Pathol. Oncol. Res.
DOI 10.1007/s12253-012-9601-1

RESEARCH

Prevention of Needle-Tract Seeding by Two-Step Freezing after Lung Cancer Biopsy

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Received: 13 August 2012 / Accepted: 21 December 2012

Abstract Fine-needle aspiration biopsy is a method to detect malignancy for undetermined pulmonary nodules, but has the potential to spread malignant cells from the tumor to the pleural cavity or chest wall. We developed a two-step freezing method to avoid needle-tract seeding, by use of percutaneous cryoablation after biopsy but before the biopsy needle was removed. A man aged 72 years was admitted because of a large mass in right upper lobe. After biopsy, the patient underwent surgery. Pathological assessment of the resected tumor showed that tissue around the biopsy probe and cryoprobe had been killed before needle withdrawal.

Keywords Biopsy · Percutaneous cryoablation · Lung cancer · Pathology

Introduction

Dissemination of tumor cells along the needle tract after needle-aspiration biopsy of lung tumor was reported before 2000 [1–6], but it was deemed to be an uncommon event, especially when fine needles are used. Malignant cells may be spread from the tumor to the pleural cavity, chest wall or paraspinal muscle during withdrawal of the needle. Spread of disease in this way can cause potentially resectable localized lung cancers to become unresectable [4] and lead to radical full-thickness excision of the pleura, chest wall or muscle [3]. Case-by-case decisions about the application of this diagnostic modality, based on the operative risk and that of the patient developing a primary lung cancer, have been suggested [5]. Needle-tract seeding has continued to be reported and fine-needle aspiration biopsy (FNAB) is now thought to have a high potential for implantation metastasis [7, 8].

Imaging-guided percutaneous cryoablation is a minimally invasive procedure with an acceptable complication rate [9, 10], including a low risk of needle-tract seeding [11]. An ice ball is formed (which appears as a low-density shadow on computed tomography [CT]) that kills the surrounding tissue. We created a two-step freezing method to kill tissue around the biopsy-needle sheath to avoid needle-tract seeding during withdrawal in FNAB.

Case Report

A man aged 72 years was admitted to our hospital because of a large mass (6×8 cm) in the upper right lobe. The patient had first felt pain in the right chest 7 months previously, which was accompanied by cough and expectoration. The cough had gradually worsened and hemoptysis had developed. The patient had undergone chest CT before being referred to our hospital for treatment.

At admission, routine blood tests, blood coagulation and liver and renal functions were all normal. Partial pressure of oxygen and carbon dioxide in blood were 11.5 and 4.6 kPa, respectively, and neuron-specific enolase concentration was 14.77 ng/mL. Electrocardiography indicated sinus rhythm and B-ultrasonography showed normal conditions in the liver, gallbladder, spleen and pancreas. No obviously swollen lymph nodes were detected in the bilateral neck or armpits. Forward and lateral chest radiography revealed a

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Published online: 30 January 2013

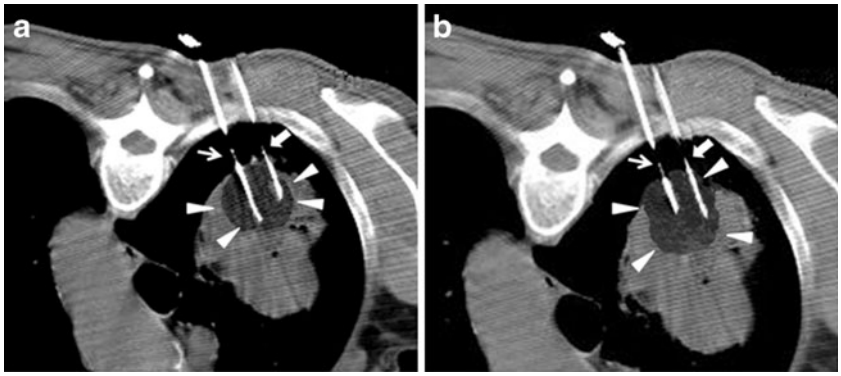

Fig. 1 Images of two-step cryoablation tumor freezing under computed tomography guidance (**a** first step, **b** second step), where *fine arrows* show the cryoprobe, *broad arrows* the biopsy needle, and *triangles* the profile of the ice ball

soft tissue mass in the posterior segment of the right upper lobe; CT of the head and chest showed peripheral lung tumor without brain metastasis.

The patient gave consent to undergo FNAB with cryoablation. Biopsy was performed under the guidance of double-row helical CT (Somatom Emotion Duo, Siemens, Germany). After general anesthesia, a 1.7 mm cryoprobe (Cryo-42), attached to an argon-based cryosurgical unit (Endocare, Irvine, CA, USA), was inserted through the right paravertebral gutter, to a depth of 3 cm from the center of the tumor. An 18-gauge Tru-cut biopsy needle (Baxter, Deerfield, IL, USA), which included a core tube and a sheath, was inserted 0.8 cm from the cryoprobe and inserted in parallel to a depth of 2 cm into the tumor. After two tissue samples were taken via the core tube of biopsy needle, the cryoprobe was used to twice freeze and warm (by natural warming) the surrounding tissue. At the end of cryoablation the ice ball could be seen on CT to cover the two probes and extend beyond the tumor boundary (Fig. 1a). While the biopsy needle remained in place, the cryoprobe was pulled out by 2 cm along the needle tract and a single-freeze procedure (10 min each of freezing and natural warming) was performed. The second ice ball also clearly covered the two probes and extended further beyond the tumor boundary (Fig. 1b). The cryoprobe and biopsy needle were both removed along the needle tracks and the wounds were treated with packing and hemostasis. Pneumothorax did not occur.

Postoperative pathological analysis indicated a diagnosis of poorly differentiated adenocarcinoma. Three weeks after biopsy, the patient underwent right upper lobectomy and thoracic cavity exploration. On the surface of the resected tumor, two deep indentations were evident, around 2.5 cm apart (Fig. 2). The larger was caused by cryoablation and was circular with a diameter of 1.67 cm. The smaller indentation was caused by FNAB and was oval (length 1.3 cm, width 0.9 cm). A tumor cross section through the indentations revealed four distinct tissue regions (Fig. 3): the peripheral unaffected lung tissue was red-brown; lung tissue immediately surrounding the cryolesion showed granulation hyperplasia and fibrosis and was bordered on the lesion side by a narrow bleeding area; the outer part of the tumor was frozen, fragile and a pale red color with distinct border around the normal tumor area; and the centre of the tumor was yellow to white, had a dark grey necrotic core with an unclear boundary and remained the same as had been seen in the biopsy samples. The peripheral lung tissue showed signs of compensatory pulmonary emphysema. The patient was followed up by CT scan for 4 months, and no evidence of needle-tract seeding, recurrence or metastasis was seen.

Discussion

Advances in imaging technology have led to an increase in use of percutaneous cryoablation in radical treatment of early-stage lung cancers [12] and palliative treatment of advanced-stage disease [10]. The feasibility of cryoablation in lung cancer patients has been demonstrated [9], but pathologic specimens have been hard to obtain, and most of the data on therapeutic efficacy have been obtained from porcine models [13–18]. In this case, combined cryoablation and pulmonary FNAB presumably prevented needle-tract seeding during biopsy.

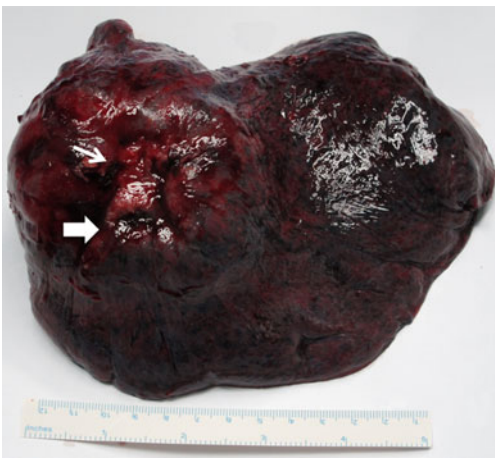

Fig. 2 Exterior surface of surgically resected sample, where the *fine arrow* shows the indentation at the cryoprobe insertion site and the *broad arrow* that of the biopsy-needle insertion site

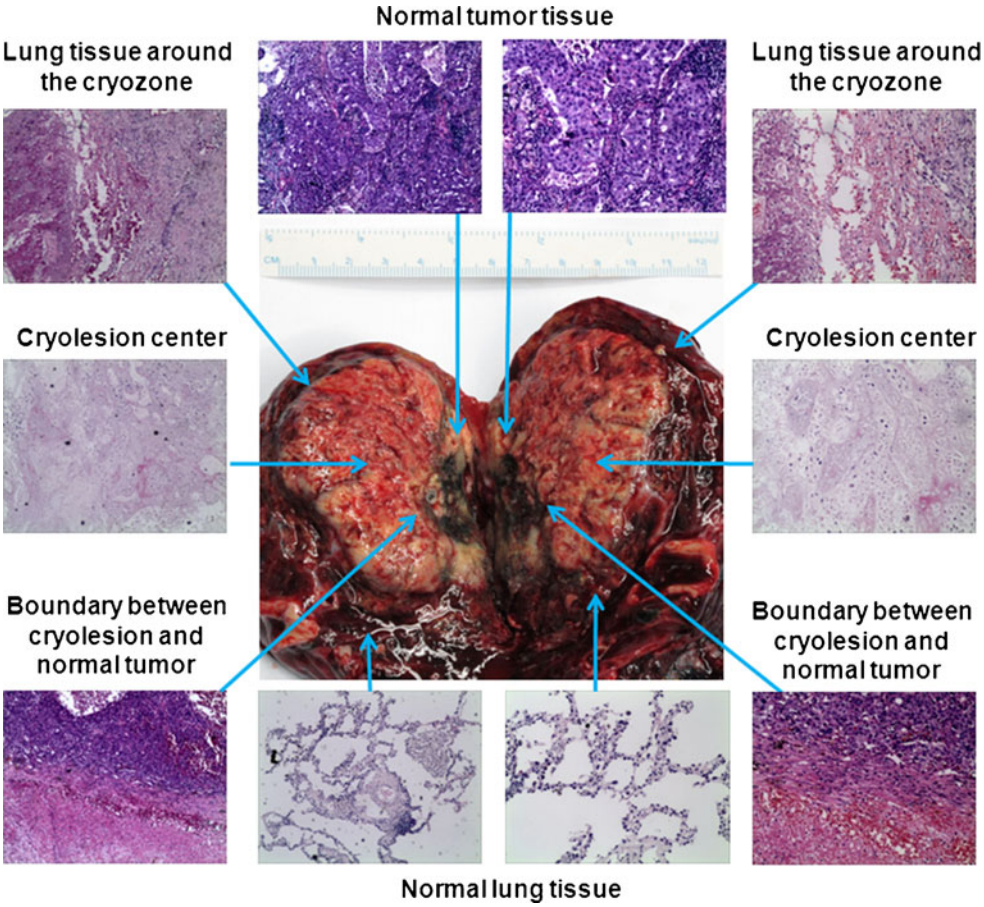

Fig. 3 Visualization of different parts of the resected tumor and surrounding tissues, on pathologic examination and with the naked eye (the five pictures on the left side are ×40 magnification, those on right are ×100)

FNAB is frequently performed in superficial sampling sites to decrease or avoid the risk of needle-tract seeding and distant metastasis [19]. To improve the efficiency and accuracy of FNAB in deep tumors, researchers have assessed various methods to inactivate tumor tissue, such as electrochemical [20] or radiofrequency ablation [21] after biopsy. Although some findings have been promising, these methods have several limitations. For instance, in electrochemical ablation selection of the appropriate electrical current and voltage is difficult when the ablation needs to cover a larger area and the scope of destruction is difficult to precisely control [20]; in radiofrequency ablation, the ablation range cannot be precisely controlled and is difficult to visualize [21].

For cryoablation, CT or B-ultrasonography can be used to guide the procedure and monitor the damage range in real time, which minimizes harm to normal tissue (Fig. 1). A multiple-step approach can be used to adjust precisely the cryoablation region in accordance with the tumor shape and size. In our case, the first step was designed to inactivate the region within the tumor and around the biopsy needle, which was 0.8 cm from the cryoprobe at insertion. An ice ball of 2.25 cm diameter was formed (Fig. 4). The second step was intended to inactivate a region beyond the tumor through which the biopsy needle would pass on withdrawal, and created an ice ball of 1.25 cm diameter (Fig. 4) [17, 18, 22]. The biopsy needle was inserted to a depth of 2 cm into the tumor. Random sampling in the tumor parenchyma showed that the penetrating depths of two ablation areas were 3.5 cm and 1.5 cm, respectively, which ensured the ice balls fully contained the target area.

We performed the pathological analysis 3 weeks after cryoablation, which is in contrast to previous animal studies, where analysis was done directly after cryoablation [13].

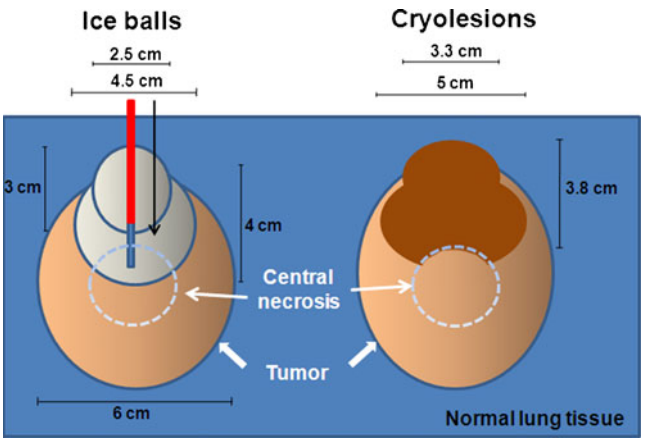

Fig. 4 Schematic of ice balls and cryolesions from steps one and two of the procedure

Immediate pathological testing showed severe congestive edema at the edges of the cryolesion [15, 17]; in the tumor from our patient, inflammation and granulation had developed in these areas and could be clearly seen with the naked eye (Fig. 3) [13]. We have noted previously and in this case that although the ice balls were of similar height to the cryolesions, the widths of the cryolesions were markedly greater (Fig. 4) [13]. The disparity might be caused by edema enlarging the distance between biopsy needle and cryoprobe; the cryoprobe and biopsy needle in this case were inserted 0.8 cm apart, but the indentations on the resected tumor surface were 2.5 cm apart (Fig. 2). Given the complex nature of cellular damage that occurs with cryoablation, the protocol for lung tissue, which has low thermal conductivity, will probably differ from those for other tissues [16].

We report a two-step freezing method that presumably prevented needle-tract seeding after biopsy of lung cancer. Pathological analysis suggests that the method was safe and effective and warrants validation.

Acknowledgments This work was supported by a grant from the Science and Technology Project of Medical Instruction (No: 2010-T-25), Guangzhou, China.

Conflicts of interest We declare that we have no conflicts of interest.

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