Review Article

Video-assisted thoracoscopic surgery (VATS) segmentectomy

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Abstract: The safety and feasibility of the video-assisted thoracoscopic surgery (VATS) approach to segmentectomy have been widely demonstrating, although the rule of anatomical sublobar resection as a definitive management of early-stage non-small cell lung cancer is still controversial. To date, thoracoscopic segmentectomy is principally indicated in elevated risk patient that cannot tolerate standard lobectomy. The different surgical technique has been described and a growing number of dedicated instrumentation and technology to safely perform anatomical segmentectomy are available. Compared to standard VATS lobectomy, segmentectomy is a more challenging procedure, and surgeon experience is critical. VATS segmentectomy should be considered as a valid option for the management of patients with small-sized early stage NSCLC, not larger than 2 cm. The only absolute contraindication to segmentectomy is the inability to obtain radical resection.

Keywords: Lung cancer; segmentectomy; video-assisted thoracoscopic surgery (VATS)

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Introduction

Over the last 2 decades, there have been significant improvements in lung cancer screening programs which have resulted in the identification of a more considerable number of small (<2 cm), early stage, lung cancer. Numerous studies have demonstrated that sub-lobar lung resection should be considered as an "oncologically effective" alternative to lobectomy for the treatment of non-solid/semi-solid small (less or 2 cm) lung tumour (1,2). Moreover, the adoption of more advanced thoracoscopic surgical technique has led to a new interest in the thoracoscopic (VATS) approach to lung anatomical segmentectomy.

The potential advantages of minimally invasive thoracic surgery, compared with an open approach, for both lobar and sublobar pulmonary resection, have been widely demonstrated and include reduced pain and release of inflammation, shorter hospital stays, better functional results, and even improved long-term survival (3,4). Many authors have recently shown that VATS approach segmentectomy for the treatment of stage I non-small cell lung cancer is feasible and safe with reduced perioperative mortality and similar overall survival when compared with VATS lobectomy. Multiple studies have demonstrated no significant differences between the two approaches regarding perioperative morbidity, operative time, local recurrence rate and overall 5-years survival (5-7); studies have also reported that patients who underwent VATS segmentectomy had similar or reduced hospital stay compared to patients undergoing VATS lobectomy.

VATS segmentectomy should be indicated for the treatment of ground glass opacity. These types of tumor are often "multi-focal" (and usually have a low rate of local

recurrences) and potentially require multi-step or redo surgery.

Moreover, in elderly patients who could possibly benefit from parenchyma-sparing procedures anatomical segmentectomy could be a valid alternative to major lung resection, if a complete resection is achievable.

However, an indication to VATS segmentectomy is still uncertain, even for small lesion and its role as the definitive management of early-stage lung cancer remains controversial; moreover, compared to standard VATS lobectomy, is a more complicated procedure and surgeon experience is critical (8).

In addition to concerns about the risk of loco-regional recurrence, possible arguments against VATS segmentectomy include:

- ❖ Adequate lymph node assessment;
- ❖ Complete segmental parenchyma division;
- ❖ Localization of small tumours in a segment.

Regarding mediastinal lymph node assessment, when comparing VATS segmentectomy with VATS lobectomy, several studies revealed no significant differences in lymph nodes harvested or nodal stations sampled. In a comparison between small-sized stage IA NSCLC patients who underwent thoracoscopic segmentectomy and thoracoscopic lobectomy, Zhong *et al.* reported no significant difference in numbers of dissected lymph nodes among the two types of operation. The investigators also reported that the local recurrence rate of thoracoscopic segmentectomy was 5.1% which was comparable to the lobectomy group (9,10).

Ren *et al.* retrospectively analysed 82 patients that underwent VATS segmentectomy and VATS lobectomy for early-stage NSCLC; The local recurrence rate and the number of lymph node dissected were assessed. The VATS segmentectomy group showed no significant difference compared with the lobectomy group regarding the number of lymph nodes harvested (11). When compared to open approach, mediastinal lymph node dissection performed by VATS can be a challenge and complicated procedure mainly when performed by surgeons at their initial experience with the VATS approach. Nevertheless, many authors reported the safety and efficacy of thoracoscopic lymph node dissection for the treatment of NSCLC and the possibility to perform an adequate lymph node resection during VATS major lung resection compared to open approach had been extensively demonstrated (11,12).

Nodal upstaging (higher N value on the final pathologic histology compared to pre-operative clinical N stage), is a predictor of the adequacy of intraoperative nodal management. The possibility to perform an adequate lymph node resection during VATS major lung resection compared to open approach has been extensively demonstrated.

In an analysis of segmentectomies from the Society of Thoracic Surgery national database, comparing the completeness of lymph node dissection during anatomic lung resection for lung cancer performed by VATS or open approaches, upstaging from cN0 to pN1 was reported in 4% among the group of 170 VATS segmentectomies compared with 5.3% among 280 open segmentectomies. The authors observed that the differences in upstaging between VATS and open approaches might have been the result of selection bias, and that equivalent nodal staging may be possible with increasing experience with VATS procedure (13).

VATS segmentectomy is technically trickier compared to VATS lobectomy; it requires a 3-dimensional knowledge of the segmental broncho-vascular relationships and possible anatomical variations. Furthermore, the intersegmental demarcation line on the surface of the visceral pleura could not be easily identified at thoracoscopic findings. The debate regarding the optimal technique used to perform a complete segmental division is still open. Demarcation of the segmental plane can be obtained with ventilation of the ipsilateral lung after the division of the segmental bronchus or a selective jet ventilation (during bronchoscopy) to inflate the segment of interest can be performed after single lung ventilation has been obtained. However, the conventional ventilation recruitment method offers some limitations. The presence of collateral ventilation (or collateral "air drifts") that occasionally take place when the reserved segment inflation method is applied, limits a clear identification the intersegmental plane.

Other options for visualization of the segmental plane, not involving lung inflation, have been recently proposed, one of these involves relies on infrared thoracoscopy with indocyanine green injection to visualize adjacent lung segments and more recently, a new method has been proposed, based on methylene blue injection into the bronchus of the target pulmonary segments (14,15).

Localization of a small tumor (less than 1 cm) or non-solid lesion in a segment, not immediately under the sub pleural surface, can be tricky. Several localization techniques have been described; injection of the radiotracer, wire hook and coil markers, radiopaque markers detected with the assistance of intraoperative fluoroscopy, and dye injection during navigational bronchoscopy (15-19). All these innovative procedures reported in the literature, have successful results. However, localization may also be

Figure 1 Lingulectomy: adenocarcinoma of the left upper lobe (21). Available online: http://www.asvide.com/article/view/24329

Figure 2 Upper segmentectomy of the right lower lobe: growing ground glass opacity of the lower lobe (22). Available online: http://www.asvide.com/article/view/24330

achieved in most patients without these techniques.

Technical considerations

Several approaches have been described to perform a thoracoscopic segmentectomy. The number of ports can vary from three to two, to single incision (uniport VATS) or as recently described lung segmentectomy can be performed through a single subxiphoid approach. This is an innovative approach that allows anatomical lung resection without performing an incision in the chest. Although the initial result is exalting, this procedure is technically demanding and require specifically designed instrumentations and may not be performed in all patients (e.g., patients with elevated BMI) (20).

The commonly performed anatomical segmentectomy include lingulectomy, lingula-sparing (left upper lobectomy or the so-called trisegmentectomy), posterior segmentectomy of the right upper lobe, superior segmentectomy of the lower lobe and basilar segmentectomy (that can be single or multiple).

Regardless the approach and the number of ports, anatomical segmentectomy is performed by isolation and division of every single segmental vascular and bronchi. On the upper lobe the most frequently sub-lobar resection performed is lingulectomy and lingual-sparing upper lobectomy. When performing a lingulectomy dissection should start from the vein. Once the vein is parted, the upper lobe bronchus is dissected distally to identify and divide the segmental branch to the lingula. At this time dissection of all hilar lymph nodes should be performed (station 11 and 12). The lingula artery is then isolated and parted. The fissure is completed, and transection of the parenchyma is finally performed (*Figure 1*).

Upper lobe trisegmentectomy is initiated by dividing the mediastinal pleura over the superior vein, and the branches superior to the lingular branch are dissected and divided with the stapler. The anterior branch of the pulmonary artery is isolated and divided. Division of the artery allows mobilisation of the upper lobe bronchus. The tri-segmental bronchus is dissected and divided, lymph nodes at levels 10, 11, and 12 are removed. The parenchymal division between the upper lobe and the lingula should easily be identified and stapled.

Superior segmentectomy of the lower lobe is the most commonly performed anatomical sublobar resection. The pulmonary ligament is incised until the lower lobe vein is exposed. The mediastinal pleura is dissected posteriorly, and the vein to the upper segment is identified and stapled. The arterial branch is identified in the fissure and stapled. This allows identification of the bronchial segment. Dissection of lymph nodes station 11 and 12 is performed. The bronchial segment is then stapled, and segmentectomy is completed dividing the parenchyma. If the fissure is incomplete dissection is performed proceeding with a posterior to anterior approach, and the sequence should be vein-bronchus-artery (*Figure 2*). Basilar segmentectomy (all four segments), can be performed, however, sparing only the superior segment may be of uncertain benefit and should be considered for selected patients.

Conclusions

The oncological value of segmentectomy is still

controversial. Several published studies report contradictory results. Most of those research is a retrospective analysis of a limited population or studies based on an extensive national database that often suffers from the incomplete record. Randomized prospective studies should be waged to clarify the rule of segmentectomy as a definitive treatment for early-stage lung cancer. To date, VAST segmentectomy is frequently performed in elevated risk patients that are not eligible to undergo standard lobectomy. In our opinion segmentectomy should be considered as a valid option for the management of patients with small-sized early-stage NSCLC, not larger than 2 cm taking care to perform a complete anatomical resection with a parenchymal margin of at least of 2 cm. The main contraindication to VATS segmentectomy is the inability to obtain radical resection.

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Footnote

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References

1. Okada M, Yoshikawa K, Hatta T, et al. Is segmentectomy with lymph node assessment an alternative to lobectomy for non-small cell lung cancer of 2 cm or smaller? Ann Thorac Surg 2001;71:956-60; discussion 961.
2. Martin-Ucar AE, Nakas A, Pilling JE, et al. A case-matched study of anatomical segmentectomy versus lobectomy for stage I lung cancer in high-risk patients. Eur J Cardiothorac Surg 2005;27:675-9.
3. Petersen RP, Pham D, Burfeind WR, et al. Thoracoscopic lobectomy facilitates the delivery of chemotherapy after resection for lung cancer. Ann Thorac Surg 2007;83:1245-9; discussion 1250.
4. Hartwig MG, D'Amico TA. Thoracoscopic lobectomy: the gold standard for early-stage lung cancer? Ann Thorac Surg 2010;89:S2098-101.
5. Leshnower BG, Miller DL, Fernandez FG, et al. Video-assisted thoracoscopic surgery segmentectomy: a safe and effective procedure. Ann Thorac Surg 2010;89:1571-6.
6. Yamashita S, Tokuishi K, Anami K, et al. Thoracoscopic segmentectomy for T1 classification of non-small cell lung cancer: a single center experience. Eur J Cardiothorac Surg 2012;42:83-8.
7. Sugi K, Kobayashi S, Sudou M, et al. Long-term prognosis of video-assisted limited surgery for early lung cancer. Eur J Cardiothorac Surg 2010;37:456-60.
8. Bertolaccini L, Solli P. COUNTERPOINT: Should Segmentectomy Rather Than Lobectomy Be the Operation of Choice for Early-Stage Non-small Cell Lung Cancer? No. Chest 2018;153:592-5.
9. Zhong C, Fang W, Mao T, et al. Comparison of thoracoscopic segmentectomy and thoracoscopic lobectomy for small-sized stage IA lung cancer. Ann Thorac Surg 2012;94:362-7.
10. Bedetti B, Bertolaccini L, Rocco R, et al. Segmentectomy versus lobectomy for stage I non-small cell lung cancer: a systematic review and meta-analysis. J Thorac Dis 2017;9:1615-23.
11. Ren M, Meng Q, Zhou W, et al. Comparison of short-term effect of thoracoscopic segmentectomy and thoracoscopic lobectomy for the solitary pulmonary nodule and early-stage lung cancer. Onco Targets Ther 2014;7:1343-7.

12. Boffa DJ, Kosinski AS, Paul S, et al. Lymph node evaluation by open or video-assisted approaches in 11,500 anatomic lung cancer resections. Ann Thorac Surg 2012;94:347-53.
13. Boffa DJ, Allen MS, Grab JD, et al. Data from The Society of Thoracic Surgeons General Thoracic Surgery database: the surgical management of primary lung tumors. J Thorac Cardiovasc Surg 2008;135:247-54.
14. Misaki N, Chang SS, Igai H, et al. New clinically applicable method for visualizing adjacent lung segments using an infrared thoracoscopy system. J Thorac Cardiovasc Surg 2010;140:752-6.
15. Grogan EL, Stukenborg GJ, Nagji AS, et al. Radiotracer-guided thoracoscopic resection is a cost-effective technique for the evaluation of subcentimeter pulmonary nodules. Ann Thorac Surg 2008;86:934-40; discussion 940.
16. Zhang Z, Liao Y, Ai B, et al. Methylene blue staining: a new technique for identifying intersegmental planes in anatomic segmentectomy. Ann Thorac Surg 2015;99:238-42.
17. Powell TI, Jangra D, Clifton JC, et al. Peripheral lung nodules: fluoroscopically guided video-assisted thoracoscopic resection after computed tomography-guided localization using platinum microcoils. Ann Surg 2004;240:481-8; discussion 488-9.
18. Moon SW, Wang YP, Jo KH, et al. Fluoroscopy-aided thoracoscopic resection of pulmonary nodule localized with contrast media. Ann Thorac Surg 1999;68:1815-20.
19. Nomori H, Horio H, Naruke T, et al. Fluoroscopy-assisted thoracoscopic resection of lung nodules marked with lipiodol. Ann Thorac Surg 2002;74:170-3.
20. Aresu G, Weaver H, Wu L, et al. The Shanghai Pulmonary Hospital uniportal subxiphoid approach for lung segmentectomies. J Vis Surg 2016 Dec 2;2:172.
21. Pardolesi A, Bertolaccini L, Gallina FT, et al. Lingulectomy: adenocarcinoma of the left upper lobe. Asvide 2018;5:403. Available online: http://www.asvide.com/article/view/24329
22. Pardolesi A, Bertolaccini L, Gallina FT, et al. Upper segmentectomy of the right lower lobe: growing ground glass opacity of the lower lobe. Asvide 2018;5:404. Available online: http://www.asvide.com/article/view/24330

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