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Lateral Decubitus Position Enables Further Advancement of the Bronchoscope into the Lung Periphery

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Bronchoscopy is a minimally invasive procedure used to obtain specimens from peripheral lung lesions. However, its diagnostic yield is still insufficient. One of the reasons for this is that bronchoscopes cannot be advanced far enough into the lung.

Technological advances have led to the development of thinner bronchoscopes, which have improved their ability to reach the lung periphery.[1–3] However, reducing the bronchoscope diameter from 4.0 to 3.0 mm (43% reduction in cross-sectional area) was found to increase the advancement into the lung by only 1 additional bifurcation.[1] Furthermore, despite significantly reducing the bronchoscope diameter from 6.3 to 2.8 mm (80% reduction in cross-sectional area), it was only possible to observe an additional 3.6 peripheral bifurcations.[1] Meanwhile, the thinner the bronchoscope, the smaller the specimen obtained.[2]

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This study was approved by the institutional review board of Osaka University Hospital (approval number 18156).

K.M.: conception and design; postprocessing and statistical analysis. K.M. and T.S.: bronchoscopy.

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During bronchoscopy, the patient is usually placed in the supine position but is sometimes moved to the lateral decubitus position. Most commonly, the lateral decubitus position is used to obtain a better fluoroscopic image with a fixed fluoroscopy system while performing a transbronchial biopsy. The lateral decubitus position is also used to recover bronchoalveolar lavage fluid. Furthermore, the position can reduce the aspiration of oral secretions during bronchoscopy.[4] Therefore, when necessary, some bronchoscopists perform bronchoscopy in the lateral decubitus position. However, the relationship between the lateral decubitus position and degree to which the bronchoscope can be advanced into the lung periphery is unknown.

In this study, we performed bronchoscopic examinations in patients with pulmonary peripheral lesions. Computed tomography (CT) images were obtained before the examination. The direct oblique method (DOM), a manual CT analytical technique for navigation,[5] was used for bronchoscopic navigation. The DOM enables bronchoscopic navigation to the extreme periphery of the lungs by using oblique CT images instead of virtual bronchoscopic images.[5] We began the bronchoscopic procedure with the patient in the supine position. After the bronchoscope was extended as far as possible into the lung periphery along the route identified through the DOM, we changed the patient's position to the lateral decubitus position, with the side of the target lesion nondependent (up) (Fig. 1A). Subsequently, we attempted to advance the bronchoscope further peripherally. Bronchoscopy was performed under premedication with midazolam and fentanyl; the patients were breathing spontaneously. The institutional review board approved this study (18,156). This study did not involve research bronchoscopies and was conducted in clinical settings.

Table 1 presents the characteristics of the 24 patients included in the analysis. The bronchoscope could be advanced further into the lung periphery with the patient in the lateral decubitus position [Fig. 1B; mean ± SEM, 3.83 ± 0.29 bronchi (supine)

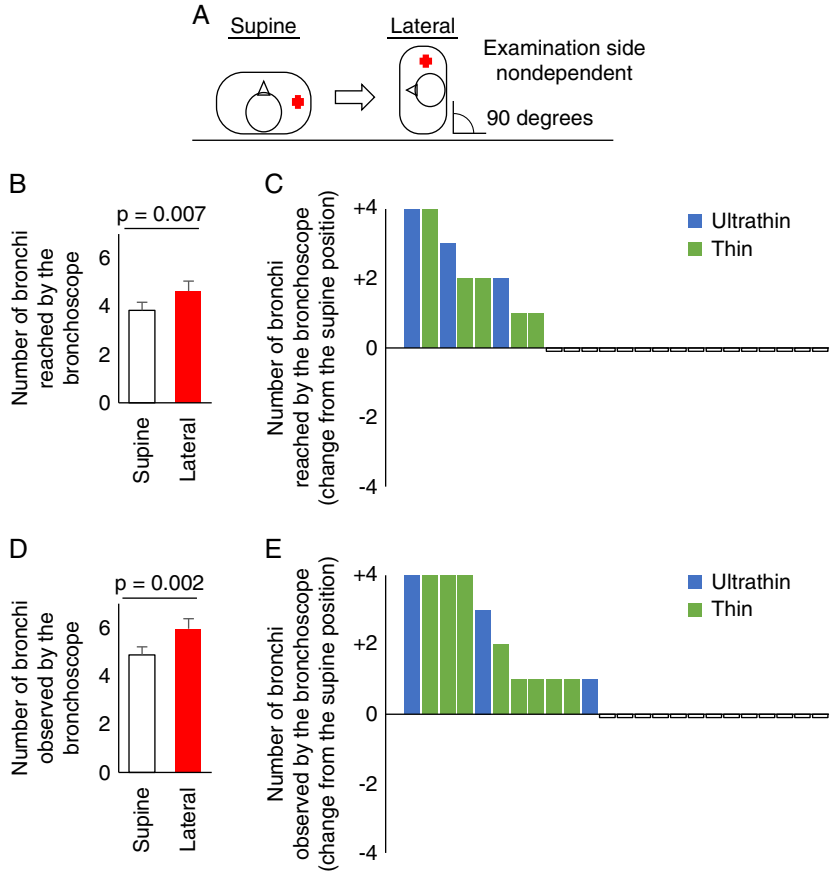

FIGURE 1. Lateral decubitus position increases the extent of bronchoscope advancement into the lung periphery. A, A schema of the positions. The patient's position was changed from the supine to the lateral decubitus position at 90 degrees. The examination side (ie, side of the lesion) was nondependent. The red crosses indicate the lesion. B and C, Number of bronchi reached by the bronchoscope. Averages are shown in (B). Individual changes due to the position change are displayed as a waterfall plot in (C). D and E, Number of bronchi observed through the bronchoscope. Averages are shown in (D). Individual changes due to the position change are displayed as a waterfall plot in (E). n = 24 for B–E.

vs. 4.63 ± 0.43 (lateral); paired *t* test; $P = 0.007$]. When we assessed each case individually, there was a difference of up to 4 bifurcations (Fig. 1C). In addition, a larger number of peripheral bifurcations were observable in the lateral decubitus position [Figs. 1D, E; mean ± SEM, 4.87 ± 0.34 bronchi (supine) vs. 5.96 ± 0.41 (lateral); paired *t* test; $P = 0.002$], which may contribute to improving the precision of transbronchial biopsies. These results indicate that changing the patient's position from the supine to the lateral decubitus position made it possible to advance the bronchoscope further peripherally and to observe additional bifurcations.

Subsequently, we assessed the features of the bronchi that were affected by the change in position. On chest CT, we measured the angles of the last bronchi reached by the bronchoscope, in relation to the horizontal plane (Fig. 2A). This analysis revealed that the bronchi affected by the position

TABLE 1. Basic Characteristics

Basic Characteristics	Total (N = 24) n (%)
Age [mean (SD)] (y)	72 (8)
Male	13 (54)
Pulmonary segments	
Right upper lobe	10 (42)
Right middle lobe	3 (13)
Right lower lobe	5 (21)
Left upper lobe	2 (8)
Left lower lobe	4 (17)
Bronchoscope	
BF-P290 (thin, O.D. 4.2 mm, Olympus, Tokyo, Japan)	20 (83)
BF-MP290F (ultrathin, OD 3.0 mm, Olympus, Tokyo, Japan)	1 (4)
BF-XP260 (ultrathin, OD 2.8 mm, Olympus, Tokyo, Japan)	3 (13)

OD indicates outer diameter.

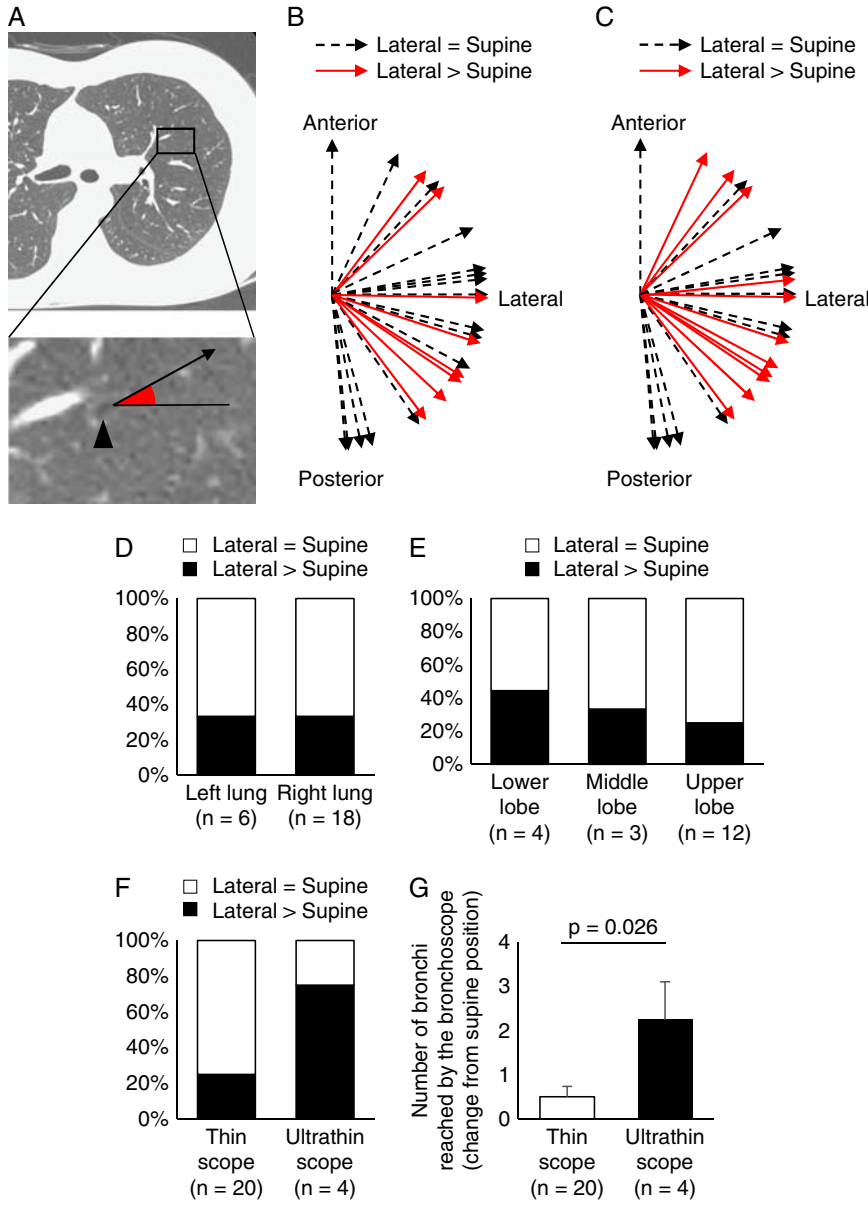

FIGURE 2. Bronchial features affected by position change. A, A schema of the analytical method. We measured the angles of the last bronchi reached by the bronchoscope, relative to the horizontal plane. The black arrowhead indicates the last bronchus. The angle between the last bronchus (black arrow) and horizontal plane (black line) is indicated in red. B, Angles of the last bronchi measured relative to the horizontal plane. The red arrows indicate the cases in which the bronchoscope could reach the periphery in the lateral decubitus position but not in the supine position. The black dotted arrows indicate the cases in which there was no difference between the 2 positions (n = 24). C, Angles of the last bronchi measured from the horizontal plane. The red arrows indicate the cases in which the bronchoscope could either reach or be used to observe the periphery in the lateral decubitus position but not in the supine position. The black dotted arrows indicate the cases in which there was no difference between the positions (n = 24). D–F, Proportions of cases in which the lateral decubitus position was more beneficial than the supine position in individual lungs (D), in individual lobes of both lungs (E), or based on the type of bronchoscope used (F). G, Comparison of the changes in the number of bronchi reached by the bronchoscopes based on bronchoscope type. a+

change were oriented laterally (Figs. 2B, C). Specifically, the bronchoscope could reach 1.1 additional bifurcations peripherally on average in the case of bronchi oriented between −53 and 53 degrees relative to the horizontal plane. Conversely, the bronchi that were oriented anteriorly or posteriorly were not affected. There was no difference between the right or left lungs (Fig. 2D) or between

the lobes of both lungs (Fig. 2E). Finally, the benefits in the lateral decubitus position were greater with an ultrathin bronchoscope than with a thin bronchoscope [Figs. 2F, G; mean ± SEM, 0.50 ± 0.24 bronchi (thin) vs. 2.25 ± 0.85 (ultrathin); Mann-Whitney *U* test; $P = 0.026$].

This is the first study to demonstrate the advantage of the lateral decubitus position in maximizing the extent to which bronchoscopes could be advanced into the lung periphery. During bronchoscopy, it is commonly observed that the diameter of the bronchi widens further during inhalation than during exhalation. On the other hand, the lateral decubitus position affects the respiratory function in each lung differently. For example, the functional residual capacity of the left lung was 1170 mL in the supine position, while it increased to 2060 mL in the right lateral decubitus position.[6] Simultaneously, the inspiratory volume decreased from 285 to 178 mL. These results were obtained from bronchospirometry tests under spontaneous ventilation with premedication.[6] Therefore, the lung that is on top in the lateral decubitus position is in a deeply inhaled state. We believe that this is the mechanism underlying our result indicating that the bronchoscope could reach the periphery.

New technologies are being introduced for the bronchoscopic examination of peripheral pulmonary lesions. Electromagnetic platforms and robotic-assisted bronchoscopy are excellent methods, which enable the performance of selective procedures in patients with peripheral lesions. However, the requirement for additional equipment is considerable with these methods, and their availability varies from country to country. On the other hand, the present study has demonstrated that no additional equipment is required with our proposed method of performing bronchoscopy in the lateral position and that this technique may improve the selectivity of bronchoscopic procedures in various situations. We believe that bronchoscopy in the lateral decubitus position does not compete with the existing techniques, but rather should be used in combination with them. For example, the lateral position would allow for more selective insertion of the guide sheath.

This study did not obtain data on the complications of biopsy performed in the lateral decubitus position because the focus of the study was on bronchoscope reachability. If there is major bleeding due to a biopsy, the lateral decubitus position might be disadvantageous. However, the lateral decubitus position is sometimes used while performing transbronchial biopsy, and may be used to obtain a better fluoroscopic image with a fixed fluoroscopy system. In this study, the biopsy procedures were performed in the lateral decubitus position.

The disadvantages of bronchoscopy in the lateral decubitus position include difficulty in performing x-ray fluoroscopy from the front. However, if the fluoroscopy system is equipped with a C-arm, it is possible to obtain fluoroscopic images of the lung from the front through horizontal fluoroscopy. Furthermore, the bronchoscope reaching further peripherally does not guarantee a higher diagnostic yield. Further research is needed to examine how bronchoscopy performed in the lateral decubitus position affects diagnostic yield.

Our findings in this study suggest that when bronchoscopists need to advance the bronchoscope further peripherally, they can change the patient's position from the supine to the lateral decubitus position.

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