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Irreversible electroporation of lung neoplasm: A case series

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A Study Design
B Data Collection
C Statistical Analysis
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Summary

Background: Percutaneous irreversible electroporation (IRE) of lung tumors is a new minimally invasive technique which has recently been used in the treatment of soft tissue tumors.

Case Reports: The case histories are presented of two patients with unresectable malignancies in the lung, who underwent irreversible electroporation as a treatment attempt. The procedure was performed under CT guidance and was uneventful.

Conclusions: At follow up 6 months later, the tumors both appeared to have recurred. To our knowledge, no similar cases have previously been reported in the literature.

key words: **lung cancer • irreversible electroporation • ablation**

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Background

An important application of irreversible electroporation (IRE) is in cancer tissue ablation. Some patients with non small cell lung cancer (NSCLC) or lung metastasis from extrathoracic malignancies are unable to tolerate standard of care surgical resection because of underlying co-morbid conditions [1,2]. Percutaneous treatments such as radiofrequency ablation (RFA), and cryoablation have been used as a minimally invasive treatment for such circumstances [3–7]. However, it can be challenging to perform thermal ablation adjacent to certain important structures such as the trachea and hilum [8]. IRE is a minimally invasive ablation procedure that targets an area of tissue using short and intense pulsing electric fields across a well-defined area by the electrodes, thus destroying cells by causing permanent damage to the cell membrane lipid bilayer [9]. We report two cases where irreversible electroporation was used to treat tumors.

Case reports

Case report 1

A 33-year-old male presented with a synovial cell sarcoma of the right thigh in 2001, which was excised in a limb sparing fashion. In 2004 he was treated with chemotherapy for pulmonary metastasis. In 2006 and 2007 he underwent bilateral pulmonary metastasectomies. He had recurrent pulmonary metastasis in 2008 for which he underwent several cryoablations of the lungs. One of the lesions in his right lung was in his hilum for which he underwent irreversible electroporation, IRE (Angiodynamics Latham, NY); this modality was chosen because of the close proximity of the lesion to several large pulmonary artery branches and lobar bronchi. The lesion measured 2.3×2.4×1.7 cm and had the shape of an upside-down triangle. General anesthesia was used for this treatment. Three IRE probes were used in a triangular pattern (Figure 1A, B). A total of 90 pulses were delivered with a maximal voltage of 2800 volts. Three separate couplets were performed. Each of the probes was between 1.5 and 2.0 cm, separated and increasing energy deposition was seen with each couplet. The tip of each probe was exposed 2.0 cm. The treatment planning grid is seen overlying the right hilar lesion in Figure 1C.

Six months later the right hilar mass showed an increase in size and displayed uniform enhancement on a contrast CT study. On PET imaging increased metabolic activity was seen. Despite additional alternative treatment, the patient's malignancy ultimately progressed. He is still alive two-and-half years later.

Case report 2

A 70-year-old female with extensive smoking history underwent a left lower lobectomy in 1996 for non small cell lung cancer; at pathological staging there were positive mediastinal nodes compatible with Stage IIIa for which she received radiation therapy. In 2007 on a surveillance CT, she was found to have a right suprahilar nodule which enlarged slowly. It was PET avid and was on biopsy found to be carcinoma with both adenocarinoma and squamous cell features similar to the initial lung cancer. This lesion was abutting the azygous vein inferiorly and had a general shape of a triangle. The dimensions were 2.1×1.9×2.1 cm. Her past medical history was pertinent for two prior cardiac valve replacements, an abdominal carcinoid tumor resection, as well as a hysterectomy for uterine carcinoma. She had significant pulmonary fibrosis from radiation changes with an FEV_1 of 47% of predicted and a DLCO of 50% of predicted. She was felt to be a poor surgical candidate. The location in the immediate suprahilar position abutting the trachea is the reason IRE ablation was chosen over other modalities. Using an Angiodynamics (Latham, NY) IRE generator 3 IRE probes were inserted in a triangular fashion (Figure 2A, B). Three couplets of 90 shocks each were applied using a total of 2800Volts. Each of the probes was between 1.5 and 2.0 cm, separated and increasing energy deposition was seen with each couplet. The tip of each probe was exposed 2.0 cm (Figure 2C). Moderate parenchymal hemorrhage was observed at the time of the procedure. A follow up CT scan with contrast two months later demonstrated continued increase of the right suprahilar mass with contrast enhancement suggesting tumor growth, and at 9 month follow up there was a suggestion of invasion of the tumor into the trachea. The cancer progressed and the patient succumbed within one year.

Discussion

Patients where the role of resection is limited because of comorbid conditions or because of extensive prior surgery are increasingly being considered for alternative methods of treatment. Several ablative therapies including RFA and cryotherapy have been shown effective and safe, controlling malignant disease in the chest [3–8]. IRE is a new modality which has been shown to cause no significant collateral damage to the surrounding normal tissues compared to the thermal ablative techniques or stereotactic body radiotherapy, at the price of needing to insert three probes in order to create adequate field vectors.

When planning a treatment zone, multiplanar reconstructed images are essential. Specifically, the exact number and position of the probe should be determined based on the geometric appearance of the tumor. The proximity to vital structures such as the trachea or large blood vessels must be determined in advance. Intraprocedural CT images are used to assess the final location of the probes. However, prior to any treatment initiation confirmation of the exact location of the probes, the distance between each of the probes and the proximity to major structures must be confirmed in multiple planes.

Each probe needs to be aligned exactly parallel, which is extremely challenging in the chest because of the interposition of the ribs. If the positioning is not parallel, the energy deposition within the tumor is inhomogeneous. Additionally, because of the geometric limitations of the device, the individual probes can be no greater than 2.0 cm apart from each other. The probes function by creating couplets. Each couplet allows the flow of electricity from one probe to the next. Because of this technique, the zone of irreversible electroporation peripheral of the probe position is minimal. Additionally, the lung is an excellent insulator to the flow of electricity thus limiting the extent of the ablation outside of the probes in lung cancer cases. Thus, optimal placement is as peripheral as possible. Each of these cases shows good positioning of the nanoknife probes. Finally, both cases show less than 1.5 cm separation between each

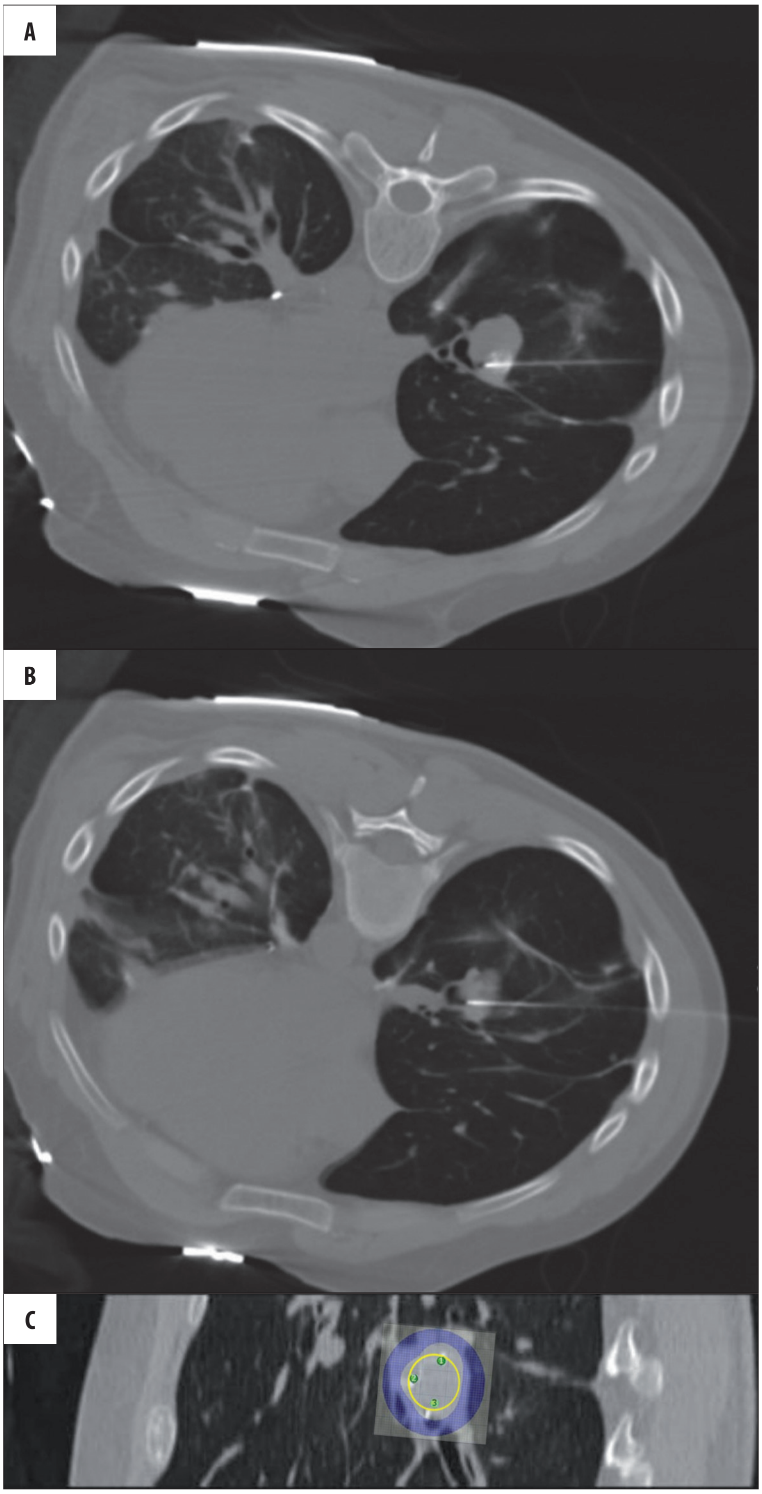

Figure 1. 33-year-old male with metastatic sarcoma to the right hilum (**A**), shows one of the three probe inserted and (**B**) shows the second probe inserted the third probe is not included. (**C**) Sagittal CT image of the chest in lung window with the overlying treatment planning grid generated by the IRE device showing the three nano-knives within the right hilar metastatic sarcoma.

of the probes. Energy deposition within the tumor appeared to be homogeneous based on the current flow diagram.

IRE has shown promise as a technique for non-thermal ablation of tumors in several organs. There has been more literature concerning the liver than any other organ [8,10]. These cases illustrate a failure of this system within the lungs. Although the exact reasons for the failure are unknown, one potential issue is that lung tissue causes significant impedance of current flow. This is related to the very low density of lung tissue. The presence of air in the lung could further result in decreased energy deposition within the tumor because of the potential of a bypass circuit around the tumor. With these issues in mind, if IRE is contemplated in the lung all probes must be within the tumor to avoid any potential for a bypass circuit, and thus decreasing the possibility of non-tumor energy deposition. This technique does not permit homogenous energy deposition around a tumor because the lung is not a solid organ.

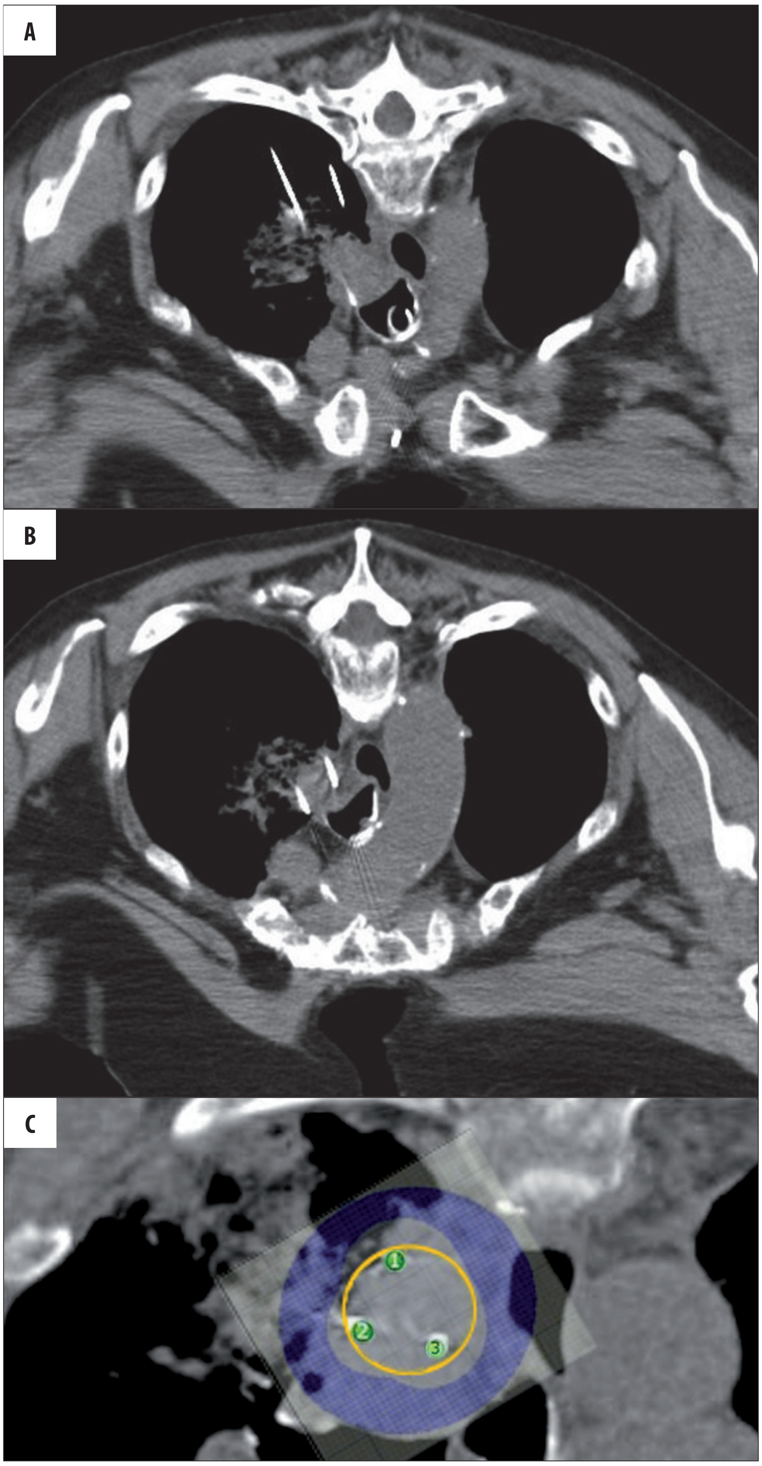

Figure 2. 70-year-old female with biopsy proven lung cancer (**A**) shows the right para-tracheal location of the mass abutting the posterior wall of the trachea mass with one of three nano-knives in place. (**B**) Right para-tracheal mass with two of the three nano-knives in place. (**C**) Probe placement plan-diagram overlying oblique coronal CT image with the three probes within the tumor.

Conclusions

IRE may represent one of several potential treatment options in cases where surgery is not appropriate. However, care must be taken with considering this new technique for lung tissue where IRE has fundamental technical limitation. We are aware of other failures of IRE in lung parenchyma and present these two cases as a cautionary tale.

References:

1. Miyamoto T, Baba M, Sugane T et al: Carbon ion radiotherapy for stage 1 non-small cell lung cancer using a regimen of four fractions during 1 week. J Thorac Oncol, 2007; 2: 916–26
2. Ghosh S, Sujendran V, Alexiou C et al: Long term results of surgery versus continuous hyperfractionated accelerated radiotherapy(CHART) in patients aged 70 years with stage 1 non small cell lung cancer. Eur J Cardiothorac Surg, 2003; 24: 1002–7

3. Dupuy DE, Mayo-Smith WW, Abbott GF et al: Clinical application of radiofrequency tumour ablation in thorax. Radiographics, 2002; 22(Special Issue): S259–69
4. Steinke K, King J, Glenn D et al: Radiologic appearance and complications of percutaneous computed tomography – guided radiofrequency – ablated pulmonary metastases from colorectal carcinoma. J Comput Assist Tomogr, 2003; 27(5): 750–57
5. Herrera LJ, Fernando HC, Perry Y et al: Radiofrequency ablation of pulmonary malignant tumors in non surgical candidates. J ThoracCardiovasc Surg, 2003; 12: 5929–37
6. Mussi A, Ambrogi MC: Percutaneous thermal ablation of lung tumours (editorial). Ann Osp San Camillo Forlanini, 2003; 5225–27
7. Ambrogi MC, Fontanini G, Lencioni R et al: A preliminary study on thermal ablation of lung tumour. Contemporary Oncol, 2004; 8373–79
8. Thomson KR, Cheung W, Ellis SJ et al: Investigation of the safety of irreversible electroporation in humans. J Vasc Interv Radiol, 2011; 22(5): 611–21
9. Lee EW, Chen C, Prieto VE et al: Advanced Hepatic Ablation Technique for Creating Complete Cell Death: Irreversible Electroporation. Radiology, 2010; 255: 426–33
10. Zemlyak A, Moore W, Bilfinger T: Comparison of Survival after Sublobar Resections and Ablative Therapies for Stage I Non-small Cell Lung Cancer (NSCLC). J Am Coll Surg, 2010; 211(1): 68–72
11. Al-Sakere B, Andre F, Bernat C et al: Tumor Ablation with Irreversible Electroporation. PLoS ONE, 2007; 2(11): e1135

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