CLINICAL STUDY

Microwave Ablation for Lung Neoplasms: A Retrospective Analysis of Long-Term Results

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ABSTRACT

Purpose: To determine the long-term safety and efficacy of microwave (MW) ablation in the treatment of lung tumors at a single academic medical center.

Materials and Methods: Retrospective review was performed of 108 patients (42 female; mean age, 72.5 y ± 10.3 [standard deviation]) who underwent computed tomography (CT)–guided percutaneous MW ablation for a single lung malignancy. Eighty-two were primary non–small-cell lung cancers and 24 were metastatic tumors (9 colorectal carcinoma, 2 renal-cell carcinoma, 4 sarcoma, 2 lung, and 7 other). Mean maximum tumor diameter was 29.6 mm ± 17.2. Patient clinical and imaging data were reviewed. Statistical analysis was performed by Kaplan–Meier modeling and logistic regression.

Results: Odds of primary technical success were 11.1 times higher for tumors < 3 cm vs those > 3 cm (95% confidence interval [CI], 2.97–41.1; $P = .0003$). For every millimeter increase in original tumor maximal diameter (OMD), the odds of not attaining success increased by 7% (95% CI, 3%–10%; $P = .0002$). For every millimeter increase in OMD, the odds of complications increased by 3% (95% CI, 0.1%–5%; $P = .04$). Median time to tumor recurrence was 62 months (95% CI, 29, upper bound not reached; range, 0.2–96.6 mo). Recurrence rates were estimated at 22%, 36%, and 44% at 1, 2, and 3 years, respectively. Recurrence rates were estimated at 31% at 13 months for tumors > 3 cm and 17% for those < 3 cm. Complications included pneumothorax (32%), unplanned hospital admission (28%), pain (20%), infection (7%), and postablation syndrome (4%).

Conclusions: This study further supports the safe and effective use of MW ablation for the treatment of lung tumors.

ABBREVIATIONS

BPF = bronchopleural fistula, CI = confidence interval, FDG = [^{18}F]fluorodeoxyglucose, MW = microwave, OMD = original tumor maximal diameter, RF = radiofrequency, RT = radiation therapy

Surgical resection remains the mainstay treatment for early-stage primary lung cancer, but as many as 15% of all patients and 33% of those older than the age of 75 years at the time of initial diagnosis will not meet surgical eligibility criteria as a result of locally advanced disease, poor cardiopulmonary function, or other medical comorbidities (1,2). For these patients, the current therapy has been stereotactic body radiation therapy (RT), with 3-year survival rates ranging from 42% to 60% (3–5). During the past decade, percutaneous image-guided thermal ablation has emerged as an effective, safe, low-cost, and repeatable alternative to RT for local tumor control (6–13).

Microwave (MW) ablation has numerous advantages over radiofrequency (RF) ablation (10). MW ablation generates greater ablative temperatures and requires shorter treatment times (14). Energy is not distributed by means of an electric current, which increases the heating radius in the poor thermal conduction environment of the lung (15).

To date, few clinical studies have examined the use of MW ablation to treat lung malignancies. These have been limited by small patient samples, and only two studies of which we are aware have reported on survival data for as long as 3 years (11–13,16–20). The present retrospective study examines the efficacy and safety of

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MW ablation for the treatment of primary and secondary lung malignancies in a larger data set with longer-term follow-up.

MATERIALS AND METHODS

Patient Demographics and Tumor Characteristics

This retrospective study was Health Insurance Portability and Accountability Act–compliant and approved by our institutional review board with a waiver of informed consent. From November 2003 through March 2013, 108 patients (42 female, 66 male; mean age ± standard deviation [SD], 72.5 y ± 10.3; 95% confidence interval [CI], 70.6–74.5 y; range, 42–89 y) underwent percutaneous MW ablation for a single lung malignancy under computed tomography (CT) guidance. All patients were deemed to have medically inoperable disease (n = 105) or refused surgery (n = 3) before the procedure. Ninety percent of patients (n = 97) were past or present smokers. Of the 108 tumors, 82 were primary non–small-cell lung cancers and 24 were metastatic tumors (nine from colorectal carcinoma, two from renal-cell carcinoma, four from sarcoma, two from the lung, and seven from other primary lesions). Tumor locations with respect to the hilum included 20 central, 28 middle, and 59 peripheral masses. Each tumor was measured in three dimensions, with a mean maximum tumor diameter of 29.6 mm (95% CI, 26.1–32.9 mm; range, 6–70 mm). Exclusion criteria included imaging or histologic evidence of thoracic nodal disease; tumors abutting mediastinal structures, hilar vessels, or mainstem bronchi; or an International Normalized Ratio greater than 1.8. For patients with pulmonary metastases, all extrathoracic lesions were smaller than 5 cm.

Preablation Assessment and Procedural Technique

Before ablation, each patient was evaluated at our institution's tumor ablation clinic by one of two nurse practitioners and a radiologist. Anticoagulation medications were temporarily stopped 2–7 days before the procedure. Each ablation session was scheduled as an outpatient procedure. Prophylactic antibiotic agents were not routinely administered before or after ablation.

All treatments were performed with CT fluoroscopic guidance (GE Medical Systems, Milwaukee, Wisconsin) with 5-mm collimation at 10–50 mA. Conscious sedation was routinely performed by using 0.5–1.0-mg doses of intravenous midazolam (Versed; Abbott Laboratories, North Chicago, Illinois) and 25–50-μg doses of intravenous fentanyl (Sublimaze; Abbott Laboratories), and local anesthesia was administered before needle insertion with a 5:1 mixture of 1.0% lidocaine buffered with 1.0%–1.5% sodium bicarbonate. No patients required general anesthesia. Continuous electrocardiographic and pulse oximetry monitoring were performed, as were blood pressure checks every 5 minutes.

MW generators from multiple manufacturers were used. The selection of the generator, power setting, number and length of antennas, and applications was determined on the basis of user preference and manufacturer availability. One antenna was used in 71 tumors, two antennas in seven tumors, three antennas in 24 tumors, and four antennas in five tumors. The mean total treatment time was 10.2 minutes ± 4.2. A single application was used in 74 tumors, two applications in 28 tumors, three applications in two tumors, and four applications in two tumors.

Manufacturer recommendations were adhered to in all cases unless the patient was unable to tolerate the total ablation time. After the procedure, each patient was transferred to the interventional radiology recovery room. A postprocedural chest radiograph was obtained 2 hours after ablation in all patients to evaluate for pneumothorax. If there was no pneumothorax or evidence of a complication on physical examination, the patient was discharged home. If a clinically significant pneumothorax was noted during or after the procedure, immediate aspiration with a 5-F catheter (Yueh; Cook, Bloomington, Indiana) or an 8–10-F pigtail catheter was performed. At the discretion of the treating physician in patients in stable condition (eg, no air leak), a Heimlich valve was placed on the pigtail catheter, and patients were then discharged home with instructions to return within 1–2 days for chest radiography. Patients with persistent air leaks were admitted overnight for wall suction and continued observation.

Follow-Up Imaging and Clinical Assessment

Nonenhanced and contrast-enhanced CT images of the chest were routinely acquired at approximately 1 month (median, 0.7 mo), 3 months (median, 3.8 mo), and 6 months (median, 7.1 mo) after the initial ablation session with the use of a multi–detector row helical CT scanner (LightSpeed VCT; GE Medical Systems) with 0.6–2.0-mm collimation. Contrast-enhanced studies used 100 mL of iohexol (Omnipaque 300; Amersham, Princeton, New Jersey) with a flow rate of 2–3 mL/s, and image acquisition began 30 seconds after injection.

A complete lack of enhancement in the ablation zone on initial follow-up chest CT signified primary technical success. A thin (< 5 mm), symmetric rim of peripheral enhancement at the ablation zone was considered to indicate benign peritumoral enhancement, in which case the treatment was designated a technical success. Irregular, nodular enhancement (> 15 HU) at the ablation site was considered to indicate recurrent or residual disease and technical failure.

For patients with primary lung cancer, tumor recurrence was defined as the development of asymmetric or