Pulmonary Radiofrequency Ablation Complicated by Tension Pneumothorax

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ABSTRACT

Pneumothorax is a common complication of radiofrequency ablation of pulmonary lesions. During a treatment session, a moderate pneumothorax was initially managed by placement of a pigtail catheter. Due to technical considerations, ablation of the lesion was not performed; given resolution of the pneumothorax, the pigtail catheter was removed. However, after a short time, the patient's vital signs abruptly deteriorated and the diagnosis of tension pneumothorax was made clinically. A small-gauge catheter was emergently inserted with prompt improvement in the patient's condition, and a chest tube was subsequently placed via this access in the interventional department for definitive treatment.

KEYWORDS: Radiofrequency ablation, pneumothorax, thoracic interventions

CASE REPORT

The patient had been diagnosed with two synchronous sigmoid adenocarcinomas, staged T3 N1, and treated with resection. One-year later 2 metastatic hepatic lesions were detected on surveillance computed tomography (CT) imaging, confirmed by percutaneous biopsy and treated with radiofrequency (RF) ablation. Approximately 4 years later, the patient had multiple pulmonary lesions detected on CT scanning of the chest that were also confirmed by percutaneous biopsy as metastatic adenocarcinoma. These tumors were determined to be inoperable, and in discussion with the patient and the referring services, the decision was made for management of these pulmonary lesions with RF ablation in addition to chemotherapy.

Treatment of the pulmonary metastases was performed under CT guidance with a single-prong 10-cm length, with 2- or 3-cm active length cooled tip electrode (Cool-tip System, Radionics, Burlington, MA) and under monitored anesthesia care administered by the

anesthesiology service. The first session addressed a 2-cm lesion in the right upper lobe and was complicated by a small pneumothorax and small pleural effusion, which were observed with serial chest radiographs and required no further intervention. The second RF ablation session addressed 2 left lung lesions, the first measuring ~1 cm and positioned in the upper lobe was treated without complication with two 12-minute ablations. Attempted treatment of a second, smaller peripheral lesion in the same session was complicated by a small pneumothorax displacing the lesion. This small pneumothorax was treated with an 8 French (8 Fr) pigtail catheter with the intent to continue with the procedure. However, although the lung was reexpanded with chest tube placement, the patient had become agitated and continuation with ablation would have required intubation and general anesthesia. The decision was made to terminate the procedure. The patient was transferred to the interventional radiology department and the initial chest tube was upsized to 12 Fr, and the patient was

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admitted for observation. The chest tube was removed after 24 hours and the patient was discharged.

Tension pneumothorax occurred as a complication of the third treatment session, during which ablation of an ~2-cm left posterior lobe lesion (Fig. 1A) was planned. Following placement of the RF electrode from a posterior approach, a moderate pneumothorax occurred (Fig. 1B). An 8 Fr pigtail catheter was placed using the original access and the lung was reexpanded as much as possible with the intent of continuation of ablation of the lung nodule (Fig. 1C). However, the lung nodule had shifted centrally to lie adjacent to the

descending left pulmonary vein and the aorta. The decision was made to not proceed with the ablation in this session due to safety concerns. The majority of the pneumothorax had been aspirated during the initial chest tube placement, the tube had been clamped without further accumulation of air, and the chest tube was removed at this time with the plan to follow the residual pneumothorax with serial chest radiographs (Fig. 1D).

During transfer to the holding area, the patient became acutely dyspneic, cyanotic, and hypoxic, and the diagnosis of tension pneumothorax was made clinically. A 19-gauge (19G), 5 Fr needle and catheter (Yueh

Figure 1 (A) Left lower lobe lesion targeted for ablation (long arrow). (B) Initial pneumothorax (short arrow) following placement of the radiofrequency electrode (electrode out of plane). (C) An 8 French pigtail catheter placed to manage the pneumothorax; displacement of the target lesion centrally. (D) A residual pneumothorax following removal of the pigtail catheter.

needle, Cook Medical, Bloomington, IN) was placed emergently into the anterior left chest and abundant air was aspirated. The patient was also intubated at this time. The patient's vital signs improved significantly and following stabilization, the patient was taken to the interventional suite where the anterior left chest access was upsized to a 14 Fr chest tube. The patient was admitted to the intensive care unit for careful observation. The pneumothorax resolved with suction, and the patient was extubated later the same day. The chest tube remained in place for 48 hours and the patient was discharged home in good condition.

The patient went on to receive 6 subsequent treatment sessions in which ablations of five different pulmonary nodules were performed. Two of these subsequent treatment sessions were complicated by pneumothorax, one requiring chest tube placement and admission. Follow-up CT and positron emission tomography (PET) imaging of the patient showed a mixed response of the treated pulmonary nodules. Some remained stable to slightly increased in size; however, others continued to enlarge and demonstrate FDG avidity. Significantly, a colonic mass was identified on follow-up CT, and colonoscopic biopsy revealed invasive adenocarcinoma. The patient remains alive at last follow-up, 23 months following the initial ablation.

DISCUSSION

Radiofrequency ablation has been shown to be a promising technique for management of inoperable primary and metastatic pulmonary lesions.¹⁻⁶ Surgical resection remains the only treatment modality offering the possibility of cure; however, the majority of patients are not surgical candidates due to anatomic or physiologic factors. An initial outcome study of pulmonary RF ablation by Simon et al has demonstrated 1-, 2-, 3-, 4-, and 5-year survivals of 78%, 57%, 36%, 27%, and 27% in ablation of stage I non-small cell lung cancer and 87%, 78%, 57%, 57%, and 57% in ablation of colorectal lung metastases.⁴ An additional study by Yan et al showed 1-, 2-, and 3-year survivals for RF ablations of colorectal metastases to be 85%, 64%, and 46%.⁵ Both of these studies also demonstrated that the benefit of RF ablation of lesions <3 cm was superior to larger lesions. Although a study by Lee et al failed to find a significant survival benefit based on lesion size, a significant difference in survival time associated with the degree of lesion necrosis (19.7 months for complete necrosis vs 8.7 months for partial necrosis) was shown, arguing for the continued study of the benefit of this technique.⁶

Pneumothorax is a common complication of RF ablation of pulmonary lesions, occurring in 16% to 52% of sessions, with 3.9% to 21% requiring placement of a chest tube for management.^{4,7-11} Risk factors for pneumothorax have been evaluated, whereas there is some

variability among studies, generalized risk factors are presence of emphysema, depth of the pulmonary lesion and increased number of lesions ablated. Thermal energy parameters related to ablation have been shown not to be associated with the incidence of pneumothorax.⁷ However, additional work investigating risk factors for the phenomenon of recurrent or delayed pneumothorax has shown that these types of pneumothorax are significantly associated with the amount of pleural surface involved in the ablation zone.¹⁰ None of the previous studies has specifically described tension pneumothorax as a complication.

In the case described, RF ablation itself was not performed; therefore, any association with the pneumothorax cannot be made. An initial pneumothorax occurred following the first pass of the 17G (4.5 Fr) RF electrode and it was necessary to place an 8 Fr pigtail catheter to manage the pneumothorax and attempt to control the position of the lesion. A study evaluating management of pneumothoraces following RF ablation has demonstrated that manual needle aspiration of air for asymptomatic and small- to moderate-size pneumothoraces (<543 cc in volume) may preclude the necessity of chest tube placement, and could be considered as an alternative to immediate chest tube placement.¹¹ In our patient, although the majority of the pleural air had resolved with chest tube placement, the shift of the target nodule toward the left descending pulmonary vein was judged too unfavorable for ablation. Because most of the pneumothorax had resolved, the chest tube was removed. Rapid progression to tension pneumothorax can be assumed to be formation of a one-way valve at the prior chest tube site.

The described complication appears to be a case of tension pneumothorax that is not specifically associated with RF ablation, but which could be associated with any percutaneous thoracic procedure where a residual pneumothorax is observed following removal of an intermediate size drainage catheter. Incidentally, the patient had had RF ablation of a peripheral left upper lobe lung metastasis approximately 3 weeks prior. Although the extent of contact of the ground glass opacity (the ablation zone) with a pleural surface has been shown to be a risk factor for delayed pneumothorax following RF ablation,¹⁰ the time to delayed pneumothorax in that study was 24 to 66 hours, much shorter than the 3-week delay between the treatments described here, and no clear association can be made between the patient's prior ablation and occurrence of pneumothorax at a separate treatment session.

The choice to remove the chest tube and monitor the residual pneumothorax in this case likely contributed to the major complication of tension pneumothorax. However, the patient was subsequently appropriately managed, recovered well, and went on

to receive additional ablations. The common occurrence of pneumothorax should not deter the use of RF ablation for appropriate pulmonary lesions, and an integrated plan for chest tube placement at each session for management of pleural air and lesion position is necessary.

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