3, 5 and 10-year overall survival of patients treated with thermal ablation (CRA, RFA or MWA) found no difference in overall survival when tumors were 2 cm or less.[55] This has also been found in a study by Atwell et al for tumors 3 cm or less.[56]

A meta-analysis published by Uhlig et al in 2019 found no significant differences in metastasis-free survival between CRA, MWA, RFA and PN; however, local recurrence-free survival was lower for all 3 (98.9% for PN and 93.0% for thermal ablation) compared to PN.[53, 54] As IRE is the newest treatment modality, oncologic data are still maturing. However, preliminary data appear acceptable, although slightly lower than other ablative therapes.[57, 58]

Oncologic outcomes for T1b tumors. Treatment of larger tumors is less common with ablative therapies as the previously reported literature has shown decreased treatment success compared to surgery. However, ablative therapy can still be an option in the T1b setting when patients are unable or unwilling to undergo surgical treatment. In a study published by Andrews et al 5-year local recurrence-free survival for T1b cases was 91.6% and 92.7% for PN and CRA, respectively.[59] Five-year metastasis-free survival rates were 94% and 90% for PN and CRA, respectively. Patients who were treated with CRA were more likely to die of any cause (5-year overall survival rates 90% vs 56%) but were older and had greater comorbidities. Other studies have found similar results for local recurrence-free survival and metastasis-free survival for RFA compared to PN.[60] Therefore, newer data would suggest that in appropriately selected patients RFA or CRA could be a treatment option for T1b renal tumors.

Oncologic outcomes based on histology. There are few studies examining differences in oncologic outcomes based on tumor histology. This is in part due to the fact that not all tumors are biopsied prior to treatment. Lay et al performed a multicenter retrospective review of 229 patients who underwent biopsy prior to RFA. They had a median follow-up of 33.2 months.[61] Lay et al reported 5-year disease-free survival rates of 89.7% and 100% for clear cell tumors and papillary tumors, respectively (p=0.04). There was no difference in overall survival (88.4% clear cell vs 89.6% papillary, p=0.76). The authors hypothesized that the difference in recurrence rates may be due to differences in tumor vascularity, with clear cell having greater vascularity and therefore more heat sinks that may make the tumor more resistant to RFA.

A retrospective study by Leibovich et al generated prognostic models for progression-free survival and cancer specific survival in patients post-radical nephrectomy or PN for clear cell, papillary and chromophobe renal cell carcinoma.[62] Progression-free survival and cancer specific survival rates were worse for clear cell than papillary or chromophobe subtypes.

Renal function. While PN has been reported to improve preservation of renal function compared to radical nephrectomy, studies have found this not to hold when compared to ablative therapies. **Meta-analyses have reported that ablative therapies (CRA, MWA and RFA) have similar, if not improved, preservation of renal function compared to PN.[53, 54]** Recent single center studies have found CRA and RFA to have significantly higher preservation of renal function than PN.[59, 60]

Management of local recurrences. Currently there are no guidelines on treatment recommendations for local recurrences after ablative therapy. Enhancement post-treatment can be misleading as CRA ablated tumors can continue to enhance up to 1 year post-treatment.[63, 64] Any increase in size of the previous ablation zone, enhancement persisting for more than 1 year or new evidence and/or increased enhancement should raise suspicion of persistence/recurrence, and renal biopsy can be performed.

Recurrences can be treated with either repeat ablation or surgical excision. However, post-ablation surgery is often more difficult due to scar tissue.[63] As a result, most recurrences (approximately 75%) are treated with repeat ablation.[65] Treatment of local recurrence with ablative therapies is very successful, with 2-year recurrence-free rates of 95%.[63, 64]

Complications of percutaneous ablative therapies. Complications for ablative therapies are rare and are lower than for surgical therapies (PN and radical nephrectomy).[52–54] Most major complications are due to energy being applied inadvertently to surrounding structures outside the treatment zone. These can include injury to the collecting system, resulting in urine leak, postoperative hemorrhage and bowel injury.[66] If treating upper pole tumors, liver, spleen and/or pleural injuries have been reported.[67] Studies have found complication rates to be comparable between CRA, MWA and RFA.[54, 67] Rates of urine leak post-ablation are low (1%–2%).[68] This rate can be further decreased by methods described above and appropriate patient selection.

Readmission rates post ablation are approximately 5% and are usually due to bleeding or injury to the collecting system.[68] Overall, ablative therapies are a safe procedure that can be performed as an outpatient.

Recommended follow-up imaging and schedule. Unlike surgery, post-ablation therapies have no final excised specimen (although guidelines recommend biopsy prior to treatment), and therefore success cannot be measured histologically (i.e. tumor margins, final size, grade). Non-contrast and contrast enhanced imaging must be used (CT or MRI) to assess for residual tumor or new tumor growth. Contrast enhanced ultrasound has been reported to have high accuracy in detecting residual enhancement but is currently not approved for detecting residual or recurrent disease.[69] After successful cryoablation the treatment area may show enhancement up to 12 months post-treatment but will involute over time. RFA treated masses have a characteristic fibrotic halo around the ablation zone and may not involute.[70] This should not be misinterpreted as recurrent disease. MWA will have involution and significant tissue contraction.[71] Post-IRE imaging shows non-enhancement in the treatment zone that involutes over approximately 6 months.[58] An understanding of the appearance of successful post-treatment imaging is paramount to both the urologist and radiologist in monitoring patients for recurrent or residual disease.

The success of ablative therapy is determined by the appearance of the ablation zone on the first follow-up imaging study. When the initial study is performed, it varies by institution but typically ranges from immediately (days) after ablation to 1–3 months.[69, 72] Imaging follow-up can vary by institution. AUA guidelines on follow-up for clinically localized renal neoplasms recommend a baseline abdominal scan (CT or MRI) within 3 to 12 months following surgery, then annually for 3 years.[73] The NCCN guidelines are similar but recommend imaging for at least 5 years.[74] At our center we follow the AUA/NCCN guidelines and perform a contrast enhanced CT immediately post-ablation, then at 3 months, then annually thereafter.

CONCLUSION

Long-term oncologic data have been published for ablative therapies (CRA and RFA) with excellent success rates, making them a viable option for the treatment of small renal masses. While local recurrence rates are slightly higher than for surgery,

this is offset by the ability to re-treat, the lower cost, lower complication rates and comparable cancer-free survival rate. While not yet mature, early MWA data have been comparable to RFA and CRA. Long-term IRE data are still lacking. **Given the new data available, clinicians should discuss with patients percutaneous ablation as a first line option in the treatment of T1a (especially smaller than 3 cm) renal masses.**

DID YOU KNOW?

- The currently available ablative therapies are cryoablation, radiofrequency ablation, microwave ablation and irreversible electroporation.
- Renal ablative therapies can be done as percutaneous outpatient procedures and have lower complication rates than surgery.
- Five-year disease-free survival for tumors 3 cm and less are comparable to surgery (93%–95%).
- Irreversible electroporation is the newest and only non-thermal ablative therapy.

Appendix 1. Major guideline recommendations for use of ablative therapies in management of small renal tumors

Association Guideline	Year Published	Recommendation	Evidence
European Association of Urology[12]	2018	Can offer radiofrequency ablation or cryoablation to elderly and/or comorbid patients for small renal masses	Strength rating: Weak
NCCN[74]	2019	Can use thermal ablation (cryosurgery, radiofrequency ablation) as an option for management of patients with clinical stage T1	Category of Evidence: 2A
American Society of Clinical Oncology[75]	2017	Should consider percutaneous thermal ablation for patients with tumors that can be completely ablated. Recommend a biopsy either before or at the time of ablation	Evidence quality: intermediate; strength of recommendation: strong
AUA[2]	2017	Thermal ablation should be considered as an alternate approach for the management of cT1a renal masses <3 cm in size. Recommend a biopsy prior to ablation	Conditional recommendation; Evidence Level: Grade C

Appendix 2. Comparison of different ablative therapies and their 5-year oncologic outcomes based on tumors 3 cm and smaller

	RFA	CRA	MWA	IRE
Advantages	Cheaper, shorter procedure time, coagulation effect	Real-time monitoring of ablation zone. Can treat larger tumors	Rapid heating, resistant to charring, less prone to heat sinks	Non-thermal, preserves extracellular architecture, can treat central tumors
Disadvantages	Efficacy sharply decreases above 3 cm, susceptible to heat sinks, skin burns (monopolar)	Systems more expensive, increased bleeding risk, longer operative time	Cannot monitor in real time, heterogeneity in systems, limited long-term data	Current short-term studies showing inferior oncologic outcomes
5-year local recurrence-free survival	95%	94%	90%	83%
5-year cancer specific survival	98%	97%	97%	N/A

Values for 5-year local recurrence-free survival and 5-year cancer specific survival adapted from Johnson and Cadeddu.[66]

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Study Questions Volume 39 Lesson 38

1. When considering treatment of a renal mass with ablative therapies, the characteristics of the tumor will largely dictate treatment options. A helpful acronym developed by Schmit et al is "ABLATE," which stands for
   a. axial tumor diameter, bowel proximity, location within kidney, adjacency to collecting system, touching sinus fat, and endophytic or exophytic
   b. axial tumor diameter, bowel proximity, lower pole, adjacency to renal hilum, touching collecting system, and endophytic or exophytic
   c. anterior position, bowel proximity, location within kidney, adjacency to renal hilum, touching sinus fat, and endophytic or exophytic
   d. anterior position, bowel proximity, lower pole, adrenal gland proximity, touching collecting system, and endophytic or exophytic

2. An 80-year-old woman had cryoablation for a left 2.5 cm upper pole exophytic renal mass. On postoperative day 2 she develops increased flank pain, left costovertebral angle tenderness and increased abdominal distention. CT is performed and is most likely to show a
   a. collecting system injury
   b. splenic injury
   c. bowel injury
   d. bleed

3. An ablative technology that utilizes dielectric hysteresis, the heating of molecules due to rapidly alternating currents (450/532 Hz to 1200 kHz) from an electrode, is
   a. cryoablation
   b. microwave ablation
   c. radiofrequency ablation
   d. irreversible electroporation

4. A 78-year-old woman with multiple medical comorbidities including chronic kidney disease has a 2.8 cm, endophytic, centrally located tumor in her right kidney that is touching the sinus fat. The tumor has doubled in size in the last 6 months. Ablation of the tumor should be performed using
   a. cryoablation
   b. microwave ablation
   c. radiofrequency ablation
   d. irreversible electroporation

5. A 75-year-old man with chronic kidney disease was treated 5 years ago using radiofrequency ablation. He was disease-free until enhanced CT performed 6 months ago found a 1.5 cm enhancing lesion at the previous treatment site posteriorly in the lower pole. The lesion is now 2.1 cm on repeat CT. The best treatment option is
   a. active surveillance
   b. repeat RFA
   c. partial nephrectomy
   d. radical nephrectomy