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Long-term outcomes after percutaneous renal cryoablation performed with adjunctive techniques

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ABSTRACT

Objective: To review the technical success of image-guided percutaneous cryoablation of renal masses in difficult anatomic locations using adjunctive techniques to displace critical structures away from the ablation zone, while also reporting longer-term outcomes within this patient population.
Methods: An IRB approved, retrospective analysis of 92 renal masses treated with percutaneous cryoablation revealed 15 cases utilizing adjunctive techniques. Tumor size and distance to adjacent organ before and after adjunctive technique and long-term outcomes were evaluated.
Results: The adjunctive techniques used were hydrodissection (n = 15) and angioplasty balloon interposition (n = 1). Before and after adjunctive technique, median tumor proximity to closest organ was 4 mm and 26 mm, respectively. All cases had appropriate ablation zones and protection of adjacent critical structures. There is no evidence of recurrence or complication on follow-up (median 51 months).
Conclusions: Adjunctive techniques to ablate renal masses in difficult locations provide technical success, safety, and favorable long-term outcomes.

1. Introduction

The use of CT and MRI for variety of diagnostic workups has led to increased diagnosis of incidental, asymptomatic small renal masses [1,2]. Currently, treatment options have expanded to include active surveillance, percutaneous ablation, or nephron-sparing surgery. With image guidance, percutaneous ablation has become a well-accepted, safe, and efficacious treatment option for patients who are poor surgical candidates [3–5].

Percutaneous cryoablation was first performed by Uchida and associates in 1995 [6]. Potential operator advantages include a more accurate zone of killing due to the predictable and consistent zone of ablation, as well as the ability to monitor the ablation zone during the procedure, most commonly with CT [7,8]. Cryoablation is minimally invasive, and has a low morbidity and rapid recovery time [9]. However, the procedure is not without risk, as cryoablation may result in damage to critical organs adjacent to the kidneys, including colon, duodenum, ureter, psoas muscle, and pancreas [10]. In order to cause complete death, the ice ball must exceed the tumor margin by 3–5 mm, thus proving critical to displace adjacent structures [11].

Adjunctive techniques to reduce non-target ablation, including hydrodissection, angioplasty balloon interposition, and carbodissection, have been proven to reduce intra-operative complications [12,13]. Hydrodissection uses targeted fluid infusion to create a mass effect and displace the critical structure(s) away from the index tumor. This technique uses 5% dextrose in water (D5W), saline, or sterile water and has been described as an effective method to displace adjacent structures [12]. Additional adjunctive techniques include carbodissection, in which CO_2 gas is used to displace adjacent structures and insulate the kidney, as well as balloon interposition, where organs are displaced by balloon inflation [14].

While the technical success of these adjunctive techniques has been reported, no study to date has reported both procedural technical success as well as long-term outcomes. The purpose of this study, therefore, is to evaluate the technical success and long-term outcomes in a series of patients treated with renal cryoablation performed with primarily the adjunctive technique of hydrodissection.

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2. Methods & materials

2.1. Selection criteria

Institutional Review Board approval was obtained for this study. A query of the radiology information system database at a single institution was performed to allow for a retrospective review of percutaneous cryoablation of renal tumors performed between July 2011 and May 2016 (n = 92). Of these patients, those who underwent hydrodissection at the time of the cryoablation procedure were isolated (n = 15). Informed consent was obtained from patients prior to the procedure being performed. Multi-phasic contrast-enhanced cross-sectional imaging was used as part of their evaluation to confirm the presence of a solid, enhancing renal mass.

Three patients had biopsy-proved renal cell carcinoma prior to the ablation procedure. Twelve patients had biopsy performed at the time of the ablation, just prior to initiating the first freeze cycle of cryoablation. Of the 15 patients who received hydrodissection, 8 were male and 7 were female. Eleven patients described their race as Caucasian and 4 patients described their race as African American. All patients in this study were treated with percutaneous renal mass cryoablation due to medical and surgical comorbidities and were classified with the R.E.N.A.L nephrometry score in order to assess the complexity of the renal mass.

2.2. Technique of cryoablation

All procedures were performed by a single fellowship trained interventional radiologist, utilizing moderate sedation with Midazolam (Roche Pharmaceuticals) and Fentanyl. CT-imaging guidance was utilized with Siemens Healthcare, 128-slice scanner (Somatom Definition AS). Based on lesion location, patient positioning (supine, prone, oblique, or lateral decubitus) was chosen by the physician. The size and number of cryoprobes used was determined by the operator. A combination of PCS-17 and/or PCS-24 cryoprobes were utilized. Percutaneous biopsy was performed either on a prior day or at the time of cryoablation, utilizing a 19-gauge trocar and 20-gauge core biopsy device (Bard, Tempe, Arizona) to obtain a single core biopsy.

Cryoablations were performed with Endocare Cryocare System (HealthTronics, Austin, Texas) using the Cryo-SL Generator. All ablations were performed with 10-minute freeze, followed by 8-minute passive thaw, followed by 10-minute freeze. CT images were obtained throughout the procedure, including before probe placement, during probe placement, at 5 and 10 min during the first ablation cycle, and after probe removal. The decision as to whether or not an adjunctive technique was necessary to protect adjacent structures from the ablation zone was made by the interventional radiologist, during and immediately after cryoprobe placement.

2.3. Adjunctive techniques

Using sterile normal saline, hydrodissection was performed via a 19-gauge trocar that was placed under CT guidance. In our experience, additional fluid is often needed to be infused via the hydrodissection trocar during the second freeze cycle, as some of the fluid may be dispersed and/or resorbed. In organs that did not adequately displace with hydrodissection, balloon angioplasty interposition is an alternative adjunct procedure.

Angioplasty balloon interposition was used in one case, when hydrodissection was unsuccessful. A 19-gauge trocar was placed with CT guidance in between ablation zone and organ of concern. The trocar was then removed over a guidewire and replaced with a 7 French sheath, and a 10 mm diameter angioplasty balloon was then placed into position over the guidewire via the sheath. The balloon was inflated with normal saline to the nominal pressure, with repeat CT images then obtained to evaluate displacement.

2.4. Post-procedure follow-up

Successful ablation for this study was defined as cryoablation performed with appropriate zone of ablation (ice-ball encompassing tumor and at least 5 mm beyond tumor margin) and displacement of adjacent critical organ at least 1.5 cm from the ablation zone. Complications, including hemorrhage, fever, intractable and/or prolonged pain, and organ injury were recorded. All patients were discharged home the same day, 5–6 h post procedure. A follow-up phone call from the interventional radiologist or nurse practitioner was made 3–4 days post procedure. Patients were followed long term with cross-sectional imaging using multiphasic CT (with and without IV contrast) or MRI (with and without IV contrast) for follow-up imaging. Follow-up images were obtained at 3, 6, 9, 12, 18, and 24 months post procedure. After 2-years, annual follow-up imaging was obtained.

3. Results

3.1. Tumor and basic procedural characteristics

Of the 92 tumors treated with percutaneous cryoablation at the institution during the study period, 15 cases consisted of adjunctive therapy in the form of hydrodissection. Three patients had prior biopsy-proved renal cell carcinoma, and the remaining 12 patients had biopsy performed at the time of the ablation, of which, 9 biopsies demonstrated renal cell carcinoma and 3 were non-diagnostic. The median tumor volume was 7.84 cm^3 (range 2.86–16.01 cm^3, Table 1). The most common tumor location was in the anterior middle of the kidney (n = 7), and the R.E.N.A.L nephrometry score is listed in Table 1.

3.2. Hydrodissection

Structures adjacent to the renal tumor were successfully displaced by hydrodissection in 14 of 15 cases. The median volume of fluid initially needed to perform hydrodissection was 310 mL (range 230–400 mL, Table 1). In the single failed hydrodissection attempt, CT images demonstrated that loops of small bowel were not displaced any further away from the kidney (Fig. 1). CT images showed that 300 mL of infused, sterile normal saline had dispersed throughout the abdomen. Balloon angioplasty interposition was then performed as previously described and the bowel was successfully displaced 19 mm (Fig. 1).

When including both adjunctive techniques used, CT images demonstrated appropriate organ displacement in all cases. CT images demonstrated appropriate cryoablation and ice-ball freeze zone and maintained appropriate organ displacement during and after the freeze cycles. Prior to hydrodissection, the median distance to closest organ was 4 mm (range 1–13 mm). The median distance of displacement with adjunctive technique was 20 mm (range 14–28 mm). The median distance from the edge of the ablation zone to closest organ after adjunctive technique was 26 mm (range 18–33 mm, Table 1).

3.3. Post-procedure follow-up & complications

No evidence of hemorrhage or other complication was noted on final CT in all cases, and no procedural complications, as previously described, were reported in the study population in accordance with practice guidelines [15]. Long-term follow-up was obtained in all cases (15 to 74 months, median 51 months), with no evidence of tumor recurrence or adjacent organ injury in all cases.

4. Discussion

Previous authors have documented the utility of adjunctive techniques when performing percutaneous renal cryoablation [10–12]. However, such studies report the intra-procedural technical success of such adjunctive techniques, not long-term outcomes following the