A Novel Needle-type Sampling Device for Flexible Ultrathin Bronchoscopy

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Diagnosis of suspected cancer in the periphery of the lung is difficult. A flexible ultrathin bronchoscope has been developed for the diagnosis of peripherally located pulmonary lesions that cannot be reached with the sampling devices for standard flexible bronchoscopes. The diagnostic yield with forceps and a brush for ultrathin bronchoscopes, however, is not adequate, especially when a lesion is not exposed to the bronchial lumen. We have thus developed a novel needle-type sampling device and tested its yield in transbronchial cytology. The device consists of an elongated dental H-file (0.4 mm in diameter and 110 cm in length), a housing sheath (1.0 mm in outer diameter), and a novel handle, which enables rapid out-and-in motion of the needle. Ten consecutive patients with a peripheral pulmonary lesion who had an indication for diagnostic procedure with a flexible ultrathin bronchoscope were enrolled. The optimal bronchial route to the lesion was analyzed with virtual bronchoscopy in a data set obtained with high-resolution computed tomography, and a novel bronchial route labeling system (prior-ridge-based relative orientation nomenclature) was employed to guide insertion of the bronchoscope. Sampling with the novel needle was performed prior to use of the forceps and brush under conventional fluoroscopy. In all the cases, sampling with the needle was successful and the amount of the specimen was sufficient for cytology. Our novel sampling system with flexible ultrathin bronchoscopes may contribute to accurate and minimally invasive diagnosis of peripheral pulmonary lesions.

Keywords: solitary pulmonary nodule; diagnostic bronchoscopy; pulmonary biopsy; cytology; puncture.

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reach of the above-mentioned diagnostic devices has been attempted with the use of ultrathin bronchoscopes, which can be inserted into more peripheral airways. There is, however, a limitation in ultrathin bronchoscopic sampling. It has been noted that forceps may be too small to obtain a specimen of sufficient size. Currently available forceps and brushes are unable to reach lesions when they are not exposed to the bronchial lumen.

Fig. 1. Novel needle-type sampling device: CYTROKE-H™ A: View of the whole system. Scale bar represents 5 cm. B: Close-up view of the handle for quick out-and-in movement of the needle. The proximal end of the needle is connected to the slider (a) of the handle and the proximal end of the sheath is connected to the main case (b) of the handle. Scale bar represents 1 cm. C: Magnified view of the tip of the needle. Inset shows a larger magnification of the sharp tip. Scale bars represent 1 mm. D: Mechanism of the handle for quick out-and-in motion of the needle. As the rack (a) is pushed in, the pinion (b) with a vertical column (c) rotates and the slider (d) with a slit (e) that holds the column moves out and in passively according to the rotation of the pinion. 1, starting position; 3, furthest out position of the slider; 5, final position; 2 and 4, transitional positions of movement.
as in a Type III lesion of Tsuboi’s classification (Tsuboi et al. 1967), thus necessitating the development of more efficacious devices for flexible ultrathin bronchoscopes (Rooney et al. 2002; Kikuchi et al. 2004; Shinagawa et al. 2004; Yamamoto et al. 2004; Asano et al. 2006), such as an aspiration needle for use with standard flexible bronchoscopes that would improve the yield and sensitivity in transbronchial diagnosis (Wang 1998; Dasgupta et al. 1999; Reichenberger et al. 1999; Tan et al. 2003; Rivera and Mehta 2007). With this need in mind, we developed a novel needle-type sampling device for use with a flexible ultrathin bronchoscope and tested its yield in transbronchial cytology.

**MATERIALS AND METHODS**

**Instrumentation:** A Novel Needle-type Sampling Device (CYTROKE-H™)

The device consists of a needle, a sheath and a handle. The design of the needle was based on that of a dental H-file. The needle is 0.4 mm in diameter and the distal 12-mm end is helically sculptured with a furrow for specimen collection. It is sufficiently elongated (110 cm in length) for bronchoscopic sampling, housed in a sheath (1.0 mm in outer diameter) and proximally connected to the handle, which is capable of quick out-and-in movement of the needle. The needle extends from the tip of the sheath to a length of 13 mm (Fig. 1; Video clip 1, 2). It is made of stainless steel, has a polished surface and is resterilizable. The device was fabricated at MANI, INC., Utsunomiya, Tochigi, Japan. The physical strength of the needle against bending and twisting was confirmed and the needle met the company’s standards (data not shown).

**Specimen Transfer Maneuver**

In order to achieve consistent specimen transfer from the needle to a slide glass, a uniform maneuver (Fig. 2) was executed after sampling.

**Patient and Study Protocol**

Ten consecutive patients (4 males and 6 females; age range, 53 to 84; mean age, 70), each with a PPL and with an indication for diagnosis employing an ultrathin bronchoscope based on bronchial route analysis were enrolled from August 2003 to January 2004 (Table 1). They all gave informed consent approved by the Institutional Review Board prior to the procedure. The optimal bronchial route to the lesion was analyzed in a 0.2-mm isometric computed tomography (CT) voxel data set in multiplanar reconstruction (MPR) and virtual bronchoscopy (VB) with medical image workstation M900QUADRA (Ziosoft Inc., Tokyo, Japan). The bronchial route to a lesion was determined and labeled according to a novel relative nomenclature system, by use of which the orientation can be maintained during ultrathin bronchoscope insertion. Sampling with the novel needle was performed prior to sampling with con-
Acquisition of a 0.2-mm isometric CT voxel data set

CT data sets were obtained with a 4-row multidetector CT scanner, Aquilion4 (Toshiba Medical Systems Corporation, Tokyo, Japan). Since this scanner cannot cover the whole lung at a collimation of 0.5 mm in one breath-hold, we performed a routine primary 3.0-mm collimation scan (3.0, 5.5, 8.0 mm and 10 for the scan slice thickness, helical pitch, image slice thickness and function number, respectively; a tube current of 300 mA and a tube voltage of 120 kV) to determine the specific axial range that included the orifice of the central airway and the lesion (Fig. 3A, B) for a secondary 0.5-mm collimation scan (0.5, 3.0, 0.5 mm and 10 for the scan slice thickness, helical pitch, image slice thickness and function number, respectively; a tube current of 260 mA and a tube voltage of 135 kV) in the specific range (Fig. 3C1). The raw data were then reconstructed in the region of interest, 102.4 mm in diameter, that included the orifice of the central airway and the lesion with reconstruction intervals at 0.2 mm to acquire a 0.2-mm isometric voxel data set as a volume of interest (Fig. 3C2).

Table 1. Patient profile.

<table>
<thead>
<tr>
<th>No.</th>
<th>Age</th>
<th>Sex</th>
<th>Location of lesion</th>
<th>Two airway segments that form initial reference ridge</th>
<th>Direction of scope insertion and route label (lesion type)</th>
<th>Lesion size (minimal distance from pleura in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>62</td>
<td>F</td>
<td>right S 3</td>
<td>Intermedius and Rt upper bronchus</td>
<td>To upper: PRDDP (4)</td>
<td>10.0 (15.0)</td>
</tr>
<tr>
<td>02</td>
<td>67</td>
<td>F</td>
<td>left S 6</td>
<td>Lt B6 and lower distal</td>
<td>To B6: DPPP (1b)</td>
<td>10.6 (27.5)</td>
</tr>
<tr>
<td>03</td>
<td>53</td>
<td>F</td>
<td>right S 3</td>
<td>Intermedius and Rt upper bronchus</td>
<td>To upper: LLRP (1a)</td>
<td>36.6 (0)</td>
</tr>
<tr>
<td>04</td>
<td>54</td>
<td>F</td>
<td>right S 4</td>
<td>Rt middle and lower bronchus</td>
<td>To middle: PRPPP (2)</td>
<td>9.3 (12.8)</td>
</tr>
<tr>
<td>05</td>
<td>71</td>
<td>F</td>
<td>right S 8</td>
<td>Rt B7 and lower distal</td>
<td>To lower: DPRPD (1a)</td>
<td>24.0 (0)</td>
</tr>
<tr>
<td>06</td>
<td>79</td>
<td>M</td>
<td>left S 1 + 2</td>
<td>Lt B1 + 2 and B3</td>
<td>To B1 + 2: RPDR (1a)</td>
<td>26.0 (0)</td>
</tr>
<tr>
<td>07</td>
<td>80</td>
<td>M</td>
<td>left S 3</td>
<td>Lt B1 + 2 and B3</td>
<td>To B3: PR (1a)</td>
<td>26.6 (0)</td>
</tr>
<tr>
<td>08</td>
<td>71</td>
<td>F</td>
<td>right S 6</td>
<td>Rt B6 and lower distal</td>
<td>To B6: LLRP (1b)</td>
<td>14.6 (20.6)</td>
</tr>
<tr>
<td>09</td>
<td>79</td>
<td>M</td>
<td>right S 1</td>
<td>Intermedius and Rt upper bronchus</td>
<td>To upper: LRPRL (2)</td>
<td>12.3 (45.3)</td>
</tr>
<tr>
<td>10</td>
<td>84</td>
<td>M</td>
<td>right S 3</td>
<td>Rt B1 and B3</td>
<td>To B3: RPL (1a)</td>
<td>28.3 (21.5)</td>
</tr>
</tbody>
</table>

Direction and route were determined in VB and a specific route label was assigned according to the successive prior-ridge-based relative nomenclature system (See Fig. 3, lower left panel). The underlined route labels were the airway segments actually visualized in ultrathin bronchoscopy. In cases 3, 4, 8 and 10, the final branch could not be visualized. The size of the lesion is the mean of the maximum length (mm) in each coordinate (XYZ). Rt, right; Lt, left. Route labels: P, proximal; D, distal; L, left; R, right. Lesion type: 1a, a bronchus is entering the lesion; 1b, a bronchus is passing through the lesion; 2, a bronchus is passing adjacent to the lesion; 4, the lesion is located beneath a branching point.
A Needle-type Sampling Device for Ultrathin Bronchoscopy

scan was performed without contrast medium.

**Bronchial Route Identification and Visualization in MPR and VB**

The bronchial route to the lesion was initially evaluated in MPR in a plane perpendicular to the normal vector defined as a spatial line from the central airway to the lesion (normal vector MPR) (Fig. 4, upper left panel), in which the relation of the airway to the PPL was identified with ease from the cross-sectional view of the bronchial tree to the lesion (Fig. 4, upper right panel; video clip 3). The bronchial route was then confirmed in the VB mode from the central airway down to the lesion. The image quality of the VB was adjusted by changing the window level and camera position manually to identify the branches in the exact frontal position to acquire exact orientation of branching (Fig. 4, lower right panel; video clip 4).

**Labeling of the Bronchial Route for Facilitation of Scope Insertion**

To facilitate the insertion of the ultrathin bronchoscope, we labeled the bronchial route to the lesion based on a novel nomenclature system utilizing the images of VB. Conventionally, the bronchial tree segments are labeled based on their anatomical orientation, i.e., anterior-posterior, lateral-medial and superior-inferior. This notation, however, does not always work well when the route is beyond the sub-subsegmental bronchi because of the occasional occurrence of unexpected scope rotation resulting in disorientation. To overcome this problem, we developed a novel non-anatomical nomenclature system for the airway tree, in which the line of the prior dividing ridge of the bronchus was used as a reference. The next bronchus is said to be proximal or distal to the prior ridge. When the next ridge is exactly perpendicular to the reference ridge, the term is changed to right or left (Fig. 4, lower left panel). Accordingly, based on its prior-ridge, every peripheral segment of the airway tree can be assigned a unique label in a series of relative orientations, with the initial ridge being defined by two well-known central airway segments and the direction of scope insertion (Table 1, column 5 and 6; Fig. 4, lower right panel; video clip 4). This nomenclature system greatly facilitates insertion of a ultrathin bronchoscope. Scope rotation changes the angle of the reference ridge, but the next branch of the route can hardly be lost unless the bronchoscopic luminal view collapses, because it is expressed in relative orientation.
Bronchoscopic Sampling

Fig. 5 summarizes the bronchoscopic sampling. The patients were premedicated with intramuscular injection of petidine hydrochloride (35 mg) for 30 min before the bronchoscopy. Pharyngolaryngeal anesthesia was achieved by spraying 3 to 5 ml of 4% lidocaine 15 min before the bronchoscopy followed by intramuscular administration of 0.5 mg atropine sulphate. Bronchoscopy was started with a standard bronchoscope (BF-240, Olympus Corporation, Tokyo, Japan; 5.9 mm in outer diameter) and anesthesia of the airway from the trachea to the segmental bronchi was assured by spraying 1% lidocaine with a spray catheter (PW-6C-1, Olympus Corporation, Tokyo, Japan) inserted into the working channel. After the airway was anesthetized, the standard bronchoscope was removed and the ultrathin bronchoscope (BF-XP40, Olympus Corporation, Tokyo, Japan; 2.8 mm in outer diameter) was inserted into the peripheral airway based on the bronchial route information determined in preprocedural VB and labeled according to the above-mentioned prior-ridge-based nomenclature system. Sampling with CYTROKE-H™ was performed (two to five times) prior to conventional sampling with forceps (five to 10 times) and a brush (one time only) under conventional fluoroscopy. The number of sampling repetitions with the needle and that with forceps was arbitrarily decided by the bronchoscopist. The ultrathin bronchoscope was removed together with the brush.
after brushing. After the removal of the ultrathin bronchoscope, the standard bronchoscope was reinserted to check for any bleeding, and standard-size brushing was performed when the lesion was reachable. Flushing with normal saline (20 ml, three times) was then performed as the final step of the bronchoscopic sampling. No post-procedural chest X-ray was taken because the samplings were not performed in the subpleural region.

**RESULTS**

**Spatial Relation of a Bronchial Route to the Lesion**

The spatial relation of a peripheral airway to the lesion determined when reviewing the cross sectional MPR images falls into one of six types: 1a) a bronchus is entering the lesion, 1b) a bronchus is passing through the lesion, 2) a bronchus is passing adjacent to the lesion, 3) a bronchus is passing apart from the lesion, 4) the lesion is located beneath a branching point and 5) a bronchial route is indeterminate due to poor airway detection (Fig. 6). Of our cases, five were type 1a, two were type 1b, two were type 2 and one was type 4. The deepest airway generation beyond the segment airway (3rd generation) varied from the 5th to the 8th generation. The ultrathin bronchoscope could be fully inserted into the predefined route except in cases 3, 4, 8 and 10, in which the last airway branch could not be visualized. The ultrathin bronchoscope was advanced to reach a target lesion under conventional fluoroscopy in all the cases (Table 1, column 6).

**Patterns of Yield with CYTROKE-H™**

In cases 1 and 2, specimen transfer was done using an arbitrary maneuver. Although the yields were adequate for cytological evaluation, in order to accomplish consistent specimen transfer, we applied a uniform maneuver for specimen transfer designated as the two-hand-roll-and-slide maneuver (Fig. 2) in cases 3 to 10. Owing to the uniform maneuver, they were all transferred as rows of tiny multiple lines (Fig. 7). Cells were transferred to slide glass either in the form of a fine
Fig. 7. Representative pattern of specimen transfer in CYTROKE-H™ observed in case 3 at low (A) and high (B) magnification. Specimens were transferred as tiny multiple lines in rows (white arrows). Paired black circles are ink markers, painted by a cytoscreener, which indicate cells (black arrows) requiring further review by a pathologist. (Papanicolaou stain; magnification: A, original × 10; B, original × 40; scale bar: A, 1 mm; B, 500 μm)

Fig. 8. Four representative patterns of cellular yield in CYTROKE-H™. A: thin thread-like yield (arrow) seen in case 9. B: islet-like yield (arrow) seen in case 3. C: yield in an irregular cluster (*) seen in case 4. D: yield in cell-scattered form (arrows) seen in case 6. (Papanicolaou stain; magnification: A-C, original × 400; D, original × 200; scale bar: A-C, 25 μm; D, 50 μm)
thread, an islet, an irregular cluster or a scatter (Fig. 8). In these 8 cases, all specimens obtained with CYTROKE-H™ were also adequate for cytological evaluation.

**Diagnoses of Modalities**

Table 2 summarizes the diagnoses of the sampling modalities. The diagnostic statuses of CYTROKE-H™ were five true negative, four true positive and one false negative, as determined based on the clinical prognostic state of each patient at the time of submission.

**Complications**

There were no noticeable complications in cases 1 to 9. In case 10, however, the patient expectorated bloody sputum once just after the bronchoscopy. He was in good condition for the next three days, but then expectorated 52 g of blood on day 4. Thereafter, his condition was good until day 9 and 10 when he expectorated 2 or 3 bloody sputa. He was given 100 mg of carbazochrome sodium sulfonate and 250 mg of tranexamic acid intravenously on each occasion. He was further followed up for 20 days without

<table>
<thead>
<tr>
<th>No.</th>
<th>CYTROKE-H</th>
<th>Ultrathin forceps</th>
<th>Ultrathin brush</th>
<th>Standard brush</th>
<th>Standard flushing</th>
<th>Remarks</th>
<th>Diagnostic status of CYTROKE-H</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>I</td>
<td>No malignancy</td>
<td>I</td>
<td>-</td>
<td>I</td>
<td>CT: unchanged for 15 months</td>
<td>True negative</td>
</tr>
<tr>
<td>02</td>
<td>II</td>
<td>No malignancy</td>
<td>II</td>
<td>-</td>
<td>II</td>
<td>CXR: unchanged for 10 months</td>
<td>True negative</td>
</tr>
<tr>
<td>03</td>
<td>V</td>
<td>Squamous cell carcinoma</td>
<td>IV</td>
<td>IV</td>
<td>V</td>
<td>Died after 14 months</td>
<td>True positive</td>
</tr>
<tr>
<td>04</td>
<td>I</td>
<td>Inadequate specimen</td>
<td>I</td>
<td>-</td>
<td>I</td>
<td>CXR: unchanged for 8 months</td>
<td>True negative</td>
</tr>
<tr>
<td>05</td>
<td>IV</td>
<td>Adenocarcinoma</td>
<td>V</td>
<td>-</td>
<td>I</td>
<td>Operated on: well-differentiated adenocarcinoma</td>
<td>True positive</td>
</tr>
<tr>
<td>06</td>
<td>II</td>
<td>Atypical cells</td>
<td>I</td>
<td>III</td>
<td>II</td>
<td>CXR: Enlarged after 4 months</td>
<td>False negative</td>
</tr>
<tr>
<td>07</td>
<td>V</td>
<td>Small cell cancer</td>
<td>V</td>
<td>V</td>
<td>V</td>
<td>Died after 22 months</td>
<td>True positive</td>
</tr>
<tr>
<td>08</td>
<td>I</td>
<td>No malignancy</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>CXR: Resolved with steroid</td>
<td>True negative</td>
</tr>
<tr>
<td>09</td>
<td>V</td>
<td>Adenocarcinoma s/o</td>
<td>V</td>
<td>-</td>
<td>III</td>
<td>Treated with stereotactic radiation</td>
<td>True positive</td>
</tr>
<tr>
<td>10</td>
<td>I</td>
<td>Missing specimen</td>
<td>I</td>
<td>-</td>
<td>-</td>
<td>CXR: Spontaneous regression in two months</td>
<td>True negative</td>
</tr>
</tbody>
</table>

Diagnostic Status of CYTROKE-H™ is based on the follow-up status of the lesion and the clinical course of the patient after bronchoscopy at the time of submission. The cause of the missing specimen of ultrathin forceps biopsy in case 10 is unclear. I, No atypical cells; II, Atypical cells without malignant features; III, Suspicious cells and/or atypical cells consistent with borderline lesion; IV, Malignant cells with low grade atypia and/or few in number; V, Frankly malignant cells; -, not done; CXR, chest X-ray.
any episode of bloody sputum. Whether these postprocedural episodes of hemoptysis and bloody sputum were related to the use of CYTROKE-H™ prior to application of the forceps and brush is unclear.

**DISCUSSION**

A novel ultrafine needle-type device for an ultrathin bronchoscope was fabricated. The sampling was always successful and the yield was adequate for cytological evaluation. The sampling procedure was easy and safe owing to the handle which enabled rapid performance.

In cases 3 to 10, the specimen transfer from the needle to slide glass was done with a uniform maneuver to try to obtain consistent transfer. The obtained specimens were sufficient for cytological evaluation, but use of rapid on-site cytopathologic examination (ROSE) would make the specimen transfer even more secure (Uchida et al. 2006). In case 6, the diagnostic status of the needle was false negative. This might have been due to the location of the lesion being adjacent to the aortic arch. The attending bronchoscopist might have directed the needle away from the aortic arch to avoid puncturing it, resulting in missing the lesion.

The needle easily penetrated a lesion even if it was hard to grasp or brush, or was not exposed to the bronchial lumen. Also, as the procedure was performed prior to the application of conventional devices that could hardly penetrate the lesion, the needle might have had the beneficial effect of creating an introductory orifice through which the conventional forceps and brush could be introduced for penetration of the lesion.

This needle can be inserted into an ultrathin bronchoscope with a working channel less than 1.0 mm through which conventional sampling devices (forceps and brush) cannot be inserted. To the best of our knowledge, the sizes of the working channel in currently available superthin bronchoscopes are 0.9 and 0.5 mm as seen in BP2-2365, BF4-2365, BP2-1865 and BF4-1865 by Machida Endoscope Co. Ltd, Tokyo, Japan and 100-1002 by FiberTech Co. Ltd., Tokyo, Japan. The outer diameter of those with a working channel of 0.9 mm is either 2.3 or 2.4 mm, and 1.9 mm for that with a working channel of 0.5 mm. Since the size of the needle used in CYTROKE-H™ is 0.4 mm, it can be inserted into a 0.9-mm working channel when the sheath size is decreased to 0.8 mm and can also be inserted into a 0.5-mm channel without a sheath. This superthin bronchoscope can be used either alone or in combination as a mini-bronchoscope that is inserted into a working channel of standard bronchoscopes. Furthermore, this needle can also be inserted into a 22-gauge needle (outer diameter: 0.71 mm). This implies a possible modified use of CYTROKE-H™ in the percutaneous approach to a PPL in a long 22-gauge needle.

As diagnosis of small nodules in the pulmonary periphery is of great concern in modern pulmonology (Ost et al. 2003; Tan et al. 2003; Libby et al. 2004), development of a minimally invasive pinpoint sampling system for lesions, including those with ground glass opacity, is an urgent theme. A peripheral lesion is accessed for sampling either via the transbronchial or transthoracic route. Although transthoracic modalities such as transthoracic needle aspiration (TTNA) and transthoracic needle biopsy (TTNB) guided with either CT or CT-fluoroscopy have higher sensitivity (Rivera and Mehta 2007), such complications as pneumothorax, bleeding and air embolism may occur (Yung 2003). Pneumothorax can be reduced by using an autologous blood clot technique (Lang et al. 2000) and a puncture site-down positioning technique (Kinoshita et al. 2006). Air embolism may occur more frequently than expected (Hiraki et al. 2007) and can be fatal (Kodama et al. 1999; Ghafoori and Varedi 2007). The potential risk of tumor spread related to the procedure has also been pointed out (Matsuguma et al. 2005; Sawabata et al. 2006). There is an anatomical limitation as well, i.e., lesions located in the mediastinal side of the lung cannot be accessed transthoracically. As for the transbronchial approach, there are at least four concerns: 1) determination of an accurate bronchial route, 2) accurate assistance for insertion of a sampling device, 3) real-time confirmation of sampling, and 4) minimally invasive and yet consistent sam-
In this paper, we have described a practical manual method for determination of the bronchial route to a lesion in normal vector MPR and VB. Although such analysis is not automated as in the method described by Kiraly et al. (2002), there was no false or missing branch since the route was precisely evaluated macroscopically in the review of cross-sectional MPR images in the specific anatomical volume of interest. The remaining task in route analysis is to find a way to overcome the partial volume effect that interferes with generation of a clear image of VB in the periphery (Maniatis et al. 2004). For accurate assistance of scope insertion, the newly developed successive prior-ridge-based relative nomenclature system herein detailed was found to be effective in maintaining orientation during insertion of the ultrathin bronchoscope as long as the luminal view remained open. Our method is fully based on nomenclature and there is no need for such instrumentation as the virtual bronchoscopic navigation system (Asano et al. 2006) or electromagnetic navigation (Gildea et al. 2006). CT fluoroscopy is available for real-time monitoring during sampling of a lesion that is difficult to visualize in conventional fluoroscopy. However, there is need for less harmful technology, since CT fluoroscopy has a limitation in terms of radiation exposure (Froelich et al. 2002). Endobronchial ultrasonography (EBUS) can confirm the placement of a guide sheath at the lesion (Kurimoto et al. 2004), but EBUS monitoring cannot be conducted during sampling itself. As for minimal invasiveness and consistent sampling, CYTROKE-H™ would appear to be a good candidate. Although the methodology remains to be refined, efforts for completion of a minimally invasive diagnostic procedure for PPL are to be continued.

In summary, a novel ultrafine needle-type sampling device characterized by safe and easy operation with consistent yield for cytological evaluation was developed. It is suggested that employment of this device with a flexible ultrathin bronchoscope may contribute to the diagnosis of a PPL and may be a significant step toward realization of a minimally invasive pinpoint sampling system for PPL diagnosis. Extensive trials of this device are to be conducted both via the transbronchial route as a primary minimally invasive sampling device aided by ROSE before the use of forceps and brushing in flexible ultrathin bronchoscopy in terms of diagnostic yield, and via the transthoracic route to evaluate its efficacy as a thinner needle in comparison with a standard needle for TTNA and/or TTNB in terms of sampling yield and rate of complications.

References


Appendix

Video clips. 1: whole view of CYTROKE-H™ in operation. 2: zoom-up view of the distal end and the handle in operation. 3: normal vector MPR. 4: VB with route labels. Video image is available upon request.