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Radiofrequency ablation of pulmonary tumors near the diaphragm

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KEYWORDS
Radiofrequency ablation;
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Abstract
Purpose: To retrospectively evaluate the feasibility, safety, and efficacy of radiofrequency ablation (RFA) of lung tumors located near the diaphragm.
Materials and methods: A total of 26 patients (15 men, 11 women; mean age, 61.5 years ± 13.0 [SD]) with a total of 29 lung tumors near the diaphragm (i.e., distance < 10 mm) were included. Mean tumor diameter was 11.0 mm ± 5.3 (SD) (range, 2—23 mm). Efficacy of RFA, number of adverse events and number of adverse events with a grade ≥ 3, based on the National Cancer Institute Common Terminology Criteria for Adverse Events, version 4.0, were compared between patients with lung tumors near the diaphragm and a control group of patients with more distally located lung tumors (i.e., distance ≥ 10 mm).
Results: RFA was technically feasible for all tumors near the diaphragm. Four grade 3 adverse events (1 pneumothorax requiring pleurodesis and 3 phrenic nerve injuries) were observed. No grade ≥ 4 adverse events were reported. The median follow-up period for tumors near the diaphragm was 18.3 months. Local progression was observed 3.3 months after RFA in 1 tumor. The technique efficacy rates were 96.2% at 1 year and 96.2% at 2 years and were not different, from those observed in control subjects (186 tumors; $P = 0.839$). Shoulder pain ($P < 0.001$) and grade 1 pleural effusion ($P < 0.001$) were more frequently observed in patients with lung tumor near the diaphragm. The rates of grade ≥ 3 adverse events did not significantly differ between tumors near the diaphragm (4/26 sessions) and the controls (7/133 sessions) ($P = 0.083$).

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Conclusion: RFA is a feasible and effective therapeutic option for lung tumors located near the diaphragm. However, it conveys a higher rate of shoulder pain and asymptomatic pleural effusion by comparison with more distant lung tumors.

Radiofrequency ablation (RFA) has been used for local treatment of primary and secondary lung cancers [1—6]. Target tumor location can affect the outcome of patients who undergo this therapy. Lung tumors near the diaphragm are challenging to target effectively and safely with RFA. The potential disadvantages of these specific location include: (i) difficulty for inserting the RFA electrode into the tumor and dislodgment of the inserted electrode because of respiratory movements, (ii) difficulty for achieving complete ablation and applying high RFA power because thermal irritation of the diaphragm causes shoulder pain [7], and (iii) the risk of tumor location-related adverse events (AEs) such as diaphragmatic injury, phrenic nerve injury, pleural effusion, pleuritis, and subdiaphragmatic organ injury.

The purpose of this study was to evaluate retrospectively the feasibility, safety, and technique efficacy of RFA of lung tumors located near the diaphragm.

Materials and methods

Patients

Between January 2010 and March 2015, 401 lung tumors were treated by percutaneous RFA at our institution. Of these, tumors located near the diaphragm were included in this study. Tumors were considered near the diaphragm if the distance between the diaphragm and the closest tumor edge was < 10 mm on chest computed tomography (CT) image obtained in the coronal plane with a slice thickness ≤ 5 mm before RFA.

Tumors that met all of the following criteria were included as a control group in the study. They included: tumors in the lower lobe or segment 5 of the lung; tumors far (i.e., ≥ 10 mm) from the diaphragm; tumors that underwent lung RFA during the same period; and tumors that underwent lung RFA in different sessions from tumors near the diaphragm.

The use of RFA for lung tumors was approved by our institutional review board. Informed consent was obtained from all patients before RFA. The ethics committee at our institutional approved this retrospective study and waived the informed consent requirement for the use of the medical data of the patients.

RFA protocol

Detailed technical aspects of the RFA procedure conducted at our institution have been described previously [8]. All RFA sessions were performed percutaneously using CT fluoroscopy guidance (Asteion® or Aquilion®; Toshiba Medical Systems Cooperation, Otawara, Japan). The procedure aimed to ablate the tumor and a margin ≥ 5 mm surrounding the lung parenchyma. If necessary, multiple overlapping ablations were performed to obtain the desired margin.

Chest CT using a slice thickness ≤ 5mm was performed immediately after RFA to evaluate the ablation zone and AEs. AEs were evaluated using the National Cancer Institute Common Terminology Criteria for Adverse Events Version 4.0 [9].

Follow-up

Chest CT with a slice thickness ≤ 5mm was typically performed before and after intravenously administering the contrast medium to assess technique efficacy and occurrence of AEs at 1, 3, 6, 9, and 12 months after RFA and every 6 months thereafter. Technique efficacy was defined as complete ablation of the macroscopic tumor on follow-up images (i.e., no local tumor progression after RFA) [10]. Technique efficacy was evaluated by comparing the size and geometry of the ablation zone to previous CT findings. Local tumor progression was diagnosed when the ablation zone enlarged circumferentially. The appearance of an irregular, scattered, nodular, or eccentric focus in the ablation zone also indicated local progression [11].

Lung spirometry was performed 1 month after RFA (and 3 months after if possible). The test parameters included forced expiratory volume in 1 second (FEV1), FEV1% of predicted (i.e., predicted compared with a well-defined population of healthy people matched for gender, age, height, and ethnic origin), vital capacity (VC), and VC % of predicted.

Statistical analysis

One month after RFA, pulmonary function values obtained during lung spirometry were compared to their baseline values (i.e., before RFA) using paired t-tests. The technique efficacy rate was the percentage of successfully eradicated tumors [10] and was calculated using Kaplan-Meier estimation. Using log-rank tests, the rates were compared between tumors near the diaphragm and control tumors. Using Fisher exact test or Mann-Whitney *U* test, the 2 groups were compared by the tumor type (i.e., primary or secondary), tumor diameter, distance between the tumor and diaphragm, follow-up period, ablated tumor number in the same session, hospital stay after RFA, 1 month-to-baseline ratio of FEV1, 1 month-to-baseline ratio of VC, and rates of each AE, grade ≥ 3 AEs, and shoulder pain during the application of RF energy. All analyses were performed using SPSS software, version 22.0 (IBM, Armonk, NY). A *P*-value < 0.05 was considered statistically significant.

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