CLINICAL STUDY

Risk Factors for Local Progression after Percutaneous Radiofrequency Ablation of Lung Tumors: Evaluation Based on a Review of 147 Tumors

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ABSTRACT

Purpose: To retrospectively evaluate risk factors related to incomplete CT-guided RF ablation of metastatic and primary lung tumors.

Materials and Methods: This study included 93 patients with 147 tumors: 70 men, 23 women; median age 54 y (range, 19–81 y); 24 cases of primary lung tumors, 69 cases of metastases; average largest diameter of tumors, 1.8 cm ± 1.2 (range, 0.3–6.0 cm). Local efficacy was evaluated based on CT follow-up scans. Complete ablation rates (CARs) for tumors were calculated according to several variables; independent risk factors for local tumor progression (LTP) were examined by binary logistic regression analysis.

Results: CAR of tumors was 60.54% within first 6 months after lung RF ablation; median interval of LTP was 1.5 months (mean, 1.3 months ± 1.0; range, 0 days to 3 months). Compared with tumors > 3 cm, CAR of tumors ≤ 3 cm was significantly higher (68.55% vs 17.39%, $P < .001$). CAR of tumors with complete ablation margin (AM) was dramatically higher compared with tumors with incomplete AM (74.77% vs 16.67%, $P < .001$). Among tumors with complete AM, CAR of tumors with shortest distance between outer edge of tumor and AM (ablative margin D) ≥ 5 mm was compared with tumors with ablative margin D 1–4 mm (85.96% vs 62.96%, $P = .005$). Multivariate regression analysis showed that lobulation and/or spicules, contact with blood vessels, and ablative margin D < 5 mm were independent risk factors for incomplete lung RF ablation. LTP was likely to develop at the edge of ablated lesions and especially the site of incomplete AM or shortest AM.

Conclusions: RF ablation for lung cancers should be individualized based on tumor size, morphology, and tumor type to obtain an adequate AM.

ABBREVIATIONS

ablative margin D = shortest distance between outer edge of tumor and ablation margin, AM = ablation margin, CAR = complete ablation rate, CI = confidence interval, LTP = local tumor progression, OR = odds ratio

The incidence of lung cancer continues to increase annually, and lung cancer has the highest incidence and mortality worldwide (1–3). Computed tomography (CT)–guided percutaneous radiofrequency (RF) ablation causes focal coagulation necrosis in tumors via the delivery of thermal energy with limited damage to adjacent healthy lung tissues. It has been demonstrated to be a generally safe procedure with minor complications and an appropriate alternative treatment with encouraging survival benefit for patients who are candidates for surgery and stereotactic body radiation therapy (4–10).

However, lung tumor RF ablation is associated with appreciable incomplete ablation with local tumor progression (LTP). More recent studies reported LTP rates of 30%–40% or more for stage I non–small cell lung cancer (9,11–13) and 13%–19% or 38% for lung metastases from colorectal cancer (5,6,14,15). Tumor size (4,6) and tumor location (16,17) are widely recognized as

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important factors related to the efficacy of lung tumor ablation. In our clinical follow-up examinations, we found that some morphologic features of lung cancers, such as lobulation and spicules, as well as an inadequate ablation margin (AM) surrounding the target tumor also had an important influence on incomplete ablation. Factors associated with incomplete ablation and how to make an early prediction for incomplete ablation by imaging after lung RF ablation are special concerns for clinical practice. This study aimed to retrospectively analyze risk factors related to incomplete ablation of primary and metastatic lung tumors after RF ablation to guide the clinical ablation practice and to improve local tumor control rate.

MATERIALS AND METHODS

Patients

The institutional ethics review board approved this retrospective study and waived the need for informed consent. Clinical records of patients with primary and metastatic lung tumors who received RF ablation in our institution between February 2008 and October 2014 were reviewed; 210 patients were treated. Lung tumor RF ablation was the only ablation treatment offered to patients with eligible lung tumors. Only cases with available CT scans obtained during the procedure and follow-up scans obtained at regular intervals and adequate duration (first follow-up interval ≤ 2 months and at least 2 time follow-up CT scans within the first 6 months and follow-up duration > 6 months) were included in the study. Cases without CT scans obtained during the procedure, cases without follow-up CT scans obtained in our institution, and cases with the first follow-up interval > 2 months or follow-up duration ≤ 6 months were excluded (Fig 1). Demographic data, operative notes, clinic notes, and radiology reports were obtained from both paper and electronic hospital charts.

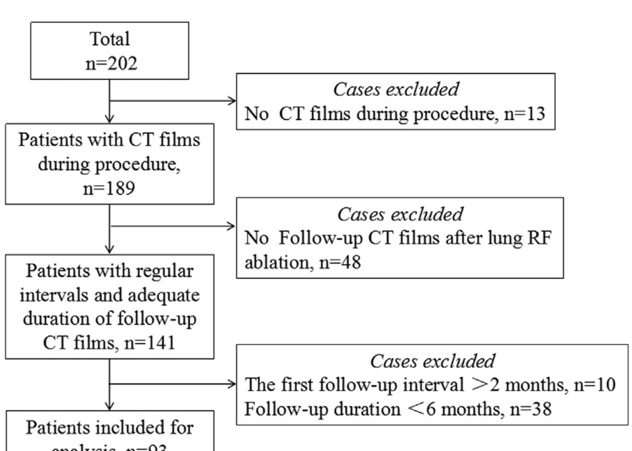

Figure 1. Flowchart showing patient recruitment.

The study population included 93 patients who met the inclusion criteria, including 70 men and 23 women with a median age of 54 years (range, 19–81 y). There were 147 tumors with an average maximum diameter of 1.8 cm ± 1.2 (range, 0.3–6.0 cm); 64 cases had a single lesion, 16 cases had 2 lesions, and 13 cases had multiple lesions (3–8 lesions). There were 24 patients with primary lung cancer (11 cases of pulmonary adenocarcinoma, 10 cases of squamous cell lung cancer, and 3 cases of small cell lung cancer) and 69 patients with metastatic tumors (29 cases of hepatocellular carcinoma, 20 cases of colorectal adenocarcinoma, 7 cases of nasopharyngeal carcinoma, 5 cases of esophageal squamous cell carcinoma, 3 cases of breast cancer, 2 cases of melanoma, 1 case of gastric adenocarcinoma, 1 case of cervical cancer, and 1 case of endometrial cancer).

Ablation Therapy

To determine the size and location of tumors, contrast-enhanced CT scans of the chest for all patients were performed 2 weeks before ablation. Patients were usually placed in the supine or prone position depending on the location of tumor. During ablation, an unenhanced chest CT scan (Philips Brilliance 16-slice spiral CT; Philips Healthcare, Best, The Netherlands), with the parameters of pore size 90 cm and slice thickness 5 mm, was performed to determine the optimal puncture point and needle path. Routine disinfection and a drape were applied around the puncture point, and 1% lidocaine was used for local anesthesia. A Cool-tip (Covidien, Mansfield, Massachusetts) or StarBurst (AngioDynamics, Inc, Latham, New York) RF electrode was inserted gradually into the inner side of the tumor along a path determined beforehand. After another CT scan, the path and depth of the electrode were adjusted when necessary to ensure that the ablation electrode was located in the proper position inside the tumor. For tumors > 3 cm, multisite ablation was performed by adjusting the path of the electrode. The power settings and exposure times were selected according to the standard recommendations provided by the manufacturers of the equipment used and according to the clinical experience with tumor RF ablation procedures. The process was targeted to achieve an AM that would theoretically enclose the tumor and 0.5–1.0 cm of surrounding lung parenchyma to eradicate microscopic disease. In each treatment, tract ablation to prevent possible tumor seeding or tract bleeding was performed before the electrode was withdrawn.

CT scan was performed immediately after the operation to assess the AM and procedural complications. A blood test and biochemical test were routinely done the first day after ablation treatment to evaluate the occurrence and severity of thoracic hemorrhage, liver function damage, and kidney function damage. Meanwhile, an upright chest posteroanterior radiograph was obtained the next day mainly to evaluate the occurrence