Original Article

CT-Guided Percutaneous Microwave Ablation of Adrenal Malignant Carcinoma

Preliminary Results

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BACKGROUND: Microwave ablation has recently been developed as a safe and effective treatment for a variety of tumors. The authors evaluated the safety and efficacy of computed tomography (CT)-guided percutaneous microwave ablation of adrenal malignant tumors. **METHODS:** Nine patients between 41 and 83 years of age (average age, 54 years) with adrenal carcinoma (a total of 10 lesions) received CT-guided percutaneous water-cooled microwave ablation. The 9 cases included 1 primary adrenocortical carcinoma and 8 metastatic carcinomas (4 from lung cancer, 2 from hepatocellular carcinoma, 1 from intrahepatic cholangiocarcinoma, and 1 from left tibial osteosarcoma). Of the 8 metastatic cases, 7 were unilateral, and 1 was bilateral. All cases were pathologically confirmed by aspiration biopsy or postsurgical biopsy. The tumor diameters ranged from 2.1 cm to 6.1 cm (average, 3.8 cm). The average number of ablation sites was 1.5 sites (1-3 sites), and the average accumulated ablation time was 7.7 minutes (4-15 minutes). The procedures were performed using a cooled-shaft antenna. **RESULTS:** The patients were followed for 3-37 months, with an average of 11.3 months. Nine of 10 lesions were completely necrotized after first treatment. The other lesion was completely necrotized after 2 treatments. One of the patients experienced hypertensive crisis during treatment. No patient experienced recurrent tumor at the treated site, and this lack of recurrence indicated effective local control. All patients had progression of metastatic disease at extra-adrenal sites. **CONCLUSIONS:** CT-guided percutaneous water-cooled microwave ablation is a minimally invasive and effective method for the treatment of adrenal carcinoma. ***Cancer*** **2011;117:5182–8.** *© 2011 American Cancer Society.*

KEYWORDS: adrenal, malignant carcinoma, microwave, ablation, therapeutic effect.

Adrenal malignant tumors comprise many pathological tumor types including primary and metastatic tumors. The majority of primary adrenal carcinomas are adrenocortical carcinoma and malignant pheochromocytoma. Most metastatic tumors to the adrenal gland arise from lung cancer, followed by renal carcinoma, melanoma, and gastrointestinal cancer.[1-3] Abdominal surgery and laparoscopic excision are the traditional treatments for primary adrenal carcinoma.[4-8] Although controversial, surgical excision of isolated adrenal metastatic tumors has been supported by some researchers.[7,9] Recently, an increasing number of minimally invasive treatments, such as selective arterial embolization, radiofrequency ablation, chemical ablation, laser ablation, and microwave ablation, have been used to treat adrenal carcinoma.[10-16]

Microwave ablation has been developed in the current decade as a new tumor ablation technique and is widely used to treat many types of malignant carcinomas including liver cancer, lung cancer, metastatic bone tumors, and renal tumors.[16-20] Microwave ablation of the adrenal gland is a promising technique for percutaneous treatment of adrenal malignant tumors, although there is limited experience reported in the literature.[16,21,22] We retrospectively analyzed patients with adrenal carcinomas who underwent microwave ablation in our department with the goal to evaluate the safety, practicality, and efficacy of CT-guided microwave ablation of adrenal carcinomas.

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Table 1. Tumor Characteristics and Treatment Procedures of 10 Lesions

Patient No.	Tumor Location	Pathology	Tumor Diameter	No. of Ablation Sites	Power Setting	Accumulated Ablation Time, min
1	Right	Tibial osteosarcoma	4.0 × 2.5	1	70	8
2[a]	Left	Adrenocortical carcinoma	6.1 × 3.8	3	70	15
3	Left	Lung adenocarcinoma	2.9 × 2.0	1	60	5
4	Right	Large cell lung carcinoma	4.1 × 3.9	2	50	10
4	Left	Large cell lung carcinoma	3.6 × 2.5	1	60	7
5	Left	Hepatocellular carcinoma	3.5 × 3.3	2	70	8
6	Right	Cholangiocarcinoma	3.6 × 1.8	1	60	6
7	Left	Hepatocellular carcinoma	2.1 × 2.0	1	50	4
8	Right	Pulmonary squamous cell carcinoma	5.2 × 4.2	2	70	10
9	Right	Lung adenocarcinoma	2.7 × 2.2	1	60	4

[a] At 1-month follow-up, computed tomography (CT) showed residual tumor. Thus, a second microwave ablation (50 W, 5 min) was performed. One month after the second ablation, follow-up showed complete tumor necrosis.

MATERIALS AND METHODS

Patients

Patient data

This retrospective study was approved by our internal review board. Before treatment, all patients received a detailed explanation of the ablation procedure, possible complications, and expected outcomes. All patients gave their written informed consent before treatment. From July 2007 to June 2010, 9 patients (8 men and 1 woman between 41 and 83 years of age; average age, 54 years) received CT-guided microwave ablation of adrenal solid tumors at our hospital. Some tumors were not operable because of other coexisting diseases, and some patients refused surgical excision. One patient a had recurrence after a surgical resection, and the tumor was not removed in a second surgical excision.

Tumor characteristics

A total of 10 lesions received ablation treatment. Five were located within the left adrenal gland, and 5 were located within the right adrenal gland. The diameters of the lesions ranged from 2.1 cm to 6.1 cm, with an average of 3.8 cm. Nine of the 10 lesions were pathologically confirmed by CT-guided fine-needle aspiration biopsy, and the other was pathologically confirmed after surgical excision. One lesion was a primary adrenocortical carcinoma, and the other 9 were metastatic adrenal carcinomas (5 from lung cancer, 2 from hepatocellular carcinoma, 1 from intrahepatic cholangiocarcinoma, and 1 from left tibial osteosarcoma; See Table 1). Before ablation, all metastatic carcinomas were isolated adrenal metastasis, and their primary tumors were all controlled by chemotherapy, microwave ablation, or surgical excision.

Preparation before the ablation

All patients received complete routine laboratory examinations, including complete blood count (CBC), blood chemistry, viral titers (such as hepatitis B virus [HBV], hepatitis C virus [HCV], and human immunodeficiency virus [HIV]), and coagulation profile examinations.

Methods

All ablations were performed with intravenous conscious sedation. The patients' vital signs were continuously monitored, especially changes in blood pressure. The blood pressure measurement was performed every 5 minutes, and its frequency was increased to every 3 minutes after the start of ablation. When the patient experienced intolerable pain during the ablation, 100 mg tramadol hydrochloride (Grunenthal, Aachen, Germany) was injected intravenously for pain relief.

Imaging guidance

Treatment of all 10 tumors was performed under CT guidance. CT was performed using the Picker CT-Twin Flash scanner (Elscint, Haifa, Israel). The adrenal gland was scanned at 120 kV, 275 mA, using a slice thickness of approximately 3-5 mm, and a pitch of 1. Except for 1 patient in the supine position (Fig. 1), other patients were scanned in a lateral or prone position before the ablation. After adrenal gland CT scanning, appropriate scanned layers were selected, and the puncture angles and depths were thereby confirmed.

Surgical technique

Local anesthesia was given at the selected puncture points with 2% lidocaine. After a surgical incision was made, the 14-gauge microwave antenna was inserted into the tumor at a predetermined angle in a stepwise manner.

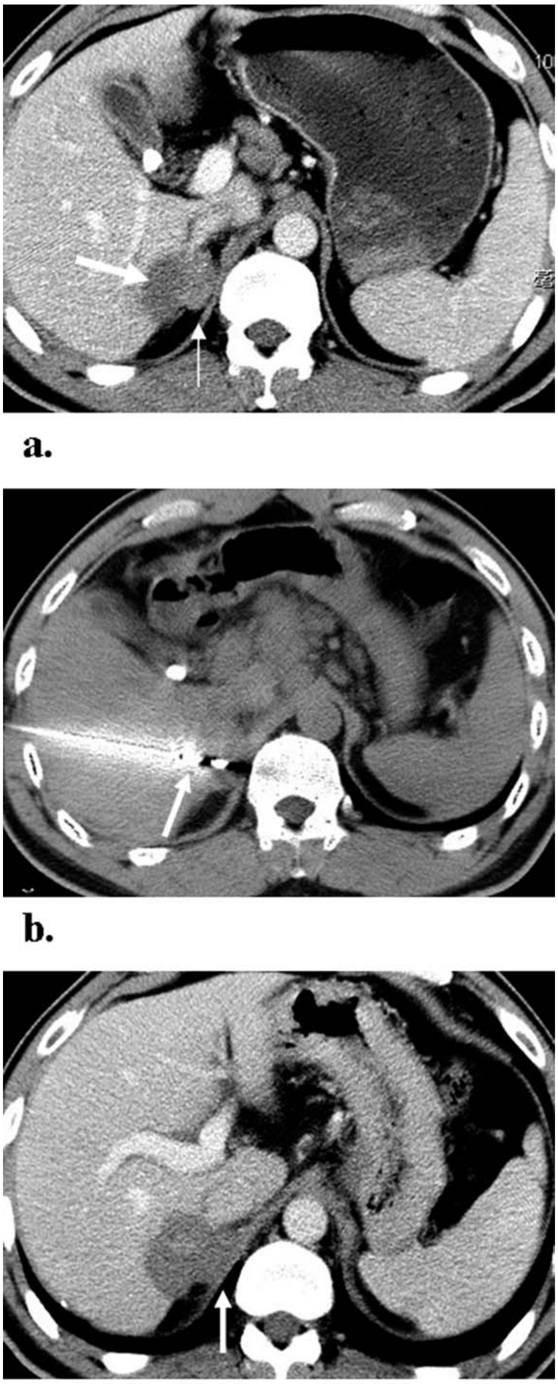

Figure 1. A male patient with intrahepatic cholangiocarcinoma involving the right lobe of the liver with isolated metastasis in the right adrenal two months after microwave ablation, with tumor size of 3.6 × 1.8 cm. (a) Enhanced CT scan on abdominal transverse section shows a low density primary tumor (thick arrow), which resulted from the ablation. (b) In the supine position, the patient receives the microwave ablation antenna in the tumor center under CT guidance (arrow indicating the microwave antenna). (c) There was no enhancement 3 months after the treatment, as revealed by enhanced CT scan.

CT scanning was performed, again, to ensure that the ablation antenna had been placed in the appropriate position within the tumor. For microwave ablation, we used a commercially available system (ECO; Qinghai Microwave Electronic Institute, Nanjing, China) and a 14-gauge cooled-shaft antenna. Internal cooling of the antenna shaft was performed with a peristaltic pump (BT01-100 LanGe-Pump; LanGe Steady Flow Pump, Baoding, China) that recirculated chilled saline solution (50≈60 mL/min) to maintain a mean shaft temperature of 10°C ± 2 (standard deviation). The power was generally set at approximately 50-70 W. The ablation time for 2≈4 cm tumors was 4≈10 minutes. For tumors larger than 4 cm, ablation was performed with multiple-site superposition, or using an appropriately elongated treatment time, depending on our previous ablation experience with other solid tumors such as liver, with the aim to completely necrotize the tumor. Nine of the 10 tumors were treated in 1 session, whereas the remaining tumor was treated with a second ablation because of tumor residuals (Table 1). We used 1≈3 ablation sites per lesion (average, 1.5 sites), with an accumulated ablation time which ranged from 4 to 15 minutes (average, 7.7 minutes). After ablation, track ablation was performed to avoid implantation metastasis in the probe's pathway. All operations were completed by 1 of the 4 interventional radiologists (Fan Wei Jun, Zhang Liang, Zhao Ming, and Huang Zi Lin), all of whom had more than 10 years of experience in tumor ablation. Following treatment, CT scanning was again performed to evaluate the immediate necrotic conditions after ablation and to examine whether there were any complications, such as bleeding.

Patient Follow-Up

After treatment, all patients received continuous electrocardiogram (ECG) and pain monitoring for 4 hours in the recovery ward. When a patient experienced pain, analgesic treatment was given. All patients were discharged after 2 days of observation.

We followed all treated patients. A dual-phase CT-enhanced scan, an arterial phase lasting 35 seconds and a venous phase lasting 60 seconds, was performed 1 month after treatment to evaluate the degree of tumor necrosis (no enhancement indicating complete tumor necrosis, areas of enhancement indicating possible residual tumor) and to observe for new areas of enhancement in the adrenal gland (indicating tumor relapse). All examinations were performed with a spiral CT scanner

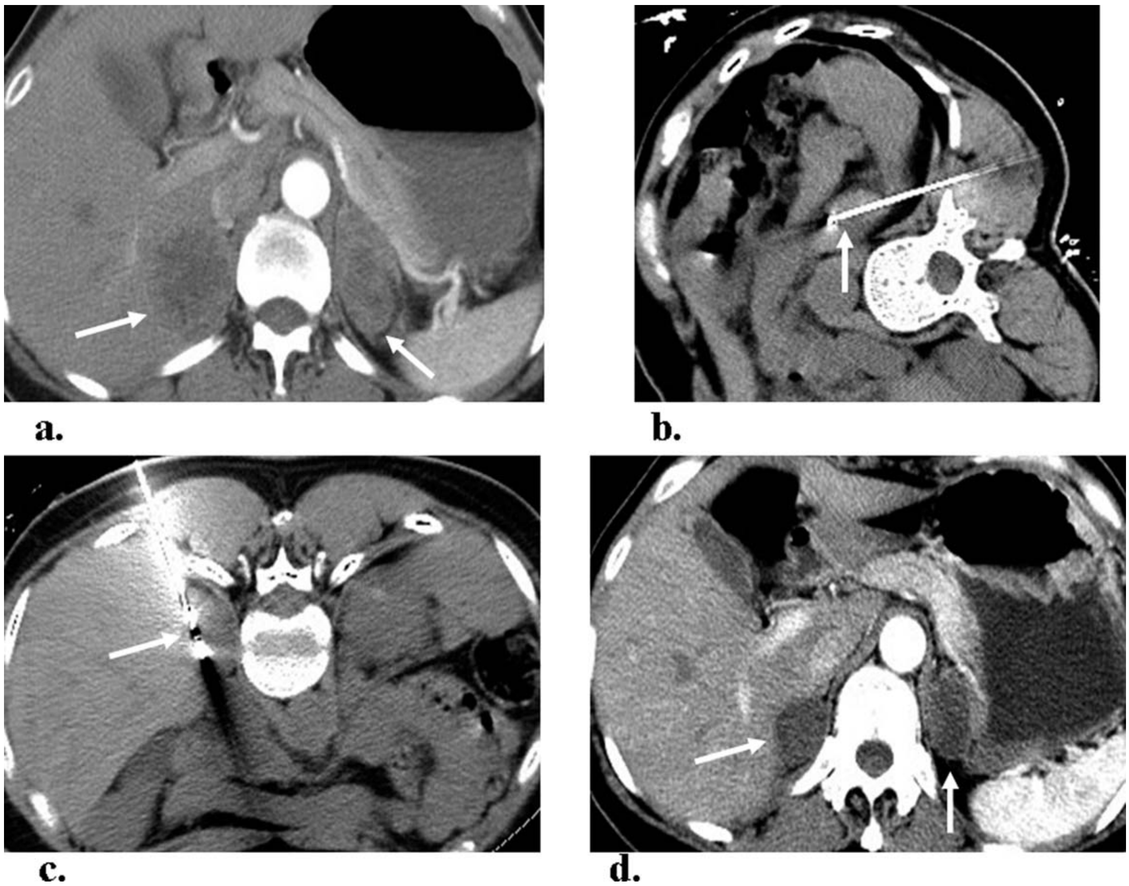

Figure 2. A 54-year-old female patient with isolated bilateral adrenal metastasis from large cell lung carcinoma with tumors measuring 4.1 × 3.9 cm (right-side) and 3.6 × 2.5 cm (left-side). (a) Abdominal transverse enhanced CT scanning shows bilateral adrenal metastasis. (b) In the right supine position, microwave ablation is performed on the left adrenal metastatic tumor. (c) In the prone position, microwave ablation is performed on the right adrenal metastatic tumor (arrow indicating the microwave ablation antenna). (d) Enhanced CT scanning shows no tumor enhancement 6 months after the operation.

(Brilliance 16; Philips, Amsterdam, the Netherlands) using a sequential acquisition of 5 mm-thick sections, 120 kV, and 250 mA. Iohexol (Omnipaque 240; Amersham Health, Princeton, NJ), at an injection speed of 3 mL/s, was used as the contrast agent. Subsequent CT examinations were performed in the third month after treatment and every 6 months afterwards, or depending on clinical conditions.

Two of the authors (Li Xin and Zhang Liang) were in charge of collecting follow-up data, including the level of tumor necrosis, the existence of residual tumor, tumor recurrence, new metastasis, progression of the primary tumor, and the overall condition (such as survival) of each patient. The data were acquired using CT scanning, direct patient contact, or review of medical records stored in the medical records room of our hospital.

RESULTS

Clinical Evaluation of the Therapeutic Effects and Patient Follow-Up

The average follow-up period was 11.3 months (average, 3≈37 months). Nine of the 10 tumors were completely necrotized after first ablation, which included 1 patient with a bilateral adrenal metastasis (Fig. 2). After microwave ablation of the bilateral adrenal tumors, the patient received substitutive treatment with oral glucocorticoid and fludrocortisones. Only 1 lesion showed residual tumor at 1-month follow-up. After the second ablation, the tumor was completely necrotized, as revealed by enhanced CT at 1-month follow-up (Fig. 3). However, subsequent visits found lung and liver metastasis in the patient. Five of the 8 patients with adrenal metastatic tumors died from the

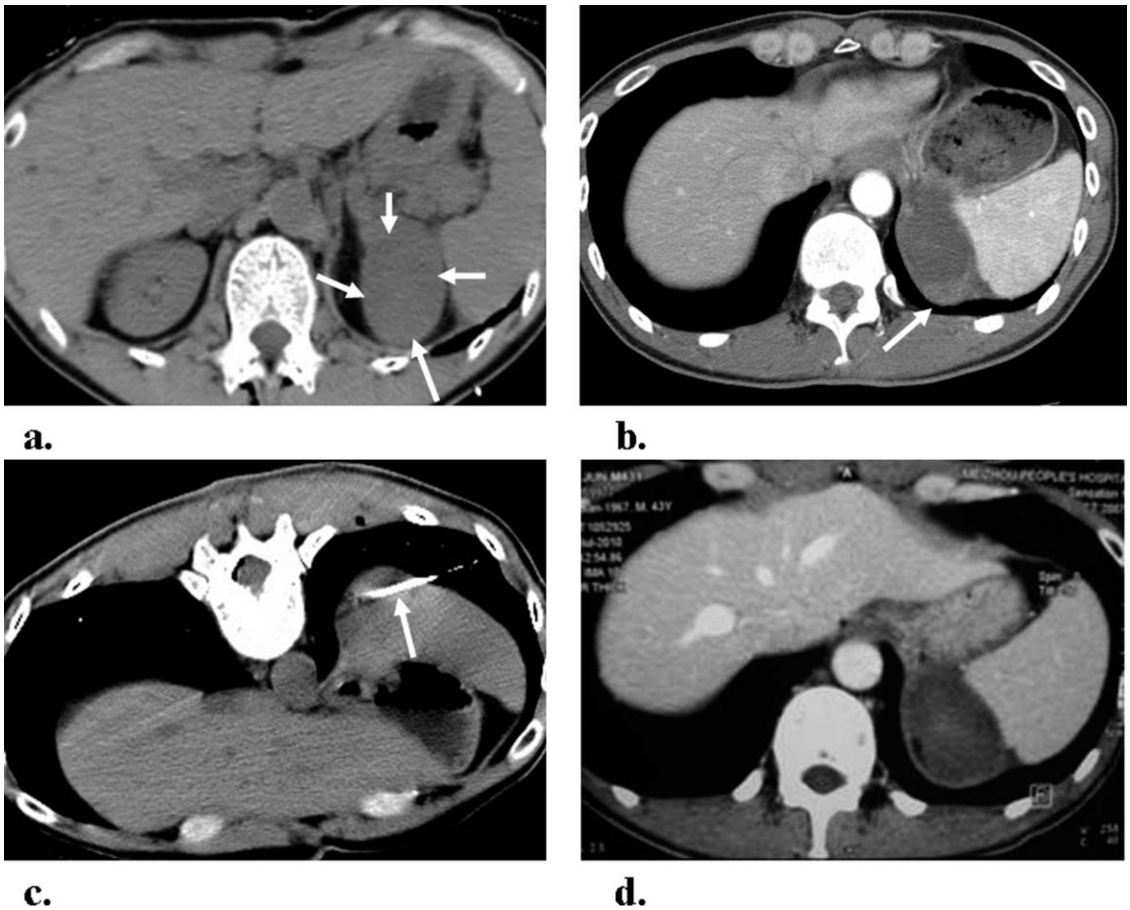

Figure 3. A 41-year-old male patient with left adrenal adrenocortical carcinoma shows a local tumor relapse 1 month after radical surgery. After the patient received 2 stages of chemotherapy with taxotere + DDP, partial progression (PR) was evaluated. The patient received another 2 stages of taxotere + DDP chemotherapy to evaluate the status of progressive disease (PD). As shown in (a), leveled CT scan reveals that the tumor is oval and measures 6.1 × 3.8 cm (arrow). (b) Abdominal enhanced CT scanning one month after microwave ablation shows that the center of the tumor is completely necrotized, with residual enhancement areas (arrow). (c) A second microwave ablation is performed. (d) One month after the second ablation, follow-up reveals that there is no tumor enhancement.

progression of their primary tumors or its metastasis to other organs.

Adverse Reactions and Complications

One patient experienced a hypertensive crisis. This patient, aged 50 years, had right-sided lung cancer accompanied by an isolated left adrenal gland metastasis. He had no previous hypertensive history with a baseline blood pressure of 136/85 mm Hg. The adrenal tumor was 2.9 cm × 2.0 cm in size. One minute after the start of ablation, the patient experienced a sudden spike in blood pressure to 243/147 mmHg accompanied by headache, tachycardia, and ventricular arrhythmia. The ablation was immediately paused, and the patient received an intravenous injection of 5 mg phentolamine mesylate (Regitine; Nycomed, Zurich, Switzerland). His blood pressure returned to baseline 5 minutes after the injection. To completely remove the tumor, microwave ablation was resumed. However, the patient again experienced a similar high blood pressure reaction. The crisis was controlled again with another 5 mg Regitine injection. Afterwards, the patient remained stable to the end of ablation. After the procedure, the patent received continuous ECG monitoring for 4 hours, and the blood pressure remained at baseline. In subsequent follow-ups, no obvious nervous or cardiopulmonary complications were noted.

Another patient experienced pain after returning to the recovery ward. Oral paracetamol tablets (Sino-American Shanghai Squibb Pharmaceuticals, Shanghai, China) were given, but the pain persisted. Afterward, the patient received an intramuscular injection of tramadol hydrochloride, which relieved the pain. No complications were reported by the other patients.

DISCUSSION

The use of image-guided heat ablation (including radiofrequency, microwave, and laser ablation) has been widely applied to all types of solid tumors as a minimally invasive treatment method. Compared with radiofrequency ablation, microwave ablation has the following advantages: continuous higher intratumoral temperatures, faster temperature rise rate, larger ablation volume, and shorter ablation time.[16,23-26] In addition, due to the inherent nonelectrical properties of the electromagnetic waves, the microwave ablation device requires no external electrodes; thus, the risk of burning caused by external electrodes used in radiofrequency ablation is avoided.[16] Furthermore, radiofrequency ablation fails to adequately heat cystic tumors. The cystic characteristics of adrenal metastatic tumors are more amenable to microwave ablation.[16]

Our preliminary results showed that microwave ablation was able to effectively destroy both primary and metastatic adrenal carcinomas. Similar to our results, Wang et al[21] performed ultrasound-guided ablations on 5 unilateral adrenal metastatic tumors of 2.3≈4.5 cm in diameter, at 1≈2 sites per lesion. The researchers found no residual tumor at the ablation locations at approximately 8-31 months of follow-up. Our study differed from the above study by the finding that 1 of the tumors we treated presented with residual tumor. The remaining tumor had enlarged to 6.1 cm in diameter and completely necrotized after a second microwave ablation. Mayo-Smith et al reported that after radiofrequency ablation, 2 of the 13 cases with adrenal tumors, which averaged more than 6 cm in diameter, showed residual tumor. These results of heat ablation showed that when the tumor's diameter exceeded 5 cm, a complete tumor ablation rate was less than 30%, despite multiple-site repeated ablation.[27,28] Therefore, adrenal malignant tumors larger than 5 cm had a greater possibility of residual tumor or relapse after microwave ablation. Regular and timely follow-ups are necessary. Secondary microwave ablation should be performed on areas with relapse or residual tumor.

In this study, complications including pain and hypertensive crisis were controlled by corresponding interventions. Due to its higher potential death rate, hypertensive crisis is a critical complication of microwave ablation. Onik et al[29] reported 2 patients with intrahepatic metastatic tumor located near the normal right adrenal gland who experienced hypertensive crisis during radiofrequency ablation. One of the 2 patients showed a prominent rise in the catechol level, 10 times higher than normal. The catechol level returned to normal after treatment. Chini et al[30] reported the first case of hypertensive crisis that resulted from ablation of adrenal metastatic tumor. In our study, 1 patient also demonstrated hypertensive crisis. To our knowledge, this is the first report of a hypertensive crisis caused directly by microwave ablation of adrenal tumor. Some researchers suggest that as microwave ablation elevates the temperature more rapidly than radiofrequency ablation, it is more likely to induce hypertensive crisis.[16] However, compared with radiofrequency ablation, microwave ablation requires less time to treat a tumor due to its faster temperature rise rate. This reduces the stimulation to the adrenal gland and the subsequent occurrence of hypertensive crisis. Long-term, randomized, controlled studies are required to determine whether microwave or radiofrequency ablation has a higher tendency to induce hypertensive crisis. In light of potential hypertensive crises, vital signs (especially changes in blood pressure) should be closely monitored during ablation of adrenal tumors, particularly tumors with endocrine function. In case of hypertensive crisis, α-blockers or β-blockers are the 2 main treatment options.[12,31]

Our study had several limitations. Although our preliminary results showed that microwave ablation resulted in excellent local control rates over adrenal carcinomas, selection of appropriate candidates for microwave ablation is crucial to accurately evaluate the therapeutic effects. In our study, all adrenal metastatic tumor patients showed progression of their original tumors or metastasis outside the adrenal gland. The patients with primary adrenocortical carcinoma developed lung and liver metastasis. These progressions had a crucial impact on the prognosis. Due to our small sample size and short follow-up period, we could not assess whether local ablation of adrenal tumors contributed to overall patient survival. Future studies on ablation not only should be conducted on a larger sample size, but they should be compared against surgical resection in a prospective, randomized, controlled design. Patients who received microwave ablation of adrenal tumors should be contrasted with those who received surgical resection in terms of progression-free survival, recurrence rates, complication rates (including hypertensive crisis), and 1-5 year survival. Meanwhile, factors affecting the prognostic outcomes following microwave ablation on adrenal carcinomas should also be analyzed. We hope that through such future studies, the benefits of microwave ablation for patients with adrenal carcinomas can be verified.

CT allows precise measurements on the angles and depths of needle entry and provides direct visualization on the locations of adrenal tumors and the antenna. Thus, CT is the imaging tool of choice for guidance of microwave ablation of adrenal tumors.

Our preliminary results showed that microwave ablation exerts a definite local control rate on adrenal malignant tumors. However, continued follow-up of patients is necessary to determine the long-term efficacy, sequelae, and appropriate patient selection criteria.

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CONFLICT OF INTEREST DISCLOSURES

The authors indicated no conflicts of interest.

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