



Precise identification of the intersegmental plane for lung cancer segmentectomy

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Surgical resection is the principal treatment for early-stage lung cancer, and lobectomy has been the standard surgical procedure since 1960 (1,2). Recently, however, the results of Japan Clinical Oncology Group (JCOG) 0802/West Japan Oncology Group (WJOG) 4607L trial, which is a phase III, randomized, controlled trials on segmentectomy versus lobectomy for clinical Stage IA non-small cell lung cancer (NSCLC), was published from Japan (3). The trial showed that segmentectomy was superior to lobectomy for overall survival. Based on the results, segmentectomy should be the standard surgical procedure for the patients with small (tumor diameter ≤ 2 cm) and peripheral NSCLC. Segmentectomy provides adequate surgical margins even for centrally located tumors, allows intraoperative hilar lymph node assessment, and is superior in cancer control, compared to wedge resection (4). On the other hand, segmentectomy requires proficiency in techniques such as precise identification of the hilar structures and the intersegmental plane. In segmentectomy for NSCLC, the precise identification of intersegmental plane is a critical issue for the following reasons: (I) to avoid postoperative complications such as prolonged air leakage or atelectasis; (II) to preserve pulmonary function; and (III) to prevent loco-regional recurrence. In also the JCOG0802/WJOG4607L trial, the segmentectomy group had a significantly higher incidence

of fistula/pulmonary-lung (air leak) and twice as many local recurrences than the lobectomy group (3,5). However, the lack of landmarks for the intersegmental line can make it difficult to precisely identify the intersegmental plane. The intersegmental plane is anatomically defined by intersegmental veins. Tracking these veins is useful only near the hilum, meanwhile; it is impossible to detect and track these veins in the peripheral lung parenchyma. Therefore, several techniques have been developed to identify the intersegmental plane precisely and accomplish anatomical segmentectomy.

Currently, the two main methods to identify the intersegmental plane in pulmonary segmentectomy are the transbronchial method and the transvascular method, and various techniques for both have been reported (*Table 1*).

In the transbronchial method, mainly gases and dyes are used. The former is a method of identification the intersegmental line by selectively pumping gas into the target segmental bronchus to dilate it or, conversely, leaving only the target segment in a collapsed (atelectatic) state (6,7). The latter is a method of identification the intersegmental line by injection a dye such as indocyanine green (ICG) transbronchially into the target segment (8,9). In the former, the boundary between the inflated and deflated lung is the intersegmental line, and in the latter, the boundary between the colored and noncolored areas is

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Table 1 Classification of the method to identify the intersegmental plane

Methods	Merit	Demerit
Transbronchial		
Gas		
Deflation of target segment		
Jet ventilation	No special equipment required Simple and easy	Required the accurate bronchoscopic techniques
Slip knot method	Precisely determine the real margin distance	Take time to delineate the intersegmental line
Modified inflation-deflation method	Suitable for thoracoscopic surgery	
Inflation of target segment		
Inflation/deflation method	No special equipment required Simple and easy	Take time to delineate the intersegmental line Leave short distance between the tumour and the intersegmental plane potentially reducing the disease-free margin Not suitable for thoracoscopic surgery
Dye		
Indocyanine green	Simple and quick	The dye could flow back from the target bronchus, spreading into the bronchial tree and compromising the identification of the intersegmental plane
Methylene blue	Precisely determine the real margin distance Suitable for thoracoscopic surgery	
Virtual-assisted mapping	Adaptable to several situations and surgery Precisely determine the real margin distance Suitable for thoracoscopic surgery	Required the accurate bronchoscopic techniques
Transvascular		
Near-infrared fluorescence navigation method using indocyanine green	Simple and easy Suitable for thoracoscopic surgery	Rapidly washed out Spread into target segments Information on the visceral pleural side only Expensive

the intersegmental line. Additionally, another variant of the latter is the virtual-assisted mapping (VAL-MAP) (10). This method uses multi-spot dye markings on the lung surface using a bronchoscope to localize the tumor and to obtain “geometric information” for dividing the intersegmental line with appropriate surgical margins.

On the other hand, the transvascular method is almost synonymous with the near-infrared fluorescence (NIR) navigation method using ICG (11). In this method, ICG is administered intravenously systemically after cutting the pulmonary artery, vein, and bronchus of the target segment. Under the NIR thoracoscopic visualization, the

intersegmental line on visceral pleura is clearly identified. The intersegmental line could be identified and demarcated for 85–100% of patients, and no adverse events related to ICG administration were reported (11,12). Moreover, this method can be easily adapted for thoracoscopic or robot-assisted thoracic surgery because there is no need to expand the lungs (12). These methods all have their advantages and disadvantages, and it is difficult to compare them properly, and there are few reports on the issue.

In a recent study, Wang and colleagues have reported regarding this issue. They compared between the bronchial methylene blue staining method as a transbronchial

method and the modified inflation-deflation method as a transvascular method (13). They retrospectively reviewed 62 patients underwent bronchial methylene blue staining, and 50 patients underwent the modified inflation-deflation method. Both methods could accurately identify the intersegmental plane; however, the time taken to clearly visualize the intersegmental line and the operation time were significantly shorter in the bronchial methylene blue staining group than in the modified inflation-deflation group. There were no significant differences between the two groups in blood loss, drainage time, postoperative hospital stays, and most other perioperative characteristics. thereby, they recommended the transbronchial method.

This finding is interesting; however, the modified inflation-deflation method is more of a transbronchial-like technique and is not representative of the transvascular method. The procedure involved cutting the target segmental vessels and bronchi, then fully inflating the collapsed lung with pure oxygen by the anesthesiologist, followed by one-lung ventilation until the intersegmental plane appeared. The target segment remained inflated because the gas in the target segment was not reabsorbed by the artery. Conversely, the gas in the adjacent segment is absorbed by the artery, so the adjacent segment is collapsed. This difference in inflation state allows visualization of the intersegmental plane (14,15). This method does not require special equipment, is simple, and can accurately and stably delineate the intersegmental plane. In summary none of the methods have been comparatively validated and objectively evaluated in a large prospective study. On the other hand, they all remain promising methods.

In conclusion, segmentectomy is an anatomical lung parenchyma-sparing resection and a useful technique that has recently been established as the standard procedure for small NSCLC. Therefore, thoracic surgeons need to be well versed in the technique. There are several methods for identifying the intersegmental plane, but they are not very different from each other. The choice of method should be determined by the surgeon's preference, the location of the operative field, and the clinical characteristics of the patient.

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