Percutaneous Microwave Ablation of Renal Cell Carcinoma Is Safe in Patients With a Solitary Kidney

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OBJECTIVE To present the results of clinical outcomes after microwave ablation (MWA) of renal cell carcinoma in patients with a solitary kidney without causing impairment to the uninvolved renal parenchyma and renal function.

METHODS Between 2006 and 2012, 14 solitary kidney patients with 16 tumors underwent percutaneous ultrasound-guided MWA at our institution. The tumor diameters ranged from 1.0 to 8.4 cm. The serum creatinine and urea levels of each patient before MWA, 1 day after MWA, and the most recent occasion on record at our institution were collected. Moreover, all the patients were followed up using contrast enhanced ultrasound and computed tomography or magnetic resonance imaging at 1, 3, and 6 months and every 6 months thereafter. The technical success, survival rates, and complications were accessed. Patients were available for clinical and laboratory evaluations at a median follow-up time of 9.5 months (range, 1-56.4).

RESULTS Complete ablation was achieved in 15 of 16 (93.8%) lesions after 1 or 2 MWA sessions; however, 2 of 14 (14.3%) patients died of widespread metastasis. The renal function was essentially preserved, and no patients require dialysis. No major complications were observed.

CONCLUSION MWA is a safe and effective treatment option for patients with a solitary kidney who suffer from inoperable renal cell carcinoma. The complication rate is low, and excellent tumor control can be achieved without deterioration of the residual renal function. UROLOGY 83: 357–363, 2014.

Renal cell carcinoma (RCC) is being detected at an increasing rate because of the advances in imaging techniques, including ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI).[1] The worldwide annual increase in the incidence of RCC is approximately 2% during the last 2 decades.[2]

For patients with localized RCC, radical nephrectomy that includes the removal of the tumor-bearing kidney remains the standard recommended curative therapy. Subsequently, to reduce patient morbidity caused by radical nephrectomy and to preserve renal function, nephron-sparing surgery, open, and laparoscopic partial nephrectomy have been more widely used and have yielded improved survival rates.[3] However, in patients with a solitary kidney, partial nephrectomy and nephron-sparing surgery depend on the tumor location and might impair the residual renal function and lead to renal failure, which will require long-term hemodialysis or kidney transplantation. This causes a dilemma for the surgeon when determining the optimal method for treating tumor lesion in a solitary kidney.

Minimally invasive percutaneous thermal ablation techniques, such as cryoablation, radiofrequency, and microwave ablation (MWA), have already been suggested as alternatives for the treatment of RCC.[1] Previous studies have shown that the local tumor control rate of percutaneous cryoablation was 92% in the management of renal tumors in patients with a solitary kidney.[4] Percutaneous radiofrequency ablation (RFA) can achieve excellent midterm outcomes that are equivalent to those of open partial nephrectomy.[5] Compared with RFA, MWA has its unique advantages, such as larger ablation volumes, less ablation time, and higher intratumoral temperatures,[6] and it also has been reported to play an effective role in treating small RCC.[7] In this retrospective study, we aimed to assess the feasibility, safety, and clinical outcomes of MWA under US guidance in patients with RCC in a solitary kidney with respect to tumor control and residual renal function.

Financial Disclosure: *The authors declare that they have no relevant financial interests.*

Funding Support: *This research was supported by the National Science Foundation of China (grant number 81127006, 81071210), the International S&T Cooperation Program of China (grant number 2012DFG32070) and the State Key Laboratory of Kidney Diseases.*

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Submitted: December 29, 2012, accepted (with revisions): May 28, 2013

0090-4295/14/$36.00
http://dx.doi.org/10.1016/j.urology.2013.05.071

Table 1. Pathologic characteristic of the tumor lesions in the solitary kidney and ablation procedure

No.	Age (y)	Cause	Size (cm)	Pathologic Results	Session	Complete Ablation	Follow-up (mo)	Survival Status
1	51	Renal hemorrhage	3.0	Clear cell carcinoma	1	Yes	56.4	Alive
2	35	RCC	5.5	Need more tissue	1	No	22.3	Dead
3	61	RCC	1.6	Clear cell carcinoma	2	Yes	28.3	Alive
4	57	RCC	1.8	Clear cell carcinoma	1	Yes	23.7	Alive
5	50	Atrophic kidney	2.2	Clear cell carcinoma	2	Yes	20.5	Alive
6	66	Renal tuberculosis	5.4	Papillary carcinoma	2	Yes	13.4	Alive
7	56	RCC	2.4/1.2	Clear cell carcinoma	1/1	Yes/Yes	10.1	Dead
8	53	RCC	3.4/3.1	Clear cell carcinoma	1/1	Yes/Yes	8.9	Alive
9	52	RCC	8.4	Mondiagnostic	2	Yes	7.2	Alive
10	27	RCC	1.0	Nondiagnostic	1	Yes	5.4	Alive
11	66	RCC	1.9	Clear cell carcinoma	2	Yes	3.7	Alive
12	40	VHL	2.7	Clear cell carcinoma	1	Yes	2.8	Alive
13	56	Renal failure	3.5	Clear cell carcinoma	2	Yes	1.2	Alive
14	48	RCC	3.3	Nondiagnostic	1	Yes	1.0	Alive

RCC, renal cell carcinoma; VHL, von Hippel-Lindau disease.

MATERIALS AND METHODS

Patients and Clinical Characteristics

This retrospective study was approved by the review board of Chinese PLA General Hospital. Written informed consent for the procedure was obtained from each enrolled patient. From April 2006 to November 2012, 14 patients with 16 tumor lesions in their solitary kidney after contralateral nephrectomy or acquired contralateral renal atrophy were included and underwent percutaneous MWA treatment at our department (9 men, 5 women; age range from 27 to 66 years; mean age, 51.2 years). Of all the 14 patients, 12 (85.7%) had a solitary kidney because of a previous radical nephrectomy. One patient (7.1%) with nonfunctioning kidneys had a tumor lesion in the transplanted kidney, and 1 patient (7.1%) had a contralateral atrophic and nonfunctional kidney. The patients were high-risk surgical candidates or had refused surgery. The MWA procedure was proposed to these patients as an alternative treatment to open partial nephrectomy. All patients had to meet the following criteria: RCC lesions had a maximum diameter of $\leq$8.5 cm in each nodule; a prothrombin coagulation time of $<$25 seconds; prothrombin activity higher than 40%; platelet count higher than 40×10^9/L; and the presence of an appropriate route for percutaneous puncture with US guidance. Before the procedure, the number of tumor nodules and the absence of renal vein thrombosis were evaluated using contrast enhanced ultrasound and CT or MRI. The RCC diagnosis was largely made through an intraoperative tumor biopsy before ablation with US guidance.

In total, 9 tumor lesions were located in the right kidney, 6 lesions were in the left kidney, and 1 lesion was in the transplanted kidney. The tumor diameter ranged in size from 1 to 8.4 cm (average diameter, 3.2 cm). In 3 cases, there was radiological or laboratory evidence of tumor spread beyond the kidney. The main pathologic characteristics of the patients and MWA-treated tumors are summarized in Table 1.

MWA System

A KY2000 MW ablation system (Kangyou Medical Instruments, Nanjing, China) consists of 2 MW generators, 2 flexible coaxial cables, and 2 cooled shaft antennae. The generator is capable of producing 1-100 W of power at 2450 MHz. The cooled shaft antenna has a 15-gauge shaft coated with polytetrafluoroethylene to prevent adhesion, which can be easily observed on US. Inside the antenna shaft are dual channels through which distilled water is circulated by a peristaltic pump that continuously cools the shaft and prevents overheating. The MW machine is also equipped with a thermal monitoring system that can measure temperatures in real time during ablation.

MWA Procedure

After local anesthesia with 1% lidocaine, US-guided biopsy was performed first using an automatic biopsy gun with an 18-gauge cutting needle; 2 or 3 separate punctures were performed. Subsequently, the antenna was percutaneously inserted with US guidance into the tumor and placed in the desired location. One antenna was inserted for tumors $<$2 cm, and 2 antennae were inserted for tumors measuring $\geq$2.0 cm with an interantenna distance of no more than 1.8 cm. A power output of 50 W for 10 minutes was routinely used during MWA. However, if the heat-generated hyperechoic water vapor did not completely encompass the entire tumor, a prolonged microwave emission was applied until the desired temperature was reached. After all insertions, intravenous anesthesia was administered using a combination of propofol (Diprivan; Zeneca Pharmaceuticals, Wilmington, DE) and ketamine (Shuanghe Pharmaceuticals, Beijing, China) through the peripheral vein during standard hemodynamic monitoring. When the antenna was being withdrawn, the applicator track was heated with sufficient microwave energy by stopping the cooling-shaft water dump.

Follow-up

After 1-3 sessions of MWA, 1-3 days after the last ablation session, contrast-enhanced imaging (US and CT or MRI) was performed to evaluate treatment effectiveness. Technique effectiveness, namely complete ablation, was defined as the absence of enhancement in any areas of the mass on enhanced images obtained at the 1-month follow-up after MWA. If complete ablation was achieved, the routine contrast-enhanced US, CT, or MRI was repeated to monitor for recurrence or metastasis at 3 months after MWA and then at 6-month intervals. US and CT or MRI complications were detected and classified according to the Clavien-Dindo Classification of Surgical Complications, and the patients were followed up by 1 month after ablation.