CLINICAL STUDY

Percutaneous Cryoablation of Renal Tumors: Is It Time for a New Paradigm Shift?

Hussein D. Aoun, MD, Peter J. Littrup, MD, Mohamed Jaber, MD, Fatima Memon, MD, Barbara Adam, MSN, APN, Mark Krycia, BS, Matthew Prus, BS, Elisabeth Heath, MD, and Edson Pontes, MD

ABSTRACT

Purpose: To retrospectively assess long-term outcomes of percutaneous renal cryoablation, including factors affecting complications and local recurrence rates.

Materials and Methods: A total of 357 computed tomographic (CT) fluoroscopy–guided percutaneous cryoablation procedures were performed for 382 masses in 302 outpatients; 347 were biopsy-proven renal-cell carcinoma (RCC) or Bosniak category > III masses (n = 28). Benign pathologic conditions (n = 18) or metastatic non-RCC disease (n = 17) were included to analyze procedural complication rate, but recurrence rates, tumor staging, and nephrometry score were limited to RCCs. The average tumor diameter was 2.9 cm (range, 1–10.3 cm), and median nephrometry score for RCC was 8 (mean, 7.4). Protection of adjacent vital structures was performed in 34% of procedures (n = 121), and ureteral stent placement was performed for 9.2% (n = 33). All major complications were graded per surgical Clavien–Dindo criteria.

Results: The average CT-visible cryoablation zone diameter was 5 cm (range, 2.5–10.5 cm). Grade ≥ 3 complications occurred in 2.8% of procedures (n = 10), and appeared related to only high nephrometry scores ($P = .0086$) and larger tumors ($P = .0034$). No significant changes in renal function before and after the procedure were noted ($P = .18$). At a mean follow-up of 31.8 months, the local tumor recurrence rate was 3.2% (11 of 347) for RCC, and no significant difference was noted between tumors larger or smaller than 3 cm ($P = .15$). The difference reached significance only among the small number of stage ≥ T2 RCC tumors ($P = .0039$).

Conclusions: Long-term follow-up of percutaneous renal cryoablation demonstrates low recurrence rates with preserved renal function, even for patients with high nephrometry scores and body mass index, assuming thorough cytotoxic technique and protection measures.

ABBREVIATIONS

BMI = body mass index, OS = overall survival, RCC = renal-cell carcinoma, RF = radiofrequency, TLP = time to local progression, TMP = time to metastatic progression

In 2014, renal cancer was estimated to account for 4% and 3% of all new cancers detected in men and women, respectively (1). Historically, treatment of renal-cell carcinoma (RCC) includes partial, simple, or radical nephrectomy via open or laparoscopic approaches. Despite improvements in modern imaging, 20%–30% of nephrectomy specimens reveal benign etiologies (2), yet percutaneous biopsy alone may be inadequate to avoid resection or ablation (3).

Laparoscopic and/or robotic partial nephrectomy show positive surgical margin rates of 2%–7% (4–6), which is consistent with discordant rates of frozen-section and final pathologic examinations (7). Local recurrence rates of 1%–4% for partial nephrectomy (8–11) increase among patients

From the Imaging Division (H.D.A., B.A., M.P.), Division of Oncology (E.H.), and Division of Urology (E.P.), Karmanos Cancer Institute, Wayne State University, Detroit, Michigan; Department of Radiology (M.J., F.M., M.K.), Wayne State Medical School, Detroit, Michigan; and Department of Diagnostic Imaging (P.J.L.), Brown University, Rhode Island Hospital, Providence, Rhode Island. Received August 15, 2016; final revision received July 11, 2017; accepted July 12, 2017. **Address correspondence to** H.D.A., Imaging Division, Karmanos Cancer Institute, Wayne State University, 4100 John R, Detroit, MI 48201; E-mail: aounh@karmanos.org

H.D.A. receives personal fees from Galil Medical (Arden Hills, Minnesota). H.D.A. and P.J.L. receive grants from Galil Medical and Endocare/HealthTronics (Austin, Texas). None of the other authors have identified a conflict of interest.

J Vasc Interv Radiol 2017; ■:1–8

http://dx.doi.org/10.1016/j.jvir.2017.07.013

with positive surgical margins and high malignant potential (4,9). Intraoperative complication rates and postoperative major complication rates (ie, grade ≥ III per Clavien–Dindo classification) range as high as 3% and 7%, respectively (5,6,12). Major complication rates can be as high as 14% for large tumors (ie, stage ≥ T1b) (10) and 18% for tumors with higher nephrometry scores (2,3,12). Surgical patients are screened for technical feasibility of treatment, yet the surgical treatments of 2%–4% of stage T1a RCC tumors are converted to open nephrectomy; this incidence is as high as 8% for stage T1b tumors (10–12).

Thermal ablation techniques such as radiofrequency (RF) ablation, microwave ablation, and cryoablation help reduce morbidity and anesthesia risk for renal mass treatment. In general, RF ablations near major vessels (≥ 3 mm) have greater difficulty in overcoming the heat-sink effect (13), leaving viable tumor in as many as 50% of patients with a central RCC > 3 cm (14). Recent meta-analyses (15) demonstrated recurrence rates after RF of approximately 12.9%. Recurrence rates after RF ablation of small tumors (< 3 cm) are reported at 3%–10%, but central and/or larger tumors (≥ 3 cm) are associated with technical failure/recurrence rates as high as 33% (16–19). Microwave ablation of renal tumors may allow faster creation of larger treatment zones, but is also associated with recurrence rates of 8%–10% (8).

Cryoablation is a well-established procedure in various tissues, including the kidney (20–22). Optimum cryoablation techniques stress the production of cytotoxic isotherms (23) to thoroughly cover all apparent tumor margins (22). The purpose of the present study is to document recurrence rates, complication rates, and imaging outcomes of percutaneous renal cryoablation. Primary outcome assessments were (*i*) technical feasibility and complications for all renal masses amenable to ablation and (*ii*) imaging outcomes in relation to recurrence rates, tumor size, and organ location. Secondary outcomes included further evaluations based on nephrometry score and body mass index (BMI).

MATERIALS AND METHODS

Patients/Tumors

All cryoablation procedures were performed between March 2001 and January 2016 under an institutional review board–approved protocol for prospective data collection. This is a retrospective evaluation of 302 patients that addresses the primary objectives of cryoablation feasibility, associated complications, and imaging-related outcomes for consecutive renal tumors amenable to ablation. Mean patient age was 64.9 years (range, 18.3–94 y), with 240 masses occurring in men and 142 masses occurring in women.

Eligibility criteria for a localized renal mass included any biopsy-proven solid enhancing and/or growing tumor ≤ 10 cm in average diameter, as well as any complex cystic mass suspicious on imaging study that would warrant surgical excision (ie, Bosniak category ≥ III). Exclusion criteria included patients who had coagulopathies or active urinary tract infection or were poor anesthesia candidates. All cases were reviewed, and procedures were performed by one of two fellowship-trained radiologists. Patients presented with a biopsy-proven diagnosis of RCC (ie, previous biopsy) or underwent biopsy at the time of cryoablation. Biopsy of three suspicious small masses (Bosniak category IV) could not be performed during the procedure after placing the first cryoprobe as a result of moderate artifact and impaired accurate targeting of the mass. Patients without previous biopsy confirmation were given the option of diagnostic biopsy alone before ablation or biopsy in combination with cryoablation because imaging was suspicious for RCC (ie, Bosniak category ≥ III). For the purposes of the present study, benign and metastatic tumors were excluded from RCC recurrence data but included for complication rates.

Nearly all tumors were confined to the kidney (ie, stage ≤ T2b for RCC) (24). One patient had a 4-cm renal tumor with segmental renal-vein invasion (ie, stage T3). Glomerular filtration rates and BMI were noted for all patients on the day of cryoablation. Available immediate postprocedure and delayed (≥ 30 d) glomerular filtration rates were also noted.

All patients had an initial computed tomography (CT) or magnetic resonance imaging scan within 3 months before cryoablation, and each tumor was measured in 3 dimensions at the level of its largest diameter. Tumor locations were defined as central or peripheral, describing tumor contact with renal pelvic fat or only perinephric fat, respectively. Nephrometry scores based on the R.E.N.A.L. criteria (radius, exophytic/endophytic, nearness to collecting system or sinus, anterior/posterior, location relative to polar lines) were recorded for all masses. BMI was calculated for all available patient data.

Procedures/Complications

All patients treated with renal cryoablation were administered local lidocaine anesthesia and moderate sedation as needed during the procedure by dedicated anesthesia staff. All patients received one preprocedural dose of intravenous antibiotic agent as recommended by the referring urologists. No patient underwent general anesthesia or was required to be in prone position during ablation. All procedures were performed under CT fluoroscopic guidance, with real-time ultrasound assistance in 5 cases. Preablation CT scans consisted of unenhanced helical scans and enhanced scans when masses were difficult to localize on unenhanced CT. CT documentation of ice progression during the procedure relied primarily on intermittent CT fluoroscopy. Helical scans were also obtained during the procedure to evaluate for potential complications and document ablation zone size.

The ablations were performed with Food and Drug Administration–approved Endocare (HealthTronics, Austin, Texas) or Galil Medical (Arden Hills, Minnesota) cryoablation systems (23,25). Cryoprobe repositioning was avoided by tandem placement of the necessary number of cryoprobes (23) around an initial 20-gauge spinal targeting needle or a 17- or 19-gauge trocar needle when a concurrent confirmatory biopsy was needed.