Review Article

Role, benefits and limitations of non-intubated anesthesia in thoracic surgery

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Abstract: Non-intubated video-assisted thoracoscopic surgery (NIVATS) is rapid growing in recent decades. Firstly the rationale of NIVATS was focused on avoidance of the adverse effects of excessively deep anesthesia, tracheal intubation, controlled ventilation, and residual muscle relaxation, particularly in patients with chronic respiratory failure or other comorbidity. Because NIVATS was proven feasible and safe with superior outcomes and lower costs, it has been increasingly advocated as an alternative for patients with a low risk for GA and the use of conventional lung separation devices. Anesthesia for NIVATS is considered on the basis of active protection rather than conventional safety. The role of anesthesia in NIVATS is to combine different systemic anesthetics and variable regional anesthesia with the goals to precisely manage airway and breathing, sedation or anesthesia, intraoperative and postoperative analgesia, stabilizing hemodynamics, and intraoperative cough control. By close cooperation between surgeons and anesthesiologists, the benefits of NIVATS include enhancing recovery with improved analgesia, reduced chest drainage, early oral intake, early ambulation, and potentially less stress and inflammatory responses associated with operations. However, there are still limitations on anesthesia for NIVATS such as excessive respiratory and mediastinal movement after artificial pneumothorax, and the complexity and difficulty of performing operations. As NIVATS is still developing to apply on variable patients and operations, the costs and benefits of different combinations on anesthesia for NIVATS should be carefully assessed.

Keywords: Anesthesia; non-intubated video-assisted thoracoscopic surgery (NIVATS)

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Introduction

In recent decades, the use of Non-intubated video-assisted thoracoscopic surgery (NIVATS) instead of conventional general anesthesia (GA) video-assisted thoracoscopic surgery (VATS) has been intensively researched and reported on. NIVATS is believed to be the most beneficial approach for high-risk patients with reduced pulmonary function to secure faster recovery, reduced morbidity, and a shorter hospital stay (1). Because NIVATS was proven feasible and safe with superior outcomes and lower costs (2) , it has been increasingly advocated as an alternative for patients with a low risk for GA and the use of conventional lung separation devices. Anesthesia for NIVATS is considered on the basis of active protection rather than conventional safety. The advantages of NIVATS include avoidance of the adverse effects of tracheal intubation, mechanical ventilation, and muscle relaxants. However, because of the large variations in VATS operations for different patient groups and different surgical requirements, the anesthetic combinations in the practices of different VATS teams varies.

Other than keeping patients non-intubated with spontaneous breathing, anesthetic considerations for NIVATS concern combinations of various systemic anesthetics and nerve blocks and can be classified into the following five dimensions: (I) airway and breathing: an adequately maintained airway with adequate breathing, oxygenation, and CO_2 elimination (use of nasal cannula and supraglottic airway); (II) amnesia: targeted amnesia (from being awake, conscious, or deeply sedated to anesthesia) depending on the costs and benefits for individual patients; (III) analgesia: optimized intraoperative and postoperative analgesia (including supplemental intravenous narcotics, local anesthesia (3), and regional anesthesia, including thoracic epidural anesthesia, paravertebral nerve blocks, and thoracoscopic intercostal nerve blocks); (IV) hemodynamic management: hypoxic effects occurring during one-lung ventilation (OLV) with anesthesia likely depend on hemodynamic impairment caused by myocardial depressant action (low cardiac output, systemic hypotension, and tachycardia); and (V) cough control during operations: a controlled cough reflex to avoid accidental surgical trauma with surgical traction. Because VATS procedures have become increasingly precise and minimally invasive (4,5), NIVATS may become more widely employed because it reduces the complexity of operations and improves the recovery of patients, including outpatients (6). This article reviews the roles, benefits, and limitations of anesthesia in NIVATS.

Major roles of anesthesia on NIVATS

The major roles of anesthesia on NIVATS are providing a precise, tailored anesthetic combinations on selecting patients. Through careful preanesthetic evaluation, the indications, costs, and benefits of NIVATS should be determined by both the surgeon and anesthesiologist, because the literature reports no absolute contraindications to GA, and NIVATS requires more experience, preparation, and vigilance than thoracic surgery with GA. In reference to the aforementioned five dimensions (airway, amnesia, analgesia, hemodynamic optimization, and cough control), anesthesia can be performed with precise goals under optimal conditions.

The feasibility of NIVATS depends on the anesthesiologist's comfort level and the surgeon's experience. However, patients must be carefully selected for NIVATS. As an anesthesiologist's experience increases, NIVATS can be a more appropriate choice for fragile high-risk patients to prevent ventilator dependency, which often occurs in those with postoperative complications and long hospital stays. For example, thoracoscopy for biopsy through uniportal surgery is a rapid procedure and can be easily performed on an awake patient to avoid difficult weaning. Keeping patients with severe emphysema awake during non-resection lung volume reduction surgery was shown to result in significant treatment advantages (7). Recently, NIVATS is being progressively extended to patients without substantial risks for GA and controlled ventilation (8), and is increasing of performing an ever larger proportion of thoracic surgical procedures in an outpatient setting (6). There were also reports with different definition of NIVATS by using a supraglottic airway (9,10).

Most patients with relatively normal lung function are unwilling to remain awake during surgery. However, GA has multiple effects on the respiratory system, including the loss of a patent airway, hypoventilation, and apnea. Ventilation-perfusion (V/Q) mismatch, shunting, and the reversal of hypoxic pulmonary vasoconstriction are also associated with anesthesia and result in faster hypoxia and hypercapnia progression. Optimal monitoring on sedation is favorable for patients' comfort and for maintaining the airway and preventing severe hypercapnia (11). Excessively deep sedation or intravenous anesthesia may be associated with hypoventilation and hypotension. By contrast, inadequate anesthetic depth may lead to an easily stimulated airway and bronchi and consequently laryngospasm, bronchospasm, and cough. In addition, monitoring on sedation can provide a means of adjusting the dose of general anesthetics. Different regional anesthetics have different sparing effects on general anesthetics and can be monitored using bispectral index (BIS) levels, including the effects of repeated nerve (12). Labored breathing may be observed when airway obstruction hinders spontaneous breathing. The movement associated with effortful breathing may make the operation field bumpy and thus make NIVATS difficult after artificial pneumothorax. Therefore, a difficult airway or potentially difficult intubation should be considered a relative contraindication for NIVATS. End-tidal capnography may be a useful monitoring technique, but it does not correlate with $PaCO_2$ data (13). Saliva reduction by using antisialagogue drugs may be preferred to prevent choking. Positive pressure ventilation after induction may increase the incidence of vomiting; therefore, it should be avoided to prevent vomiting and aspiration.

Different regional anesthesia procedures, such as thoracic epidurals (2,7,14,15), paravertebral blocks (15), intercostal nerve blocks (16,17), or even local anesthesia (18) have been performed as part of analgesia by either anesthesiologists or surgeons.

In NIVATS, artificial pneumothorax causes the nondependent lung to collapse and enlarge the operation field. Respiratory movement is severely affected after artificial pneumothorax. Apnea, hyperventilation with effortful respiration, paradoxical respiratory patterns, and mild mediastinal shifts are not uncommon immediately after iatrogenic pneumothorax. Apnea, hyperventilation with effortful respiration, paradoxical respiratory patterns, and mild mediastinal shifts are not uncommon immediately after iatrogenic pneumothorax. However, respiration generally stabilizes within 5 to 10 minutes. Without controlled ventilation, efficient contraction of the dependent hemidiaphragm in spontaneous one-lung breathing during NIVATS ensures a favorable match between ventilation and perfusion. Consequently, oxygenation is usually adequately maintained during OLV and returns to a value comparable to the baseline after resumption of two-lung ventilation. Although hypercapnia may occur with sedation and OLV, it is usually mild and well tolerated even under intravenous anesthesia monitored by using the BIS level (16). Surgeons and anesthesiologists should evaluate the physiological and surgical feasibility of conversion to conventional intubated VATS if a favorable surgical condition cannot be achieved.

For maintaining suitable physiological condition, hemodynamic management not only provides adequate perfusion to the whole body but also prevents hypotension and hypoxemia during OLV after artificial pneumothorax (19).

Control of the cough reflex is vital for operations near the hilum and bronchi to prevent accidental surgical injuries to vessels and bronchi. Cough reflex inhibition can be achieved by adding intravenous narcotics, deepening sedation, performing a vagal nerve block, or using local anesthetics.

Benefits of non-intubated anesthesia for thoracic surgery

With individualized anesthetic planning and precisely performed and monitored anesthesia, the benefits of Non-intubated anesthesia for thoracic surgery include enhancing postoperative recovery and reducing the inflammatory responses that are associated with operations:

(I) Enhancing recovery by obviating the adverse effects of tracheal intubation, mechanical ventilation, and muscle relaxants: studies have reported severe trauma associated with trachea intubation (20), endobronchial catheter (21), and endobronchial blockers (22). Bronchospasm associated with intraoperative adjustment of lung separation devices through fiberoptic bronchoscopy is not uncommon.

(II) Enhancing recovery by reducing the interference of anesthesia with pulmonary mechanic function. General anesthetics, including intravenous anesthetics and narcotics, reduce ventilation and impair the ventilatory response to hypercapnia and hypoxia. The functional residual capacity (FRC) is reduced soon after anesthesia induction because of changes in the chest wall shape (23) and a cephalad shift of the diaphragm through a loss of the diaphragmatic end-expiratory tone. However, the closing capacity (CC) remains constant during anesthesia, and lung collapse and airway closure easily result when the FRC falls below the CC. Consequently, hypoxemia develops easily when the CC exceeds the FRC, particularly in elderly (24) and patients with chronic obstructive pulmonary disease. Patients who were paralyzed exhibited a greater cephalad shift of the diaphragm. In patients who were positioned in the lateral decubitus position, anesthesia was observed to increase shunting due to the effect of gravity. Most patients develop a small area of atelectasis during anesthesia (25). In addition, the adverse effects on gas exchange during anesthesia include reduced minute volume of ventilation, increased dead space and shunting, and an altered V/Q (26). Therefore, keeping patients awake is a method for avoiding the adverse effects of intravenous and inhalational anesthetics (7,27). Epidural anesthesia was reported not to disturb respiratory or parenchymal functions (28). In theory, many of the aforementioned changes are considered normal during anesthesia and are easily overcome by increasing the fraction of inspired oxygen. NIVATS can be safely performed on patients whose cardiopulmonary condition is normal.

(III) Enhancing recovery by avoiding muscle relaxants: postoperative pulmonary complications were reported to be associated with residual muscle relaxation, particularly among elderly patients receiving prolonged surgical procedures (29). The incidence and severity of symptoms of muscle weakness increased in the postanesthesia care unit in patients with a train of four (TOF) <0.9 (30).

(IV) Enhancing recovery by continuing postoperative pain management: Retained or repeated regional anesthesia improves postoperative pain control and reduces postoperative narcotic usage (31). However, postoperative multimodal pain control is still recommended because regional anesthesia blocks only pain from parietal pleural and incision wounds. An apnea sensation or respiratory discomfort from visceral pleural stimulation continues regardless.

(V) Advantages of awake thoracoscopy under thoracic epidural anesthesia or paravertebral blocks include improved respiratory function, an attenuated stress response (32), reduced inflammation as measured by lower postoperative white blood cell counts and tumor necrosis factor-α and C-reactive protein levels (2,33), improved analgesia, reduced chest drainage, early oral intake, early ambulation, and shortened recovery time (8,34).

Limitations

The reported drawbacks of NIVATS include inadequate analgesia, panic attacks, respiratory movement of the lung and mediastinum, hypoxia, hypercapnia, and the conversion to GA. There remain risks of lost airway and aspiration attributable to the loss of airway patency and cough reflex. Secretions (or refluxed gastric contents) can affect the vocal cords, causing laryngospasms, and enter the trachea and lungs, causing bronchospasms and ultimately infection. For prolonged operations, inadequate protection of the dependent lung should be avoided. Intubated VATS operations are indicated for patients who require airway or dependent lung protection.

Excessive respiratory and mediastinal movement and inadequate lung collapse can interfere with bronchovascular dissection and resection, requiring conversion to GA. Therefore, NIVATS is unsuitable for patients with extreme body mass index values. The complexity and difficulties of performing operations remain limitations of applying NIVATS. Although NIVATS bronchial sleeve resection (35) and NIVATS pneumonectomy (36) have been reported, the costs and benefits of applying NIVATS to complex operations and postoperative care should be carefully assessed. Common surgical difficulties, such as severe pleural adhesion and accidental pulmonary arterial bleeding, might contraindicate NIVATS and increase the risk of conversion to intubated VATS. Some surgical difficulties derive from inadequate space to accommodate the endoscopic instruments. The size of the surgical field is determined on the basis of the pneumothorax-induced collapse of the lung, but for patients with deformed thoraxes, NIVATS requires the surgeon to have more skill and experience.

Because VATS operations have developed rapidly and broadly for various thoracic operations, NIVATS development is still underway. However, for patients who receive intubated VATS, protective ventilation strategies (37), that can reduce the incidence of atelectasis and pulmonary infections are recommended.

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Footnote

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