

# Multiportal video-assisted thoracic surgery, uniportal video-assisted thoracic surgery and minimally invasive open chest surgery—selection criteria

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**Abstract:** Thoracic surgery started the path to minimally invasive surgery over a hundred years ago, with the first thoroscopic procedure performed by Jacobeus in 1910. Interestingly, these first procedures were performed using a single port approach and were used for diagnostic and minor procedures only. For a long period of time, the progress for minimally invasive thoracic surgery was considerably slow until the early 90s, when video assisted thoracic surgery started to be used for major pulmonary resections. Since then, video-assisted thoracic surgery (VATS) had a widespread use around the world and an ongoing search for a less invasive procedures evolved into uniportal VATS. Now, thoracic surgeons have a variety of choices for minimally invasive thoracic surgery and must be trained in these approaches to keep up with the evolution of the specialty and be up to date with the recommended treatments for diseases needing surgical intervention. The approach chosen by each surgeon is a matter of preference, while keeping in mind certain characteristics specific to the pathology and patient to be treated, the level of training of the surgeon, and the healthcare resources available. As more evidence is collected, the choice for video-assisted procedures, which have currently been proven safe, effective, less invasive and, in general, show good results, will prevail.

**Keywords:** Video-assisted thoracic surgery (VATS); uniportal video-assisted thoracic surgery (uniportal VATS); lobectomy; minimally invasive thoracic surgery (MITS)

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## Introduction

Thoracic surgery has evolved continuously into a less invasive approach. As a result of this continuous progress, various techniques have been developed, which allow performing safe and effective procedures with minimal trauma to the patient. The first steps were taken by Jacobeus over 100 years ago, performing these types of surgeries mainly for diagnostic purposes (1). For many decades, a minimally invasive approach was selected only for

minor procedures and it wasn't until the early 90s that video assisted thoracic surgery was developed and used to perform major pulmonary resections (2).

Since then, the speed of evolution for this technique has increased significantly, pushed by thoracic surgeons in search for a less invasive approach and technological advances, providing better instruments, cameras, and hemostatic devices that make this process more manageable for all involved (3).

Minimally invasive thoracic surgery (MITS) can be

divided into two major groups: minimally invasive open chest surgery [mini thoracotomy, hybrid video-assisted thoracic surgery (VATS)] and pure video assisted thoracic surgery (multiportal and uniportal VATS).

Nowadays, it is not a matter about if a minimally invasive approach is better for patients but rather about which approach to choose to offer the optimal care for every patient. Each approach has its own benefits and which to select must be tailored to the surgeon, patient and disease.

VATS is no longer a novelty or a trend, it is well-established and possibly the standard of care for many thoracic diseases requiring surgery. It has been proven that it enhances recovery, reduces pain (4), minimizes postoperative complications, and shortens the length of hospital stays (5).

Currently, the thoracic surgeon should be able to train for and adopt a VATS approach and the question that is going to be faced is which VATS approach should be adopted. Should it be dealt in a step wise manner beginning with mini thoracotomy, hybrid VATS and then develop a pure VATS approach, starting with three port VATS and progressing through until finally arriving to a uniportal approach? Or should the surgeon select any of the approaches from the beginning and train to perfect it?

The purpose of this article is to evaluate the different techniques available for minimally invasive thoracic surgery and the different factors that surgeons should consider in the process of developing any of them.

### **Minimally invasive open chest surgery**

Muscle sparing thoracotomy (MST) and hybrid VATS (combines muscle sparing thoracotomy and video assistance) can be included in this group. Both are performed with some degree of rib spreading, representing the major difference with pure VATS. Varying criteria exists regarding the length of a mini thoracotomy, but it is usually between 4 and 10 cm. Some authors even suggest that incisions larger than 6cm, without rib spreading, should be considered an open procedure or a hybrid VATS (6).

In MST, surgery is performed with direct visualization and dissection is done directly through the incision, allowing for direct palpation of the tissues. It offers the advantage of a smaller incision and, perhaps, it serves as a good transition procedure for the surgeon beginning the path to minimally invasive surgery, but his majority of cases are still being performed through a posterolateral thoracotomy.

Hybrid VATS, a term describe by Okada, combines direct and thoracoscopic visualization and allows hand maneuvering dissection (7). It serves as an option when complex cases are challenging for pure VATS or for those where surgeon is not comfortable with a VATS approach, such as large tumors, fused lymph nodes at the hilum or diffuse, thick adhesions.

One of the benefits of these techniques is that it can be used as a bridge from conventional thoracotomy to VATS surgery, allowing the surgeon to get used to working in a smaller surgical field and thoracoscopic visualization without losing direct hand dissection. The contrary also applies, as they can be used as conversion techniques for VATS procedures that result technically challenging.

The key benefit of these techniques is that the surgeon is able to directly palpate the structures, which results very useful in cases of lymph nodes fused to vascular structures, lung cancer with prior neoadjuvant therapy or tuberculosis, in which the dissection plane is difficult to find and sometimes can only be “felt” in order to find it.

Both serve as a good choice for centers with a restricted budget, as almost all the procedure is completed through manual maneuvering (dissection, ligation, suturing), hence the need of surgical staplers, and clips is usually avoided, significantly reducing costs. (8)

Both, MST and Hybrid VATS can be selected by surgeons starting their path in minimally invasive surgery and have a strong background in open surgery, allowing a friendlier transition. Bronchial and vessel suturing are technically less demanding through this approach, which could make it preferable for surgeons without extended experience in VATS suturing in high-volume centers.

### **Video assisted thoracic surgery**

Procedures in this group are performed through one (single port VATS) or multiple incisions (multiport VATS), but all of them are completed without rib spreading and visualization is done only with the thoracoscope. Different VATS techniques can be used for surgery of similar conditions and it is up to the surgeon to choose the best suited approach. Additionally, there are other factors that can influence the decision and choice of technique is up to the surgeon's discretion.

### **Surgeon-related factors**

At the present time, many active thoracic surgeons have

a strong background in open surgery procedures prior to starting with VATS approaches. Nonetheless, as time passes by and VATS becomes the standard approach for most thoracic conditions, many of the thoracic surgeons will have a stronger background with VATS than with open surgery. This same trend has already occurred in general surgery (9) and it is probably the most likely path in the surgical field, as more advances in technology become more widely available. The familiarity of a surgeon with a certain VATS approaches depends on many factors, but a key factor is the technique used in the center where they complete their residency. The technique surgeons are taught will be the one they will prefer to use in their first solo cases or when facing with complex surgical situations.

Since multiportal VATS has been around for more than 20 years (2,10), it is logical that most thoracic surgeons began their experience with this approach and are more acquainted with this technique. Even the most experienced uniportal surgeons began their journey in minimally invasive surgery with the three and two port technique before progressing to major pulmonary resections with a single port approach (5,11). This is usually the recommended path for surgeons that start a VATS program and it is advisable to gain experience with minor and major procedures with multiportal VATS before progressing to uniportal techniques.

The increase in experience gained using uniportal VATS around the world has resulted in many surgeons making a direct transition from open surgery to uniportal VATS, showing that prior experience in multiportal VATS is not an absolute requirement for surgeons. Some surgeons have experienced an easier transition by progressing directly from open surgery to uniportal VATS, as the approach mimics the hand-eye disposition of open surgery and avoids diamond-based dispositions (12,13).

The learning curve for VATS procedures can differ according to various factors, such as individual skills and the volume of cases handled by the center in which the surgeon is training, but it is suggested that surgeons should perform 100 minor procedures with VATS before attempting major pulmonary resections. For VATS lobectomies, the recommended learning curve is 50 cases (14). To date, no study has been performed to determine the learning curve for uniportal VATS lobectomies, but it is likely to be very similar to the one proposed for conventional VATS. It is very important for any VATS surgeon to participate in courses, wet labs, and train in high volume centers to gain experience and perform VATS surgeries safely and

successfully (3,14).

Consequently, the approach selected for each given case will depend entirely on the individual preference of each surgeon and the familiarity, experience, and confidence in performing the procedure that each surgeon has with multiportal or uniportal VATS. It is of uppermost importance that the surgeon feels comfortable and confident while performing any VATS, to avoid unnecessary complications or accidents during the procedure.

Uniportal VATS is gaining a lot of popularity among thoracic surgeons around the globe in part due to that the teaching of this technique has been particularly enhanced by the fact that one of the pioneers, Dr. González Rivas, has been willing to travel around the world in an effort to make it available for almost any thoracic surgeon interested in learning the technique.

### **Disease-related factors**

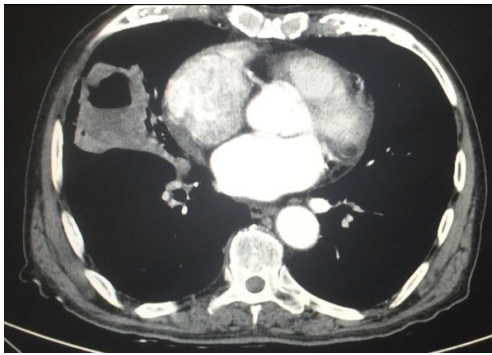
As with every new development in surgery, all techniques must go through a series of steps before becoming a consolidated practice. The first thoracoscopic procedures were only reserve for diagnostic purposes and minor therapeutic surgeries (1,15,16), but as the approach was adopted by different centers and surgical teams around the world, the complexity of cases in which VATS is being use continues to grow and expand, covering the vast majority of thoracic surgical conditions. In present times, multiportal and uniportal VATS has been successfully used to treat benign and malignant conditions, with similar results (17).

### **Benign conditions**

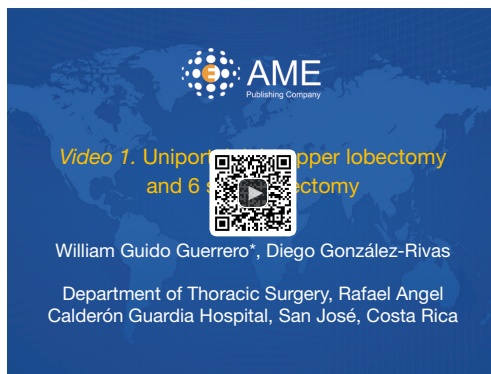
The wide range of benign conditions that can be treated with a VATS approach includes relatively simple procedures, such as pleural biopsies and wedge resection to major anatomic resections.

There are few published studies comparing the results between both techniques, but a best evidence topic by Akter *et al.* concluded that uniportal may offer improved pain scores when compared to multiportal approaches, with no difference in length of stay, drainage, or complications (17).

A meta-analysis comparing the approaches only for primary pneumothorax showed shorter length of stay, lower postoperative pain score, less drainage, and lower incidence of postoperative paresthesia in the uniportal group, although conceding the need for large scale and high



**Figure 1** Middle lobe adenocarcinoma. The picture shows a CT of a tumor with a cavitation and abscess formation and peribronchial lymph nodes that will predict a technically difficult video-assisted thoracic surgery (VATS) lobectomy.



**Figure 2** Uniportal right upper lobectomy and 6 segmentectomy. This video shows a very challenging case with severe and diffuse adhesions, with fibrosis and inflammatory changes around hilar perihilar structures (33).

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quality studies for validation of their conclusions (18). In a prospective study Mier *et al.*, also showed a lower pain score when comparing uniportal *vs.* multiport VATS for minor procedures, although they used SILS device for the uniportal approaches (19).

Regarding major lung resections for benign conditions, such as bronchiectasis, aspergilloma, lung sequestration, even fewer reports addressing the result of VATS have been published. A couple of studies published in 2016 showed the VATS lobectomy was feasible and safe for benign conditions, albeit more challenging given the particularities more frequently associated with benign or inflammatory conditions, such as adhesions and hilar and interlobar

lymphadenopathy. In both studies, a multiportal approach was used (20,21).

Although benign lymphadenopathy represents a challenging condition, experienced surgeons can perform anatomic dissection of lymph nodes and bronchial and vascular structures safely through a uniportal approach (22).

Given the complexity of lobectomy cases that have been published in oncologic conditions having been successfully performed with uniportal VATS, a significant difference in results will not be expected. However, the lacks of studies comparing both approaches limit any conclusion.

For minor procedures, uniportal VATS might be a preferable option, yet for major lung resections for benign conditions, it would depend on the experience of the surgeon with each technique, although VATS is preferable.

### Malignant conditions

For malignant conditions, avoiding pleural, lung biopsies, and palliative procedures, such as VATS pleurodesis for malignant pleural effusion, the therapeutic procedures are usually complex and involve anatomic lung resections for lung cancer with lymph node dissection (*Figure 1*).

In the present time, VATS lobectomy is the recommended procedure for early stage lung cancer (23), given the evidence showing better recovery without compromising oncological results (24-26). It took more than a decade for this evidence to be well established for VATS lobectomy, in relation to the gold standard, which was lobectomy by open surgery. Multiportal VATS lobectomy has been successfully performed in early stage lung cancer and in more complex cases involving sleeve lobectomies and carinal reconstruction (27).

Since uniportal VATS is a more recent approach for major pulmonary resections and has only been around for about 5 years, there is still a lot of road to cover in terms of evidence for the approach to prove it is a better option than conventional VATS (28). However, at this time, it has proven to be safe and feasible, and in the hands of expert VATS surgeons can be used reliably for procedures involving complex cases, including bronchial, vascular and carinal reconstruction (29-32). Challenging cases with diffuse pleural adhesions can be completed with excellent visualization and good control during dissection (*Figure 2*). In terms of safety and feasibility both techniques are well established.

A meta-analysis recently published comparing uniportal



**Figure 3** The picture shows the instrumentation and use of energy devices during uniportal video-assisted thoracic surgery (VATS) surgery.

vs. multiportal, the first one to meta-analyze clinical outcomes, shows that uniportal VATS was associated with a statistically significant reduction in chest tube drainage, in hospital stay, and overall morbidity (34). These results need to be reproduced by other meta-analysis that include more prospective studies and evaluate the results once the learning curve of uniportal VATS is surpassed in multiple centers around the world.

Thus, regarding the matter of which technique to choose for lung cancer and anatomical resections both have proven to be comparable in their results, and the evidence available is insufficient to declare one option as superior (28).

Stating this, there could be some reasons why a uniportal approach might be preferred. The approach to the target lesion is similar to open surgery, only one intercostal space is involved during the surgery, given at least a cosmetically advantage and reduces the possibility of pain



**Figure 4** Picture shows the use of a robotic arm that holds and moves the camera during a uniportal surgery, allowing the surgeon to perform it more comfortable.

in other intercostal spaces and it seems that the advances in technology are facilitating the performance of the surgeon in this technique (articulated staplers, energy devices for hemostasis and dissection (35) (*Figure 3*).

Key points:

- ❖ Minimally invasive open chest surgery:
  - ♦ MST and hybrid VATS could help to provide a friendly transition from open surgery to VATS for thoracic surgeons;
  - ♦ Both techniques represent a good choice for complex cases and center with limited resources.
- ❖ Multiportal and uniportal VATS:
  - ♦ Available evidence suggests both approaches are acceptable and have similar outcomes;
  - ♦ Each surgeon should choose the approach that fit them best and always keep in mind that neither is mandatory always, since numerous factors make every operation different.

## Future and perspectives

The VATS road is far from ending and continues to improve every day, as the search for a less invasive approaches is always in the horizon. In this sense, the thoracic surgeon needs to be aware of the different techniques available, and after thoughtful consideration choose with path to take. Current evidence suggest that VATS procedures have better results than open surgery in term of patient recovery, postoperative pain and in hospital stay, with similar oncological outcomes. In this scenario, pure VATS approaches tend to have a lead, since future developing in technology will focused on making these techniques more feasible and easier for the thoracic surgeon. Therefore, at

least for now, the future seems to be focused on improving minimal invasive surgery and the search for the ideal procedure is far from ending (*Figure 4*).

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## Footnote

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

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