CLINICAL STUDY

Percutaneous MR Imaging-Guided Cryoablation of Small Renal Masses in a 3-T Closed-Bore MR Imaging Environment: Initial Experience

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ABSTRACT

Purpose: To assess the feasibility of percutaneous magnetic resonance (MR) imaging–guided cryoablation of small renal masses (SRMs) in a 3-T environment and to evaluate intraprocedural imaging, procedural safety, and initial outcomes.

Materials and Methods: The analysis included 9 patients (4 men; median age, 72 y; range, 70-82 y) with 9 SRMs (diameter, 12–30 mm). Lesions underwent biopsy, and cryoneedles were inserted under ultrasound guidance. Verification of needle positions and ice-ball monitoring were performed by T1-weighted volumetric interpolated breath-hold examination and T2-weighted half-Fourier acquired single-shot turbo spin-echo sequences. On image analysis, needle positioning was considered appropriate if the target lesion border was visible, the needle tip was inside the target lesion, and the ice ball was expected to cover the target lesion with a 5-mm margin. If these criteria could not be assessed, imaging was considered inadequate. Technical success was defined as tumor coverage with a 5-mm margin and no residual disease on 1-mo follow-up MR imaging.

Results: Median total procedure time was 170 min (range, 135–193 min). Intraoperative imaging allowed adequate needle visualization in 67% of acquired scans (4 of 7 T1-weighted and 6 of 8 T2-weighted). Appropriate positioning of two or three needles used for each procedure was confirmed in all cases on T1- or T2-weighted imaging. Ice-ball formation was adequately visualized in all patients. Technical success rate was 100%. No local recurrences were detected on follow-up imaging at a median of 12 mo (range, 3–22 mo).

Conclusions: Percutaneous MR-guided cryoablation of SRMs in a 3-T MR imaging environment is safe and feasible, showing adequate intraoperative imaging capabilities with promising short-term clinical outcomes.

ABBREVIATIONS

HASTE = half-Fourier acquired single-shot turbo spin-echo, NSS = nephron-sparing surgery, SRM = small renal mass, VIBE = volumetric interpolated breath-hold examination

Nephron-sparing surgery (NSS) is the standard of care for small renal masses (SRMs; $\leq$ 4 cm) if technically feasible (1). However, NSS can be unsuitable in patients with chronic kidney disease or multiple tumors, who are unsuitable for surgical intervention as a result of the extent of comorbidities, or have undergone previous renal surgery (2). Within these patient groups, active surveillance with delayed intervention in case of progression might be considered as an alternative to surgery (3).

There is growing evidence to support the use of minimally invasive image-guided ablative treatments, such as percutaneous cryoablation, for patients with SRMs (4–8). Clinical studies have shown that cryoablation is an effective and safe treatment alternative with a low complication rate and good preservation of renal function (4–6). These results

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were confirmed in larger studies reporting recurrence-free survival rates of 95% or even higher after follow-up of 3–5 years (7,8).

Although magnetic resonance (MR) imaging–guided percutaneous cryoablation of SRMs has been described in small cohorts, previous studies reported experience only with a relatively low magnetic field strength (0.2–0.5 T) and in an open-bore MR imaging environment (9). So far, we are aware of one study (10) that has described experience in a 1.5-T closed-bore MR imaging system. By using a higher magnetic field strength, intraoperative image quality may be improved as a result of increased signal-to-noise ratio. Moreover, imaging sequences with short acquisition times may provide near–real-time imaging of ice-ball growth (11). Such improved imaging capabilities may be beneficial in procedural safety and clinical outcomes and may reduce the rate of local recurrences after cryoablation.

The objective of the present study was to assess the feasibility of percutaneous 3-T MR imaging–guided cryoablation of SRMs and to evaluate intraprocedural imaging, procedural safety, and initial outcomes.

MATERIALS AND METHODS

Patient Selection

Patients with clinically diagnosed stage T1a renal tumors on imaging suggestive of renal-cell carcinoma were discussed in a multidisciplinary team of urologists, oncologists, and radiologists. When consensus was reached that treatment was indicated, treatment options, including active surveillance, were considered based on relative and absolute contraindications for NSS (Fig 1). Active surveillance was chosen in case of tumor characteristics unfavorable for percutaneous cryoablation, such as higher nephrometry score (based on radius, exophytic/endophytic properties, nearness of tumor to the collecting system or sinus, and anterior/posterior location relative to polar line), more central location, and proximity of vascular structures or ureter (5,12,13). Otherwise, patients were offered percutaneous cryoablation under MR imaging guidance. Only in cases of contraindications to MR imaging (eg, cardiac pacemaker or foreign metal object), procedures were performed under computed tomography (CT) guidance. Institutional review board approval was obtained for the use of patient data, and all patients gave written informed consent for the use of their data for research purposes.

Patient Population

Ten consecutive patients with SRMs were scheduled to undergo MR imaging–guided percutaneous cryoablation between October 2014 and February 2016. Six patients had absolute contraindications and four had relative contraindications to NSS (Fig 1). One procedure was converted to CT guidance because of a technical problem with the MR system while scanning to verify the position of the needles. Therefore, nine patients (four men) with nine

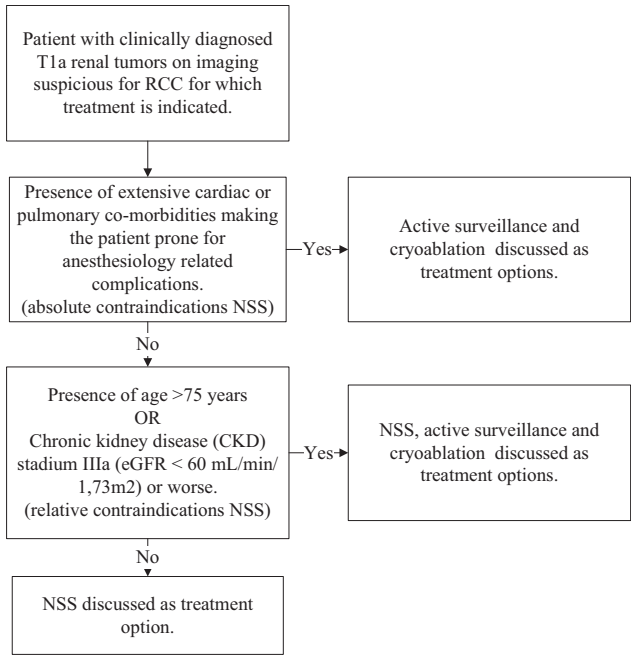

Figure 1. Treatment decision algorithm for patients with clinically diagnosed stage T1a renal tumors on imaging suspicious for renal-cell carcinoma (*RCC*) for which treatment was indicated. eGFR = estimated glomerular filtration rate; NSS = nephron sparing surgery.

SRMs were treated with near–real-time MR imaging guidance and included for analysis. Median patient age was 72 years (range, 70–82 y). Most tumors were located in a posterior location (n = 6) and in the lower pole (n = 4). Median lesion diameter was 25 mm (range, 12–30 mm). Other patient and tumor characteristics are summarized in Table 1. Seven patients were treated for primary localized disease. In one patient diagnosed with metastatic disease, treatment of the primary tumor was indicated. Two patients were treated after previous cryoablation and NSS, respectively.

Treatment Planning and Patient Positioning

All procedures were performed by one of two interventional radiologists (J.J.F. or S.F.J., with 11 and 6 y of experience, respectively) together with one urologist (H.L., 9 y of experience) in an MR imaging suite dedicated to interventional purposes, equipped with a wide-bore 3-T MR scanner with a 70 × 173-cm bore (MAGNETOM Skyra; Siemens, Erlangen, Germany). An argon/helium-based cryoablation system (MRI Seednet; Galil Medical, Yokneam, Israel) was used.

During the entire procedure, patients were positioned in prone position, except for one patient who was positioned in supine position because of a lateral tumor position. The arm of the ipsilateral side was positioned above the head to gain maximum accessibility to the flank. Before general anesthesia was administered, a first scan for treatment-planning