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Cryoablation of lung malignancies recurring close to surgical clips following surgery: Report of three cases

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Abstract

Background: Minimally ablative therapies are now available for the treatment of lung malignancies. However, selection of the appropriate technique is not always easy and requires accurate preoperative planning. **Aims:** To describe the treatment of lung tumors with cryoablation. **Settings and Design:** We report three cases of lung malignancies that recurred close to surgical clips after surgical treatment, successfully treated by cryoablation. **Materials and Methods:** An initial freezing cycle was performed for 10 min, followed by a 5-min thawing cycle, and an additional 10-min freezing cycle. A final 5-min thaw was necessary to remove the needle from the iceball formed during the freezing cycle. **Results:** The procedures were completed successfully with no signs of surgical-clip misplacement, and excellent ablation of the lesions. **Conclusion:** Cryoablation is a relatively new procedure that potentially permits the local treatment of lung tumors with minimal loss of lung parenchyma.

Key words: Computed tomography guidance; cryoablation; lung cancer; lung metastasis

Introduction

Primary and secondary lung tumors are the leading causes of cancer-related mortality worldwide.[1]

However, not all patients with non-small-cell lung carcinoma (NSCLC) or lung metastasis are suitable candidates for surgery, because of complications such as pulmonary dysfunction or co-morbidities. Various alternative treatments are currently available, such as chemotherapy, radiotherapy, microwave ablation (MWA), radiofrequency ablation (RFA) and cryoablation.[1] However, selection of the appropriate technique is difficult and depends on specific features of the lesion, patient, and device. In this report, we describe three cases of lung malignancies that recurred close to surgical clips after surgical treatment, and which were successfully treated by cryoablation. The Institutional Review Board (IRB) approved the present study.

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Informed consent was obtained from research subjects.

Case Reports

Case 1

In April 2007, a 51-year-old-woman underwent surgical resection of a 3 cm mass in her right leg. Histological analysis proved it to be a high-grade leiomyosarcoma. Postoperative radiation therapy was performed on the surgical site. A computed tomography (CT) scan performed 2 years after surgery showed a 14 mm nodule in the basal-posterior segment of the left inferior pulmonary lobe coupled to another 12 mm nodule in the basal-posterior segment of the right inferior pulmonary lobe. The patient underwent surgical resection of both nodules. A cycle of adjuvant chemotherapy was started. The patient continued to receive follow-up CT scans and a new 11 mm nodule was detected 3 years after surgery for lung metastasis, located close to the surgical clips positioned during the metastasectomy in the basal-posterior segment of the right inferior pulmonary lobe.

The patient was referred to the Department of Interventional Radiology at our institution for biopsy and evaluation for local ablative treatment. A CT-guided percutaneous lung biopsy (Biopince, 18g × 11 cm, Angiotech, USA) was performed on the nodule, which was confirmed as metastatic by subsequent histological analysis. Cryoablation of the nodule was therefore performed [Figure 1]. One probe (Icesphere, Galil Medical, USA) was placed into the lesion via a posterior CT-guided percutaneous approach. During the procedure, we used an augmented reality navigation system (SIRIO, MASMEC S.p.a, Modugno, BA, Italy) to ensure accurate placement of the probe. SIRIO (MASMEC S.p.a, Modugno, BA, Italy) obtains chest CT images and uses them to create a virtual three-dimensional (3D) model. Using an automatic calibration algorithm, the system then aligns the 3D model of the chest with the patient's chest and with the probe by means of infrared optical signs. It is then possible to advance the probe into the patient's chest following the virtual model visualized on the SIRIO (MASMEC S.p.a, Modugno, BA, Italy) screen in two orthogonal directions. An initial freezing cycle was performed for 10 min, followed by a 5-min thawing cycle, and an additional 10-min freezing cycle. A final 5-min thaw was necessary to remove the needle from the iceball formed during the freezing cycle.The surgical clips showed no signs of misplacement at the end of the procedure. No minor or major complications were noted at the end of the procedure or during the following 1- and 6-month follow-up CT scans. Nodular evolution of the ablated lesion was noted at the 1-month CT follow-up and significant shrinkage of the nodule coupled with signs of central cavitation, indicating necrotic evolution of the area, was noted at the 6 month CT follow-up [Figure 2].

Case 2

In May 2008, an 80-year-old man underwent surgical resection of a 12 mm non-small-cell lung carcinoma (NSCLC) of the posterior segment of the right upper lobe. In December 2010, he underwent a follow-up CT scan that revealed a new 40 mm lung recurrence in the posterior segment of the right upper lobe. The recurrent disease was close to the surgical clips positioned during the previous surgery. Accordingly, he was referred to our institution for radio-chemotherapy, which resulted in shrinkage of the nodule (from 40 mm to 30 mm), though a Positron Emission Tomography (PET) scan showed high metabolic activity with standardized uptake value (SUV) of 11.8. The patient was therefore referred to the Department of Interventional Radiology at our institution in February 2012 for evaluation for local ablative therapy. Cryoablation was performed to treat the persistent 30 mm lesion close to the clips in the posterior segment of the upper lobe of the right lung. Cryoablation was then performed by placing parallel probes (Ice-Road, Galil Medical) using a CT-guided posterior percutaneous approach. The probes were 5 mm apart. The procedure was completed successfully with no signs of surgical clip misplacement, and no misplacement

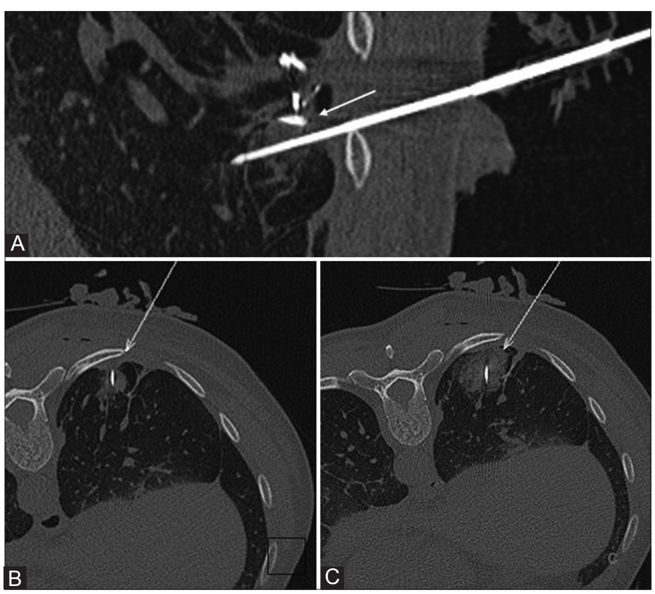

Figure 1 (A-C): CT-guided percutaneous lung biopsy in a 56-year-old woman. The nodular lesion was close to a surgical clip (A, white arrow). Probe placement during cryoablation with subsequent iceball formation (B, C, arrow)

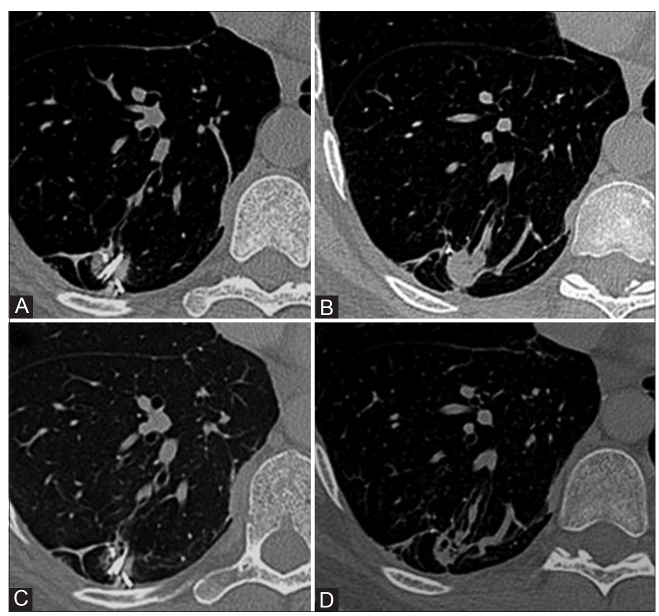

Figure 2 (A-D): Same patient as Figure 1. One month CT follow-up showing nodular evolution of the lesion with no misplacement of the surgical clips (A, B). Six month CT follow-up showing shrinkage and cavitation of the nodule (C, D)

was detected at a 1 month follow-up CT scan. A PET scan at 6 months' follow-up showed a reduction in size of the malignant mass, coupled with a significant reduction in SUV (from 11.8 to 2.8) [Figure 3].

Case 3

In April 2000 a 38-year-old female patient affected by a carcinoma of the pancreatic tail underwent a distal spleno-pancreatectomy. In 2004, follow-up CT scans revealed two new lung malignancies in the right and left inferior lobes that were subsequently resected. In 2006 the patient again underwent surgery of two new nodules of the right inferior lobe and in 2008 for atypical resection of two malignancies of the right and left inferior lobes. In June 2012 a CT scan showed a new 20 mm pulmonary nodule in the dorsal segment of the right superior lobe, close to the surgical clips positioned during the previous surgical interventions. In July 2012, the patient was therefore referred to our Department of Interventional Radiology for evaluation for local ablative therapy. Cryoablation of the nodule was performed by means of one probe (Icesphere, Galil Medical, USA) placed into the lesion via a posterior CT-guided percutaneous approach. During the procedure, the augmented reality navigation system (SIRIO, MASMEC S.p.a, Modugno, BA, Italy) was used to ensure accurate placement of the probe.A CT scan at 3 months' follow-up [Figure 4] and a PET CT scan at 6 months' follow-up showed dimensional reduction of the nodule and signs of central cavitation, indicating necrotic evolution of the area, coupled with a substantial reduction in SUV (3.8 vs. 9.9) and no signs of surgical clip misplacement.

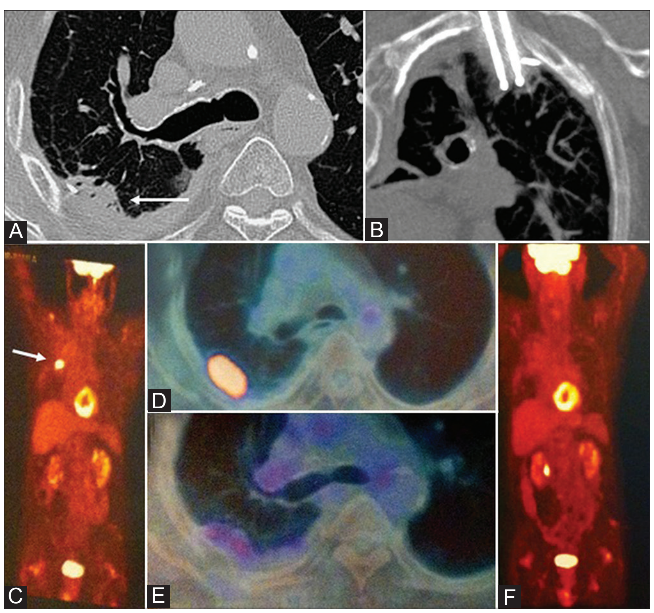

Figure 3 (A-F): CT-scan image of an 80-year-old man obtained in the axial plane showing a sub-pleural lung consolidation consistent with NSCLC, close to a surgical clip (A, white arrow). Two parallel probes were placed to perform cryoablation (B). PET scans performed before the procedure showing a high-metabolic lesion (C, D white arrow) and repeated 6 months after the procedure showing significantly reduced metabolic activity (E, F)

Discussion

Minimally invasive treatments including radiofrequency ablation (RFA) have been successfully and increasingly used in the last few years for the treatment of lung malignancies.[1] RFA in particular has become one of the leading therapies among physicians in the therapeutic setting of lung metastasis, though its major limitation involves the well-known 'heat-sink effect' that occurs when the tumor is localized near the blood vessels or the mediastinum.[1] A further limitation is the potential for unintentional overtreatment of healthy tissues surrounding surgical clips close to the target area.[2] Accumulation of charge on the clip could lead to significantly greater heating of the surrounding tissue, compared to other ablated areas with no clips;[3] moreover, the differential conductivity within the ablated tissue may alter the distribution of the electric field, thereby altering the expected size or shape of the thermal lesion.[3] This phenomenon can also occur with microwave ablation (MWA), and MWA energy deposition into the tissue is also known to be less favorable compared to RFA.[4] Cryoablation is a relatively new procedure that potentially permits the local treatment of lung tumors with minimal loss of lung parenchyma. In contrast to RFA, it has shown good feasibility and safety, even when used for lesions near mediastinal structures.[5] The main advantages of cryoablation are related to the ability to visualize the iceball on CT or magnetic resonance imaging during the procedure, giving a precise indication of the extension of the ablated area, as well as its preservation of collagenous architecture, and low intra-procedural pain.[6] Cryoablation induces tissue damage through two separate freezing-related events: A direct toxic effect on the cells, and an indirect effect on the tumor vasculature. The final result is a coagulative necrosis.[7] The direct effect involves enzymatic and cell membrane dysfunction caused by intra- and extra-cellular ice formation at temperatures below 0°C,[7] resulting in osmosis of water out of the cells and cellular

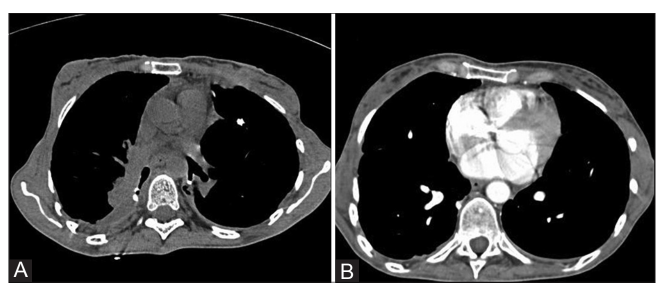

Figure 4 (A and B): CT scan image of a 38-year-old female patient affected by lung metastasis from a carcinoma of the pancreatic tail showing a nodule in the dorsal segment of the right superior lobe, close to the surgical clips positioned during the previous surgical interventions (A). 3 months follow-up CT scan showing dimensional reduction of the nodule (B)

dehydration. During the thawing cycle, water returns to the intracellular space and causes cellular lysis. The indirect effect results in occlusion of small blood vessels because of the extreme cold.[7] The present study involved three cases of lung malignancies (one metastasis from leiomyosarcoma, one NSCLC and one metastasis from pancreatic carcinoma) that recurred close to surgical clips at a site of previous surgical treatment. In each case, the decision to perform cryoablation was influenced mainly by the presence of the clips close to the lesion, and the need to avoid potential RFA-related thermal damage due to overheating of the clips, resulting in unpredictable necrosis. To the best of our knowledge, this is the first report of successful cryoablation of lung lesions located close to surgical clips.

Conclusion

This report presented three cases of lung malignancies close to surgical clips that were successfully treated by cryoablation. We suggest that this technique should be considered as a valid alternative for treating lung malignancies recurring close to surgical clips, although further studies are needed to substantiate the potential of this new application.

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