An update on anesthesia for thoracoscopic surgery

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Purpose of review

The surgical management of patients partly determines the anesthetic management. A shift has taken place in thoracic surgery, with a large portion of procedures now being performed through a video-assisted thoracoscopic surgery (VATS) approach. This review is intended to provide the anesthesiologist with an update on the management of thoracic surgical patients presenting for VATS.

Recent findings

Although there are cosmetic and economical advantages to the VATS approach, large randomized controlled trials are still lacking documenting the benefit of VATS versus conventional 'thoracotomy'. The classic division in abs\olute and relative indications for one-lung ventilation (OLV) should be viewed as antiquated. All VATS procedures represent an indication for OLV. A better classification is to divide the purpose of OLV: separation versus isolation. Treatment for hypoxemia during OLV also needs to be modified. Patient expectations are also different as a minimal invasive approach is often falsely associated with minimal risk. This leads to an additional stress factor imposed upon the anesthesiologist.

Summary

Minimal invasive VATS is gaining widespread popularity among our surgical colleagues. The anesthesiologist must recognize the impact that this change in surgical philosophy will have upon the anesthetic management of these complex patients.

Keywords

double-lumen tubes, minimally invasive surgery, one-lung ventilation, video-assisted thoracoscopy

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Introduction

Over the course of the last two decades, both cosmetic and potential medical benefits have driven many surgical subspecialties towards 'minimal invasive surgery'. Thoracic surgery is no exception. The last few years have seen a shift taking place with more thoracic procedures being performed in a minimal invasive fashion than ever before. Although the cosmetic benefits drive many patients to request video-assisted thoracoscopic surgery (VATS), as physicians, we have an obligation to ensure that any change from a proven technique is in the overall best interest of the patient. Questions, such as the ability to achieve the same end result, degree of safety and, for cancer patients especially, the ability to perform an oncologically sound operation, have been raised and require an answer before minimal invasive surgery can be considered a substitute for the conventional 'open' approach. Without doubt, the 'VATS' approach shows benefits in regards to postoperative pain and economics, with data depicting reduced pain scores, improved pulmonary function, length of chest tube placement and length of hospital stay [1–4]. However, only a few articles compare VATS with open surgery in a randomized controlled fashion in regards to safety and oncological outcome.

As the surgical management of these patients will partly determine the anesthetic management, it is imperative for the anesthesiologist to become acquainted with minimal invasive surgical techniques. This article will review the literature and provide the reader with an update on the current role of the anesthesiologist involved in the care of patients presenting for VATS.

Indications

The first utilization of thoracoscopy to treat illnesses within the chest cavity was reported in 1910 by the Swedish physician Jacobaeus [5]. This technique was used primarily to treat tuberculosis-induced pleural effusions. After the introduction of tuberculostatics, this surgical approach was practically abandoned until the early 1990s when advancement in fibro-optic light transmission, image display and instrumentation made VATS possible [6,7]. Although initially used only for simple

Table 1 Indications for video-assisted thoracoscopy

Diagnostic	Therapeutic
Pleural disease	Pleural disease
Thoracocentesis	Pleurodesis
Tuberculosis	Decortication
Staging	Empyemectomy
Lung cancer	Parenchymal disease
Mesothelioma	Wedge resection
Esophageal cancer	Lobectomy
Parenchymal disease	Pneumonectomy
Interstitial fibrosis	Blebectomy
Solitary nodules	Lung volume reduction
Mediastinal tumors	Pericardial disease
Metastatic	Stripping, window
Lymphomas	Mediastinal disease
Pericardial disease	Thymectomy
Biopsy	Chylothorax
Effusions	Esophageal surgery
	Vagotomy
	Heller myotomy
	Antireflux procedures
	Sympathectomy
	Hyperhidrosis, RSD
	Spinal surgery
	Minimally invasive valve and coronary artery procedures

RSD, reflex sympathetic dystrophy.

procedures of the mediastinum, pleura and lungs, thoracic surgeons are now performing very complex surgical procedures, such as lobectomies, through a VATS approach. Table 1 provides an overview of which procedures can be performed by a VATS approach today.

Numerous case series can be found in the literature showing the efficacy and safety of VATS for complex surgeries [2,3,8,9•,10••,11]. Unfortunately, there are only a few randomized trials comparing VATS resections to conventional 'open' thoracotomy. These trials have not been able to show a benefit in regards to survival; however, there tended to be a higher rate of complications in the 'thoracotomy' group [12,13].

Anesthetic implications

The choice of anesthetic technique is variable and dependent upon the wishes of the patient and the experience level of the clinician. Whereas simple diagnostic procedures can be performed under local anesthesia by infiltrating the chest wall accompanied by light sedation, more complex procedures that require sampling of tissue are best done under regional (epidural, intercostal blocks) or general anesthesia. The main disadvantage of local and regional anesthesia is that the patient is required to breathe spontaneously. Although this is generally tolerated for brief periods of time, most VATS procedures today are performed under general anesthesia utilizing one-lung ventilation (OLV) techniques, which provide better exposure and guarantee a secure airway in the lateral decubitus position.

One of the hallmarks that define thoracic anesthesiologists is their in-depth understanding and management of difficult airway scenarios. Historically, most textbooks divided the indications for OLV into two groups (absolute and relative). Although this was true for most circumstances in the pre-VATS era, contemporary practice of thoracic anesthesia mandates a different approach. We believe the terminologies lung isolation and lung separation better define the expectations that are imposed upon the anesthesiologist. Lung isolation includes the classical absolute indications for OLV, such as massive bleeding, pus, alveolar proteinosis or bronchopleural fistula. The goal here is to protect the nondiseased contralateral lung from contamination. Lung separation, on the contrary, presents with no risk of contamination to the dependent lung and is performed primarily to improve surgical exposure. VATS for diagnostic and therapeutic procedures, which require a well collapsed lung, should be included in the latter category. OLV is equally important in both groups, as clinical practice shows that the inability to completely deflate the nondependent lung during VATS leads to poor surgical exposure, which, in turn, can jeopardize the success of the procedure, potentially requiring conversion to an open technique.

Equally important is to note that prior algorithms used to improve oxygenation during OLV cannot be used during VATS. The application of continuous positive airway pressure (CPAP) by oxygen insufflation to the nondependent lung represented an attractive maneuver to treat hypoxemia during OLV in the open thoracotomy patient. Unfortunately, the application of CPAP is poorly tolerated during VATS because of the obstruction of the surgical field by the partially inflated lung. Alternative methods, such as the application of positive end-expiratory pressure (PEEP) to the dependent lung, recruitment maneuvers or intermittent inflation of the nondependent lung, should be employed.

The scope of most thoracic anesthesia practices today will show that there is an increased need for meticulous OLV. At our institution, approximately 80% of all thoracic surgical procedures are initiated or performed entirely by VATS. Of these procedures, the majority require lung separation and only a small fraction require lung isolation.

The use of double-lumen tubes (DLTs) has classically been considered the 'gold standard' for achieving OLV. Only recently though a study was conducted by Narayanaswamy *et al.* [14••] that showed that in 100 patients undergoing left-sided lung surgery, in regards to quality of surgical exposure, there was no difference found between the use of bronchial blockers (Arndt wire-guided, Cohen Flexi-tip, Fuji Uni-blocker; Cook Critical Care, Bloomington, Indiana, USA) and a left-sided DLT

(Mallinckrodt Medical). However, significant differences were found favoring the use of DLTs in regards to time to initial lung deflation and amount of repositions required after initial placement of the lung isolation device. The conclusion of the authors was that these three bronchial blockers provided equivalent surgical exposure to left-sided DLTs during left-sided open or VATS procedures. Consequently, as most VATS procedures require lung separation and not isolation, the insertion of a bronchial blocker to obtain OLV is an attractive alternative to a DLT, especially as multiple intubations of the trachea will not be necessary when using a bronchial blocker. Additionally, the incidence of difficult intubation is much higher when using a DLT.

Although the use of mechanical ventilation is an absolute indication in an anesthetized, paralyzed patient, it is not without risks and side effects. It is well established in the critical care population that large tidal volumes (12–15 ml/kg) and excessive airway pressures can lead to lung damage [15]. The term ventilator-induced lung injury (VILI) is frequently used to describe alveolar damage that is caused by excessive stretch mechanisms during mechanical ventilation that in turn leads to an inflammatory response, which perpetuates a vicious cycle of systemic inflammation and end-organ damage [16]. Protective ventilation strategies utilizing low tidal volumes (6 ml/kg) and PEEP have been shown to improve survival in patients with the acute respiratory distress syndrome (ARDS) [17]. Evidence is also available to support the use of lung protective strategies in patients with normal lungs. Esteban *et al.* [18] found in a large observational study that patients who were ventilated with plateau airway pressures greater 35 cmH_2O had increased 28-day mortality rates when compared with those who did not. A recent study by Garutti *et al.* [19•] showed that the mode of OLV (pressure controlled versus volume controlled) did not affect arterial oxygenation during OLV or during the early postoperative period as long as a tidal volume of 8 ml/kg was applied. The question, however, as to what tidal volume should be used during OLV is still open and requires further investigation.

The controversy surrounding the use of either inhalational or intravenous anesthesia for OLV procedures persists, and much has been debated about this topic. Although work published in the 1980s was able to make a clear association between the blunting of hypoxic pulmonary vasoconstriction (HPV) and inhalational anesthetics in rat lungs [20], a recent meta-analysis by Bassi *et al.* [21•] was unable to demonstrate a benefit of one technique over the other in humans. A study published by De Conno *et al.* [22•] showed that patients receiving the volatile anesthetic sevoflurane during OLV expressed lower levels of inflammatory mediators than patients receiving a target controlled infusion of propofol. This study is remarkable because it was not only able to show a difference in levels of inflammatory mediators but also an improvement in clinical outcome in the sevoflurane group.

Monitoring

Owing to the fact that the majority of these patients will receive general anesthesia with some form of OLV, the insertion of an indwelling arterial catheter is strongly advised. Although the utility of invasive blood pressure monitoring and intermittent sampling of arterial blood gases (ABGs) can be debated in patients in otherwise good overall physical condition [American Society of Anesthesiologists (ASA) I–II] and short procedure times (<30 min of OLV), the majority of patients presenting for VATS will not fall into either of these categories. A potential for injuring vital intrathoracic organs is constantly present requiring rapid identification and treatment. During periods of OLV, an obligatory right–left shunt will persist despite compensatory mechanisms (e.g. HPV). Noninvasive pulse oximetry can provide the clinician with important information; however, false readings, especially in the setting of poor peripheral perfusion, can limit the utility of this technology. With point of care testing becoming readily available in the operating room setting, intermittent ABG sampling to confirm noninvasive pulse oximetry readings provides an additional layer of safety for the patient.

As previously stated, VATS procedures carry the same risks related to any form of intrathoracic surgery; however, if massive hemorrhage occurs, the surgeon is often unable to easily gain control of large vessel bleeding without converting to an open thoracotomy. Maintaining stable hemodynamics, while the surgeon performs a thoracotomy, is extremely challenging and mandates the placement of large bore intravenous catheters prior to the start of the procedure. Consequently, having well functioning intravenous access is even more critical for VATS procedures than for open thoracotomy, for which achieving control of the hilar blood vessels is generally easier.

In patients in whom peripheral venous access is difficult or cardiovascular comorbidities are present, central venous access is recommended for rapid volume resuscitation and for the central administration of vasoactive medications.

Postoperative analgesia

A commonly cited advantage of VATS when compared with open thoracotomy is a reduction in postoperative pain [1,2]. Although this is true in a relative sense, VATS procedures are still associated with a significant amount

of postoperative pain, that is, not only disturbing to patients but may also be associated with pain-related morbidities and prolonged hospital stays [23,24].

Thoracic epidural analgesia has a long track record of efficacy and safety and is considered the gold standard in pain relief by many anesthesiologists during the postoperative period for the thoracic patient [25,26]. Although other forms of postoperative analgesia are possible, many are associated with unwanted side effects. Systemic opioids are respiratory depressive and inhibit the cough reflex. Nonsteroidal anti-inflammatory medication can inhibit coagulation and in isolation, does not suffice to control the immediate postoperative pain experienced by this patient population. The utilization of paravertebral blocks has shown promise as an alternative to epidural analgesia [27••].

Increased level of stress for the anesthesiologist

A false assumption that is made by patients coming for minimal invasive surgery is that the perioperative risk will also be 'minimal'. VATS is frequently described to the patient and their family as a 'simple three-hole' entry into the chest. Although, as previously stated, VATS is associated with improved healing, lung function and shorter hospital length of stay, by no means should one be lured into thinking that the procedure is any less invasive than an open thoracotomy.

Diagnostic VATS procedures are being increasingly performed on ASA III–IV patients, who historically would have been classified as inoperable using an open approach. A typical example would be a patient on the cardiac transplant list who needs a pretransplant tissue diagnosis of a lung lesion seen on a preoperative chest radiograph.

Consequently, very ill patients requiring flawless lung separation techniques, who expect an uneventful perioperative course, pose a tremendous burden of psychological stress upon the anesthesiologist.

Complications

In a large series published by Shaw *et al.* [9•], atrial fibrillation (10%) was the most common complication seen in 180 patients after VATS. Air leak (7.2%), followed by pneumonia (2.0%), respiratory failure (2.0%), empyema (1.3%) and deep venous thrombosis (0.7%) were additional complications reported by the investigators.

Conclusion

The field of thoracic surgery is dynamic and constantly evolving. A shift to video-assisted surgery is clearly taking place. Although certain procedures have gone out of favor due to unexpected disappointing results (e.g. lung volume reduction surgery) [28], other areas are rapidly embracing this technology. Electrophysiologists are using VATS to isolate the pulmonary veins in the hope of achieving improved results in the treatment of chronic atrial fibrillation [29]. As anesthesiologists, we must stay in tune with developments occurring within the field.

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References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

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- •• of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 116).

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