Review Article on Thoracic Surgery

Physiopathology aspects of anatomical video-assisted thoracic surgery resections: current status and prospects of development

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Abstract: Pulmonary lobectomy remains the gold standard therapy for early-stage lung cancer. With the spread of video-assisted thoracic surgery (VATS), surgeons began using this approach also to perform lobectomies, becoming progressively widespread worldwide. However some early-stage lung cancer patients are of questionable eligibility for open lobectomy being considered at high-risk to develop postoperative complications due to compromised pulmonary function or cardiopulmonary reserve. Herein we evaluate pathophysiology of VATS, focusing on: the correlation between the traditional predictors of outcome and overall complications, the current status of different VATS approaches and the role of VATS segmentectomy in high-risk patients, unable to tolerate lobectomy for their compromised cardiopulmonary reserve.

Keywords: Lung cancer; video-assisted thoracic surgery (VATS) lobectomy; VATS segmentectomy; VATS pathophysiology; postoperative complications

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Introduction

Pulmonary lobectomy is considered the gold standard in the surgical treatment of early-stage non-small cell lung cancer (NSCLC). With the spread of video-assisted thoracic surgery (VATS) started in the early 1990s (1), surgeons began using this approach also to perform lobectomies becoming progressively widespread worldwide (2,3).

We previously reported that VATS lobectomy did not offer any functional recovery advantage in comparison to open approach 3 months after the operation, showing a noticeable decline in terms of forced expiratory volume 1 (FEV1), diffusing lung capacity for carbon monoxide (DLCO) and exercise capacity recovery examined postoperatively, both for open and VATS lobectomy patients (4). However, although long-term patients' global functional status was not influenced by the surgical approach, the role of VATS is crucial in the immediate postoperative period when the cardiovascular, respiratory and metabolic compensatory mechanisms have not achieved a high level of efficacy and stability, especially in patients considered at high risk to develop cardiopulmonary complications.

Indeed, several studies showed that patients undergone VATS lobectomy have a lower overall morbidity/mortality rates, a shorter duration of chest tube drainage, a shorter length of stay and a superior overall survival rate compared with conventional open access (5-9). In particular a recent meta-analysis demonstrated favourable outcomes for uniportal VATS lobectomy compared to the conventional multiportal approach, showing advantages in duration of chest tube drainage, hospital stay and overall morbidity (10).

Furthermore, surprisingly, VATS may reduce the risk to develop postoperative complications, allowing patients with prohibitive pulmonary function or impaired VO_2 max to undergo pulmonary resection (11-14).

Herein we focused the attention on pathophysiology aspects of VATS reporting:

(I) correlation between the traditional predictors of

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outcome and overall complications;
(II) current status of different VATS approaches;
(III) the role of VATS segmentectomy in high-risk patients, unable to tolerate lobectomy for their compromised cardiopulmonary reserve.

VATS *vs.* open lobectomy: outcome

Pulmonary lobectomy remains the gold standard therapy for early-stage lung cancer. Recently, VATS lobectomy has been accepted worldwide with equal oncological efficacy and long-term outcomes compared to open approach (5-9). Furthermore, some patients with early-stage lung cancer and poor cardiopulmonary function may not be suitable for open approach being considered at high-risk to develop postoperative complications.

Indeed, some authors (12,13) reported that preoperative pulmonary function (FEV1 and DLCO) and VO_2 max, traditionally used to assess risk of pulmonary complications after lobectomy, may not longer be strong predictors of postoperative morbidity in patients undergoing VATS lobectomy compared with thoracotomy.

The reasons behind these advantages may likely be due to less pain and injury to the chest wall mechanics, earlier chest tube removal and better immunological status, resulting in better preservation and faster recovery of pulmonary function.

Indeed, VATS lobectomy patients with poor cardiopulmonary function (defined as FEV1<60% predicted or VO_2 max <15 mL/kg/min) were not associated with an increased surgical risk.

These results were confirmed by a recent study (11) that demonstrated how preoperative pulmonary function was predictive of complications after thoracotomy but not after VATS lobectomy, showing no difference in overall survival and morbidity in VATS patients considered at high and standard risk.

Therefore, patients should not be denied necessary operative procedures on the basis of the traditional pulmonary function testing selection (developed for open surgery).

Accordingly, on the basis of the published studies, a recent review encouraged the use of VATS approach for high-risk patients reporting that patients with compromised lung function undergone VATS lobectomy, experienced significantly lower pulmonary morbidity and reduced operative mortality compared with open lobectomy patients (15).

However, data regarding this aspect are limited and more prospective trials are warranted to evaluate the real role of these predictors of complications in VATS patients.

Our experience: biportal and uniportal VATS lobectomy

In our Thoracic Surgery Unit (Ospedali Riuniti, Ancona, Italy), 367 consecutive consenting patients (57% male, median age of 68.3 years old) underwent elective VATS pulmonary lobectomy over the period January 2012 to March 2017. We performed VATS lobectomy according D'Amico's technique (biportal approach) from 2012 to 2014 in 152 patients and according Rivas' technique (uniportal approach) from 2014 to March 2017 in 215 patients.

As previously published (16), we considered intraoperative protocols for operative technique (fissureless technique), air leak evaluation (measured by ventilator spirometer), chest tube (single 24-French chest tube thru the incision collected to electronic drainage systems) and intraoperative pain management, infiltrating the IV, V and VI intercostal spaces with ropivacaine 0.75%.

Instead, in the postoperative period, we adopted standardized treatment protocols for the following potential cardiopulmonary complications (atrial fibrillation, pneumonia and atelectasis).

Chest physiotherapy was received by all patients during the postoperative hospital stay, producing functional benefits in resectable lung cancer patients.

Three-hundreds-forty-four patients underwent VATS lobectomy for primary pulmonary cancer, 8 patients for metastatic disease and 15 patients for benign lesions. Cardiopulmonary, pulmonary and overall complications rate was of 18.5% (68/367), 6.3% (23/367) and 24.8% (91/367), respectively. No postoperative 30-day mortality was reported.

The mean operative time was 201 min and mean pleural effusion after 48 postoperative hours was 445 mL. Chest tube duration and hospital length of stay were the same (5.6 days).

Results showed no statistically significant correlation between overall complications and FEV1 or DLCO, but we found a statistically significant correlation between DLCO and pulmonary complications confirming its primary role as strong predictor of this kind of complications (P=0.12). Instead, no correlations were found between FEV1 and pulmonary complications. Our results confirm data published in literature (9,10), showing that VATS lobectomy

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can be safely performed also in high-risk patients.

Uniportal *vs.* multiportal VATS lobectomy

Which is the best VATS approach to adopt for reducing patients' morbidity without compromising safety or oncologic principles is still object of debate. However, some retrospective study suggested that uniportal VATS lobectomy patients may have a better outcomes compared to multiportal ones.

Indeed, as reported by a recent systematic review (10) that analysed eight observational studies, uniportal VATS lobectomy was associated with a statistically significant shorter duration of chest tube, shorter hospital stay and lower overall morbidity compared to multiportal VATS without showing significant differences for number of lymph nodes dissected, operative time or rates of conversion to open thoracotomy. To date, only one prospective, randomized study has been carried out to evaluate if uniportal VATS lobectomy has more favourable postoperative outcomes that multiportal ones (bi- and triportal approach) (17). Perna *et al*. reported that uniportal VATS lobectomy offers no measurable benefits compared with other VATS approaches. However, as reported by Gonzales-Rivas *et al*. (18), the study had some limitations and flaws: firstly, there were only non-significant results. Secondly, the authors grouped the Duke technique with the Copenhagen technique even if the biportal technique is actually closer to uniportal surgery than to the triportal approach.

To date, there are not data that demonstrate the superiority of uniportal over multiportal approach; therefore, long-term follow-up and others prospective randomized studies are needed.

VATS *vs.* open segmentectomy: outcome

Anatomic segmentectomy described in 1939 by Churchill and Belsey (19), is excision of one or more pulmonary segments, with ligation and division of the bronchi and vessels serving those segments. This sublobar resection allows to spare parenchyma, especially for patients considered at high-risk to develop postoperative complications, unable to tolerate lobectomy for their impaired cardiopulmonary reserve. Several published studies have shown that segmentectomy can be performed safely without compromising oncologic results (20,21), in particular if performed in VATS that is currently a better choice than thoracotomy. From the evidence reported in literature (22), population suitable to sublobar resection is defined by: stage IA disease, small tumors up to 2–3 cm diameter, peripheral location of tumor and predominantly ground glass opacity appearance on computed tomography imaging or benign conditions not suitable to be performed by wedge resection.

VATS segmentectomies are usually more difficult than lobectomies, although there are some segments that can be easily excised, such as lingular, superior, and basilar segments, and others much more complex, requiring preoperative evaluation of branches of pulmonary veins or trans-bronchial indocyanine green injection and the use of infrared thoracoscope in addition to a perfect knowledge of the bronchial and arterial anatomy and possible anomalies of vascular branches (23).

However, compared to open segmentectomy, VATS segmentectomy showed reduced post-operative pain, shorter length of stay with equivalent morbidity and mortality (24). Furthermore, compared to multiportal approach, uniportal VATS is more ergonomic, allowing surgeon to obtain similar angle of view as for open surgery and resulting a feasible and safe procedure when performed by skilled surgeons, in experienced VATS centers (23,24).

Our experience: VATS segmentectomy

Using standardized protocols previously described, we performed in our centre, from 2000 to 2014, 122 anatomical segmentectomies: 100 open segmentectomy (OS) and 22 thoracoscopic segmentectomy (TS). We evaluated operative and postoperative outcomes in two well matched groups of patients undergone open (22 OS) and thoracoscopic segmentectomy (22 TS).

Similar operative time was observed in both groups. TS group showed statistically significant lower pleural effusion compared to the OS group (370 *vs*. 589 mL, P=0.006). Besides we found higher rate of total complications in OS group (6 *vs*. 2, P=0.08). Chest tube duration and hospital length of stay were significantly shorter in the TS group (2.3 *vs*. 6.2, P=0.004 and 4.4 *vs*. 7.0, P=0.01 respectively).

Our results suggested that VATS segmentectomy is a feasible, safe procedure and may be an alternative option to open segmentectomy showing better morbidity and reduced hospital stay.

Conclusions

Minimally invasive thoracic surgery after major lung

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resections is a surgical option that thoracic surgeons can offer to patients as an acceptable alternative to thoracotomy. In particular VATS resection is mandatory in patients considered at high-risk to develop cardiopulmonary complications.

Indeed, although VATS lobectomy does not offer any long-term functional advantages in comparison to the muscle-sparing thoracotomy approach, minimally invasive technique guarantees better perioperative outcomes.

More studies are needed to find new predictors of postoperative complications after VATS lobectomy and to define the best VATS approach for performing major lung resection.

Sublobar resection remains a useful treatment alternative for a selected population of NSCLC patients, even with advanced age or poor lung function.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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