Original Article

The value of a novel percutaneous lung puncture clamp biopsy technique in the diagnosis of pulmonary nodules

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Abstract

Background: Computed tomography-guided percutaneous lung biopsy is a crucial method to determine pulmonary anomalies, and is highly accurate in detecting evidence of malignancies, allowing medical practitioners to identify the stage of malignancy and thus help to plan the treatment regimens of patients.

Objective: To explore the clinical application of a new computed tomography-guided percutaneous lung puncture clamp biopsy technique in the diagnosis of pulmonary nodules, characterized by ground-glass opacity on chest computed tomography images.

Methods: A unique instrument named 'combined percutaneous lung biopsy forceps', consisting of a biopsy forceps, a 15-gauge coaxial needle and needle core, was designed. The new tool was used to obtain specimens in nine patients with pulmonary ground-glass opacity. The specimen volumes and the safety of using the instrument were measured. The samples obtained were also assessed to see if they were sufficient for conducting histological tests.

Result: Samples were obtained in all nine patients – a success rate of 100%. Consistently, the volume of each specimen was sufficient to make a histological diagnosis. No serious complications, such as pneumothorax – primary spontaneous pneumothorax or secondary spontaneous pneumothorax – occurred during the biopsy.

Conclusions: The application of this new tool in obtaining tissue specimens in patients with pulmonary ground-glass opacity under the guidance of chest computed tomography was invaluable in terms of its high accuracy and safety. Moreover, its effect was better compared to using a fine-needle aspiration biopsy or a cutting-needle biopsy. Therefore, this instrument can be used for histological diagnosis. [*Ethiop. J. Health Dev.* 2021; 35(2):85-90]

Key words: Ground-glass opacity; percutaneous lung puncture clamp biopsy; fine-needle aspiration biopsy; cutting-needle biopsy

Introduction

Chest computed tomography (CT)-guided percutaneous lung biopsy is widely applied in clinics due to its advantages, such as simple operation and minimal invasion. It has significant application value in the diagnosis of lung lesions. Fine-needles and cutting-needles are commonly used as puncture needles, some research reports that both fine-needle aspiration biopsy (FNAB) and cutting-needle biopsy (CNB) have significant application in the diagnosis of pulmonary ground-glass opacity (GGO) through chest CT-guided percutaneous lung biopsy. Approximately 0.2% to 0.5% of population across the globe have been shown to be positive for GGO (1).

In recent years, with the gradual improvement of biopsy equipment, it had been necessary to select alternative puncture needles to reduce procedure-related complications and improve diagnosis. The novel percutaneous lung puncture clamp biopsy technique can be effectively applied for its high diagnostic accuracy in the detection of malignancy, guidance regarding the stage of malignancy, and appropriate treatment plan. To that end, we invented a unique instrument named 'combined percutaneous lung biopsy forceps' and explored its application value in the clinical diagnosis of GGO. Pathologically localized GGOs existing for months or longer have been reported to correspond to have pre-cancerous lesions and early-stage adenocarcinoma.

From October 2015 to December 2019, using this newly invented tool, nine patients with lung GGO underwent CT-guided percutaneous lung biopsy. In the study, nine patients of different age groups and sex were selected, depending on the availability of reported lung complication. Regular monitoring and close observation of these patients was our prime focus in order to check the efficacy of this novel forceps The results we obtained from our sample pool were satisfactory for the purposes of the study, although the needle and novel forceps may not be suitable for a large sample.

Materials and methods

Apparatus construction: The new combined percutaneous lung biopsy forceps (see Figure 1) includes a biopsy forceps, a 15-gauge coaxial puncture needle and a needle core. The biopsy forceps have a silica gel positioning device. The silica gel is used as the backing material to achieve better precision. The needle core or the clamp stem of the biopsy forceps is penetrated and located in the positioning coaxial puncture needle sleeve, the biopsy forceps pass through the positioning coaxial puncture needle sleeve, and the upper and lower clamp pieces are occluded by gripping the clamp handle, and the tissue is clipped.

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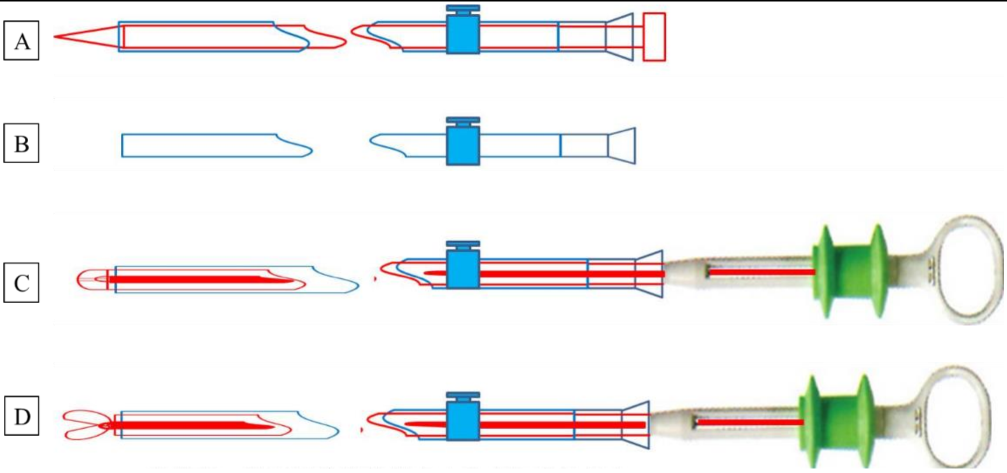

Figure 1: **The diagrammatic sketch of the new combined percutaneous lung biopsy forceps**

A. Penetrate the needle core through coaxial puncture needle sleeve. Percutaneously insert the needle with the sleeve into the edge of the lesion or 0.5cm away from the lesion; B. Take out the needle core, leaving the sleeve for the next biopsy; C. Insert the biopsy forceps through the sleeve with the silica gel positioning point until the front-end resistance is felt; D. Open the biopsy forceps and gently push them to obtain the sample.

Case data: A total of nine patients with lung GGO were selected as participants in this study. Of these nine cases, three were males and six were females, ranging from 42 to 78 years old. The size of lung GGO ranged from 0.7cm to 2.9cm. In four cases, lung GGO was located in the right lung and five were in the left lung.

Preparation before puncture**:** Before puncture, routine blood test, prothrombin time, infectious disease, electrocardiogram and other routine examinations were completed. These patients had no obvious bleeding tendency disease or serious insufficiency in terms of cardiac or pulmonary function. Before puncture, chest CT images were reviewed by the operator to obtain the information of lung GGO in terms of size and shape. The relationships between adjacent tissues, blood vessels, trachea and the GGO were confirmed. The position of puncture, the direction of needle insertion and the position of patients were set in advance. Here, the pre-procedural imaging technique was applied to demonstrate any accessible extrapulmonary disease.

Operation mode: The position of the patient before performing the chest CT scan was decided, followed by the CT scan and the measurement of the direction, angle and depth of puncture. The selected puncture point was marked on the skin with a marker pen, then the local skin was disinfected using iodine. Local infiltration anesthesia was performed by injection of 5ml lidocaine (2%). In addition to the sedative effect of 2% lidocaine, is was used to block the intercostal nerve to reduce post-thoracotomy pain.

Next, a 15-gauge coaxial needle was inserted into the edge of the lesion or 0.5cm away from it. The core of the needle was withdrawn, and the biopsy forceps was inserted to the silica gel positioning point until front-end resistance was felt. The biopsy forceps was opened, gently pushed to clamp the tissue, then withdrawn. The last biopsy step was repeated three to five times. The chest CT scan was repeated during the biopsy procedure to determine whether the coaxial needle had displaced. Careful observation was carried out to see if there was any bleeding. After withdrawing the biopsy forceps, FNAB was performed as the comparison. Then, the needle core was inserted and the coaxial needle was pulled out. After the specimens were taken out, they were quickly placed in 10% formalin bottles for further histopathological and cytological examination; after 5 to 10 minutes, a chest CT scan was performed to observe whether there were procedure-related complications, such as pneumothorax, hemothorax or hemorrhage.

Ethical considerations: This study protocol was reviewed and approved by the Institutional Review Board and the Ethics Committee of Second Affiliated Hospital of Fujian Medical University. Informed consent was obtained from every patient or their assignee.

Position	Sex	Age (years)	Size (cm)	Fine-needle aspiration cytology	Biopsy histopathology	Complication	Follow-up/Post-operative condition
Left upper lobe	Female	73	2.2×2.3	Adenocarcinoma	Adenocarcinoma	None	Loss to follow-up
Right lower lobe (Figure 3)	Male	52	1.2×1.0	Cancer cells	Adenocarcinoma in situ	None	Consistent with the operative histopathology
Right upper lobe	Female	42	1.2×1.2	Pulmonary epithelial cells	Invasive carcinoma	None	Consistent with the operative histopathology
Right upper lobe	Male	78	2.9×1.9	Cancer cells	Adenocarcinoma	None	Loss to follow-up
Left upper lobe (Figure 2)	Female	58	0.9×0.7	Histiocytes, lymphocytes, lobulated nuclear cells and ciliated columnar epithelial cells	Alveolar septum widened slightly with fibrous tissue hyperplasia and a small amount of lymphocyte infiltration	None	Focal absorption
Right upper lobe	Female	56	1.5×0.9	Histiocytes, lymphocytes and ciliated columnar epithelial cells	Alveolar septum widened and interstitial fibrous tissue proliferated	Minimal pneumothorax	Loss to follow-up
Left lower lobe	Female	55	1.3×1.2	Epithelial cells, lymphocytes, neutrophils	The epithelioid cells were concentrated and a few nuclei were slightly stained with epithelioid cells	Minimal pneumothorax	Loss to follow-up
Left upper lobe	Male	56	1.9×1.7	Ciliated columnar epithelial cells, lymphocytes	Alveolar space was narrow; interstitial fibrous tissue hyperplasia; a small number of lymphocytes	None	Focus reduction
Left lower lobe	Female	54	1.4×0.8	Ciliated columnar epithelial cells, macrophages, lymphocytes	Flat epithelium and cuboidal epithelial cells; small fibrous stromal tissue	None	Focus reduction

Table 1. Results of the novel percutaneous lung puncture clamp biopsy in nine patients

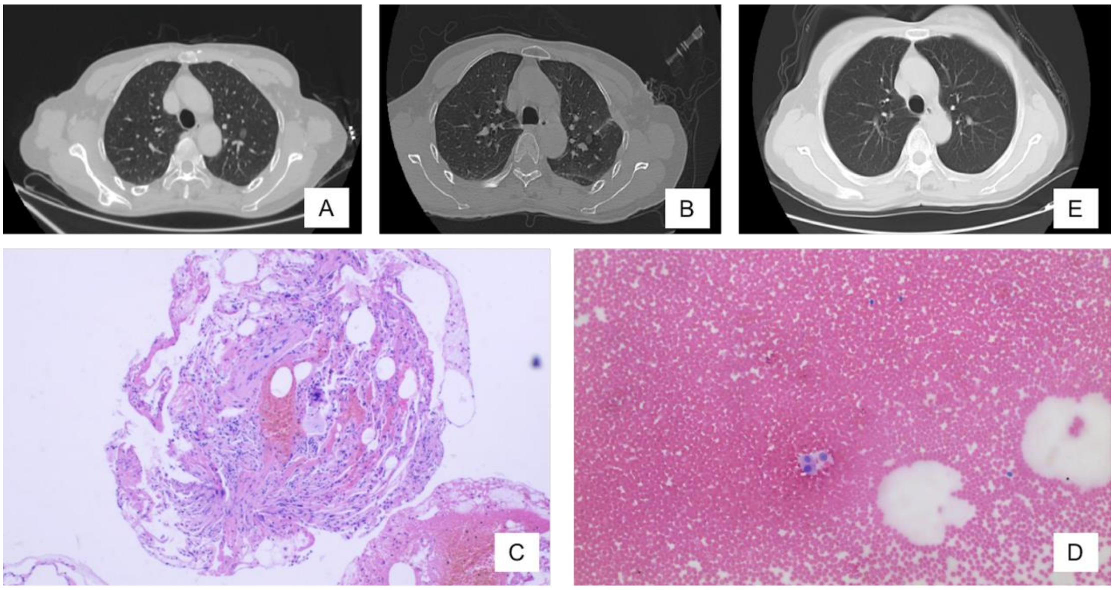

Figure 2: **Chest CT images and histological manifestations of a 58-year-old female patient**

A. Chest CT scan showed a ground glass-like nodule in the left upper lobe with a size of 0.9cm×0.7cm; B. Chest CT-guided percutaneous lung biopsy was conducted; C. Histopathological results from forceps biopsy showed a slightly widened alveolar septum with fibrous tissue hyperplasia and a small amount of lymphocyte infiltration; D. Cytological results from fine-needle aspiration biopsy showed histiocytes (cells of either the macrophage or Langerhans cell lineages, involved in immune and non-immune cellular reactions, as well as in the genesis of a variety of benign and malignant neoplasms), lymphocytic cells, lobulated nuclear cells (segmented nuclear cells), and ciliated columnar epithelial cells; E. After a follow-up period of eight months, the lesion chest CT image of the lesion had improved significantly.

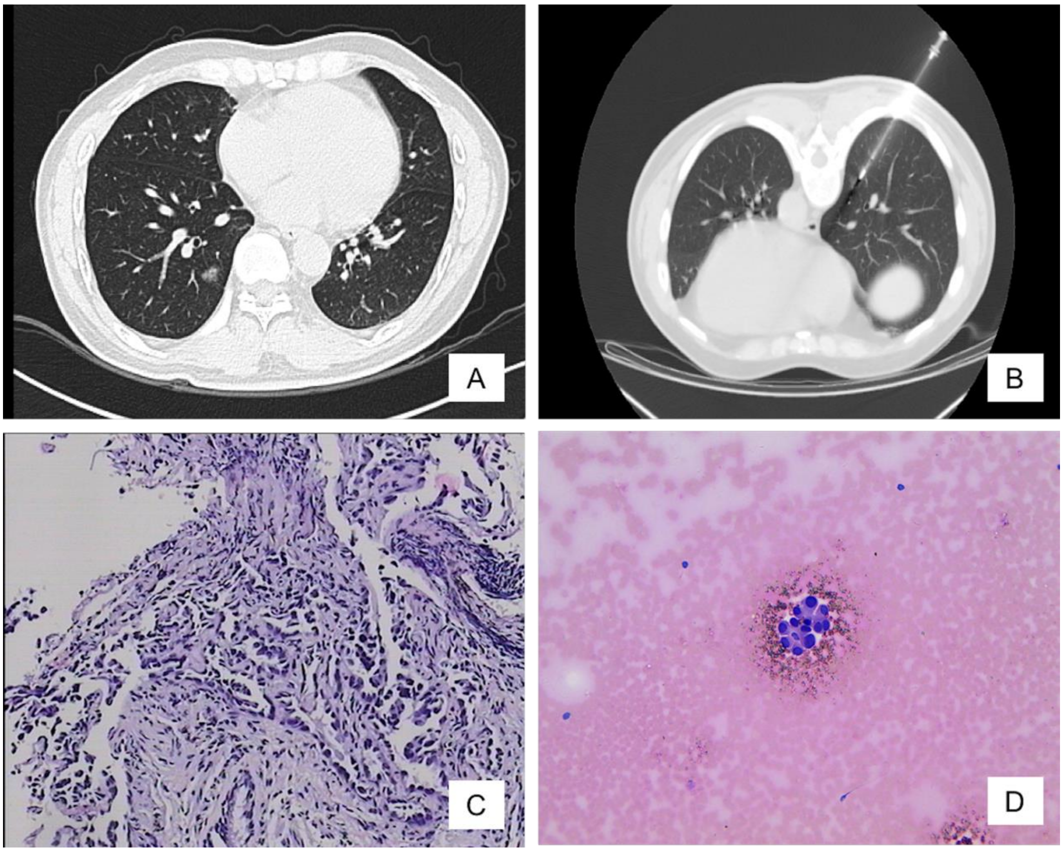

Figure 3: **Chest CT images and histological manifestations of a 52-year-old male patient**

A. Chest CT scan showed a ground glass-like nodule in the right lower lobe with a size of 1.2cm×1.0cm; B. Chest CT-guided percutaneous lung biopsy was conducted; C and D. Histological results of samples obtained by chest CT-guided percutaneous lung biopsy with forceps biopsy showed adenocarcinoma in situ and carcinoma cells.

Discussion

Pulmonary GGO is a kind of pulmonary nodule. For GGO disease, chest CT-guided percutaneous lung biopsy is mainly used in clinics, and the examination method has an ideal effect. The main advantages of chest CT-guided percutaneous lung biopsy are simple diagnosis, easy operation and less invasion. For lung lesions that are difficult to be identified by conventional bronchoscopy and sputum cytology, chest CT-guided percutaneous lung biopsy is adopted. Some scholars have shown that the diagnosis rate of chest CT-guided percutaneous lung biopsy ranges from 70% to 100% (2); similar research results were obtained in the present study.

It is noteworthy that in the process of percutaneous lung biopsy, the selection of puncture needles is important. The fine-needle and the cutting-needle are both widely used in the clinic where the present study was conducted. Research has shown that these two kinds of needles have their advantages, including assisting in improving the sensitivity, specificity and accuracy of examination, and reducing the rate of operation-related complications (3).

Combined with relevant research, it was found that the role of FNAB in cytological diagnosis of pulmonary nodes is significant, but it is difficult to obtain sufficient samples for histopathological examination. Correspondingly, if the cytopathologist finds the sample difficult to analyze, the sensitivity and accuracy of diagnosis will be limited. That said, the advantages of FNAB are obvious, including its reduced invasiveness and fewer complications (3). For CNB, three types of biopsy needle are used in the study clinic: manual cutting-needle, semi-automatic cutting-needle and automatic cutting-needle. The main feature of these needles is that they are relatively thick. Based on theoretical analysis, using a thicker puncture needle can obtain a larger sample which can lead to a high positive rate of diagnosis. At the same time, it is easy to judge the cytological type and immune-histochemistry staining. Some researchers indicate that through the application of semi-automatic CNB, it is not necessary to hold the needle during the chest CT scanning process, which can avoid the influence of radiation. This reflects the advantages of semi-automatic CNB. However, compared with FANB, there is no obvious difference with regard to the sensitivity and specificity of diagnosis, indicating that the both FNAB and CNB are recommended (4).

The use of an automatic cutting-needle can improve the success rate of one-time CNB, reduce the number of biopsies, decrease the incidence of alveolar bleeding, and shorten the operation time. However, due to the relatively large impulse force, it is easy to have needle tract bleeding, which then needs to be treated

It is known that the CNB puncture methods share the same complications, the main ones being pneumothorax, alveolar hemoptysis and hemoptysis (5). Pneumothorax is one of the most common complications of percutaneous lung biopsy. Studies have shown that the use of a cutting-needle, characterized by mechanical rapid impact force, will lead to an increase in the incidence of pneumothorax. Priminary spontaneous pneumothorax has an incidence of 7.4-18 cases (age-adjusted incidence)/100,000 population per year in males, and 1.2–6 cases/100,000 population per year in females. These incidences may be higher when smokers are included. In terms of alveolar bleeding, in the case of a repeated puncture, it is easy to increase the incidence of alveolar bleeding, so it is necessary to ensure the success of one-time puncture. Besides, the occurrence of hemoptysis has a close relationship with lesion pathological character and puncture techniques; for example, many investigations have shown that the size of the lesion, tumor and pleural distance, with or without emphysema, pulmonary bullae and cavitary lesions are related factors of the aforementioned complications. The failure of avoiding the relevant blood vessels and the uncertified puncture technology of the operator are also common risks of causing procedure-related complications. The new forceps used here requires relatively less recovery time, and the procedure is less invasive. Also, any kind of secondary infection rate is lower. Therefore, this is an indispensable tool in the evaluation of pulmonary abnormalities. In short, it is necessary to ensure that the technology is certificated and operated as per the standard operation procedure, thereby reducing the incidence of complications (6-9).

Herth *et al.* used the Archimedes navigation system newly developed to perform bronchoscopic transparenchymal access of nodules. This technology can closely reach the lesion via bronchoscopy. Under the guidance of the virtual bronchoscopy navigation path, the operator can puncture at the point of the avascular bronchial wall displayed by the system, perform balloon dilation after penetration, and then implant the sheath to establish a direct tunnel, combined with X-ray C-arm positioning to locate and clamp the lesion. The sampling effect of this technique is accurate, similar to the clamping technique of percutaneous lung biopsy device. But the cost of the equipment and the consumables for this technique are high, the training and learning of the procedure are difficult, and the operation is time-consuming (10-11).

Conclusions

In this study, the use of combined percutaneous lung biopsy forceps technology for pulmonary nodules, especially GGO lesions, can be targeted at local limited lesions for sufficient tissue biopsy, rather than cytological biopsy, and can avoid ineffective cutting of surrounding normal tissues as far as possible. The procedure also reduces the occurrence of local bleeding and pneumothorax. Of the nine patients, four cases with malignant lesions can further identify the classification of lung cancer through the pathological results of forceps, and the quality of classification is better than that of FNAB cytology. The histopathological results of the other five cases with benign lesions were more comprehensive than those of FNAB cytology. The technique is simple, and the cost is low, which saves medical expenses.

To sum up, for patients with lung GGO, the new combined percutaneous lung biopsy forceps technology under CT guidance is better than a fine-needle aspiration, with high safety, and has a significant effect with cutting -needle puncture. It can be used as an effective method of pulmonary nodule diagnosis to provide an objective, scientific and effective basis for improving the accuracy of clinical diagnosis.

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