Percutaneous Microwave Ablation of Hepatocellular Carcinoma with a Gas-Cooled System: Initial Clinical Results with 107 Tumors

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ABSTRACT

Purpose: To retrospectively review the results of hepatocellular carcinoma (HCC) treatment with a high-power, gas-cooled, multiantenna-capable microwave device.

Materials and Methods: A total of 107 HCCs in 75 patients (65 men) with a mean age of 61 years (range, 44–82 y) were treated via percutaneous approach. Combination microwave ablation and transarterial chemoembolization was performed for 22 tumors in 19 patients with tumors larger than 4 cm (n = 10), tumors larger than 3 cm with ill-defined margins (n = 7), or lesions not identified with ultrasonography (n = 5). Mean tumor size was 2.1 cm (range, 0.5–4.2 cm), with median follow-up of 14 months, for ablation alone; compared with 3.7 cm (range, 1.0–7.0 cm) and 12 months, respectively, for combination therapy. All procedures were performed with a single microwave system (Certus 140) with one to three 17-gauge antennas.

Results: Mean ablation time was 5.3 minutes (range, 1–11.5 min). All treatments were considered technically successful in a single session. Primary technique effectiveness rates were 91.6% (98 of 107) overall, 93.7% (89 of 95) for tumors 4 cm or smaller, and 75.0% (nine of 12) for tumors larger than 4 cm; and 91.8% (78 of 85) for ablation alone and 90.9% (20 of 22) for combination therapy. There was no major complication or procedure-related mortality. The overall survival rate was 76.0% at a median 14-month clinical follow-up, with most deaths related to end-stage liver disease (n = 11) or multifocal HCC (n = 5).

Conclusions: Treating HCC with a gas-cooled, multiantenna-capable microwave ablation device is safe, with promising treatment effectiveness.

ABBREVIATIONS

HCC = hepatocellular carcinoma, RF = radiofrequency

Radiofrequency (RF) ablation is becoming increasingly accepted to treat unresectable tumors of the liver, kidney, lung, and bone (1). However, based on the results of multiple clinical trials (2,3), a broad consensus has now been reached about the limitations of treating tumors larger than 3.0 cm in diameter with RF alone. Microwave ablation has physical advantages that can potentially overcome many of the current limitations of RF ablation. These advantages include a wider zone of active heating resulting in shorter procedure times, insensitivity to charring, sustained tissue temperatures beyond the threshold of water vaporization, true multiple applicator capability that takes advantage of electromagnetic and thermal synergy, and less susceptibility to vascular heat sinks (4–6). However, until recently, clinical microwave systems available in the United States

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and Europe were limited by antenna shaft heating from reflected power, large antenna diameters, and low power output leading to small-diameter ablation zones (7–9). The introduction of water or gas antenna cooling has resulted in a proliferation of higher-power microwave systems in the United States, Europe, and Asia. Although a series of more than 1,000 patients with hepatocellular carcinoma (HCC) treated with a microwave system only available in Asia has been reported with promising results (10), data from the United States and Europe are limited and currently include only series performed with single-antenna, water-cooled systems (3,11). The purpose of the present study is to report our single-center results with the treatment of 107 HCCs with a high-powered, gas-cooled, multiple antenna–capable microwave system, with particular emphasis on the rate of local control and complications.

MATERIALS AND METHODS

Patient Selection

Institutional review board approval was obtained to deidentify a clinical database for research purposes, and a waiver of informed consent was granted. All patients who underwent percutaneous microwave ablation for HCC between December 2010 and March 2013 at a single tertiary-care hospital were included in the analysis. A total of 107 lesions were treated in 75 patients (10 women, 65 men) during 81 procedures. The mean patient age was 61.3 years (range, 44–82 y), and the mean Model for End-stage Liver Disease score was 10 (range, 6–18). Mean lesion diameter was 2.5 cm ± 1.2 (range, 0.5–7.0 cm). All patients had cirrhosis with underlying causes that included hepatitis C (n = 37), combined hepatitis C and alcoholic liver disease (n = 16), alcoholic liver disease (n = 8), nonalcoholic steatohepatitis (n = 6), autoimmune hepatitis (n = 2), primary biliary cirrhosis (n = 2), hepatitis B, coexistent hepatitis B and C, hemochromatosis, and cryptogenic cirrhosis (n = 1 each). All patients had one to three foci of HCC at the time of the ablation (59 sessions treated one tumor each, 16 sessions treated two tumors, and six sessions treated tumors). All tumors were diagnosed as HCC per American Association for the Study of Liver Diseases guidelines except for the three tumors smaller than 1 cm treated in patients with coexistent larger tumors, all of which met the criteria of late arterial-phase hyperenhancement and delayed washout (12). Percutaneous ablation was determined to be the best treatment option for each patient by a multidisciplinary team of radiologists, hepatologists, oncologists, and hepatic and transplant surgeons at a consensus conference. All patients referred for ablation of HCC during the study period underwent microwave ablation with the exception of two patients who underwent RF ablation within the first year based on operator preference.

Procedure

All ablations were performed under general anesthesia via a percutaneous approach by one of four radiologists experienced in tumor ablation (with 19, 10, 3, and 1 year of experience at the beginning of the study, respectively). Patients were administered cefazolin (or clindamycin if allergic) immediately before the procedure. All ablations were performed with a single high-powered, gas-cooled, multiple antenna–capable microwave system (Certus 140, 2.4 GHz; Neuwave Medical, Madison, Wisconsin) with one (33 sessions), two (33 sessions), or three (15 sessions) antennas (**Fig 1**). Duration of treatment and power application was determined by the performing physician based on manufacturer guidelines, with adjustment for tumor size, proximity to vulnerable structures, and real-time intraprocedural monitoring. Antenna placement was performed under real-time ultrasound (US; GE E9, GE Medical Systems, Waukesha, Wisconsin; 78 sessions) or computed tomographic (CT) fluoroscopy (Optima 580; GE Medical Systems; three sessions) guidance, with CT reserved for tumors not visualized by US. Procedures were monitored in real time by US and/or CT fluoroscopy to ensure that the visible zone of gas encompassed the tumor and an ablative margin of ~5 mm.

Combination therapy with transarterial chemoembolization within 2 weeks before microwave ablation was performed on 22 tumors in 19 patients (conventional chemoembolization, 21 tumors in 18 patients; chemoembolization with drug-eluting beads, one tumor in one patient). A total of five tumors in three patients underwent chemoembolization to localize tumors that could not be identified by US, and 17 tumors in 16 patients underwent chemoembolization because the largest tumor was greater than 4 cm (n = 10) or greater than 3 cm and ill-defined (n = 7; **Fig 2**). Two patients with tumors larger than 4 cm did not undergo chemoembolization before microwave ablation.

At the completion of 80 of 81 procedures, a contrast-enhanced biphasic (late arterial and portal venous) CT scan of the abdomen was performed to determine adequacy of ablation and evaluate for immediate complications. Noncontrast CT was performed in one patient because of a history of anaphylaxis with CT contrast agents. If there was residual enhancing tumor or the ablation zone did not cover the area of visible tumor on the preprocedure images on the postprocedural CT examination, repeat ablation was performed in the same session. Periprocedural complications were monitored and recorded during an overnight stay and via telephone contact 5–7 days after the procedure. Delayed complications were evaluated with follow-up imaging and at clinical visits. Complications were classified according to the Society of Interventional Radiology classification system for complications by outcome (13). The completion of each procedure was used to define technical