



Beyond the limits: journey to feasible and safe uniportal VATS surgery for lung cancer

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Comment on: Wang G, Yu Z, Li J, *et al.* Anatomical segmentectomy under uniportal video-assisted thoracoscopic surgery for early staged non-small cell lung cancer: a case report. *J Thorac Dis* 2022;14:3613-23.

Keywords: Uniportal video-assisted thoracoscopic segmentectomy; uniportal video-assisted thoracoscopic surgery (uniportal VATS); segmentectomy; minimally invasive surgery

Submitted Dec 30, 2022. Accepted for publication Jan 10, 2023. Published online Feb 03, 2023.

doi: 10.21037/jtd-22-1877

View this article at: <https://dx.doi.org/10.21037/jtd-22-1877>

When the readers review history, they can find fascinating facts and fathom the future direction of evolution. Lung cancer treatment has undergone the most dramatic evolution in the last century. The introduction of one-lung ventilation enables lung surgery safely, and the introduction of the thoracoscope opened the era of minimally invasive surgery. With the help of modern anesthesia, pulmonary resection, which was considered impossible, has changed as the primary choice of early-stage lung cancer treatment (1). Interestingly, pneumonectomy has remained the gold standard regardless of the size or location of the tumor for the first 30 years. Indeed, simple lobectomy for lung carcinoma was regarded as illogical, less surgical, and less anatomical (2). However, Shimkin *et al.* published the legendary article declaring equivalent survival and lesser morbidity of lobectomy compared to pneumonectomy. Afterward, the surgery paradigm changed from pneumonectomy to lobectomy (3).

Then the next significant leap is the introduction of thoracoscopy. Pioneers began thoracoscopic surgery around 1910, first targeting pleural disease, but the patients had to wait about 80 years before the era of video-assisted interventions for non-small cell lung cancer. In the early 1990s, thoracoscopic surgery and surgical stapler were cautiously introduced for minor lung surgeries, such as

pulmonary biopsy, bullectomy, and mediastinal tumor resection. Moreover, these attempts were steadily expanded and finally applied to lobectomy and pneumonectomy (4).

What for did we briefly review the history? Through 100 years of history, notwithstanding various resistances, the device, technology, and surgical method have developed in the direction of maintaining oncological outcomes while being less invasive and lesser resection preserving the pulmonary parenchyma. When a new surgical method is introduced, it always goes through a thorough verification stage, and at least three fundamental things should continually be assessed; (I) the purpose of the surgery, (II) safety and patient outcome, and (III) feasibility. The purpose of the surgery for non-small cell lung cancer, confessedly, is the oncological outcome. The second issue includes many essential things, including operative morbidity, mortality, and patient-oriented outcomes such as respiratory function, quality of life, and return to daily life. The third issue is feasibility, which is addressed in this article.

For the last decades, the medical environment has changed dramatically. Advances in computed tomography (CT) technology and the popularity of low-dose CT screening increased the diagnosis of ground-glass opacity (GGO) lesions, which changed the paradigm of lung cancer treatment (5). Additionally, with the evolution

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of immunotherapy and targeted therapeutic agents, second primary lung cancer has emerged as another medical concern as the number of lung cancer survivors increases. In other words, the recent issue is how to treat surgically resectable second primary lung cancer, multiple primary GGOs, and the best option of treatment for GGOs (6). Japan Clinical Oncology Group (JCOG) has published a series of clinical trials on which conditions the segmentectomy is oncologically compatible with lobectomy, categorized by tumor size and the ratio of tumor consolidation to tumor size (7,8). Finally, patients demand less pain in the treatment process, rapid return to daily life and work, and preservation of lung function. For these reasons, minimally invasive therapy continues to develop.

The article “Anatomical segmentectomy under uniportal video-assisted thoracoscopic surgery for early staged non-small cell lung cancer” clearly describes the issues mentioned above (9). The article consists of two parts, the first section shows how a surgeon can perform an uniportal segmentectomy, and the second section deals with the main issues in uniportal lung cancer surgery through interactive discussion.

Adopting new surgical technology requires several prerequisites; it has to be technically not too challenging for ordinary surgeons to do, it has to be possible in general situations, and at the same time, thoracotomy conversion should be easy to deal with in emergencies (10). Video-assisted thoracoscopic surgery (VATS) enabled major and minor thoracic procedures for various diseases with small incisions. Not long after the spread of multiport VATS, the first lung biopsy through uniport was reported by Jutley *et al.*, and the first uniportal VATS lobectomy was done by Gonzalez, the pioneers of the uniportal VATS developed the techniques (11). Also, the investigators developed convenient and optimized surgical instruments for uniportal VATS, and the new surgical techniques gained popularity quite rapidly, considering the long history of lung cancer surgery (12).

The characteristics of the uniportal procedure have attributed to this successful settlement. First, the procedure of uniportal VATS is compatible with current practice: no rib spreading, use of videothoracoscope, same energy source, and primarily same incision in the fourth or fifth intercostal space as in the multiportal VATS procedure (13). Since the thoracic society is already familiar with the double or tri-port VATS procedure, changing from multiport to uniport was not easy but possible for ordinary surgeons. Many enthusiastic pioneers have published “how-to-do”

series and offered the opportunity to observe live surgeries. The development of optimized long and curved instruments for uniportal VATS contributed to the advancement of technology.

Is the procedure feasible for ordinary surgeons in average hospitals? This question is the key for one technique to be universalized. Indeed, there are still controversies regarding the feasibility and outcome of uniportal VATS, especially for malignant diseases. We can get the clue from the many articles for the last ten years since many researchers reported the feasibility and outcomes of the various procedure in various diseases done by uniportal VATS. Zuo *et al.* compared the uniportal *vs.* three-port VATS lobectomy for clinical stage I–II non-small cell lung cancer. They reported no differences in the postoperative morbidity, operative time, number and N2 lymph node dissection stations, and the total number of dissections between the two groups (14).

Now let us move on to the next chapter: segmentectomy. Cheng *et al.* reported an exciting study about the feasibility and safety of the uniportal VATS segmentectomy (15). They used the same instruments as conventional VATS and divided the whole patients into four groups by order of surgery. They reported that relatively stable procedures were reached after around 33 cases were completed. They suggested that accumulated experience in performing uniportal surgeries and converting uniportal to multiports in case of dense adhesions, cooperation with surgeons and assistance, and finally, specialized equipment might decrease the learning curve. More recent research by Chen *et al.*, updated the learning curve up to 58–63 cases for mastery (16).

Clearly, uniportal VATS segmentectomy requires a surgeon’s patience and considerable experience, regardless of its natural feasibility. Although the basic surgical approach is the same, the surgical view differs between the multiport and uniport VATS. The view of uniport is the same as that of open thoracotomy; thus, the details of surgical techniques can differ. Reflecting this difference, many how-to-do papers and case reports in the literature describe the tips and pitfalls of the uniportal VATS segmentectomy. It is worth reading the general methods and precautions in each segmentectomy written by Kim *et al.* in detail (17). Also, there are many surgical tips, especially for complex segmentectomies, such as a ligamentum-based approach for S9 segmentectomy (18).

Another interesting study comparing the clinical result of common (left upper lobe upper division, lingual, basal, or superior segment of the lower lobe) and uncommon

segmentectomy (other than common segmentectomy) performed by uniportal *vs.* multiportal VATS showed comparable results in terms of operative time, chest tube drainage, postoperative hospitalization days, and postoperative complications (19).

Feasibility includes whether it is technically practicable and whether it can achieve clinical objectives with at least the same results as the previous standard techniques, either thoracotomy or multiport VATS. Also, the procedure can be repeated in general hospitals, and ordinary surgeons can perform it without difficulty. The first section of the article deals with “how-to-do” anatomical segmentectomy, and the various techniques have been discussed repeatedly throughout the literature.

Now we need to focus on the other objectives of the surgery itself. For lung cancer, the oncological outcome is paramount in the recurrence and the patient’s survival. Since the uniportal VATS segmentectomy for lung cancer is still a new procedure, the data on long-term survival is rare. In addition, there are no randomized trials or well-designed case-control studies of this technique; we still have only a handful of low-grade evidence. A few series only comment on the clinical results, focusing on perioperative morbidity. While we wait for the long-term data, we might use the number of mediastinal lymph node dissection, pathological staging, or margin recurrence as surrogate markers, though not perfect. There is still debate about the quality and number of mediastinal lymph node dissections. The number varies; Delgado Roel *et al.* reported that uniportal VATS is better than multiportal VATS. However, Mu *et al.* demonstrated overall number is lower in the uniportal VATS than in multiport (20,21). In a new exciting paper by Xie *et al.*, clinical IA 537 uniportal and 519 multiportal segmentectomies were compared to operative and oncological outcomes using propensity score-matched analysis (22). After matching, survival analysis was done for only invasive adenocarcinoma (325 patients), and surgical techniques (uniport *vs.* multiport) were not a risk factor in disease-free survival or overall survival. The recurrence rate during the median 52.0 months follow-up was 9 in the uniportal group and 16 in the multiportal group ($P=0.247$). The 5-year overall survival was 96.7% and 96.5%, respectively.

The second section, the interactive section of the article, describes the issue of segmentectomy itself strictly; the indications of segmentectomy, resection margins, development of intersegmental plane, proper lymph node dissection, and pulmonary function. Whether a surgeon

uses uniport or multiport, the surgical principles should not be hampered for the patient’s best outcomes. As the authors wrote, the indications of segmentectomy are almost identical for uniportal or multiportal VATS except in technically demanding cases with severe pleural adhesions. Furthermore, enough resection margin is paramount for preventing the early recurrence of lung malignancies: the recommended resection margin for small peripheral lung tumors is at least the diameter of the tumor. Moreover, new technology, 3D visualization techniques, would help surgeons plan intersegmental planes and dissect vascular structures accurately.

In conclusion, although this procedure still has hurdles to overcome to become more widespread, the uniportal VATS segmentectomy is feasible and safe. The uniportal VATS procedure requires skilled surgical assistance, a surgeon’s experience in thoracoscopic surgery, quite a long learning curve, and the patience and cooperation of the whole surgical team. Since the number of patients with limited pulmonary function or early lung cancer including GGO lesions will continue to increase, the uniportal VATS segmentectomy, which is currently a state-of-art technology at present, it is expected to become universal in the near future.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, Journal of Thoracic Disease. The article did not undergo external peer review.

Conflicts of Interest: The author has completed the ICMJE uniform disclosure form (available at <https://jtd.amegroups.com/article/view/10.21037/jtd-22-1877/coif>). The author has no conflicts of interest to declare.

Ethical Statement: The author is accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Cite this article as: Moon MH. Beyond the limits: journey to feasible and safe uniportal VATS surgery for lung cancer. *J Thorac Dis* 2023;15(2):246-249. doi: 10.21037/jtd-22-1877