



The intersegmental plane: an emerging concern for the thoracoscopic surgeon

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The profile of patients who are operated on for lung cancer is evolving. More and more ground glass opacities and early stage lung carcinomas are discovered, either because lung cancer screening programs are being set up or because patients or their physician ask more easily for a CT-scan than in the past. Until recently, many of these patients—when a non-small cell lung carcinoma (NSCLC) was suspected - underwent a lobectomy whatever the size and clinical stage of the tumor. Although the results of ongoing trials comparing survivals of lobectomy and sublobar resections (SLR) for early NSCLC are pending, most pulmonologists, oncologists and surgeons agree that many of these patients should rather have a SLR than a lobectomy. Indeed, most studies demonstrate that the morbidity rate after SLR is lower than after lobectomy, especially with respect to pulmonary complications. Depending on the series, the survival rate is either equivalent or non-significantly reduced by SLR when compared to lobectomies. However, with regard to the postoperative outcome, it is also proven that, when comparing open and closed-chest surgery, there is a clear advantage in favor of the thoracoscopic approach, in particular for patients with impaired pulmonary function (1). In other words, the surgeon who wants to treat a GGO or an early stage carcinoma and do a better tolerated procedure than a lobectomy, must perform a thoracoscopic segmentectomy. In open chest surgery, anatomical segmentectomies are belonging to the range of techniques the thoracic surgeon does master. Even surgeons who are not experts in this field can achieve these procedures, thanks to the

natural vision of the anatomy and the use of both hands that greatly ease exposing the segments. Discovering the intersegmental vein is also not an insuperable problem and dividing the intersegmental plane along this vein, whatever the technique used, is something the surgeon knows how to do. However, when performed by VATS, difficulties of several orders do appear. With knowledge of the anatomical variations and patience, bronchial and vascular dissection can be performed, but identification and division of the intersegmental plane remain challenging, even in the hands of experienced surgeons. This is due to several factors: (I) an optimal exposure is more difficult to achieve without manual assistance; (II) digital palpation is impossible; (III) spatial disorientation—partly related to the two former factors—poses problems, especially when dealing with the lower lobes. Consequently, dissection of the bronchovascular elements, which should be the most difficult part of the operation is sometimes much more straightforward than the final step of the procedure, i.e., the division of the intersegmental plane.

With the unavoidable rise of thoracoscopic SLR, overcoming these issues will be one of the forthcoming concerns for the thoracic surgeon. Although research in this field is purely technical and not so rewarding, its clinical impact will be of major importance. It will comprise two distinct parts: (I) how determining the location and direction of the intersegmental plane; (II) once identified, how to sever the plane with ease and safety. Inadequate determination and division of the intersegmental can have indeed serious consequences of oncological and surgical

order.

Determining the anatomy and volume of segments can rely on preoperative modelisation. Studies confirm that correlation between 3-dimensional (3D) reconstruction and intraoperative findings is almost perfect (2,3). In some software, as the one we routinely use, it is possible to turn around the lung, navigate layer by layer and displaying, for instance, the target segments and their intersegmental vein. Safety margins can also be simulated. However, 3D reconstruction, although very helpful, is not the ultimate tool because the size and volume variations of the lung throughout the procedure do not render a perfect similarity of landmarks. The ideal solution would probably be an augmented reality visualization system that makes it possible to merge computer reconstruction and real video imaging into a single image, giving the surgeon the possibility to follow the dissection pattern as with a GPS. Because of the above-mentioned issues, it seems we are still far away from such a technology. Even for liver surgery, which poses less problems than lung surgery because the organ is solid and stable, this technology is not yet mature and not routinely used (4). Meanwhile, an alternate solution could be the use of rapid prototyping (5) and 3D printers to give a better idea of spatial organization and depth of segments and vessels. Several companies are working on these solutions with—so far—high prices. But costs could rapidly be reduced and, in a near future, a 3D printer will most likely be available in hospital services.

In addition to computer solutions, staining the target segment is theoretically the simplest technical solution as it only relies on the surgeon. Discussing in this editorial all reported techniques would be too long and tedious. There are indeed numerous methods, all of them with their advantages limitations and even complications (6): use of an inflation-deflation line either after inflation of the whole lung (7) or of the segment to be resected, inflation of the target segment by endoscopy (8) or by puncture of the segmental bronchial stump (6,9), endobronchial (10,11) or systemic (12) injection of indocyanine green (ICG), endobronchial injection of fluorescent vitamin B2 (13), thermography (14). We can only note that the inflation-deflation method as well as intrabronchial dye injection, despite some interesting published results (11), have shortcomings due to intra-parenchymatous diffusion of air or dye, resulting in an imprecise marking of the segmental borders. Systemic injection of ICG with infrared camera has the advantage of being only based on blood flow, thus not requiring lung inflation. However, the need to have a

dedicated camera can be an obstacle and the fluorescence vanishes in a very short period of time. The VAL-map technique described by Sato *et al.* (15) that consists in a preoperative marking of several spots on the edges of the target or adjacent segment is an appealing solution that requires, however, thorough preoperative preparation.

Finally, once the intersegmental demarcation line has been either localized or pictured, its division is not the simplest step. It can be done by cutting or stapling as the surgeon cannot rely on digital manipulation as he would do during an open peeling technique.

The conventional way of dividing the intersegmental plane is to cut the parenchyma along the segmental vein, either with electrocautery or with a vessel sealing device, reinforced or not with fibrin sealant or covered or not with a mesh. This technique is supposed to preserve the parenchyma but is at risk of bleeding and air leaking. The rapid development of the thoracoscopic approach has favored the stapling method, which is considered easier. Although stapling may have some limitations, it causes less air leaks. In a series we published recently, the rate of prolonged air leaks was only 4.2% and none of the leaks required pleurodesis or reoperation. In a series comparing electrocautery and the use of staplers for dividing the intersegmental plane, prolonged air leaks were observed in 8% of the patients and some of them underwent a chemical pleurodesis or were reoperated for aerostasis. None of these complications occurred in the stapler group (16). An indirect sign suggesting that splitting the intersegmental by electrocautery is a concern, is the number of studies dealing with reinforcement of the parenchymal plane by various types of sealants and/or meshes (17-20).

However, stapling is not the ideal solution. Some surgeons recommend division of the intersegmental plane by electrocautery because it allows complete expansion of the residual segments (19,20), while staples can interfere with the expansion of preserved lung, due to the visceral pleura being caught in the staple line. However, we have shown that the rate of incomplete re-expansion at 1 month follow-up was low (2.8%) and that none of these patients must undergo specific measure, such as chest drainage or reoperation (21).

In addition, stapling the intersegmental plane—despite advantages in terms of safety—raises other issues. Its handling is not easy, especially in patients with narrow or small chest cavity. Loading thick tissues can be tedious, as their opening is still limited, and disruption of the staple line can occur. Another theoretical concern is the non-

preservation and/or compression of the intersegmental vein, which could impair gas exchanges and viability in the preserved segment (22). Some authors have suspected that some so-called stump consolidations, i.e., partial atelectasis, observed several months after thoracoscopic segmentectomies could be related with misidentification of the intersegmental plane (20). Eventually, stapling the intersegmental plane, a widely-adopted method, can have some drawbacks that deserve investigations.

In conclusion, even though most thoracic surgeons are convinced that SLR must be preferred to lobectomy in many patients with GGO, early stage lung carcinoma or solitary deeply located metastases, and even though they are also convinced that these procedures should be done by closed chest surgery, the fact remains that management of the intersegmental plane, when done thoracoscopically can be frustrating and even unsatisfactory. Overcoming the current issues is a task for the forthcoming years. Finding solution(s) will greatly contribute decreasing the morbidity of SLR, which is already lower than the one of lobectomies.

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References

1. Traibi A, Grigoroiu M, Boulitrop C, et al. Predictive factors for complications of anatomical pulmonary segmentectomies. *Interact Cardiovasc Thorac Surg* 2013;17:838-44.
2. Ikeda N, Yoshimura A, Hagiwara M, et al. Three dimensional computed tomography lung modeling is useful in simulation and navigation of lung cancer surgery. *Ann Thorac Cardiovasc Surg* 2013;19:1-5.
3. Yang Q, Xie B, Hu M, et al. Thoracoscopic anatomic pulmonary segmentectomy: a 3-dimensional guided imaging system for lung operations. *Interact Cardiovasc Thorac Surg* 2016;23:183-9.
4. Nicolau S, Soler L, Mutter D, et al. Augmented reality in laparoscopic surgical oncology. *Surg Oncol* 2011;20:189-201.
5. Akiba T, Nakada T, Inagaki T. Simulation of the fissureless technique for thoracoscopic segmentectomy using rapid prototyping. *Ann Thorac Cardiovasc Surg* 2015;21:84-6.
6. Otsuka T, Nakamura Y, Harada A, et al. Extremely rare but potential complication of diffuse brain edema due to air embolism during lung segmentectomy with selected segmental inflation technique by syringe needle during video-assisted thoracoscopic surgery. *J Thorac Cardiovasc Surg* 2011;142:e151-2.
7. Gossot D, Zaimi R, Fournel L, et al. Totally thoracoscopic pulmonary anatomic segmentectomies: technical considerations. *J Thorac Dis* 2013;5:S200-6.
8. Sonobe M, Date H. Technology on Partial Resection and Segmentectomy for Early-stage Lung Cancer. *Kyobu Geka* 2016;69:676-80.
9. Kamiyoshihara M, Kakegawa S, Morishita Y. Convenient and improved method to distinguish the intersegmental plane in pulmonary segmentectomy using a butterfly needle. *Ann Thorac Surg* 2007;83:1913-4.
10. Sekine Y, Kaiho D, Toyoda T. Novel approach for precise anatomical segmentectomy utilizing a lung volume analyzer and infrared thoracocopy with transbronchial injection of indocyanine green. *EJCTS sous presse* 2015.
11. 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.

12. Tarumi S, Misaki N, Kasai Y, et al. Clinical trial of video-assisted thoracoscopic segmentectomy using infrared thoracoscopy with indocyanine green. *Eur J Cardiothorac Surg* 2014;46:112-5.
13. Ohsima M, Waseda R, Tanaka N, et al. A new fluorescent anatomic pulmonary segmentectomy using PDD endoscope system and vitamin B2: evaluation in a clinical setting using living animal. *Surg Endosc* 2016;30:339-45.
14. Sakamoto K, Kanzaki M, Mitsuboshi S, et al. A novel and simple method for identifying the lung intersegmental plane using thermography. *Interact CardioVasc Thorac Surg* 2016;23:171-3.
15. Sato M, Yamada T, Menju T, et al. Virtual-assisted lung mapping: outcome of 100 consecutive cases in a single institute. *Eur J Cardiothorac Surg* 2015;47:e131-9.
16. Miyasaka Y, Oh S, Takahashi N, et al. Postoperative complications and respiratory function following segmentectomy of the lung - comparison of the methods of making an inter-segmental plane. *Interact Cardiovasc Thorac Surg* 2011;12:426-9.
17. Yoshimoto K, Nomori H, Mori T, et al. Comparison of postoperative pulmonary function and air leakage between pleural closure vs. mesh-cover for intersegmental plane in segmentectomy. *J Cardiothorac Surg* 2011;6:61.
18. Nomori H. Anatomical segmentectomy for clinical stage IA non-small cell lung cancer. *Nihon Geka Gakkai Zasshi* 2011;112:264-6.
19. Ohtsuka T, Goto T, Anraku M, et al. Dissection of lung parenchyma using electrocautery is a safe and acceptable method for anatomical sublobar resection. *J Cardiothorac Surg* 2012;7:42-6.
20. Nakano T, Endo S, Mitsuda S, et al. Stump consolidation after video-assisted thoracoscopic segmentectomy. *Kyobu Geka* 2011;64:792-5.
21. Ojanguren A, Gossot D, Seguin-Givelet A. Division of the intersegmental plane during thoracoscopic segmentectomy: is stapling an issue? *J Thorac Dis* 2016;8:2158-64.
22. Asakura K, Izumi Y, Kohno M, et al. Effect of cutting technique at the intersegmental plane during segmentectomy on expansion of the preserved segment: comparison between staplers and scissors in ex vivo pig lung. *Eur J Cardiothorac Surg* 2011;40:e34-8.

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