CLINICAL STUDY

Feasibility of Real-Time Intraprocedural Temperature Control during Bone Metastasis Thermal Microwave Ablation: A Bicentric Retrospective Study

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ABSTRACT

Purpose: To evaluate feasibility of using a thermocouple for temperature monitoring during microwave (MW) ablation of metastatic bone disease.

Materials and Methods: This retrospective study comprised 16 patients (8 men with mean age 63 y and 8 women with mean age 59 y) with 18 bone metastases treated with MW ablation using a thermocouple between March 2012 and October 2015. The mean maximum tumor size was 29.5 mm. MW ablation power was set between 15 W and 40 W and applied for 1–6 minutes. Thermocouple placements were as follows: epidural space (n = 7 cases), nerve roots (n = 9 cases), pleura (n = 1), and pericardium (n = 1). The procedure was considered technically successful when the MW and the thermocouple probes were accurately placed and thermoablation was initiated. Clinical success was defined as a 50% visual analog scale score decrease at 1 month as assessed by the operators.

Results: Mean MW ablation time was 4.3 minutes with a mean energy of 30 W. Procedural success was 100%. In 16 cases with neural structure monitoring, temperature did not increase > 43°C. In 8 cases, MW ablation had to be discontinued because of temperature reaching 42°C. Efficacy of the procedure in regard to pain was achieved in 17 of 18 ablation sessions at 1 month.

Conclusions: Use of a thermocouple during bone MW ablation is a feasible technique and may be a potentially useful tool to help avoid nontarget ablation surrounding tumors.

ABBREVIATIONS

MW = microwave, VAS = visual analog scale

Microwave (MW) ablation has been shown to be useful in the management of painful bone neoplasms (1–5). Uncontrolled extension of the ablation zone beyond the tumor has been considered to be one of the most serious complications associated with ablation therapy, especially concerning neural damage, as may occur when temperature reaches 45°C (6). Neural damage after bone tumor ablation has been estimated to occur in up to 17% of cases (7,8). Some authors have reported that MW ablation may not be safe when performed near a vital structure because of a rapid temperature increase and potential subsequent large ablated zones (3,9).

Several techniques for protecting neural structures have been reported (10) with satisfactory results. The use of a thermocouple for real-time temperature monitoring has also specifically been reported for spinal canal temperature monitoring during spinal radiofrequency (RF) ablation (11). The main objective of this study was to evaluate the feasibility of a thermocouple for temperature monitoring during MW ablation of

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metastatic bone disease. The secondary objective was to assess intraprocedural thermocouple data and clinical complications to evaluate usefulness of this technique to prevent possible injury of the surrounding adjacent vital structures.

MATERIALS AND METHODS

Study Design

This was a retrospective bicentric study performed between March 2012 and October 2015. Local institutional review board approval was obtained, and written informed consent was waived. Patients who underwent MW ablation of painful refractory (visual analog scale [VAS] score > 5/10) bone metastases were queried, and patients in whom a thermocouple was used were reviewed. Of the 42 MW ablation procedures performed between 2012 and 2015, 18 MW ablation procedures were performed with the use of a thermocouple (7 in 1 center and 11 in another center). In the remaining 24 MW ablation procedures, a thermocouple was not used for 1 of the following reasons: the tumor was not located near a vital structure; the tumor was located at a safe distance from a vital structure; or, in some cases, a thermocouple was unavailable. The decision to use a thermocouple was made in cases of close proximity (2 cm) of a vital structure to the tumor and based on the availability of a thermocouple. In 4 cases, 2 thermocouples were used. The procedure was considered technically successful when both the MW and the thermocouple probes were accurately placed and thermoablation was initiated. Complications were noted and were graded according to the Common Terminology Criteria for Adverse Events (12).

Patient, Tumor, and Pain Characteristics

The study cohort comprised 16 patients, including 8 men with a mean age of 63 years and 8 women with a mean age of 59 years (Table). The mean maximum tumor size was 29.5 mm (range, 11–50 mm). Of 18 tumors, 14 were osteolytic, 2 were osteosclerotic, and 2 were mixed osteolytic/osteosclerotic. Patients presented before the procedure with a mean VAS score of 8.3 of 10 (range, 5–10).

Procedure

MW ablations were performed under computed tomography guidance using Siemens SOMATOM Sensation 64 (Siemens Medical Solutions, Erlangen, Germany) or Philips Brilliance 40 (Philips Healthcare, Amsterdam, The Netherlands) scanners during a hospital stay lasting 1–2 days. The MW generator used was either a 2.45-GHz Acculis MTA System (AngioDynamics, Inc, Latham, New York) or an Amica (Hospital Service, Rome, Italy). All procedures were performed under either local anesthesia and nitrous oxide ventilation or minimal sedation. A 12-gauge Bonotpy (AprioMed AB, Uppsala, Sweden) bone needle was used coaxially in cases of osseous osteosclerotic lesions or osteolytic lesions that were located far from the cortical bone. In cases of lytic bone lesions, the MW probe was directly inserted into the lesion.

In 1 patient with a tumor measuring 50 mm, the MW probe shaft was repositioned between ablation cycles to obtain a larger thermoablation zone. The MW ablation power was set between 15 W and 40 W and applied for 1–6 minutes. Repeat MW cycles lasting 30–120 seconds were performed.

Thermocouple Placement

The thermocouple used was the temperature control feature of an RF generator that consisted of an electrode inserted into a 22-gauge insulated needle. In 1 center, a Neuro N50 Generator (Inomed Medizintechnik GmbH, Emmendingen, Germany) was used; in the other center, a NeuroTherm NT Generator (St Jude Medical Inc, St Paul, Minnesota) was used. The thermocouple was placed in the epidural space in 7 cases to monitor spinal cord temperature (Fig 1a, b), in the nerve roots in 9 cases (Fig 2), near the pleura in 1 case, and near the pericardium in 1 case. The maximum accepted temperature threshold was 42°C (6,13,14) in cases of neural structure temperature monitoring and 45°C for other structures. Thermoablation was discontinued when the thermocouple reached the temperature threshold. Clinical examinations (motor and sensory) were also performed between MW ablation sessions. The patients were instructed to alert the operator in case of radiating pain.

Pain

Pain was assessed using VAS scores. VAS scores were assessed by the operators immediately before and after each procedure (day 0) and 1 week and 1 month following the procedure. Clinical evaluations after 1 month were performed by the referring physician.

Statistical Analysis

Continuous variables are expressed as mean ± SD. Paired Student *t* tests were used to evaluate the parameters before and after MW ablations at the scheduled follow-up evaluations. *P* values < .05 were considered statistically significant. All statistical analyses were performed using SYSTAT version 12 (Systat Software, Inc, Chicago, Illinois).

RESULTS

Procedure

Technical success as previously defined was 100%, as both the thermocouple and the MW probes were placed in accurate position as determined beforehand in all