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Microwave treatment of renal cell carcinoma adjacent to renal sinus

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ABSTRACT

Purpose: To evaluate the efficacy and safety of ultrasound (US)-guided percutaneous microwave ablation (MWA) for renal cell carcinoma (RCC) adjacent to renal sinus.

Materials and methods: This retrospective study included 41 patients who underwent US-guided percutaneous MWA of 41 RCCs adjacent to the renal sinus from April 2006 to December 2015. Contrast-enhanced images of US and computed tomography (CT) or magnetic resonance (MR) imaging were performed at pre-ablation and 1 day, 1 month, 3 months, and every 6 months after ablation. Initial ablation success (IAS), disease-free survival (DFS), RCC-related survival (RRS), and overall survival (OS) were recorded at the follow-up visits.

Results: IAS was achieved in 92.7% (38/41) of the study subjects. The IAS significantly differed between patients with RCCs ≤4 cm (100%, 29/29) and RCCs >4 cm (75%, 9/12, $p = 0.021$). During the median follow-up of 37.6 (range, 3.0–97.3) months, the estimated 1-, 3-, and 5-year DFS of patients with an initial tumor of ≤4 cm were 100%, 89.7%, and 81.5%, respectively. The 1-, 3-, and 5-year RRS were 100%, 93.3%, and 93.3%, respectively. The 1-, 3-, and 5-year OS were 97.1%, 87.8%, and 83.6%, respectively. The multivariate analysis using the Cox proportional hazard model revealed no independent predictor of recurrence among all the variables. There were no MWA-related deaths among the study subjects. One patient developed a retroperitoneal abscess after ablation.

Conclusion: US-guided percutaneous MWA appears to be a promising method for RCCs adjacent to renal sinus, especially for tumors ≤4 cm.

1. Introduction

Over the past two decades, image-guided percutaneous local thermal ablation has become a promising approach for patients with small RCC, especially for those with a single kidney or serious comorbidities. The rapid development of image-guided percutaneous local thermal ablation may due to its benefits, including minimal invasiveness, short recovery time, repeatability, and low blood loss. Common methods of local thermal ablation for RCC include radiofrequency ablation (RFA) [1–3], cryoablation [4,5], and microwave ablation (MWA) [6,7]. Compared with other invasive techniques, MWA offers several advantages such as higher thermal efficiency, less "heat-sink" effect, faster ablation time, larger coagulation zoon, and real-time protective temperature monitoring [8]. Recent retrospective studies have compared MWA and nephrectomy in the treatment of small RCC [9,10], and the 5-year RCC-related survival (RRS) rate after MWA was 97%, which is similar to that obtained after radical nephrectomy.

Tumor location plays an important role for interventional treatment. Thermal treatment for endophytic tumors near the renal sinus would be at a higher risk of injury to the collecting system and incomplete tumor necrosis [1,11], even with laparoscopic partial nephrectomy [12]. Researchers are currently seeking feasible treatment techniques, particularly to treat cases with severe comorbidities and single kidney. Thus far, no special research has evaluated the efficacy after percutaneous thermal treatment of RCCs adjacent to the renal sinus. In this article, we retrospectively reviewed patients with RCCs near the renal sinus after ultrasound (US)-guided percutaneous MWA with a long follow-up time, in order to evaluate the safety and efficacy of this technique.

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2. Materials and methods

2.1. Patients

In this study, we reviewed the data of patients who underwent US-guided percutaneous MWA at our institution from April 2006 to December 2015 for the treatment of RCC. A total of 41 patients, whose tumor was adjacent to the renal sinus, were enrolled in this study. The following inclusion criteria were applied: patients with RCCs adjacent to the sinus diagnosed by pre-ablation percutaneous biopsy, patients with old age losing resection chance because of comorbidities, patients with single kidney, and patients preference. Comorbidities included cardiovascular or cerebrovascular disease, renal dysfunction, severe diabetes, and cirrhosis. Patients with more than one renal RCC tumor adjacent to the sinus, renal vein invasion, retroperitoneal lymph node metastasis, and extra renal spread of tumor were excluded from the analysis. All cases were evaluated at the pre-ablation stage by a multidisciplinary team including a urologist, oncologist, interventional physician, and radiologist. An informed consent was obtained from each patient prior to the procedure. The retrospective study was approved by the Institutional Review Board of our institution.

2.2. Pre-procedure preparation

Each patient underwent gray scale US (Sequoia 512, Acuson, Mountain View, CA) and contrast-enhanced US (SonoVue, Bracco, Milan, Italy) to confirm the size, number, edge, and location of the tumor. Tumor size was determined by measuring the maximum diameter in contrast-enhanced US images in the arterial phase. Contrast-enhanced computed tomography (CT, lightspeed 16, GE, Milwaukee, WI) or magnetic resonance (MR, Signa EchoSpeed; GE, Milwaukee, WI) imaging was performed to evaluate tumor characteristics, the exact location (upper, middle, or lower) of the tumor, its relationship with the renal sinus (adjacent to, partly in, central), and to determine whether or not it is adjacent to the bowel. For patients with renal function insufficiency, non-contrast-enhanced CT or MR was performed to protect renal function. Tumors <0.5 cm away from the renal sinus were considered as being adjacent to the sinus. An endophytic tumor that was partially in the renal sinus was considered as a tumor partly in the sinus. A tumor that was almost entirely within the renal sinus was considered a central tumor. From January 2012, a self-designed three-dimensional (3D) visualization software [13] was used (H. H., S. D.) for RCCs >4 cm and difficult to choose appropriate antenna passes to guide ablation and to visualize the relationship between the tumor and surrounding organs in a 3D space. This software would provide a 3D visualization model of the tumor based on the DICOM format data of contrast-enhanced CT/MR (Fig. 1).

Laboratory examinations of routine blood test, coagulation function, serum creatinine, serum urea nitrogen, and urinalysis were obtained prior to the procedure. Requirements for coagulation parameters were as follows: prothrombin time of <25 s, prothrombin activity >40%, and platelet count $>40 \times 10^9$ cells/L.

2.3. MWA equipment

A KY-2000 microwave ablation system (Kangyou Medical, Nanjing, China) with 1–100 W power-producing capability at 2450 MHz was used in this study. An output power of 50 W was routinely used for kidney ablation. This system can simultaneously drive two antennae. The antennae have a 15-gauge and an 18-cm shaft with dual channels inside, through which room-temperature distilled water is pumped by a peristaltic pump, while continuously cooling the shaft proximal to the radiating segment. The microwave system also has thermal monitoring equipment that can provide real-time temperature through a 21-gauge thermal sensor needle.

2.4. MWA procedure

The patients were placed under local anesthesia with 1% lidocaine, and a US guidance tumor biopsy was performed to obtain 2 or 3 pathohistologic diagnostic samples per patient. Intravenous anesthesia was administered via the peripheral vein during MWA using a combination of propofol and ketamine. With US guidance, the antennae were inserted as preoperatively planned, avoiding vessels and surrounding organs. Routinely, one antenna was used for tumors smaller than 2 cm and two antennae were simultaneously used for ablation of tumors between >2 and ≤4 cm in size. The ablation time typically did not exceed 10 min. For tumors that were more than 4 cm in length along the needle passing through, the antennae were pulled back by 2 cm after ablation for 5–10 min and ablation would be continued for another 5–10 min. For tumors wider than 4 cm, 1–2 insertion would be added for 5–10 min. If the heat-generated hyperechoic vapor did not cover the whole tumor, another insertion would be performed. The endpoint of treatment during a session was determined as complete coverage of the tumor with the hyperechoic vapor. Needle tract ablation was performed by stopping the peristaltic pump when each antenna was withdrawn to prevent tumor seeding. A thermal sensor needle was used at the tumor edge near the renal pelvis. Ablation time was adjusted to achieve the desired protective temperature of 50–54 °C. When the protective temperature reached 50 °C for patients with a prior laparotomy history or 54 °C for patients without a prior laparotomy history, the microwave emission would be paused. The emission would then be restarted until the temperature decreased to 45 °C. The ablation would be stopped when the cumulative ablation time of 50 °C lasted for 5 min or 54 °C for 3 min. For patients with the tumor adjacent to the bowel, normal saline (NS) was injected to separate the bowel from the tumor with a 2 cm distance to protect the bowel from thermal injury. All MWA was performed by three doctors (P. L., X. Y., and Z. C.) with more than 10 years of experience in US-guided ablation.

2.5. Post-procedure evaluation

After treatment, all the patients were closely observed for possible complications in hospital for 3–5days. Two images of contrast-enhanced US and CT or MR (Z. C., Z. H., J. Y.) would be performed 1 day and 1 month after treatment to determine the presence of residual or collecting system injury (fistula or active urinoma). For those with renal function insufficiency, non-contrast-enhanced CT or MR scan was performed to protect renal function. The MWA coagulation zone was measured using contrast-enhanced US in the arterial phase. Supplementary MWA would be performed if residual tumor was found.

Serum creatinine, serum urea nitrogen, and urinalysis were also monitored at 1 day and 1 month after treatment.

2.6. Follow-up

Follow-up was started from the time of MWA and the final follow-up concluded in December 2015 or when the patient died. Contrast-enhanced US and CT or MR were performed at 3 months and then every 6 months after MWA. Furthermore, non-contrast-enhanced CT or MR scan was performed in patients with renal function insufficiency and the same modality (CT or MR) was used in these patients in the pre-procedure evaluation and follow-up for better comparability. Four evaluation methods were recorded. Initial ablation success (IAS) was considered if patients had no residual tumor on enhanced images from the time of discharge to 3 months