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Video-Assisted Thoracic Surgery – State of the Art

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Abstract

Video-assisted thoracic surgery (VATS) is one of the main medical revolutions of the past decade. For its satisfactory performance, the following prerequisites are essential: (1) knowledge and experience in thoracic surgery; (2) team of experienced anesthesiologists; (3) preoperative assessment of respiratory function; (4) adequate postoperative care; and (5) instruments specially designed for thoracoscopic surgery.

VATS is routinely performed under general anesthesia with double lumen endotracheal intubation for separate control of each lung. Insufflation of carbon dioxide must not exceed 1-3 mm Hg. Too high pressure may cause harmful reduction of venous return and mediastinal shift with impairment of ventilation. Presence of adhesions should be determined by finger exploration of the pleural cavity. Operative ports should be placed carefully, avoiding damage to the intercostal nerves and vessels.

The video technique can be used with efficiency for the following indications: pneumothorax, resection of pulmonary nodules, biopsies of lung, pleura and mediastinal structures, resection of mediastinal tumors, management of empyema, and hemostasis and closure of lacerations after trauma. Indications for esophageal procedures include esophagomyotomy for achalasia and resections of benign lesions. Repair of perforated esophagus is a matter of controversy, but in early stages it can be done thoracoscopically. Although video-pericardioscopy has been performed by some surgeons, this procedure can be done easier and faster using the direct approach without the video equipment. There are differences of opinion with regard to major pulmonary and esophageal resections for cancer. The apparent advantage of diminished pain is offset by inadequate resection, spread of malignant cells and potential damage to the resected specimen with loss of important information concerning pathology.

Complications of VATS are few, and include prolonged air leak, dysrhythmia, respiratory failure, bleeding and infection.

Due to progress over the past several years, VATS has become an inseparable part of thoracic surgery and should be included in the basic training of every thoracic surgeon.

Key words: Video assisted techniques, thoracic surgery.

Introduction

The thoracoscopic approach to the diagnosis and treatment of intrathoracic disease was initiated in 1910, when Jacobaeus inserted a cystoscope into the pleural cavity and observed changes in a patient with pulmonary tuberculosis (1). This procedure provided a route for division of pleural adhesions, a prerequisite for therapeutic pneumothorax. In 1948, Kux described thoracoscopic sympathectomy (2), and in 1955, Wittmoser used the same route for a vagotomy (3), followed by lung biopsy and treatment of empyema (4). A decisive breakthrough of endoscopic thoracic surgery came in 1991 with the introduction of video techniques to thoracoscopic surgery (5). Once available, the minimal access route became quickly adopted for extensive use in abdominal and thoracic surgery, resulting in rapid and uncontrolled rise in the number of inadequately trained "minimally-invasive" surgeons (6). Consequently, a marked worldwide increase in the incidence and severity of complications was noted, including vascular injuries, spread of malignant cells and others (6).

Several conditions must be fulfilled, before one attempts to do an operation inside the chest without opening it. *First*, the person performing the procedure must have experience in open thoracic surgery. In the video-assisted thoracic surgery, as of now, the view is two-dimensional, which makes the operation more difficult. An operation started as a minimal access procedure may be impossible to complete without a thoracotomy. Also, thoracotomy may become necessary to treat immediately any complications. For example, bleeding from an injured vessel leaves no time to transfer the patient to a thoracic surgeon in another hospital. The person who did the video-assisted operation must be able to open the chest and to take care of the complications. Accordingly, before starting a thoracoscopic procedure, one must obtain the patient's informed consent for an open thoracotomy. It could be summarized that thoracoscopy *is not* a starting point for thoracic surgery.

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Riassunto

LA CHIRURGIA TORACICA VIDEO-ASSISTITA

La chirurgia toracica video-assistita è uno dei principali metodi rivoluzionari dell'ultima decade.
Per ottenere risultati soddisfacenti sono essenziali alcuni prerequisiti: conoscenza ed esperienza nel settore della chirurgia toracica, un valido team di anestesisti, una valutazione preoperatoria della funzione respiratoria del pazienti, un'adeguata assistenza dopo l'intervento e gli strumenti per la chirurgia toracoscopia.
La VATS avviene abitualmente in anestesia con doppio lume di intubazione endotracheale, per il controllo separato di ciascun polmone. Le aree operative devono essere localizzate con attenzione evitando danni ai nervi intercostali ed alle vene.
La tecnica video può essere utilizzata con efficienza nei seguenti casi: pneumotorace, resenzione di noduli polmonari, biopsia polmonare, pleura e strutture mediastintiche, resenzione di tumori mediastinici, trattamento dell'empiema, emostasi e sutura di ferite dopo trauma.
Indicazioni per trattamenti dell'esofago includono esogagomiotomia per aclasia e resenzione di lesioni benigne. Il trattamenti dell'esofago perforato è causa di controversie, ma ad uno stadio precoce può essere curato con tecnica toracoscopica.
Le complicazioni della VATS sono poche e comprendono prolungata perdita di aria, disritmia, insufficienza respiratoria, emorragia ed infezione.

It is the other way around: one must learn open thoracic surgery first, and only then proceed to video-assisted thoracic surgery (VATS). *Second*, there must be a team of experienced anesthesiologists. *Third*, there must be a complete infrastructure available, with the possibility of preoperative assessment of cardiovascular and pulmonary function and evaluation of any possible risks. *Fourth*, adequate postoperative care is essential. *Fifth*, instruments specially designed for thoracoscopic surgery must be available. The use of unsuitable instruments designed for laparoscopy, but unfit for the chest and improperly modified is unacceptable.

All video-assisted procedures are routinely performed under general anesthesia, with double lumen endotracheal intubation for separate ventilation of each lung. This is absolutely essential. Without separate ventilation of each lung, video-assisted thoracic surgery should not be attempted.

Carbon dioxide is insufflated to create a pressure of 1-3 mm Hg in order to keep the lung collapsed and aid in visualization. Higher pressure should be avoided, as this may lead to a harmful reduction in venous return to the heart and to mediastinal shift impairing ventilation of the contralateral lung.

In patients with emphysema or other causes of air trapping, there may be some difficulty in collapsing the lung. However, this can be overcome by occasional suction on the endotracheal tube, and in most cases, complete lung collapse will be achieved.

For most procedures, a 2 cm incision is made in the 7th intercostal space, just below the angle of the scapula. If possible, the pleural cavity should be explored first with a finger: palpation will determine the presence of adhesions. In children, this may be difficult, but at least exploration with the little finger should be attempted. At this stage, initial thoracoscopy is performed by means of projection on the video screen. After that, additional cannulas can be inserted; one or two, depending on the type and site of the lesion and on the type of operation. Most of the procedures are carried out through three incisions in a triangular configuration. Location of operative ports should be carefully planned to be used either in a thoracotomy (should conversion become necessary) or for placement of pleural drains at the end of the procedure. While ports are inserted, one must avoid damage to the ribs and to intercostal nerves and vessels that could result in intercostal neuralgia or bleeding. It is better to insert additional ports, than to struggle with those that were poorly placed. Once inside, one should handle tissues gently and avoid tears that might lead to bleeding and significant postoperative air leaks. At the end of the procedure, a wide-bore drain should be placed in the pleural cavity.

Indications for VATS

Pneumothorax

This is an important indication for a video-assisted procedure. Therapeutic measures should be employed according to the findings. Most commonly, it will be excision of emphysematous bullae and subpleural blebs, along with pleurodesis. Air leaks must be looked for, particularly at the apex of the lung. If the leak is not easily found, warm saline is introduced into the chest, and the anesthetist inflates the lung. When air bubbles appear, the leaking area is grasped, and the stapler is placed across the base of the bleb and fired. The stapler line must be again carefully examined for any possible air leak (7). Alternatively, instead of using a stapler, the leaking areas can be ligated with endoloops and then excised. We prefer the stapler method. Pleural abrasion is then performed to aid in the formation of adhesions.

Another good method to create adhesions is by insufflation of talc. The solid adhesions caused by talc prevent pneumothorax very effectively. However, a word of caution must be added. Talc is a natural mineral, a rock mined in various geographic regions, and its contamination with asbestos must be seriously considered. Asbestos is a known carcinogenic agent and has been implicated in the etiology of mesothelioma and of bronchogenic carcinoma. Therefore, medicinal talc used for pleurodesis must be free of asbestos fibers. Pure talc, free of asbestos does not cause

cancer. The talc used in our medical center is produced according to the requirements of the British Pharmacopoeia (Tab. I). It is mined in Italy and is imported to Israel by Frutarom, Inc. It is guaranteed to be free of asbestos. For additional safety, we have it tested periodically in the electron-microscopic laboratory (8, 9). In order to avoid excessive pleural fibrosis, no more than 2 grams of sterile iodized talc should be lightly sprinkled over the entire lung surface. Even distribution of talc is assured by changing direction of the cannula, until every part of the lung has been treated.

Tab. I – TALC: MAXIMUM LIMITS OF IMPURITIES

Alkalinity	2 ml HCL	N/10%
Iron (Fe)		0.004%
Acid-soluble matter		1.0%
Water-soluble matter		0.2%
Loss on drying		1.0%
Loss on ignition		6.0%

Resection of pulmonary nodules

The nodule is identified by means of inspection and instrumental palpation, then grasped with forceps inserted through a second port. Through a third incision, the endo-GIA stapler is inserted and is fired as many times as needed in order to achieve a wedge resection of the nodule, with some normal lung tissue around it. The lung is then allowed to expand.

Pulmonary, pleural and mediastinal biopsies

After exploration, a wedge lung biopsy is taken using a stapler. For biopsy of pleural or mediastinal lesions, we use biting forceps with a cutting edge. Electrocoagulation is used for hemostasis.

Mediastinal tumor resection

Under video control, the mediastinum is thoroughly investigated. Ring forceps and other grasping instruments are used for traction, electrocoagulation and gentle pushing for dissection. If the tumor cannot be recovered through a port incision, an additional minithoracotomy incision may have to be made, for manipulation by hand.

Thoracoscopic management of empyema

Empyema in the fibrinopurulent stage requires thorough debridement. Adhesions must be divided and loculations must be broken, until all closed spaces are eliminated. The pleural cavity is thus converted into one space. Any remaining "peel" should be dissected off the lung surface, to enable its complete expansion. Presence of air leaks is checked by flushing the space with sufficient amount of warm saline, while the anesthesiologist should be inflates the lung. At the end of the procedure, all remaining liquid is evacuated and drainage tubes are placed in the most dependent position. Empyema in the organizing stage with fibrous tissue firmly adherent to the lung cannot be managed at VATS. Such attempts in the past have been unsuccessful. Empyema at this late stage should be treated by decortication at open thoracotomy (10, 11, 12).

Thoracoscopy for trauma

All blood and blood clots should be flushed out using warm saline and suction. Following evacuation of blood, the pleural cavity must be thoroughly inspected to identify any bleeding points and lacerations of the lung parenchyma and diaphragm. Bleeding points are usually controlled using coagulation or clips. Lacerations are either sutured or approximated with clips. Closure of diaphragmatic tears must be meticulous and should be done patiently. Hurried closure of diaphragmatic tears invites future diaphragmatic hernia with possible incarceration (13).

Esophageal procedures

These can be divided into three groups. The first one comprises clearly indicated VATS operations, such as fundoplication, esophagomyotomy for achalasia and resections of benign lesions (e.g. leiomyomas) (14, 15). The video approach for these indications offers unquestionable advantages over conventional open thoracotomy. Excessive trauma and pain are avoided, and time and cost are saved while the purpose of operation is not compromised. The indications in the second group are relative and include early perforations of the esophagus. Using the video or the open approach depends on the stage of perforation and the amount of damage to the esophagus. Perforation with minimal damaged caused by endoscopic manipulation or a foreign body, can be managed within the first 24 hours using the video approach. Beyond this early period, and for perforations involving extensive damage, open thoracotomy with wide drainage is necessary and VATS should not be attempted. The third group involves VATS resections of the esophagus, particularly for cancer. This group is highly controversial and, in my opinion, doubtful. These operations have be recommended by several groups of surgeons (16, 17). However, multi-institutional clinical trials are underway to evaluate the endosurgical staging of carcinoma of the esophagus and VATS should not be

considered a standard approach until those trials are completed (18). Until then, I recommend conservatism.

Major pulmonary resections for cancer

The most controversial point concerns the use of VATS for therapeutic resections of lung cancer. Studies conducted by Landreneau and associates in the United States (19) and by Monson in the United Kingdom have shown that one year after the operation, there was no difference in pain between open thoracotomy and those following VATS. In addition, the short-term benefits of less pain might be at the price of long-term problems. These included recurrence of cancer on account of a less radical non-anatomic wedge resection or incomplete nodal staging (20), or due to spreading malignant cells while struggling to remove the specimen through a port-hole incision. There are more and more reports on chest wall tumor implants (21) and on major bleedings (22), which could be easily avoided, had the chest been open from the beginning. And, of course, while the specimen is being removed through the port-hole, usually by force, much damage can be done to it, frequently with loss of important information about its pathology. To prevent all these scenarios, the "half open" technique has been developed, which means a small thoracotomy, but then the advantages of thoracoscopic surgery can hardly be recognized. A question thus comes to mind: is it really important to resect a lobe without the routine thoracotomy incision? Indeed, there are some clear-cut contraindications to video-assisted lobectomy, and they include T_3 tumors, endobronchial tumor seen at bronchoscopy, positive cervical mediastinoscopy, centrally located tumors and lobar and hilar nodes adherent to pulmonary vessels. In any case, the video-assisted lobectomy should be limited to Stage I non-small cell lung cancer.

Video-assisted lobectomy can be done for benign lesions, such as bronchiectasis, if fissures are complete and anatomy is favorable. There are obvious advantages to the utility, safety and versatility of video-assisted lobectomy, but they should not obscure the potential hazards of summarily substituting it for every lobectomy. Some are better done the open way.

Pericardioscopy and pericardial window

The video access has also been used for pericardioscopy and creation of a pericardial window (23). This is unnecessary. In view of the efficacy of the subxiphoid approach, I see no reason why one should use the video equipment, a double lumen tracheal intubation and the lateral decubitus position. Pericardioscopy with creation of a window can be done easily through the subxiphoid approach, with the patient in supine position, through a small incision, using a single lumen tracheal tube and a simple mediastinoscope. The procedure is safe and the exposure excellent.

The advantages of VATS over the standard thoracotomy include size of the incision, shorter operative time, preservation of pulmonary function, less postoperative pain, earlier mobilization, reduced hospitalization time, earlier return to work and avoidance of postoperative scar. In addition, with the enlarged field and use of angled optics, the view is better.

The disadvantages of the video approach include the two-dimensional video screen, lost possibility of palpation and potential spread of malignant cells. Difficulty with retrieval of large specimens may cause damage to the specimen with loss of important pathologic information. This can be avoided by additional incision, which, however, defeats the purpose of VATS. To compensate for these disadvantages, the surgeon's wide experience is essential.

Complications of VATS are few and include prolonged air leak, dysrhythmia, respiratory failure, bleeding, infection and pleural effusion.

In conclusion, VATS has been shown to be a safe, extremely useful and progressive method, applicable both diagnostically and therapeutically. Its pendulum is swinging both sides, perhaps too far at times. However, VATS has been established already as an integral part of thoracic surgery and should be included in the basic training of every thoracic surgeon.

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