CLINICAL STUDY

Preliminary Outcome of Microwave Ablation of Hepatocellular Carcinoma: Breaking the 3-cm Barrier?

Somrach Thamtorawat, MD, Robert M. Hicks, MD, Jenifer Yu, BS, Surachate Siripongsakun, MD, Wei-Chan Lin, MD, Steven S. Raman, MD, Justin P. McWilliams, MD, Michael Douek, MD, Simin Bahrami, MD, and David S.K. Lu, MD

ABSTRACT

Purpose: To evaluate preliminary outcomes after microwave ablation (MWA) of hepatocellular carcinoma (HCC) up to 5 cm and to determine the influence of tumor size.

Materials and Methods: Electronic records were searched for HCC and MWA. Between January 2011 and September 2014, 173 HCCs up to 5 cm were treated by MWA in 129 consecutive patients (89 men, 40 women; mean age, 66.9 y ± 9.5). Tumor characteristics related to local tumor progression and primary and secondary treatment efficacy were evaluated by univariate analysis. Outcomes were compared between tumors ≤ 3 cm and tumors > 3 cm.

Results: Technical success, primary efficacy, and secondary efficacy were 96.5%, 99.4%, and 94.2% at a mean follow-up period of 11.8 months ± 9.8 (range, 0.8–40.6 mo). Analysis of tumor characteristics showed no significant risk factor for local tumor progression, including subcapsular location ($P = .176$), tumor size ($P = .402$), and perivascular tumor location ($P = .323$). The 1-year and 2-year secondary or overall treatment efficacy rates for tumors measuring ≤ 3 cm were 91.2% and 82.1% and for tumors 3.1–5 cm were 92.3% and 83.9% ($P = .773$). The number of sessions to achieve secondary efficacy was higher in the larger tumor group (1.13 vs 1.06, $P = .005$). There were three major complications in 134 procedures (2.2%).

Conclusions: With use of current-generation MWA devices, percutaneous ablation of HCCs up to 5 cm can be achieved with high efficacy.

ABBREVIATIONS

HCC = hepatocellular carcinoma, LTP = local tumor progression, MWA = microwave ablation

Percutaneous radiofrequency (RF) ablation has become a standard treatment for hepatocellular carcinomas (HCCs) < 3 cm associated with underlying liver disease (1). Several studies reported RF ablation in this patient population to be comparable to liver resection in overall survival with fewer complications (2–5). RF ablation has also been shown to be more cost-effective than hepatic resection in HCCs < 3 cm (6). In contrast, RF ablation in tumors > 3 cm has not been as successful, and tumor size is considered one of the most important factors influencing outcome of RF ablation in general (7–9). In the Barcelona Clinic Liver Cancer guidelines for treatment of HCC, only tumor nodules up to 3 cm are considered candidates for RF ablation as first-line treatment. The decreased effectiveness of RF ablation in larger tumors is multifactorial,

From the Department of Radiology (S.T., J.Y., W.-C.L., S.S.R., J.P.M., M.D., S.B., D.S.K.L.), David Geffen School of Medicine at the University of California, Los Angeles, California; Department of Radiology (S.T.), Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand; Albert Einstein College of Medicine (R.M.H.), Bronx, New York; Department of Radiology (S.S.), Chulabhorn Hospital, Bangkok, Thailand; Department of Radiology (W.-C.L.), Cathay General Hospital, Taipei, Taiwan; and School of Medicine (W.-C.L.), Fu-Jen Catholic University, New Taipei City, Taiwan. Received October 30, 2015; final revision received and accepted January 5, 2016. **Address correspondence to** D.S.K.L., Ronald Reagan UCLA Medical Center, 757 Westwood Plaza, Los Angeles, CA 90095-7473; E-mail: dlu@mednet.ucla.edu

D.S.K.L. received funding for this study from NeuWave Medical (Madison, Wisconsin). None of the other authors have identified a conflict of interest.

J Vasc Interv Radiol 2016; 27:623–630

http://dx.doi.org/10.1016/j.jvir.2016.01.011

including increased likelihood of tumor abutting adjacent vessels or sensitive structures, resulting in more "heat-sink" effect and more challenging access to parts of the tumor. As tumor volume increases, the need for "sculpting" of the tumor by multiple applicators or reinsertions also renders the procedure more technically challenging.

Microwave ablation (MWA), although not new, has gained increasing popularity more recently as a method of thermal ablation. MWA has several theoretical advantages compared with RF ablation. For example, larger ablation zones can be produced faster as a result of hotter tissue temperatures achievable by microwaves. Simultaneous activation of multiple microwave applicators is not influenced by the electrical interference seen in RF ablation, allowing for synergistic tissue heating (10). Two randomized trials showed no significant difference in outcomes between RF ablation and MWA for HCC treatment (11,12). Liang et al (13) reported tumor size, tumor number, and Child-Pugh classification to be significant factors influencing survival of patients with HCC after MWA. However, these studies were conducted with earlier generation MWA systems. New MWA devices and antennas have been introduced, with more efficient energy delivery (10,14). The purpose of this study was to evaluate the effectiveness of current-generation MWA devices in the treatment of HCCs up to 5 cm by analyzing the preliminary outcomes, including local tumor progression (LTP) and control of tumor, using current-generation MWA devices in patients with HCCs up to 5 cm. We also sought to determine the influence of tumor size, especially tumors > 3 cm.

MATERIALS AND METHODS

The study was approved and need for patient consent was waived by the medical center institutional review board. Electronic records were searched for HCC and MWA. Between January 2011 and September 2014, 129 patients with 173 HCCs up to 5 cm were treated by MWA without additional assistive or combined procedures other than hydrodissection. Patients included 89 men and 40 women (age range, 39–89 y; mean age, 66.9 y ± 9.5). All patients had liver disease, including hepatitis B (n = 28), hepatitis C (n = 70), hepatitis C and alcoholic liver disease (n = 5), alcoholic liver disease (n = 6), coexistent hepatitis B and C (n = 2), nonalcoholic steatohepatitis (n = 7), cryptogenic cirrhosis (n = 9), hemochromatosis (n = 1), and autoimmune hepatitis (n = 1) (**Table 1**). The diagnosis of HCC was based on either pathology or imaging criteria (Liver Imaging Reporting and Data System 5, Organ Procurement and Transplantation Network 5, and American Association for the Study of Liver Diseases) (1,15,16).

Table 1. Patient Characteristics

Characteristic	No. Patients (n = 129)
Age (y)	66.9 ± 9.5 (range, 39–89)
Sex (male:female)	89:40
Etiology of liver disease	
Hepatitis B	28 (21.7%)
Hepatitis C	70 (54.2%)
Hepatitis B and C	2 (1.6%)
Hepatitis C and alcoholic hepatitis	5 (3.9%)
Alcoholic hepatitis	6 (4.6%)
Autoimmune hepatitis	1 (0.8%)
Hemochromatosis	1 (0.8%)
Nonalcoholic steatohepatitis	7 (5.4%)
Cryptogenic cirrhosis	9 (7.0%)
Child-Pugh classification	
A	92 (71.3%)
B	33 (25.6%)
C	4 (3.1%)

Note–Values are number (percent) unless otherwise indicated.

MWA Procedure

Percutaneous MWAs were performed by one of five abdominal interventional radiologists with 3–22 years of experience with hepatic tumor ablation (S.S.R., J.P.M., M.D., S.B., D.S.K.L). All patients underwent monitored or general anesthesia administered by an anesthesiologist. All cases were performed with combined ultrasound (iU22; Philips Healthcare, Bothell, Washington) and computed tomography (CT) guidance, which is standard protocol at our institution. Two systems were used for MWA at our institution, both operating at 2.45 GHz: the AMICA device, which supports a 16-gauge antenna (HS Medical, Boca Raton, Florida), and the Certus device, which supports up to three 17-gauge PR (short tip) or LK (long tip) antennas (NeuWave Medical, Madison, Wisconsin). Number of applicators, ablation stations, and power and time of each ablation were determined by the performing physician, with the aim of generating a sufficient ablation zone to encompass the visible mass and at least a 5-mm ablation margin. The Certus device was used to treat 139 tumors, and the AMICA device was used to treat 34 tumors. Multiple applicators or overlapping technique was used in tumors > 2.5 cm. In cases where multiple applicators were deemed to be necessary, the Certus device was used because the AMICA system supported only a single antenna. Feedback for completeness of ablation was provided primarily through visualization of the microbubble zone by real-time ultrasound or CT during active heating and on-table contrast-enhanced CT after ablation, with additional ablation performed if necessary. Tract ablation was performed in all patients.

In 65 ablation procedures, hydrodissection was performed for subcapsular tumor locations adjacent