MRI-Guided and Monitored Laser Ablation for Renal Malignancy: A Step toward Moving Interventional MRI Technology to Mainstream Usage?

Sherif G. Nour[1,2], Andrew David Nicholson[1,2], Tracy E. Powell[1,2], Melinda M. Lewis[3,4], and Viraj Master[4,5]
[1]Radiology and Imaging Sciences, Emory University Hospital, Atlanta, GA, United States, [2]Interventional MRI Program, Emory University Hospital, Atlanta, GA, United States, [3]Pathology, Emory University Hospital, GA, United States, [4]School of Medicine, Emory University, GA, United States, [5]Urology, Emory University Hospital, GA, United States

Target Audience: Interventional radiologists, interventional MRI scientists, physicians interested in thermal ablation technology and outcomes.

Introduction & Purpose: Percutaneous ablative treatment has become a viable treatment option for selected patients with localized malignant renal neoplasms. The primary ablative technologies used are cryoablation and radiofrequency ablation (RFA), commonly performed under CT or ultrasound guidance. The use of MRI guidance has shown an added value for intraprocedural confirmation of a tumor-free ablation zone, thereby reducing the incidence of residual /recurrent neoplasms [1, 2]. MRI guidance of these procedures has, in our experience as in others', been hampered by the cumbersome handling of cryoprobes and RFA probes and their cablings within the already limited room available within the MRI gantry, particularly when utilizing superconducting magnet designs. The aims of this investigation are to a) describe the technical aspects of using laser fibers to deliver ablative energy to renal tumors, circumventing the space constraints within the MRI environment; b) describe patient tolerance and complication rates; and c) report the short and intermediate term efficacy of laser ablation of renal malignancies.

Patients & Methods: 8 patients (4M, 4F, age=28-83y) with 14 renal masses underwent MRI-guided biopsies followed by laser ablations in the same session. Procedures were performed within an interventional MRI suite equipped with 1.5T wide bore scanner. Interventions were performed under general anesthesia, entirely within the scanner bore while viewing real-time image updates on an in-room monitor. Interactive visualization on a tri-orthogonal plane True-FISP sequence (TR/TE/FA=2700/84/170°) was used to guide a 14.5-cm-long, 14G MRI-compatible introducing needle into the targeted lesion. 20G FNA and, if inconclusive, 18G core samples were obtained. A laser fiber with 15mm diffusing tip encased in 5.5 F cooling catheter (Visualase, Texas, USA) was then introduced into the target lesion through the pre-existing short 14G introducing needle (Figs 1&2). The optic fiber and cooling tubing were extended through a waveguide to a laser generator located outside the MRI room. A test dose of diode laser energy (980nm,30sec,9W) was applied to verify the location of ablation nidus on real-time temperature and cumulative damage estimate mapping(TE/TE=24/10). Subsequently, ablative energy dose was delivered (27W for cycles of 90-180sec) with treatment endpoint based on on-line thermal monitoring of growing ablation. Fiber repositioning for additional ablation was conducted as needed. Final ablations were evaluated on TSE-T2 and pre- and post-contrast VIBE scans.

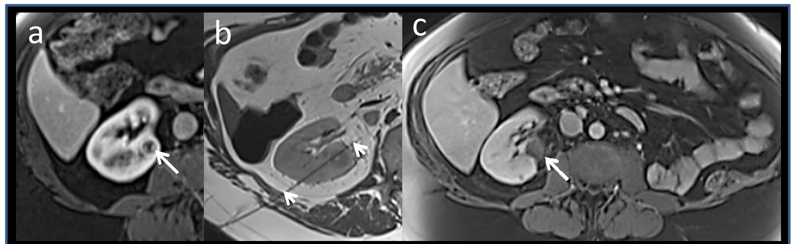

Fig 1: 48-year-old male with history of left radical nephrectomy for RCC and a new 1.7-cm enhancing lesion on gadolinium-enhanced VIBE in the interpolar segment of the right kidney (arrow, a). MRI-guided biopsy performed in the same ablation session confirmed a clear cell RCC. The laser fiber placement is confirmed on TSE-T2 prior to ablation (arrowheads, b). Venous phase post contrast VIBE scan obtained 3 weeks following ablation demonstrate a circumscribed non-enhancing ablation zone (arrow, c) without residual tumor or delayed complications.

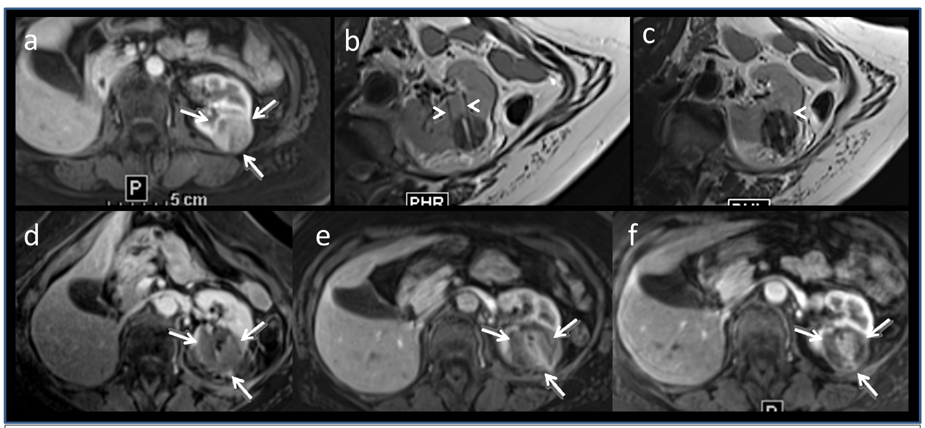

Fig 2: 83-year-old female with history of right radical nephrectomy for RCC. A 3.8-cm mildly enhancing left kidney lesion is noted on gadolinium-enhanced VIBE (arrows, a). MRI-guided biopsy performed in the same ablation session confirmed a oncocytic RCC. Multiple laser fiber placements were necessary based on initial size and on actual thermal damage maps obtained during ablation. The laser fiber placements are confirmed on intraprocedural TSE-T2 (arrowheads, b&c). Post contrast VIBE scans obtained immediately following ablation (d), after 5 weeks (e), and after 5 months (f) demonstrate a circumscribed non-enhancing ablation zone (arrows, d-f) without residual tumor or delayed complications.

Results: One biopsy was inconclusive. This analysis therefore includes 13 laser ablations of renal tumors. Biopsy results showed 12 RCCs (7 clear cell, 2 chromophobe, 1 oncocytic, 2 not specified) and one renal metastasis from lung cancer. Target tumor sizes were 0.7-3.8 cm (9 right-, 4 left-sided). 4 patients (50%) had a single kidney, 2 patients (25%) had prior ipsilateral partial nephrectomy, and 2 lesions were recurrent masses at prior cryoablation margins. Access to the desired part of the kidney using the 14.5-cm-long introducing needle was feasible in all cases, including one morbidly obese patient, with no space constraints encountered within the 70-cm magnet bore. The flexible nature of optic laser fibers eliminated the complexity of handling bulky ablation probes, and the traction exerted by their cablings and fitted the MRI environment. The short ablation cycle facilitated accurate temperature mapping during controlled suspended ventilation without the need to implement motion correction algorithms. Applied laser energy was 4050-78732J per lesion, with dosage calibrated based on real time feedback of tumor response to ablation. One patient had a moderate self-limited perinephric hematoma related to the biopsy part of the procedure. Otherwise, no early or delayed complications were encountered. Follow-up durations ranged between 3 weeks and 8 months. No residual or recurrent neoplasm was identified in any patient.

Discussion & Conclusion: This investigation reports the improved access for interactive guidance and real time monitoring of renal ablation procedures performed entirely within an interventional MRI suite via the use of a short introducing needle and a flexible laser fiber. The technique represents a considerable departure from the complex handling of cryo- and RFA probes within the MRI environment and may facilitate a better future dissemination of MRI-guided renal ablation as a mainstream technology. The procedure appears to be well tolerated with a high safety profile. Short and intermediate term follow ups also point to a promising, efficacious ablative technique with no residual or recurrent neoplasms in our series. Further assessment of long-term efficacy in a larger cohort of subjects is underway.

References:

[1] Lewin JS, Nour SG, Connell CF, et al. Radiology. 2004; 232(3):835-45.
[2] Silverman SG, Tuncali K, vanSonnenberg E, et al. Radiology. 2005; 236(2):716-24.