REVIEW ARTICLE

Microwave Ablation Compared to Radiofrequency Ablation for Hepatic Lesions: A Meta-Analysis

Ya Ruth Huo and Guy D. Eslick, DrPH, PhD

ABSTRACT

To evaluate the efficacy and safety of microwave (MW) ablation compared with radiofrequency (RF) ablation for hepatic lesions by using meta-analytic techniques. Overall, 16 studies involving 2,062 patients were included. MW ablation was found to have significantly better 6-year overall survival than RF ablation (odds ratio, 1.64, 95% confidence interval, 1.15–2.35), but this was based on a few articles (n = 3 of 16). MW ablation and RF ablation had similar 1–5-year overall survival, disease-free survival, local recurrence rate, and adverse events. Based on similar safety and efficacy outcomes, either MW ablation or RF ablation may be used for effective local hepatic therapy.

ABBREVIATIONS

CA = complete ablation, CI = confidence interval, DFS = disease-free survival, HCC = hepatocellular carcinoma, LRR = local recurrence rate, MW = microwave, OR = odds ratio, RF = radiofrequency

Radiofrequency (RF) ablation is currently the most widely used thermal ablative technique for unresectable hepatic malignancies. However, microwave (MW) ablation is gaining popularity worldwide. Theoretical benefits of MW ablation over RF ablation include larger ablation volumes, shorter duration, no charring and electrical insulation, and resistance to the heat-sink effect (1). It has been suggested that these characteristics translate to better local control with MW ablation versus RF ablation (1,2). Numerous studies have compared the efficacy of MW ablation versus RF ablation, with contrasting results in terms of local control, overall survival, and adverse events (3–5). It is currently unclear whe`ther the evidence is scientifically rigorous enough to recommend one ablative therapy over the other. The purpose of the present meta-analysis is to evaluate the efficacy and safety of MW ablation versus RF ablation based on the results of published retrospective and prospective studies.

From the Discipline of Surgery, The Whiteley-Martin Research Centre, University of Sydney, Nepean Hospital, Level 3, Clinical Building, P.O. Box 63, Penrith, NSW 2751, Australia. Received January 8, 2015; final revision received March 23, 2015; accepted April 5, 2015. Address correspondence to G.D.E.; E-mail: guy.eslick@sydney.edu.au

Tables E1 and E2 are available online at *www.jvir.org*

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MATERIALS AND METHODS

Study Protocol

We followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines (6). A systematic search of the MEDLINE, PubMed, EMBASE, Current Contents Connect, Google Scholar, and Cochrane Central databases from inception through December 1, 2014, was performed to identify relevant articles. The search used the terms "radiofrequency" and "microwave," which were searched as text words and as exploded medical subject headings where possible. The reference lists of relevant articles were also searched for appropriate studies. No language or time restrictions were used in the search or study selection. A search for unpublished literature was not performed.

Inclusion Criteria

Acceptable publications complied with the following criteria: (i) hepatocellular carcinoma (HCC) confirmed pathologically or diagnosed by computed tomography (CT) or liver metastases confirmed on the basis of characteristic imaging patterns from contrast-enhanced ultrasonography, contrast-enhanced CT, or magnetic resonance imaging with a known history of primary malignancy; (ii) trials were described as randomized clinical trials or nonrandomized controlled clinical trials; (iii) trials included a group receiving MW ablation and a group receiving RF ablation; and (iv) data on at least 1-year overall survival, local recurrence rate (LRR), complete ablation (CA), or disease-free survival (DFS)

for the calculation of the odds ratio (OR) at a 95% confidence interval (CI).

Exclusion Criteria

Trials were excluded if they did not meet the aforementioned criteria or if they (i) involved animal or in vitro studies; (ii) were abstracts, letters, editorials or expert opinions, reviews without original data, or case reports; or (iii) represented duplicate publications of other studies previously identified in our systematic evaluation.

Data Extraction

Data extraction was performed by using a standardized data extraction form in collecting information on (i) study characteristics (publication year, design, intervention group size, country); (ii) patient and tumor characteristics (mean age, nodule number, tumor size, clinical stage); (iii) ablation intervention (current in megahertz, power in Watts, ablation tip type, ablation time, brand of ablation machine); (iv) outcomes such as survival, LRR, CA, adverse events, and costs. One- to 6-year overall survival rates were collected as reported in the trials or as derived from the survival curves.

Statistical Analysis

Pooled ORs and 95% CIs were calculated for the effect of MW ablation versus RF ablation on overall survival, LRR, DFS, and adverse events by using a random-effects model (7). We tested heterogeneity with the Cochran Q statistic, with $P < .10$ indicating heterogeneity, and quantified the degree of heterogeneity by using the I^2 statistic, which represents the percentage of the total variability across studies that results from heterogeneity. I^2 values of 25%, 50%, and 75% corresponded to low, moderate, and high degrees of heterogeneity, respectively (8). We quantified publication bias by using the Egger regression model (9) with the effect of bias assessed by using the fail-safe number method. The fail-safe number was the number of studies we would need to have missed for our observed result to be nullified to statistical nonsignificance at the $P < .05$ level. Publication bias is generally regarded as a concern if the fail-safe number is less than $5n + 10$, with n being the number of studies included in the meta-analysis (10). All analyses were performed with Comprehensive Meta-analysis (version 2.0; Biostat, Englewood, New Jersey) for Windows (Microsoft, Redmond, Washington).

RESULTS

A total of 2,063 studies were identified on our initial broad search. After carefully reading titles and abstracts, a large portion of references were excluded because they were conference abstracts or had titles that suggested they were reviews or involved only animal/in vitro studies. In the remaining studies, the abstracts were examined to determine whether their study would have data on overall survival, LRR, CA, or DFS. Finally, 30 articles were selected for possible inclusion in the review. After reading the full text, three were excluded because the outcomes for MW ablation and RF ablation were combined, and another 11 were excluded because of duplication or because the objective did not satisfy the inclusion criteria. Manual search of the bibliographies did not find additional articles. Ultimately, 16 trials (2,062 patients) fulfilled our inclusion criteria (**Fig 1**).

The percentage of studies that described the mean age of their patients, the number of nodules, and the size of nodules was each 88% (14 of 16; **Table 1**) (3–5,11–23). All nodules in each study were ablated by MW ablation or RF ablation. Cooled-tip MW ablation was used in 53% of the trials (eight of 15), with the remaining using non–cooled-tip MW ablation. Cooled-tip RF ablation was used in 57% of the trials (eight of 14), with the remaining using expandable-tip RF ablation. The electrical power for MW ablation ranged from 45 to 100 W, and that for RF ablation ranged from 60 to 200 W. Time per application ranged from 1 to 25 minutes for MW ablation and from 6 to 25 minutes for RF ablation. The machines and techniques used for both ablative methods are listed in **Table E1** (available online at *www.jvir.org*) (3–5,11–23).

Meta-Analysis Outcomes

MW ablation appeared to significantly improve 6-year survival compared with RF ablation (OR, 1.64; 95% CI, 1.64–2.35, $P = .007$; **Fig 2**). There was no significant

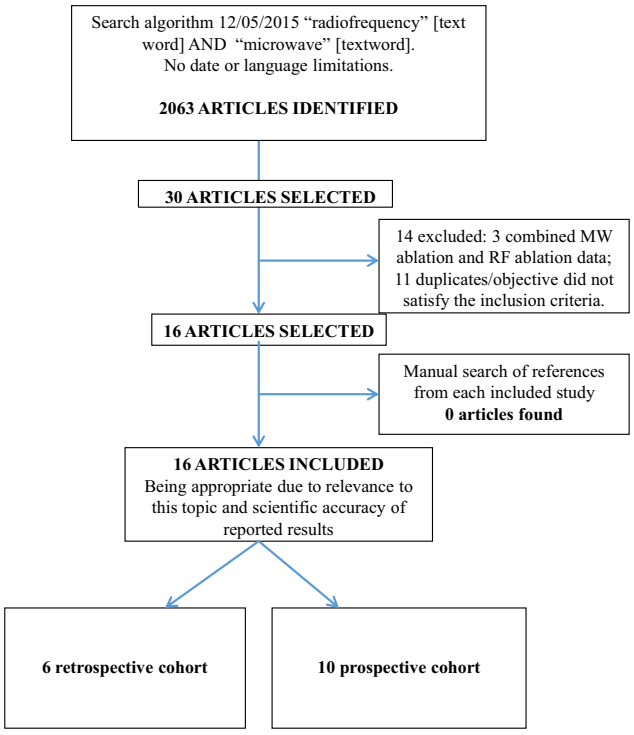

Figure 1. Search algorithm and identified articles.