Percutaneous radiofrequency thermal ablation of primary and metastatic lung tumors

Loukas Thanosa, Sofia Mylonaa, Maria Pomonia, Kalliopi Athanassiadi b,*, Nick Theakos b, Leonidas Zoganasc, Nikolaos Batakisa

a Department of Radiology 'Korgialenio-Benakio' Red-Cross Hospital, Athens, Greece
b 1st Department of Thoracic Surgery, General Hospital for Chest Diseases 'Sotiria', Athens, Greece
c Department of Thoracic Surgery 'Korgialenio-Benakio' Red-Cross Hospital, Athens, Greece

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Abstract

Objective: Primary lung cancer is the leading cause of death from cancer. For patients with inoperable lung cancer, percutaneous radiofrequency thermal ablation (RFA) under CT-guidance represents a minimally invasive treatment. It can also be applied in combination with radiation therapy and chemotherapy. Materials and methods: In a period of 18 months, RFA under CT-guidance 27 ablations were applied on 22 patients, 14 patients with primary lung cancer and 8 patients with metastatic lung tumor. There were 15 men and 7 women ranging in age between 48 and 79 years. All patients were not surgical candidates either due to the advanced stage or due to comorbid diseases, while five denied surgery. The lesions' size was no bigger than 6 cm (range 1—6 cm) with an average of 3.8 cm. The diagnosis of all treated lesions was obtained with percutaneous biopsy under CT guidance. The procedure was performed under local anesthesia. Results: There were no major complications observed, but a small pneumothorax and a minor hemoptysis in four cases, all conservatively treated. All patients were hospitalized for 24 h. Follow-up was initially done in 1, 3, 6 and 12 months after RFA and it was accomplished by personal interview or by telephone call up to December 2005. Median progression free intervals were 26.4 months for primary lung cancer and 29.2 months for metastatic tumor. Conclusion: RFA is a minimally invasive technique that can be used as a palliative treatment in nonsurgical candidates with primary or metastatic lung tumor with a low morbidity and mortality.

Keywords: Minimal invasive therapy; Primary lung tumors; Radiofrequency ablation; Percutaneous CT-guided; Pulmonary metastasis

1. Introduction

Percutaneous radiofrequency thermal ablation (RFA) under CT guidance is a minimal invasive technique that is used over a decade for the treatment of primary and secondary liver tumors [1,2]. It is a low cost method that provides treatment on an outpatient basis and has low complication rates in experienced hands.

Primary lung cancer is the most common cause of cancer-related deaths [3]. When the initial diagnosis is made, most cases are unresectable or the patients' condition does not permit surgical interventions [4,5].

RFA under CT guidance without thoracotomy may be considered an interesting alternative of local treatment in inoperable cases of primary and metastatic lung tumors; it can also be used in combination with systemic chemotherapy, or radiotherapy and may possibly contribute to a decrease of morbidity and mortality [4—6].

The value of RFA for the treatment of lung tumors has not yet been established. Early reports on RFA of malignant lung tumors (even in small-cell carcinoma) performed under CT guidance and controlled by CT or positron emission tomography (PET) are encouraging [6—9].

The authors describe the successful application of percutaneous CT-guided RFA in 22 patients with primary or metastatic lung tumor.

2. Materials and methods

During an 18 months’ period, between July 2002 and January 2004, 27 RFAs under CT guidance were applied on 14 patients with primary lung cancer and on 8 patients with metastatic lung tumor. There were 15 men and 7 women ranging in age between 48 and 79 years (median 69).

Evaluation of all patients was done by thoracic surgeons and oncologists during tumor conferences. No patient with...
non-small cell lung cancer (NSCLC) stage I was included in this study. Eight patients had oncologically nonoperable primary lung cancer (advanced stage IIIB or IV not responding to adjuvant therapy or downstaging), while the rest had either limited pulmonary reserve (VO$_{2\text{max}}$ < 20 ml/(kg min)) or presented heart failure (NYHA III—IV) or both and they were considered to be poor surgical candidates (Table 1). Concerning the eight patients with metastatic disease, three of them were also not amenable to conventional therapies (surgery, chemotherapy and radiotherapy) due to comorbid diseases while the rest denied surgery since they had one metastasis in two different organs (Table 2). The lesions’ size was no bigger than 6 cm (range 1—6 cm) with an average of 3.8 cm. The diagnosis of all treated lesions was obtained with percutaneous biopsy under CT guidance.

3. Technique of the procedure

The RFA was carried out by a consultant radiologist specializing in biopsies and liver RFA having a thoracic surgeon present. Sixteen of the 22 patients were treated with a 6,4-F multi-array RF device (RITA) (Fig. 1a), while four were treated with a 19G spiral electrode (MIRAS RC) (Fig. 1b). The decision concerning the device to be used depended on the size and location of the lesion. The second type of electrode was used in lesions < 2 cm and in the ones located near major airways and vessels (aorta, pulmonary arteries and veins, superior vena cava).

All patients had screening blood tests including measurements of international normalized ratio (INR), partial thromboplastin time (PTT), and platelet count.

The procedure was performed under local anesthesia. The patient was placed to the appropriate position considering the localization of the lesion. Using a spiral CT 5-6, 5 mm contiguous slices were taken in order to specify the exact skin entry site for the device insertion. Subsequently, the

Table 1
Histology of the primary lesions

<table>
<thead>
<tr>
<th>Histology</th>
<th>N</th>
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<tbody>
<tr>
<td>Adenocarcinoma</td>
<td>6</td>
</tr>
<tr>
<td>Squamous cell carcinoma</td>
<td>4</td>
</tr>
<tr>
<td>Broncoalveolar carcinoma</td>
<td>2</td>
</tr>
<tr>
<td>Large cell carcinoma</td>
<td>2</td>
</tr>
<tr>
<td>Tumor stage</td>
<td></td>
</tr>
<tr>
<td>Stage II</td>
<td>6</td>
</tr>
<tr>
<td>Stage III—IV</td>
<td>8</td>
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</tbody>
</table>

Table 2
The origin of metastatic tumors

<table>
<thead>
<tr>
<th>Histology</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorectal cancer</td>
<td>2</td>
</tr>
<tr>
<td>Breast cancer</td>
<td>2</td>
</tr>
<tr>
<td>Renal cancer</td>
<td>1</td>
</tr>
<tr>
<td>Gastric cancer</td>
<td>1</td>
</tr>
<tr>
<td>Melanoma</td>
<td>1</td>
</tr>
<tr>
<td>Prostatic cancer</td>
<td>1</td>
</tr>
<tr>
<td>Tumor number</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>3</td>
</tr>
<tr>
<td>Multiple</td>
<td>5</td>
</tr>
</tbody>
</table>

Fig. 1. (a) Percutaneous spiral CT-guided RFA of a lung primary adeno-Ca in the apical segment of the left lower lobe with a multi-array electrode with seven expandable electrodes. (b) The immediately postablation CT with no enhancement of the lesion. (c) The control CT in the 6 months’ follow-up shows a remarkable decrease of the lesion.
skin to the edge of the lesion was calculated from a relevant CT image. When the preparation was completed, two dispersive electrodes were applied to the patient’s abdomen or back, depending on his position.

Before inserting the RITA device, the cap from the infusion port was removed, filled with normal saline and the electrodes were fully retracted by holding the main body in place and pulling back on the deployment shaft disk. The MIRAS RC device was tested once or twice and was inserted in a stepwise fashion through the shortest distance, while the tip of the trocar was controlled with 3 contiguous 5 mm CT images. After the tip was confirmed to be placed approximately 1 cm proximal to the center of the target area, we deployed the electrodes slowly by holding the main body with an additional 3 contiguous CT images. When the ablation was completed the electrodes were retracted by pulling on the deployment shaft disk.

Once the RFA was completed, the patient was turned (if he/she was not supine) to a supine position and the procedure was evaluated with a dual phase spiral CT after IV contrast medium administration checking also for a possible hemorrhage.

4. Results

The placement of the ablation probe in all treated lesions was successful. The ablation time varied from 15 to 30 min. The total procedure time ranged from 45 to 70 min with an average of 56.3 min depending on the difficulty of accessing the lesion and the patients’ cooperation since the procedure was under local anesthesia. In the three bigger lesions, the electrode was repositioned for better results and complete treatment. Immediate postablation images demonstrated ground-glass opacification surrounding all treated lesions, which likely represented localized edema and hemorrhage. In 11 of the patients with primary carcinoma and in 7 with metastatic lesions, there was no enhancement of the lesions. In the rest 4 lesions there was a partial enhancement. There were no major complications observed, but a small pneumothorax and a minor hemoptysis in four cases, all conservatively treated. All patients were hospitalized for 24 h.

Follow-up was initially done in 1, 3, 6 and 12 months after RFA and it was accomplished by personal interview or by telephone call up to December 2005 (Fig. 1a). A biopsy was performed in our first three patients with primary lung cancer in the 3 months follow-up revealing tumor necrosis. Death occurred in three patients with NSCLC either due to heart failure (n = 2) or recurrence (n = 1) and in two patients with metastatic tumor due to metastatic disease (n = 2) within the first year.

All lesions but one showed a ‘cystic’ transformation in the month follow-up and their size remained stable (Fig. 1b). In the non-responding case, a second RFA procedure was performed with better results. At the 3 months follow-up the size of the lesion remained stable in 15 patients and in the rest there was a diminution in size. In a follow-up of 6 months the size remained stable in 12 cases, while in 4 patients we had an increase and a second RFA procedure was decided with good response of the tumor. Among the patients who had 12 months follow-up, 3 presented a stable lesion and 2 had a decrease of size (Fig. 1c). Cumulative survival rates were calculated by the Kaplan—Meier method for the 22 patients (Fig. 2). Follow-up was planned in 1, 3, 6 and 12 months after RFA and ranged from 24 to 48 months. Median progression free intervals were 26.4 months for primary lung cancer and 29.2 months for metastatic tumor.

5. Discussion

RFA is a minimally invasive technique used since 1990 for the treatment of liver tumors under ultrasound or CT guidance [1,2]. It can provide controlled regions of coagulation necrosis with a single application to an area as large as 3–5 cm depending on the blood flow in the treated tissue [10]. The hypoxic cells with limited blood supply such as those found in the center of necrotic tumors can be resistant to chemotherapy and external-beam radiation therapy but might be more sensitive to RFA because of their increased sensitivity to heat in the hypoxic state and to decrease heat dissipation due to poor tumor perfusion [6,11].

RFA was applied in those patients who either could not tolerate or refused pulmonary resection or the downstaging was ineffective [4,5,8,9]. It has been considered as a new option either alone or as an adjuvant to chemotherapy and radiation [7,12,9,13]. In contrast to the studies of Herrera et al. [5], in our experience there is no need for general anesthesia and the patient can be released from the hospital after only 24 h or even a few hours later [14]. RFA cannot realistically be expected to achieve the same degree of tumor therapy as complete pulmonary resection. However, it is a very well tolerated method by patients who are not candidates for surgery [9,13,14]. Compared to radiotherapy...
and chemotherapy needing 20–30 Gy or 5–6 sessions, respectively, RFA has a great advantage, it requires only one or two sessions, while side effects are minimal.

All patients had an excellent tolerance including those with emphysema and cardiac failure with minimal or no pain at the time of ablation, and the complications were limited and similar to those reported in the literature. There were two cases of minor hemoptysis conservatively treated in 3 patients with hilar tumors, while Herrera et al. [5] and Vaughn et al. [15] reported two cases of massive hemoptysis. Suh et al. [9] reported 12 cases of pneumothorax in 19 RFAs, while in our series only 2 cases of small pneumothorax in our 22 patients (27 ablations) were observed. The small number of minor complications in our series could be probably explained by the fact that an experienced radiologist specialized in liver RFA and CT-guided lung biopsies performed all ablations and the devices used were selected according to the tumor size and location. During our study, five patients died either from cardiac failure, metastatic disease or recurrence. These five deaths were not considered related to the protocol.

The authors decided to use at peripheral lesions and at lesions >2 cm the RITA device, while for lesions <2 cm and central ones (hilar lesions near large vessels or airways) the MIRAS RC device turned to be more useful. In our opinion, RFA devices for lung lesions still need improvement in order to diminish the procedure time and the complications.

The follow-up results seem to be encouraging for using RFA as a palliative treatment of lung cancer, especially since the method might be used in combination with chemotherapy and radiotherapy. A CT densitometry protocol [9] was used in order to evaluate the method and not the modified RECIST criteria [4]. Patients demonstrated a variable change in size after the ablation treatment. The ‘cystic’ transformation of the lesion we studied indicated the tumor necrosis [9,14]. There should be a high percentage of suspicion in those cases where only a partial enhancement is present. The enhancement of the lesion after 1 month follow-up seemed to be residual or recurrent tumor and needed further treatment with a second session [9,14]. The authors did not use PET to re-evaluate the lesions, since from their personal experience, especially in metastatic tumors they had PET false negative results. The biopsy performed in our first 3 patients with primary lung cancer in the 3 months follow-up encouraged the authors to continue the study as the results concurred with the images post RFA treatment [14]. It should be emphasized that postablation biopsy would have provided a more short-term reference standard, but the possibility of sampling error would remain.

Our results are equivalent to those reported by Steinke et al. [16] who undertook surgical resection of ablated tumors and studied the histopathological results.

Our median progression free intervals were 26.4 months for primary lung cancer, if one considers that no NSCLC stage I was included in the study and 29.2 months for metastatic tumor. There are also additional reports on the effectiveness of RFA treatment of pulmonary tumors including those of Dupuy et al. [13] who treated three patients with lung tumor (primary or metastatic), the ones of Sewell et al. [7] who ablated successfully non-small cell cancer tumors in 10 patients, and finally the study of Suh et al. [9] who ablated successfully 12 patients with primary and metastatic lung disease.

In conclusion, we believe that RFA in lung tumors is a safe and very promising minimally invasive technique that gives patients, who are not candidates for surgery, the opportunity for a better quality of life, especially in central and big lesions that probably would have produced atelectasis of the lung or pressure on vital organs if left untreated. RFA can also be used in combination with systemic chemotherapy or radiotherapy and might contribute to an important decrease of morbidity and mortality. Long-term studies are needed to determine ablation effectiveness.

References