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Artificial pneumothorax in CT-guided radioactive iodine-125 seed implantation in the treatment of mediastinal tumors

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Abstract. – OBJECTIVE: To explore the efficacy and safety of CT-guided radioactive Iodine-125 seed implantation in treating mediastinal tumors in the thorax with artificial pneumothorax.

PATIENTS AND METHODS: Artificial pneumothorax was created using the 22G thoracic puncture needle in 36 patients with mediastinal tumors, followed by CT-guided radioactive Iodine-125 seed implantation. An equal volume of gas was extracted after the treatment.

RESULTS: The treatment was completed in 35 patients. The tumor target volumes for the radiation treatment were not significantly different before and after the artificial pneumothorax (p = 0.265). No severe complications such as refractory pneumothorax, hemoptysis, or diffuse hemorrhage in the implantation area was observed.

CONCLUSIONS: Artificial pneumothorax can reduce the CT image interference caused by the needle tract bleeding during the radioactive Iodine-125 implantation.

Key Words:
Artificial pneumothorax, Radioactive Iodine-125 seed implantation, Mediastinal tumor.

Introduction

Implanting radioactive Iodine-125 seed used to treat mediastinal tumors can interfere with the observation of the tumor target area. Thus, we created the artificial pneumothorax for treating mediastinal tumors before the implanting the radioactive Iodine-125 seed in 2009. We summarized our experiences using this technique, and focusing on the influence of artificial pneumothorax on the tumor target area as well as the postoperative complications.

Patients and Methods

Clinical Data

A total of 36 patients with mediastinal tumors (9 cases of lung adenocarcinoma, 12 cases of thymoma, and 15 cases of squamous cell carcinoma) who underwent radioactive Iodine-125 seed implantation in our hospital from May 2009 to September 2013 were enrolled in this study. Amongst them, 32 men and 4 women aged 43 to 78 years (median: 61 year) were part of the study group. The implementation sites were located at the anterior mediastinum (n=21), main pulmonary window (n=4), aortic arch (n=2), posterior mediastinum (right upper paratracheal, n=1; subcarinal, n=8). The study protocol was in accordance with the ethical guidelines of the 1995 Declaration of Helsinki and was approved by independent ethics committees at Daping Hospital, Third Military Medical University.

Devices and Materials

The devices used in this study included: Philips Brilliance Big Bore 16-Slice CT scanner; high-ozone UV germicidal lamp; 22G puncture needles; 18G seed implantation needles; and computer-based treatment planning system (FTT Technology Co. Ltd, Beijing, China). The radioactive Iodine-125 seeds (0.8 mCi, with a half-life of 59.6 days) were manufactured by JACO, Ningbo, China.

Pre-operative Preparation

Prior to surgery, the CT room was disinfected with an ultraviolet (UV) lamp for 30 min. The CT room must conform to the requirements of type-II

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environment, with the suspended particles in the air ≤ 200 cfu/m^{3}, [1]. The routine blood indicators and the coagulation time were tested before the surgery to rule out any hemorrhagic disorders.

Surgical Procedures

Upon administering low flow oxygen, the implantation site was sterilized twice. The needle punctured the flexible hose and connected with the 5 ml normal saline. After the needle punctured the parietal pleura (for mediastinal, see Figure 1; for lung, see Figure 2), the normal saline inside the flexible hose flowed into the pleural cavity due to the negative pressure between visceral pleura and parietal pleura gaps.

With the air injected at a speed of 2-3 L/min, the intrathoracic pressure was at 6-10 mmHg, making the lung tissue along the path compress. The repeated puncture did not cause diffused bleeding in the lung tissue.

When the lung tissue compressed outside the puncture path and reached an ideal status, an enhanced CT scan was performed (Figure 3). Due to the impact of the artificial pneumothorax, the location and morphology of the mediastinal tumors changed accordingly. Upon the completion of seed implantation, the equal volume of gas was extracted (Figure 4).

Comparison of the target Volume for Seed Implantation Before and After the Creation of Artificial Pneumothorax

The CT images before and after the artificial pneumothorax were copied into the 3-D particle treatment system, in which the pre-operative plans were established, and the artificial pneumothorax influences on the target volume and tumor size were assessed.

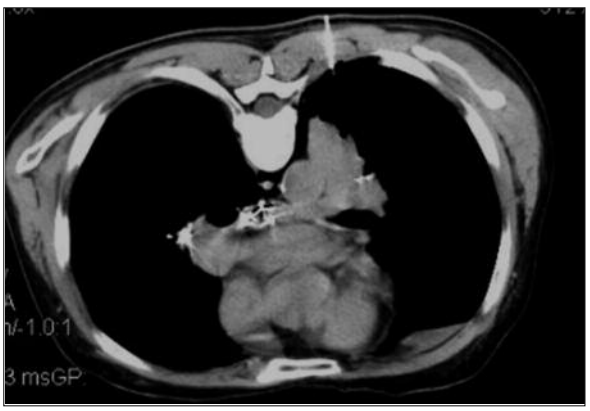

Figure 1. Parietal pleura – mediastinal window.

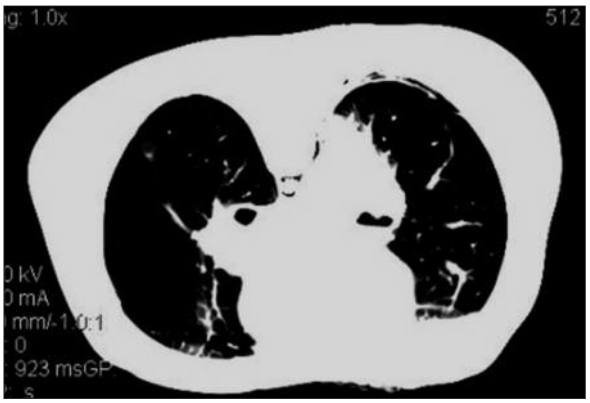

Figure 2. Parietal pleura – lung window.

Adverse Reactions

The conditions of the patients were observed 1-3 days after the surgery. Any pneumothorax or hemoptysis was observed and assessed using a chest X-ray.

Statistical Analysis

In 35 patients with the artificial pneumothorax, the target volumes in the pre-operative plans before and after were compared using paired t test, with $p < 0.05$ as statistically significant.

Results

Procedure Outcomes

During the continuous administration of low flow oxygen, 35 of 36 patients felt mild chest distress/distention. The seed implantation lasted 42-112 min (mean: 58.6 min), with an average gas infusion volume of 960 ml (560-1400 ml).

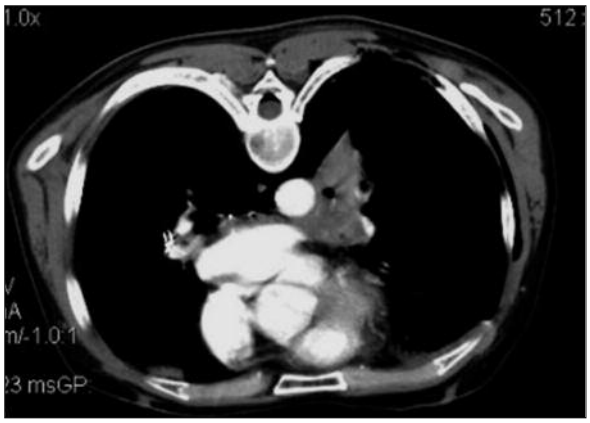

Figure 3. Enhanced CT scan.

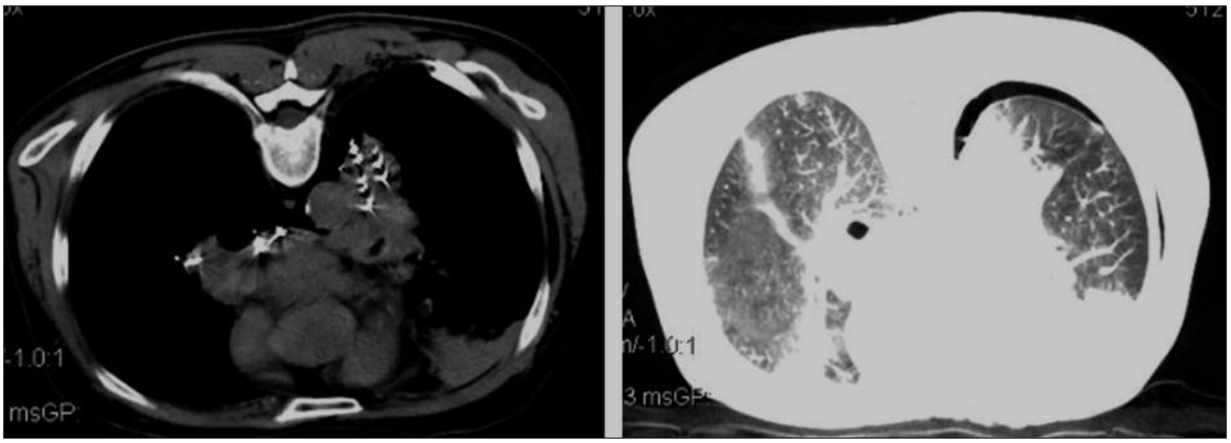

Figure 4. Target volume for seed implantation after the creation of artificial pneumothorax. Left, mediastinal window; Right, lung window.

One patient had cold sweats and became irritable after the intrapleural injection of 150 ml gas. An equal volume of gas was then extracted, and the procedure was canceled.

Comparison of the Target Volume in the Pre-operative Treatment Plans Before and After the Creation of Artificial Pneumothorax

Thirty-five patients successfully underwent the seed implantation following the creation of artificial pneumothorax. Amongst them, the tumor target volume showed no significant change (p = 0.265) (Table I).

Adverse Reactions

All 35 patients could tolerate the implantation procedure. After administering oxygen, no chest distress/distention, difficulty breathing, or other symptoms were noted. After the seed implantation, an equal volume of gas was extracted. A small amount of residual gas was found in the thoracic cavity (the lung compression rate was < 3% in 24 cases, < 5% in 8 cases, and < 8% in 3 cases). One patient had cold sweats and chest tightness and became irritable during the creation of the artificial pneumothorax; thus, the treatment was terminated. After an equal volume of gas was extracted, the CT scan showed that a small amount of residual gas in the thoracic cavity was present, with a lung compression rate of about 6%. Amongst the 35 patients, the chest X-rays were performed again two days later, and no intractable pneumothorax was identified. In addition, no hemoptysis was noted during the clinical observations.

Discussion

The gap between the visceral and parietal pleura is a big challenge for surgeons when creating the artificial pneumothorax. Needle must be inserted slowly and once it penetrates the parietal pleura, saline will automatically be absorbed because of the negative gap pressure. Air can then be injected at a speed of about 100 mi, during which, a CT scan should be performed to avoid subcutaneous emphysema.

The repeated puncture of the seed applicators during radioactive ^{125}I seed implantation can easily cause pneumothorax. Haramati et al[3] compared the complications after the CT-guided nee-

Table I. Comparison of the target volume in the pre-operative treatment plans before and after the creation of artificial pneumothorax (mean ± standard deviation).

Classification	Mean	t	p
Target volume before the creation of artificial pneumothorax	15.75 ± 4.744	1.170	0.265
Target volume after the creation of artificial pneumothorax	15.70 ± 4.732		

dle biopsy through an aerated versus a non-aerated lung. Patients in whom the needle traversed the aerated lung, complications developed in 51% (40 of 79). The rate of pneumothorax was 46% (36 of 79). For patients in whom the needle did not traverse the aerated lung (n = 52), the only complication was a minor hemoptysis in one patient (2%). Scalzetti[4] created 24 cases of artificial pneumothorax using a novel puncture needle, amongst whom 20 achieved success. The reasons for the failures included pleural adhesions (n=1) and failed insertion of the puncture needle into the pleural cavity (n=3). In our current study, we successfully created the artificial pneumothorax in 35 patients. Upon administering oxygen, the patients' oxygen saturation increased and the cardiopulmonary events reduced, improving tolerance to the surgery[5]. Thus, radioactive ^{125}I seed implantation can be performed under artificial pneumothorax. Amongst these 35 patients, the puncture path was not via the lung tissue. An equal volume of gas was extracted after the seed implantation, and the patients were administered with low-flow oxygen. No hemoptysis was noted.

After the artificial pneumothorax was created, the tumor size and morphology demonstrated certain changes due to air compression. In the 35 patients, comparison of the tumor size prior surgery, before and after the creation of artificial pneumothorax, showed no significant change (p = 0.265); also, the target volume had no difference. Thus, the artificial pneumothorax did not influence the tumor volume for seed implantation.

Lin and Li[6] applied the "protective pneumothorax" method, in which the air was injected into the pleural cavity to compress the lung tissue along the puncture path, and reduce bleeding. Repeated punctures are required during the radioactive ^{125}I seed implantation. The accumulated flocculent bleeding along the puncture path interferes with the imaging results in the implantation area. Ideal path requirements are met after creating the artificial pneumothorax in the 35 patients, reducing the diffused bleeding interference on the implantation area.

The duration of the radioactive ^{125}I seed implantation for the mediastinal tumors is long. The artificial pneumothorax upon administering oxygen provides a puncture path that does not interfere with the lung tissue. This reduces the needle tract bleeding and avoids the impact of the bleeding along the puncture path on the tumor area. In addition, there is no intractable pneumothorax and, therefore, is a safe and effective method.

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Conflict of Interest

The Authors declare that there are no conflicts of interest.

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