Perspective on uniportal thoracic surgery: where do we stand and what is the future

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Abstract: Uniportal video assisted thoracic surgery (U-VATS) is undoubtedly one of the recent most significant innovation in the field of pulmonary resection. The concept of a single incision, minimally invasive, thoracic procedure moved its first step in the late 90'. In more recent years we had several reports of uniportal surgery for major lung resection, complex surgery and also awake major pulmonary surgery. In this perspective we will try to understand the definitions, the potential benefit, its limitation and the future possible evolution of this relatively novel technique.

Keywords: Uniportal; video assisted thoracic surgery (VATS); lung cancer; lobectomy; microlobectomy

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Introduction

Thoracic surgery is living its second period of enthusiasm towards minimally invasive approaches. Despite video assisted lobectomy is 25 years old its adoption was very uncertain in its first steps.

After the first report, many surgeons raised concern against the safety of this procedure and discouraged its experimentation. Nevertheless, it is undeniable that striving for less traumatic techniques, as long as concentrating on the development of novel techniques themselves and on the basic science research, are the only tools that can take our specialty alive and play an important duty in taking care of patients affected by thoracic oncology conditions. In the context of more attractive and fast developing alternatives for the patients affected by pulmonary malignancy, we have to redefine the role of the thoracic surgeons. As practicing physicians, our daily commitment must be to find different way to perform lung surgery with the goal of a better patients' outcome. This is mainly measured in terms of enhanced recovery and longer disease-free survival. Therefore, working daily on the progress of surgical science itself it should be part of our commitment as scientist.

With this premise, uniportal thoracic surgery is undoubtedly one the most interesting innovation of the last 20 years.

Historical perspectives

Jacobaeus (1) described the use of the thoracoscope for diagnostic and simple therapeutic maneuvers, like adhesiolysis and therapeutic pneumothorax for pulmonary tuberculosis. He is classically referred to as the father of the thoracoscopy. Modern thoracoscopes had an instrument channel that could allow simple maneuvers inside the pleural cavity.

Uniportal surgery was born in the late 90' from the ambitious idea to replace the thoracoscope with a single port: the first attempt to perform surgical procedure through a single port was performed in 1998 by Migliore *et al.* (2). A single trocar technique was successfully applied for the treatment of several conditions and described in 2001. Its principle was to replace the thoracoscope with a single, flexible trocar, which could contain in its lumen a more modern camera alongside one or two operative instruments. This enhanced the movements of the surgical instruments as the only fulcrum was at the chest wall, where the instruments go through the port. They named the procedure 'single-trocar minimally invasive surgery of the chest' (3,4).

Subsequently, in 2004, Rocco *et al.* (5) described a similar

procedure for pulmonary wedge resections and named this approach "Uniportal VATS (U-VATS)". They initially described 15 cases of pneumothorax and lung biopsies for diffuse pulmonary disease.

In this period the term "thoracoscopic" was abandoned in favor of the more modern "video assisted thoracic surgery (VATS)", to underline the use of modern optic systems and distinguish these procedure from the outdated thoracoscopy. We think that, nowadays, this distinction is of little importance and the term VATS, endoscopic and thoracoscopic will be interchangeably used in the rest of this manuscript.

Parallel to the development of U-VATS, other authors developed multi-port minimally invasive techniques for major lung resections. In 1992, Roviaro *et al.* (6) described what is recognized as the first endoscopic lobectomy for pulmonary malignancy. Almost at the same time, in Edinburgh, Walker *et al.* (7) performed the first thoracoscopic lobectomy and described the posterior approach. This, first British experience, applied the principle of the open surgery to a port access technique. There were no other experience and these pioneers' surgeons acted on the basis of what was more reasonable and appeared safer to their eyes. The ports, in the posterior approach, are on the line of a possible postero-lateral conversion thoracotomy. The operator and the assistant stand posteriorly and the camera faces the tips of the instruments which are always under direct view. The conversion to open procedure, in case of severe complications, would have been connecting the three ports together merging in a postero-lateral thoracotomy and making this maneuver faster. All these features, which are actually the opposite of subsequent descriptions of video assisted lobectomy, were intended to maintain the standard of safety of the lobectomy moving to a port, minimally invasive, technique.

Three years later, in 1995 in US, McKenna *et al.* (8) described their innovative approach. They moved the surgeons anteriorly. They underlined the importance of a 30-degree camera and described the utility port. Further two small ports were used respectively for retraction and camera. The utility port is planned according to the anatomy and to the procedure to be performed. It was laterally to the superior pulmonary vein and one interspace lower for middle and lower lobectomy. This will be revolutionized by the Copenhagen group (9) which theorized the standard anterior approach. In their procedure, which received worldwide acceptance, the ports' placement is performed regardless the procedure to be faced. Burfeind and D'Amico (10) reduced the number of the ports, in the attempt to decrease the surgical trauma, and, maintaining the same surgical principles, removed the posterior port.

Is from this, already innovative modification of the VATS lobectomy, that Gonzalez-Rivas *et al.* (11,12) took inspiration to reduce further the number of the port, from two to one port and described the first U-VATS lobectomy. In fact, in the Duke's technique all the surgical instruments are in one port with an additional port for the camera. Moving the camera into the same port of the instruments (utility anterior port) allowed to work in the direction of the view, making the procedure even easier because more similar to the open procedure. The instruments are all in parallel lines and in caudo-cranial perspective which maintain the depth of field's visualization (13) (*Figure 1*).

Essential is to use dedicated uniportal instruments that, with a thinner and longer shaft, can move freely inside the hemithorax, passing through the utility port.

Thorough uniportal technique is possible to accomplish complex procedure (14) and also awake surgery.

In the initial description of uniportal lobectomy the incision is similar to the utility port of the standard anterior approach. In more recent reports the same group demonstrated the feasibility of major pulmonary resection through a subxiphoid single port. A total of 148 cases of major lung resections, lobectomies and segmentectomies, performed adopting this technique were reported in 2016 (15). The subxiphoid port has the advantage to spare completely the intercostal space. It can spread more, as it is not delimited by the ribs, spreading in a circular fashion when used for specimen retrieval. Compression on the intercostal nerves is abolished. The location of the subxiphoid port, at the end of an imaginary projection of the oblique fissures, makes it ideal to perform hilar dissection. This applies even for upper lobectomies or segmentectomies of the upper lobes. The postoperative pain should be significantly less (16), and even when pain is present this should not impede a good cough effort. On the other hand, the dissection of the posterior mediastinum is more difficult and so it is the subcarinal region clearance when adopting a subxiphoid only approach. Of note, to control promptly major bleeding may be more challenging, questioning the safety of this procedure. These problems may be overtaken by the development of dedicated uniportal-subxiphoid instrumentation and learning curve. Also, patient's selection is very important as we experienced that obesity and left ventricular hypertrophy (for left sided procedure) are relative contraindication. As we work in a country where

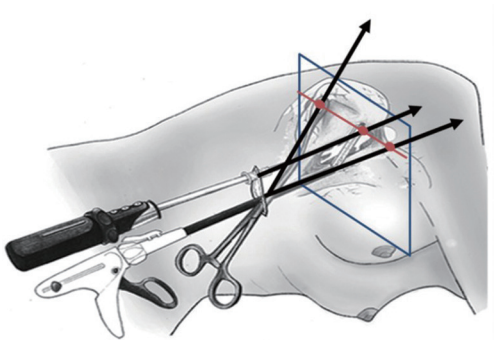

Figure 1 Uniportal VATS for pulmonary lobectomy. The instrumentation works in a parallel line with the camera and this maintains a prospective field (courtesy of Dr. Diego Gonzalez Rivas).

Figure 2 Ports' placement during microlobectomy. The Microlobectomy is an innovative procedure to perform pulmonary lobectomy. The subxiphoid port replaces the utility incision and is used for specimen retrieval and chest drainage. This enhances the postoperative pain avoiding any ribs' spreading. The name refers to the size of the ports used in the intercostal spaces (only 5 mm diameter ports).

obesity is a frequent and severe co-morbidity we did not find this procedure easily applicable on a routine basis.

Future perspectives

Pulmonary adenocarcinoma is the plague of the 21st century and its incidence is increasing. To offer a chance of cure from lung cancer does not mean to have the right to cause irreversible injury to the chest wall, to musculoskeletal function, to teguments and to the self-image. If when undertaking complex arterial or bronchial reconstruction, tracheal, complex mediastinal surgery or transplants, an extensive exposure of the surgical field is still justified, in the routine lobectomy for peripheral, stage I/II, malignancy is mandatory to consider as relevant also other issues: like enhanced recovery, quick return to daily activity and work, which pair with shorter hospitalization and so less post-operative complications. The access to the thorax must not compromise the radicality of the oncologic resection but also the poor quality of life after surgery should not compromise the rest of the patient's life. Even 'open surgeons' moved toward minimally invasive thoracotomy for stage I disease, and some authors sustain to perform a quicker procedure through an incision which is very similar to the utility port of the VATS lobectomist. They may obtain some of the advantages of the endoscopic approach combined with a shorter anesthesia time (17).

In some dedicated, high volume, thoracic centres the open team works alongside and in cooperation with the VATS team, each striving to push the boundaries towards the next achievements. Therefore, the era of conflicts between open and VATS surgeons should really leave place to more modern and more interesting subjects.

If large comparison studies will establish that U-VATS provides improved surgical and oncological outcome for patients affected by early stage lung cancer, this could help to extend the indication to fragile patients and those with poor predicted post-operative pulmonary function. U-VATS already demonstrated to be an option when performing sublobar or parenchymal sparing resection. More elderly patients and patients with poor pulmonary reserve could be surgical candidates in view of the longer survival offered by minimally invasive resection over thoracotomy or over alternative treatments for pulmonary malignancy (18).

U-VATS confers the benefit of injuring only one interspace, but still the wound is very similar to the utility port of the previously described bi-portal and 3-portal approaches. This raised controversy over the definitions of single incision versus single port (uniportal) technique (19). Our group, alongside other institutions, proposed an experimental procedure which eliminates completely the utility port from the hemithorax and, potentially, reduce further the postoperative pain. The key, we suggest, is to use 5 mm ports, only, in the intercostal spaces. These are used for instrumentation and camera with the addition of a 12 mm subxiphoid port for retraction, suction and use of large stapling devices (*Figure 2*). These creates a sealed system

which allows to inflate the hemithorax with carbon dioxide in order enhance the field and facilitate the operation. The subxiphoid port is then enlarged and used for retrieval of the specimen (20).

U-VATS could live a second evolution when this approach will meet robotic thoracic surgery. The advantages of the two techniques, combined in one, could make the difference. Despite some authors raised concern (21,22), the application of the robotic technology for thoracic surgery has clearly some potential advantages (23). This is true especially when performing complex resections, where there is a reconstructive part of the procedure (i.e., oesophageal surgery, sleeve lobectomy, carinal resection) which can be made easier with the aid of the robotic instrumentation. At present, one of the limits of the robot is that a very high number of ports is required. To be able to use the 3D view, the magnification, the dexterity and the filtration of movements into a small single incision has undoubtedly interesting potential. Technology that can realize this project is under development and we are looking forward to perform a "Robotic Uniportal Subxiphoid" lobectomy in the next few months.

Technology will continue to help the evolution of minimally invasive thoracic surgery but not always expensive devices are fated to establish revolutions. A complete mechanical tool was recently developed by surgeons and engineers of the University of Michigan (24) and, if coupled with 3D camera systems, may offers the same advantages of robotic dexterity with less surgical trauma, in view of the 5-mm shaft. This could be used through a 5-mm port or during U-VATS. This tool could easily find application for uniportal complex procedure, and further the number of operations that are feasible by minimally invasive techniques. Due to incredibly low cost, this tool will be accessible to all kind of units. There will be no significant additional learning curve, for a VATS surgeon, in using this device.

Conclusions

We need further comparison studies in order to evaluate the advantages of U-VATS over "traditional" VATS (25). Development of future technology like articulating curved instruments, wireless cameras, smaller sealing devices may open a new era in the therapies of pulmonary malignancy by minimally invasive surgery. Further investigations will establish if the uniportal technique, which cause injury in only one intercostal space, is able to reduce significantly the postoperative pain and so the post-operative complications. Also, long term follows up studies are urgently needed in order to propensity match compare the oncological outcomes of patients treated with the adoption of different surgical approaches. Some advantages brought by U-VATS are obvious in view of the cosmetic outcome and patient's satisfaction.

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Footnote

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

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