Extended uniportal video-assisted thoracic surgery for lung cancer: is it feasible?

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Abstract: Since the first description of uniportal video-assisted thoracic surgery (U-VATS) (or single-port) lobectomy, several centers in Asia and Europe rapidly adopted this technique as a standard approach for treatment of early stage non-small cell lung cancer (NSCLC). Despite the controversies regarding feasibility and completeness of resection, thoracic surgeons in high volume centers keep pushing the limits to perform very complex procedures also known as "extended resections" through minimally invasive surgery. Published series and case reports confirm the viability of U-VATS in highly complex surgical cases such as pneumonectomy, chest wall resection and bronchoplasty, which require experience and technical ability to be performed through a 3–6 cm single incision. In this article, the authors would like to present several clinical indications of locally advanced NSCLC and the technical aspects to accomplish an extended resection through U-VATS.

Keywords: Uniportal video-assisted thoracic surgery (U-VATS); single-port VATS; extended resection; lung cancer

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Introduction

Since the first description of uniportal video-assisted thoracic surgery (U-VATS) lobectomy in 2010 (1), the acceptance and implementation of this technique has spread worldwide. Considering it took a decade for VATS to be acknowledged as standard treatment for early stage lung cancer (2,3), it is natural to expect for U-VATS studies to validate the feasibility and the safety of the technique. Furthermore, completeness of resection with oncologic principles and similar outcomes when compared to multiportal VATS or thoracotomy should also be validated (4,5).

In high-volume centers, as surgeons gain experience in U-VATS lobectomy, more complex cases are managed with this approach (6-9). It reflects the natural instinct of the thoracic surgeon to push the limits without compromising safety and the quality of the oncological resection. In our own series, once the learning curve was achieved, we performed pneumonectomies, bronchoplasties, chest wall resections and post-chemotherapy cases through the uniportal approach (10) with similar oncologic and technical results to thoracotomy.

In this article, we will describe and discuss the clinical indications and the techniques for some of the extended resections that can be performed by U-VATS such as: bronchoplastic procedures, lung and chest wall resections, pneumonectomy and lobectomy post-induction treatment in locally advanced NSCLC. The authors will add some tips and tricks on how to avoid common pitfalls when practicing these techniques.

U-VATS bronchoplastic procedures

Clinical indications

The classical indication of a bronchoplasty is a central

Figure 1 Right upper lobe bronchoplasty for lung cancer (13). Available online: http://www.asvide.com/article/view/23527

NSCLC. The tumor is usually located at the entrance of a lobar bronchus. This procedure should be performed every time a pneumonectomy can be avoided (11). In the past, bronchoplastic resections were indicated as a lung sparing procedure. However, data has proven that as long as a complete oncological resection (negative bronchial and vascular margins and radical lymphadenectomy) is performed, bronchoplasty should be preferred over pneumonectomy (12).

Technique

These are one of the most complex procedures to perform by U-VATS. It not only requires previous experience in U-VATS anatomic lung surgery but also in open bronchoplastic procedures (4). Nevertheless, the improvement of the surgical instruments and medical equipment helps minimize the difficulty to implement these techniques.

The bronchoplastic procedures can be classified in wedge bronchoplasties and sleeve bronchoplasties. In the wedge bronchoplasties, the resection is carried out longitudinally along the bronchus, so the bronchial reconstruction is performed transversely. However, sleeve bronchoplasties are full circumferential resection of the involved bronchi and a reconstruction with an end-to-end anastomosis. This is our preferred type of resection for oncological and technical reasons.

We routinely perform a video-mediastinoscopy (V-MED) during the same anesthesia immediately before proceeding to the sleeve resection. The V-MED allows mediastinal lymph node staging and clearance but furthermore, full release the main bronchus. This will result in maximal mobilization of the bronchus and ultimately a decrease tension in the anastomosis. It is unadvisable to perform this in a 2-step procedure since, after the mediastinoscopy adhesions between the airway and the hilum will incur.

Surgery starts with a standard lobectomy, keeping the dissection of the bronchus for last. Under bronchoscopic surveillance the proximal and distal bronchial ends are cut-open. Once the specimen is removed, the inferior pulmonary ligament is released to facilitate mobilization of the residual lung. We perform the anastomosis using a 3.0 polydioxanone with a double-needled suture. Two running sutures are performed, one clockwise and one anti-clockwise. While we are performing the suture, we ask the anesthesiologist to leave the bronchoscope in the main bronchus to assure poise between both ends of the anastomose. We use an intercostal muscle flap or pleural flap around the anastomosis to avoid the contact between the pulmonary artery and the bronchial anastomose. It is fundamental to have the appropriate minimally invasive instruments to perform this suture. The need holder must be light and easy to use.

The principles of bronchoplasty reconstruction are the same that in the open procedures: tension free-anastomosis, preserving the bronchial vascularization, using monofilament absorbable sutures (polydioxanone, polyglactin, polyglycolic acid), and knots tied outside the bronchial lumen. Some key factors for this procedure may facilitate the surgery: liberation of the pulmonary ligament to diminish the tension for the anastomosis and reinforcement of the suture with an intercostal muscle flap, pericardial fat or pleural flap. The anastomosis can be performed either by interrupted, running sutures or both. Diameter discrepancies between the two ends are best managed by careful spacing of the sutures. It is important to check for air leak before adding a patch (*Figure 1*).

U-VATS and chest wall resection

This is a hybrid approach in which the lung resection is performed through the uniportal access and the chest wall resection is performed through a limited thoracotomy under direct vision (6).

Clinical indication

The primary indication is a lung tumor that invades the chest wall, ideally limited to 4 or fewer ribs. Patients with larger tumors or mediastinal lymph node involvement are

Figure 2 Lung and chest wall resection (16).
Available online: http://www.asvide.com/article/view/23528

Figure 3 Right pneumonectomy (17).
Available online: http://www.asvide.com/article/view/23529

not suitable candidates for this approach (14,15). Pancoast tumors should be considered differently.

Technique

We perform the anatomic lung resection and the lymphadenectomy through the U-VATS. Once the specimen is only attached to the chest wall, we delimitate intra-pleural the macroscopic margin of resection of the chest wall. The thoracoscopic view confirms where the tumor invades the chest wall hence where the thoracotomy should be performed. Combining both external and internal views, the surgeon dissects directly above and below the ribs included in the specimen to achieve an oncologic resection. Rib shears, endoscopic rib cutter, rotary burrs or even Gigli's saws are some of the instruments used. However, no rib retractors are necessary. Reconstruction of the chest wall with a mesh can be performed although it should be analyzed case by case. When the tumor is just below the scapula or when only one or two ribs are involved, the reconstruction may not be necessary (*Figure 2*).

U-VATS pneumonectomy

Clinical indications

- Lung cancer that involves all the lobes or with transgression of the interlobar fissures.
- Endobronchial spreading either directly by the lung cancer or lymph nodes that does not allow a bronchoplastic procedure.

Technique

Right pneumonectomy

The procedure is performed through a single 5 cm incision, at the 5th right intercostal space anteriorly. Once the resectability is confirmed, through the absence of malignant pleural effusion or pleural metastases, we start to dissect the pulmonary hilum. Primarily, our strategy is to control the right pulmonary artery. To achieve this goal, we start releasing the anterior trunk from all adhesions and, subsequently divided with a stapler device and a vascular load. Next we recommend dissecting the superior pulmonary vein; however, the right upper lobe vein is dissected separately. This maneuver allows a safer and wider dissection of the right upper lobe pulmonary vein and a safer control and transection with the stapler. Once this vein is transected, the right main pulmonary artery is widely exposed which allows a secure dissection. The sole structure behind the artery is the airway, which allows a safe dissection and transection with the staple. The middle lobe vein and the inferior pulmonary vein are the two last vascular structures. Due to the straight angle between the incision and the middle lobe vein we recommend individual control and transection. This will reduce the chances of tearing. The main right bronchus is the last structure to be managed. After full dissection, with a caudal traction a bronchial stapler load is used for transection. All care is taken to avoid a long bronchial stump. In lung cancer cases, radical lymphadenectomy is routinely performed (*Figure 3*).

Left pneumonectomy

The incision and initial evaluation is performed in the same way that previously described for the right pneumonectomy.

Figure 4 Lobectomy post-chemotherapy/large tumors (20). Available online: http://www.asvide.com/article/view/23530

Again, our primary objective is to control the main pulmonary artery. We begin the dissection opening the mediastinal pleura in front of the hilum and between the pulmonary artery and the superior pulmonary vein. The dissection is carried out around the pulmonary artery to release all the adhesions between the artery and the superior pulmonary vein, and between the pulmonary artery and the aorta posteriorly. With a long right angle, the artery can be safely encircled. It is very important not to put pressure over the artery and to dissect towards underneath the aorta. Once the pulmonary artery is encircled, it can be transected with a vascular stapler. The remaining of the procedure becomes much less demanding. Both veins are dissected away from the hilum and divided with a vascular stapler device. At last, the main left bronchus must be fully dissected in all directions until the main carina and can be stapled under traction. This decreases the chances of having a long bronchial stump.

The surgeon should always have a few tips in mind to facilitate this procedure:

(I) Intra-pericardial dissection allows better oncological margins and a safer resection of the vascular structures in very central tumors.

(II) Protecting the bronchial stump is advisable to reduce the risk of bronchopleural fistulas mainly on the right side.

U-VATS for large tumors or post-induction treatment

VATS lobectomy has been proven as a valid approach in patients that have undergone induction chemotherapy for locally advanced NSCLC (18,19). Also, in tumors with 5 cm or more, this may be a straight forward approach. However, we recognize the conversion rate is higher due to vascular accidents. In our experience, the enlargement of the incision is usually related to the patient's body habitus and not necessarily to the size of the tumor. Like in any other extended U-VATS procedure, it is recommended to have a significant experience in VATS/U-VATS before performing these challenging cases (6).

Clinical indications

For resection of advanced clinical stage NSCLC with tumors greater than 5 cm or in patients with single station N2 disease that received neoadjuvant treatment (18), U-VATS is performed as our preferred approach. All patients are completely staged with CT scan, PET scan, brain MRI and invasive mediastinal staging.

Technique

The inadequacy to perform a lobectomy for larger tumors is the limited mobilization of the affected lobe. Since the lobe is heavy due to the mass, the hilum is in general dissected from anteriorly to posteriorly. Independently of the lobectomy, we try to control the artery first. Eventually, we will control the main pulmonary artery proximally and distally first, and then proceed with the resection. This maneuver may prevent major bleeding.

The delicate step in a lung resection after induction chemo/radiotherapy is the vascular dissection due to inflammation, adhesions and fibrosis surrounding the vascular and bronchial structures. In fact, the procedure is the same as a conventional lobectomy however in this case, we always perform the mediastinal lymphadenectomy first. This allows proper oncological staging and facilitates the vascular and bronchial dissection. Due to the higher risk of vascular accident, it is important to acquire strategies to avoid and protect the vessels. The intra-pericardial dissection and the control of the main pulmonary vessels are some of the classic maneuvers to avoid accidents (*Figure 4*).

Conclusions

U-VATS is an excellent oncological technique in thoracic surgery. Over the last five years its acceptance has increased considerably. Several series form high volume centers have validated the U-VATS approach as an optional approach

for anatomic lung cancer resection in locally advanced NSCLC. Surgeons interested in this technique must be perseverant and dedicated to achieve the learning curve and then progress to more complex cases.

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None.

Footnote

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

Informed Consent: All participants gave informed consent before taking part in this work and included in their clinical record.

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