Characterization of In Vivo Ablation Zones Following Percutaneous Microwave Ablation of the Liver with Two Commercially Available Devices: Are Manufacturer Published Reference Values Useful?

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ABSTRACT

Purpose: To analyze in vivo ablation properties of microwave ablation antennae in tumor-bearing human livers by performing retrospective analysis of ablation zones following treatment with two microwave ablation systems.

Materials and Methods: Percutaneous microwave ablations performed in the liver between February 2011 and February 2013 with use of the AMICA and Certus PR ablation antennae were included. Immediate postablation computed tomography images were evaluated retrospectively for ablation length, diameter, and volume. Ablation length, diameter, and volume indices were calculated and compared between in vivo results and references provided from each device manufacturer. The two microwave antenna models were then also compared versus each other.

Results: Twenty-five ablations were performed in 20 patients with the AMICA antenna, and 11 ablations were performed in eight patients with the Certus PR antenna. The AMICA and Certus PR antennae showed significant differences in ablation length ($P = .013$ and $P = .009$), diameter ($P = .001$ and $P = .009$), and volume ($P = .003$ and $P = .009$). The AMICA ablation indices were significantly higher than the Certus PR ablation indices in length ($P = .026$) and volume ($P = .002$), but there was no significant difference in ablation diameter indices ($P = .110$).

Conclusions: In vivo ablation indices of human tumors are significantly smaller than reference ex vivo ablation indices, and there are significant differences in ablation indices and sphericity between devices.

ABBREVIATION

RF = radiofrequency

Thermal ablation as a method of locoregional therapy for primary and metastatic disease in the liver is being used more frequently for patients who are not surgical candidates because of impaired hepatic function, other comorbidities, and/or tumor unresectability (1–3). Although radiofrequency (RF) ablation has been studied more extensively as a heat-based ablation tool, microwave ablation appears to create larger ablation volumes and is less susceptible to the heat-sink effect of peritumoral vessels (4–6). Microwave ablation also differs mechanistically from RF ablation because it relies on the oscillation of polar molecules rather than the conduction of electricity, which allows for continuous power application for the duration of treatment (7). This advantage presumably increases the ability to produce an optimal ablation zone covering the tumor with a 1-cm margin on all sides. In addition to the large ablation

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zones and decreased susceptibility to heat-sink effects, the microwave ablation procedure has acceptably low mortality and complication rates (1,8–10).

Currently, there is sparse literature on the accurate dimensions of microwave ablations in tumor-bearing human liver; current estimates of ablation dimensions are derived from ex vivo and in vivo healthy animal models (11–14). For example, the reference ablation dimensions for AMICA microwave ablation antennae (HS Medical, Boca Raton, Florida) and Certus PR antennae (NeuWave Medical, Madison, Wisconsin) were determined in ex vivo bovine liver at 25°C (15,16). The reference necrosis tables for these two commonly used microwave ablation antennae can produce ablation lengths and diameters as large as 8 × 5.7 cm (AMICA) and 4.65 × 3.06 cm (Certus PR). Although operators often refer to these reference values when planning for a microwave ablation treatment of a liver tumor, the reference values given by the manufacturer usually overestimate the ablation cavity produced clinically. For this reason, the zone of ablation may be much smaller than presumed, and this could lead to the possibility of inadequate treatment and subsequent tumor recurrence. Some investigators (13) have attempted to better characterize ablation protocols by using an in vivo perfused porcine liver model, which showed a plateau of ablation diameter at settings of 150 W and 8 minutes. Therefore, the purpose of the present study was to compare published reference material based on ex vivo bovine normal liver versus in vivo hepatic ablation dimensions in tumor-bearing human liver. Separately, the performance of the AMICA and Certus PR microwave ablation systems in vivo was compared.

MATERIALS AND METHODS

Patients

This study received approval from our institutional review board for a retrospective review of charts from February 2011 through February 2013 of patients undergoing microwave ablation for primary or secondary liver cancers. Diagnosis of liver malignancy and index tumor size was established based on preprocedure imaging with contrast-enhanced computed tomography (CT) or magnetic resonance (MR) imaging. Patients with a diagnosis of metastatic liver disease had a known history of primary lung, gastroesophageal, colorectal, renal, or breast malignancies.

Ablation Procedures

Ablation procedures were performed at a single major academic research hospital under moderate sedation or general anesthesia. The procedures were performed following standard techniques of image-guided placement of a 16-gauge AMICA antenna (HS Medical) or a 17-gauge Certus PR antenna (NeuWave Medical) by one of six interventional radiology faculty members. Figure 1 depicts images of the ablation antennae used. Ablation was applied by using power ranging from 20–90 W for times ranging from 3 minutes to 26 minutes. Individual patient treatment settings are listed in Table 1. All procedures were performed with a single ablation antenna at a single power setting. During eight ablations with the AMICA antenna and nine ablations with the Certus PR antenna, serial ablations were performed with the needle in the same position. The duration of ablation for these procedures was considered the sum

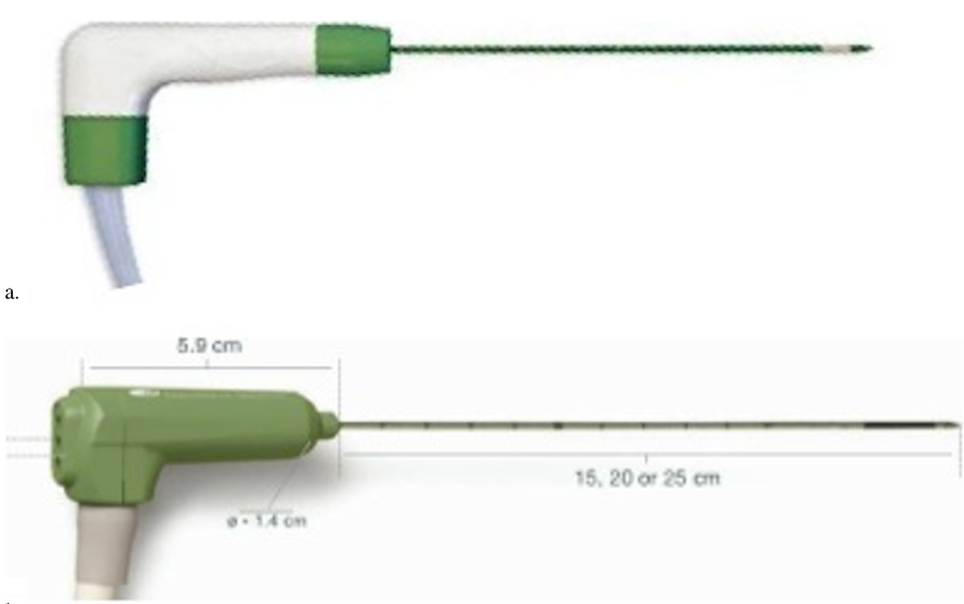

Figure 1. Photographs of the AMICA 16-gauge microwave ablation antenna **(a)** and 17-gauge Certus PR microwave ablation antenna **(b)**. (Available in color online at *www.jvir.org*.)