Applications of Tomosynthesis to Bronchoscopic Examinations

Department of Radiology, Dokkyo Medical University Koshigaya Hospital
Masahiro Nakajima

Introduction

Transbronchial tumor biopsies (TBTB) and CT-guided lung biopsies are performed for the definitive diagnosis of lung cancer. At present, approximately 200 transbronchial tumor biopsies are performed at this hospital each year. However, in some cases, positional confirmation under fluoroscopy can be difficult for diseases exhibiting faint shadows such as ground-glass opacity (GGO). While CT-guided lung biopsies offer excellent contrast, they can present surgical difficulties in the upper lung field. Combining tomosynthesis with the biopsy forceps and positional confirmation of lesions under fluoroscopy for transbronchial tumor biopsies simplifies the positional confirmation. To date, at this hospital we have jointly used tomosynthesis in examinations in approximately 50 cases.

Fig. 1 GGO Case

Method

Tomosynthesis is used for transbronchial tumor biopsies in cases where positional confirmation by bronchoscopic examinations is difficult, including faint shadows such as ground-glass opacity (GGO) or lesions at the lung peripheries **(Fig. 2)**. In cases where tomosynthesis is used, chest tomosynthesis is performed to check that the biopsy forceps can reach the associated bronchial tube and to confirm the reconstruction position and reconstruction range. This allows the doctor to check images as rapidly as possible during the examination. In some cases, DICOM Viewer is used to create oblique images from these pre-tomosynthesis images to check the paths of the bronchial tubes **(Fig. 3)**. Pre-imaging is performed using the normal radiography conditions (Slow mode). However, the actual examination is performed in Fast mode to reduce X-ray exposure to the patient and shorten the breath-holding time **(Fig. 4)**.

The radiography and reconstruction conditions are shown below.

(1) Radiography conditions

Pre-imaging: 120 kV, 1 mAs, 74 shots (Slow mode), 1 scan, 5 sec

TBTB imaging: 120 kV, 1 mAs, 36 shots (Fast mode), 1 scan, 2.5 sec

* Radiography conditions are adjusted according to the body thickness.

(2) Reconstruction conditions

Pre-imaging: Thickness - - Slice pitch 1 mm (0.5 mm, creating oblique images)

TBTB imaging: Thickness + - Slice pitch 3 mm

A thin slick thickness is set for pre-imaging to simplify positional confirmation of lesions. However, the slice thickness is increased and the slice pitch somewhat extended for reconstruction during the transbronchial tumor biopsy to ensure that the target region remains within the reconstruction range, as the reconstruction position may become displaced due to breathing or other causes.

Tomosynthesis imaging is performed when the biopsy forceps arrive and grasp the lesion. The surgeon can confirm images on the monitor in the examination room to confirm the biopsy **(Fig. 5)**.

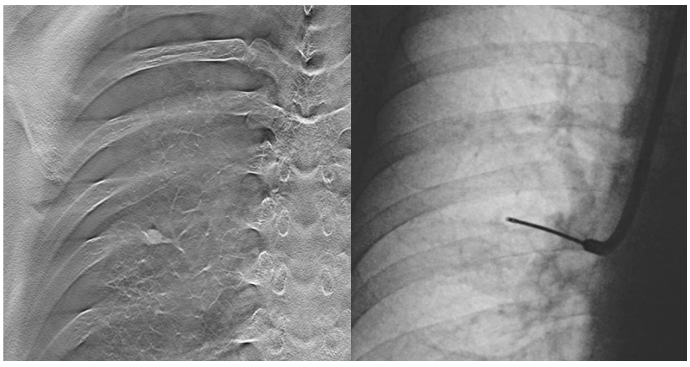

Fig. 2 Comparison of Fluoroscopic Image (Right) and Tomosynthesis Image (Left)

Fig. 3 MPR Display by DICOM Viewer

Fig. 4 Transbronchial Tumor Biopsy

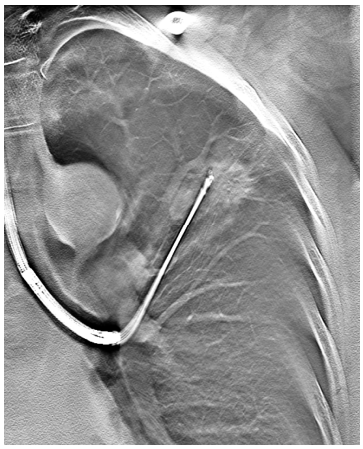

Fig. 5 Confirming Biopsy Position

Results

Faint shadows such as ground-glass opacity (GGO) could not be observed by positional confirmation fluoroscopy. However, tomosynthesis tests with phantoms were able to observe nodules with -600 CT value **(Fig. 6)**. Positional information in the body-thickness direction can be reconstructed up to 0.5 mm reconstruction slice pitch. Changing the slice pitch according to the nodule size makes observations easier. Using filters to reduce the metal artifacts during image reconstruction can restrict artifacts due to the biopsy forceps to facilitate observations **(Fig. 7)**. During actual examinations, tomosynthesis and image reconstruction are performed at the position where the lesion is thought to be grabbed by the biopsy forceps. Previously, during a bronchoscopic examination, the side station images could be displayed on the console monitor only. However, the monitor switching function can display these images on monitors in the examination room. The images can be displayed on monitors in the examination room after approximately 2 minutes for reconstruction of 15×15 images. As the reconstruction time differs according to the image size, the time can be reduced by decreasing the size of the image. Tomosynthesis imaging is performed to easily confirm that the biopsy forceps have arrived and grasped the lesion. In particular, tomosynthesis simplifies positional confirmation of the biopsy forceps and the lesion in situations where positional confirmation by fluoroscopy is not possible, such as biopsies at the peripheries. The height information in the body-thickness direction permits reconfirmation by image reconstruction at the position of the peripheral bronchial tubes to facilitate reentry of the biopsy forceps.

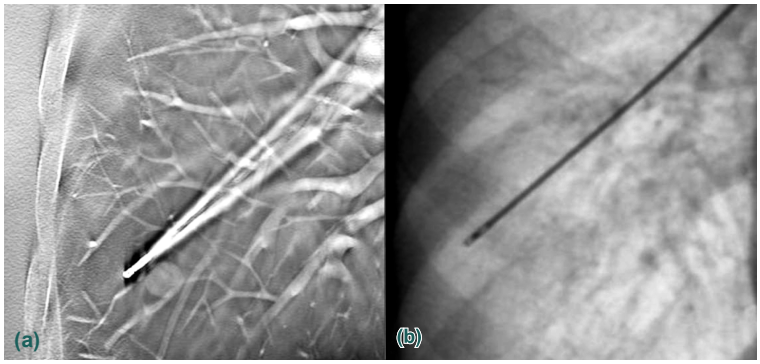

Fig. 6 Evaluation of -600 CT Value Nodule
(a) Tomosynthesis Image, **(b)** Fluoroscopic Image

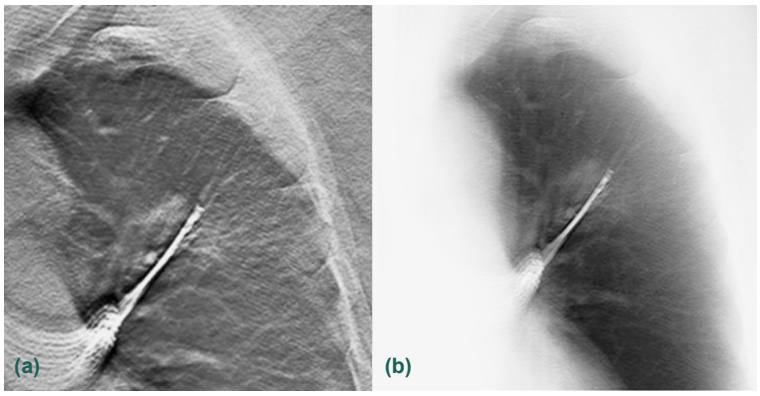

Fig. 7 Comparison of Tomosynthesis Filters
(a) Tomosynthesis Image **(b)** Tomosynthesis image using metal-artifact filter

Discussion

As tomosynthesis simplifies positional confirmation for transbronchial tumor biopsies and permits observations around the peripheral bronchial tubes during re-examinations, it is expected to enhance the rate of lesion biopsies. It may also be able to reduce the exposure dose for CT-guided biopsies. However, one scan takes 2.5 seconds for tomosynthesis imaging, even in Fast mode. With the current time resolution, displacement of the reconstruction position may cause blurring of the image for biopsies near the heart due to cardiac motion, which can make it difficult to identify lesions with faint shadows. Therefore, enhanced time resolution and electrocardiogram-synchronized image reconstruction methods to improve the image quality remain to be investigated in the future.