Microwave Ablation for the Treatment of Hepatic Adenomas

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ABSTRACT

Microwave (MW) ablation was used to treat 12 hepatocellular adenomas in six patients (five women and one man; mean age, 39.6 y). Mean treated tumor size was 2.7 cm ± 2.0. Tumor response was evaluated with serial cross-sectional imaging for a mean follow-up of 12.6 months ± 7.1. Primary treatment effectiveness and local tumor control were 100%. There were no instances of hemorrhage, malignant transformation, new hepatic tumors, or extrahepatic metastases. This early experience of treatment of hepatic adenomas by MW ablation demonstrates it to be a safe and feasible treatment modality at short-term follow-up. Continued investigation, including comparison with other treatment modalities, is warranted.

ABBREVIATION

HAE = hepatic arterial embolization

Hepatic adenoma is a benign liver tumor most commonly associated with use of oral contraceptives, use of anabolic steroids, and glycogen storage disease. The rationale for treatment of hepatic adenomas is based on (*a*) a risk of 5% for malignant transformation, particularly in tumors that are positive for β-catenin expression, and (*b*) a risk of spontaneous rupture or hemorrhage, which increases with increasing tumor size (1). Surgical resection is considered the standard of care, but because of concerns about surgical morbidity and prolonged recovery times, there is interest in less invasive treatment options (2).

Given the success of image-guided ablation in treating malignant hepatic tumors (3), there is increased interest in treating benign masses with percutaneous ablation. More recent reports described the successful use of radiofrequency (RF) ablation for the treatment of hepatic adenomas (4–6). In the case of hepatic adenomas, the goals of treatment are to destroy the tumor completely, arrest tumor growth, and prevent future hemorrhage and malignant transformation.

Microwave (MW) ablation has been increasingly used in recent years as a percutaneous thermal ablation method for the treatment of hepatic tumors. Compared with RF ablation, MW ablation creates higher tissue temperatures more rapidly, does not require the use of ground pads, and readily penetrates charred and dehydrated tissue (7). Despite widespread use of MW ablation for the treatment of hepatocellular carcinoma and liver metastases, there is a paucity of data on the application of MW ablation for the treatment of hepatic adenomas. The purpose of this single-center retrospective study is to describe our experience using percutaneous MW ablation for the treatment of hepatic adenomas.

MATERIALS AND METHODS

Patient Selection

This retrospective study was approved by the institutional review board and complied with the Health Insurance Portability and Accountability Act. All patients with hepatic adenomas who were treated with

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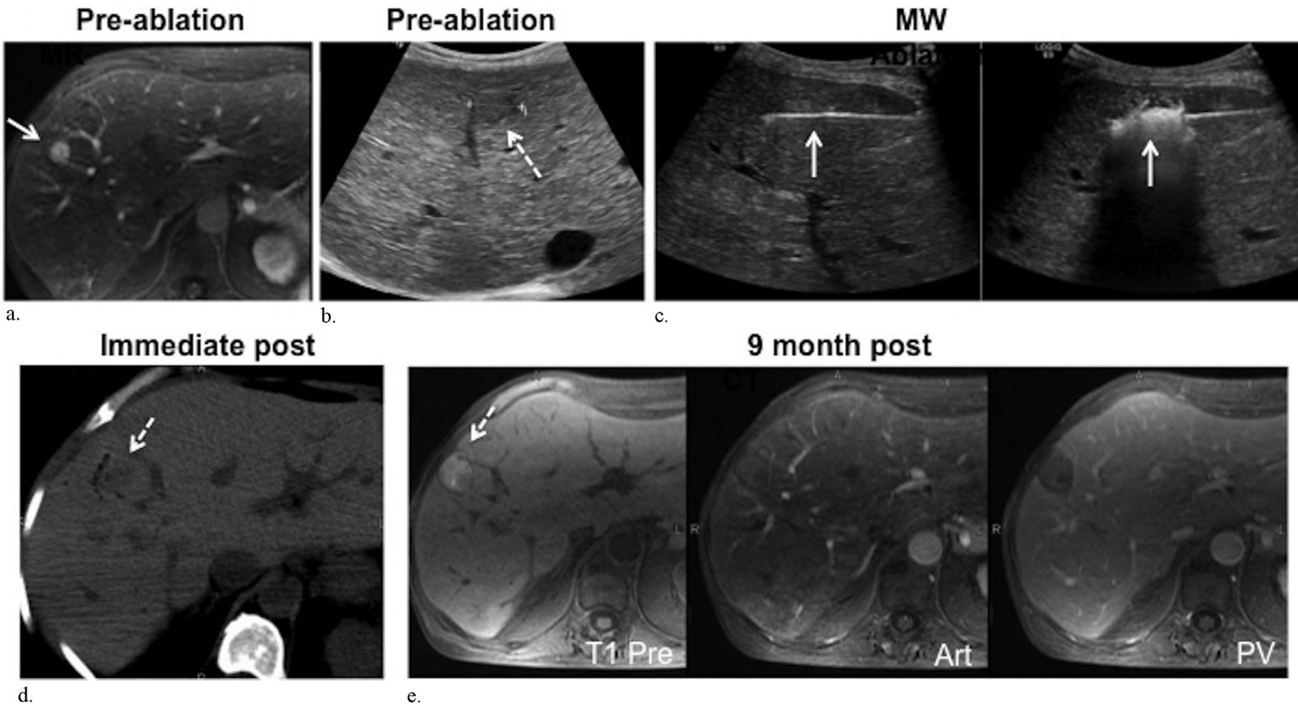

Figure 1. Patient 4 was a 45-year-old woman with type 1 glycogen storage disease and a growing hepatic adenoma. **(a)** MR imaging performed before ablation demonstrates an arterially enhancing adenoma in the right lobe (white arrow). **(b)** Ultrasound performed before ablation demonstrates a 2.4-cm hypoechoic mass corresponding to the MR imaging finding (dotted white arrow). **(c)** Ultrasound images obtained during the ablation procedure show a single MW antenna extending through the mass and gas bubble formation (white arrows). Ablation was performed with a single antenna for 5 minutes total at 65 W (3.5 min) and then 45 W (1.5 min). **(d)** CT image obtained immediately after the procedure (scan was performed without contrast material because of renal insufficiency) demonstrates ablation zone encompassing tumor (dashed white arrow). **(e)** MR imaging performed 9 months after ablation demonstrates inherent T1 hyperintensity within the ablation zone as a result of desiccated tissue (dashed white arrow) and no postcontrast enhancement.

MW ablation at a single center between May 2011 and January 2015 were included in this study. Tumors were selected for treatment by percutaneous MW ablation after review at a multidisciplinary tumor board that included radiologists, hepatologists, oncologists, hepatobiliary surgeons, and transplant surgeons. Decisions to pursue MW ablation therapy were based on a multidisciplinary discussion of multiple factors, including patient preference, number and location of tumors impacting the extent of a possible liver resection and hepatic reserve, success of MW ablation at controlling malignant tumors, and the decreased morbidity of percutaneous ablative procedures compared with surgery.

Imaging performed before the procedure was reviewed for tumor size, any concerning tumor features including hemorrhage and malignant transformation, and background liver disease. No patients had active hemorrhage or demonstrated characteristics of malignant transformation by imaging before MW ablation. There was no evidence of cirrhosis in any of the patients. Tumor size was measured on the most recent contrast-enhanced computed tomography (CT) or magnetic resonance (MR) imaging performed before the procedure in the largest axial dimension.

Biopsy of tumors was performed in five of six patients before a treatment decision yielding a diagnosis of hepatocellular adenoma. Subtyping was not routinely performed at our institution during the study period and is unavailable for our study population. For the single tumor for which biopsy was not performed, the patient and tumor fit the typical clinical and imaging features of hepatic adenoma—a young woman without hepatitis or cirrhosis with classic MR imaging findings of a T2 hyperintense mass with enhancement during the hepatic arterial phase and washout during the portal venous phase and no hepatobiliary phase hyperintensity (8).

Ablation Technique

Image-guided percutaneous MW ablation was performed on all patients under ultrasound guidance using a high-powered, gas-cooled MW ablation system (Certus 140; NeuWave Medical, Madison, Wisconsin) approved by the US Food and Drug Administration. All ablations were performed by one of five board-certified radiologists experienced in the procedure (1–20 y of ablation experience). Procedures were conducted with the patient under general anesthesia in a CT imaging suite. After induction of general anesthesia and sterile preparation, real-time ultrasonography (LOGIQ E9; GE Medical Systems, Waukesha, Wisconsin) was used to place one to three 17-gauge MW antennas. A CT scan confirmed antenna position. The performing physician determined

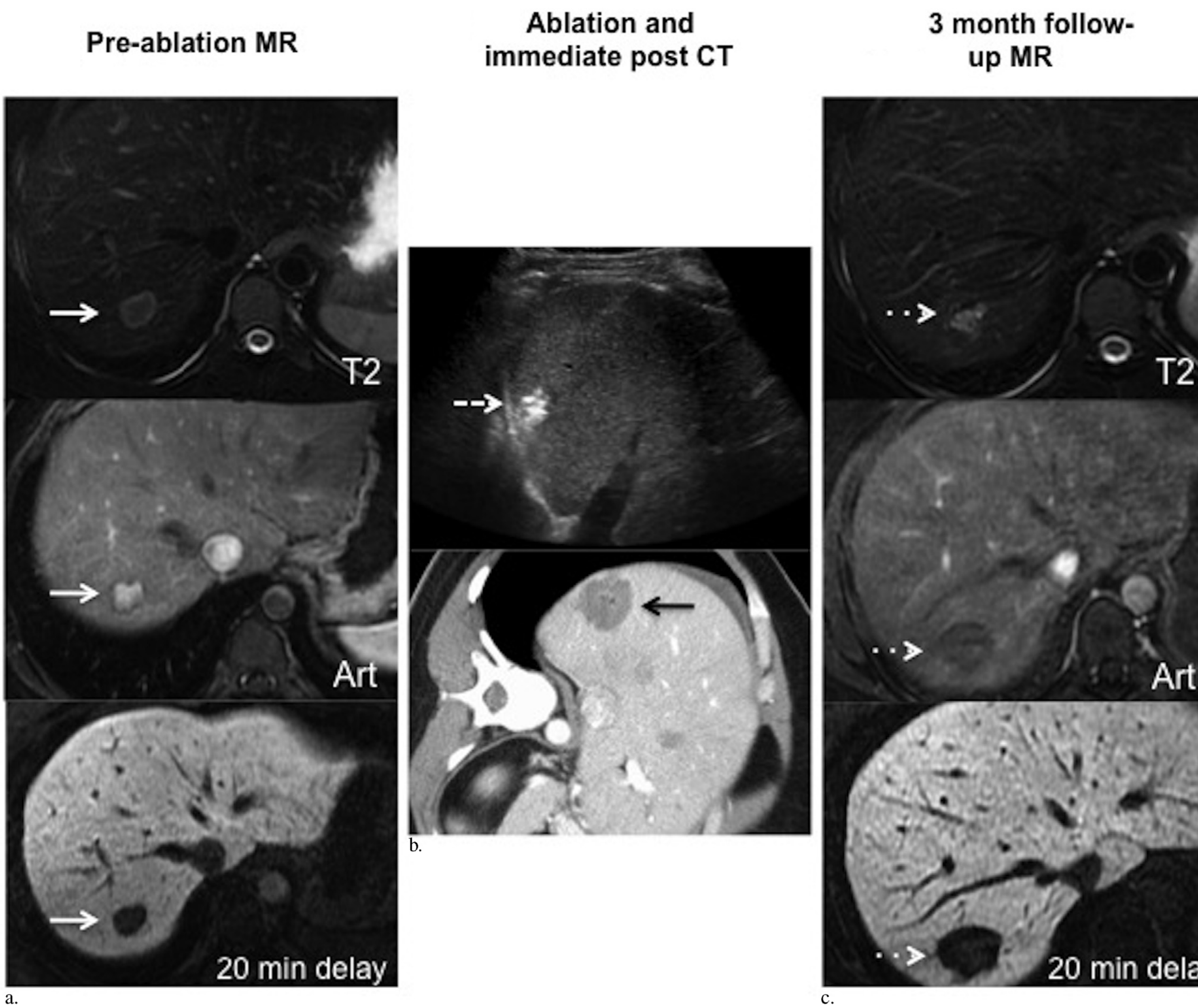

Figure 2. Patient 5 was a 33-year-old woman planning pregnancy. **(a)** MR imaging performed before ablation shows a 2.3-cm T2 hyperintense arterially enhancing lesion (white arrows) in the right hepatic lobe, which is hypointense on the delayed phase image (examination was performed with gadoxetate disodium). **(b)** Gray-scale ultrasound image obtained before and during ablation demonstrate the MW antenna in the tumor and subsequent gas bubble formation (dashed white arrow). Ablation was performed using one gas-cooled MW ablation antenna powered at 65 W for 5 minutes. Contrast-enhanced CT image obtained immediately after ablation demonstrates complete treatment of the lesion (black arrow). **(c)** MR imaging performed 3 months after ablation demonstrates the nonenhancing ablation zone (dotted white arrows).

power and time settings based on tumor size and intraprocedure findings, including adequacy of tumor coverage by the ablation zone. Arterial and portal venous phase contrast-enhanced CT (Lightspeed Ultra; GE Medical Systems) scans using 100–150 mL of intravenous contrast agent (Omnipaque 300; GE Healthcare, Waukesha, Wisconsin) were performed immediately after the procedure to document the ablation zone, assess technical success, and evaluate for immediate complications. In one patient with renal insufficiency, a noncontrast CT scan was performed immediately after the procedure.

Follow-up

Patients were followed clinically and with serial imaging studies after treatment. The electronic medical record was accessed for evaluation of clinical symptoms and complications up to the most recent clinic visit. Imaging follow-up was performed with either contrast-enhanced MR imaging or CT. Average time to first, second, third, and fourth imaging follow-up was 1.9 months, 7.6 months, 11.5 months, and 16.3 months. All images obtained after the procedure were reviewed for local tumor progression and complications using accepted reporting (9).

RESULTS

The study group comprised 12 hepatic adenomas receiving a course of treatment in six patients (five women and one man; average age, 39.6 y) in a single session (six patients, 11 tumors) or two sessions (one patient with an

8.3-cm adenoma who underwent a planned staged ablation). Etiologies for hepatic adenoma formation included idiopathic (n = 9), oral contraceptive use (n = 2), and glycogen storage disease (n = 1) (Fig 1a–e).

Mean tumor size (± SD) was 2.7 cm ± 2.0 (range, 0.8–8.3 cm). Mean ablation power setting was 75 W, and mean ablation time was 6.3 minutes ± 4.2 (Table). As assessed on CT performed after ablation by analysis of adequate tumor coverage by the ablation zone (Fig 2a–c), technical success was 100%, including an 8.3-cm tumor that received treatment in two planned sessions (Fig 3a, b).

There were no cases of hemorrhage or other immediate major complication, as defined by the Society of Interventional Radiology (SIR) classification system (10). One patient required a short-term (overnight) readmission for pain control on day 5 after the procedure. There were no significant clinical complications, such as persistent pain or liver failure, over a follow-up interval of 18 months ± 11.3. There were no instances of local tumor progression, growth, hemorrhage, malignant transformation, new hepatic tumors, or metastases evident by imaging criteria over a mean imaging follow-up period of 12.6 months ± 7.1.

DISCUSSION

The results of this study demonstrate that MW ablation can be used as a minimally invasive approach to treat hepatic adenomas successfully. All adenomas were completely treated by ablation, and there were no major complications or cases of tumor recurrence or malignant transformation to date.

Although adenomas are typically benign, treatment is often indicated because of infrequent but potentially severe complications. Spontaneous hemorrhage has been reported in 25% of patients and in rare cases can be fatal (approximately 3% of tumors) (11). Untreated adenomas may also increase in size, and an enlarging adenoma has been shown to be an independent risk factor for rupture (11). Approximately 5% of adenomas undergo malignant transformation (12). In particular, adenomas associated with the β-catenin mutation, which account for 10%–15% of adenomas, are at greatest risk for malignant transformation (13).

Prophylactic surgical resection has been considered the gold standard for treatment of hepatic adenomas. Local tumor control is excellent after surgical resection with a local tumor progression rate of up to 8% (14). However, surgical morbidity is the major drawback to resection of hepatic adenomas. Serious complications, including biliary fistula, pulmonary embolism, pneumonia, pleural effusion, and surgical site infection, have been reported at a rate of 10.5%–15% (14,15).

Because of the known drawbacks to surgical resection, other minimally invasive treatment strategies have been

Table. Case Details

	Patient Details			Tumor Details			Procedural Details		Follow-up	
Tumor No.	Patient No.	Age (y)	Sex	Diameter before Ablation (cm)	Etiology	Indication for Treatment	Mean Power (W)	Ablation Time (min)	Imaging Follow-up (mo)	Clinical Follow-up (mo)
1	1	43	F	8.3*	Spontaneous	Risk of malignant transformation/hemorrhage	65/65	13/10	9	9
2	1			3.5	Spontaneous	Risk of malignant transformation	95	8	9	9
3	2	37	F	1.5	Spontaneous	Risk of malignant transformation	95	2	15	29
4	2			0.8	Spontaneous	Risk of malignant transformation	95	2	15	29
5	2			1.0	Spontaneous	Risk of malignant transformation	95	2	15	29
6	2			2.3	Spontaneous	Risk of malignant transformation	95	5	15	29
7	2			3.8	Spontaneous	Risk of malignant transformation	95	15	15	29
8	3	40	M	2.4	Spontaneous	Risk of malignant transformation	60	5	18	18
9	4	45	F	1.7	von Gierke disease	Risk of malignant transformation	55	5	23	11
10	5	33	F	2.3	Spontaneous	Patient desired pregnancy	65	5	15	16
11	6	34	F	1.5	Oral contraception	Risk of malignant transformation/hemorrhage	60	5	1	1
12	6			3.8	Oral contraception	Risk of malignant transformation/hemorrhage	65	8	1	1
Mean		39.6		2.2			79.5	5.6	12.6	17.5

F = female; M = male.
*Staged treatment.

Pre-ablation MR

a.

9 month post CT

b.

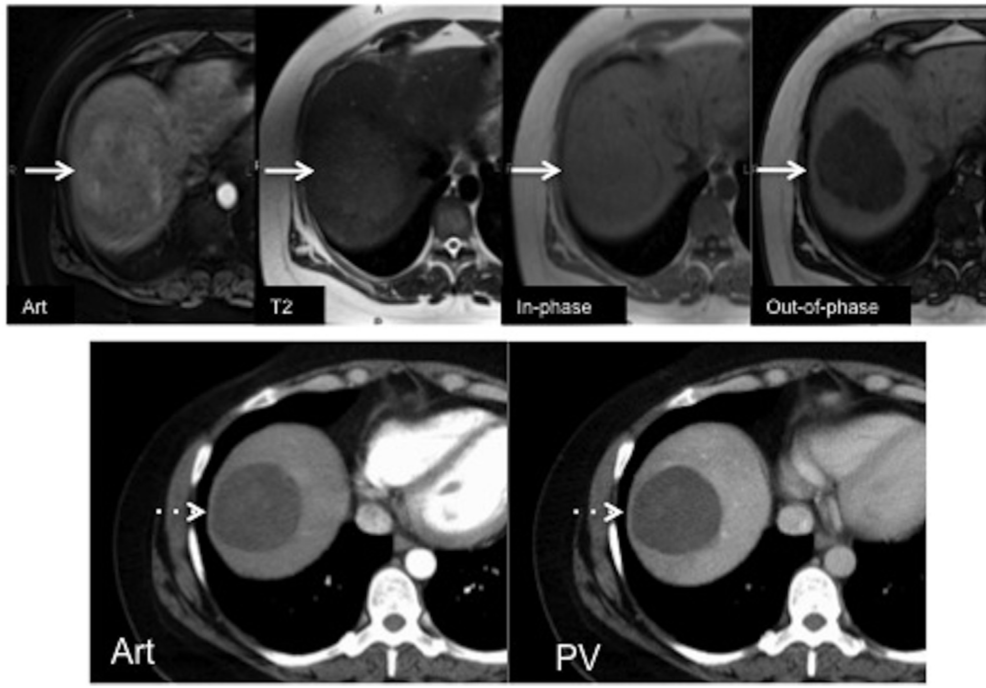

Figure 3. Patient 1 was a 43-year-old woman with multiple large hepatic adenomas. **(a)** MR imaging performed before ablation demonstrates the largest adenoma measuring 8.9 cm in the dome (white arrows), which shows heterogeneous arterial enhancement, mild T2 hyperintensity, and significant signal dropout on the out-of-phase sequence consistent with lipid content. **(b)** CT scan performed 9 months after ablation demonstrates a hypodense ablation zone without enhancement (dotted white arrows).

attempted to treat hepatic adenomas, the most widely reported being hepatic arterial embolization (HAE) (4,5,16). The rationale for HAE appears particularly strong in patients who present with acute hemorrhage or large or multiple tumors. The complication rate with HAE is low, and most complications are not serious (16). The major drawback to embolization as monotherapy appears to be uncertainty as to whether the treatment eradicates all cells within a targeted adenoma; this is particularly relevant for the β-catenin and inflammatory subtypes that have a higher risk of malignant transformation (13). Retreatment rates for HAE of 25% have been reported (17).

In contrast, there were no major complications in this study of adenomas treated by MW ablation. Only one patient experienced significant pain. Furthermore, no cases in our study group have required retreatment for recurrence or malignant transformation to date.

The rationale for thermal ablation of hepatic adenomas is based on the complete destruction of all cells within a targeted tumor, reducing the risk of malignant transformation and devascularization of the tumor to prevent future hemorrhage. Data on the results of RF ablation for the treatment of hepatic adenomas are limited, but several small series ranging from three to 18 patients studied for up to 35 months demonstrated efficacy that appears to diminish with increasing tumor size (4–6). In the largest of these series, RF ablation of 45 adenomas with median size of 3.0 cm (range, 0.8–7.3 cm) resulted in a relatively high local technical failure rate of 42% (6). The authors theorized that large tumor size, lack of cirrhosis, and tumor capsule may have contributed to this result. We hypothesize that the lack of failures in our study is related to the larger ablation volumes produced by MWs as well as the relative insensitivity to background tissue properties and greater ability to overcome blood perfusion (18).

The most important limitation of this study is the small sample size. However, hepatic adenoma is an uncommon tumor, and the incidence of tumors in the treatable size range is low. By way of context, other studies of percutaneous image-guided modalities for treating hepatic adenomas demonstrated a similar-sized patient population (4,14). Although our evolving understanding of adenoma subtyping may help guide patient selection for treatment in the future, the present study did not include subtyping because it was not routinely performed at our institution during the study period. An additional study limitation is the relatively short follow-up period. This short follow-up is partly a reflection of the relative newness of MW ablation. Longer follow up will be useful to confirm treatment durability.

In conclusion, percutaneous treatment of hepatic adenomas with MW ablation is safe and feasible, able to eradicate targeted tumors and prevent hemorrhage. Further investigation with a larger patient population and longer follow-up time is warranted.

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