Current overview of awake, non-intubated, video-assisted thoracic surgery

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Abstract

Awake video-assisted thoracoscopic surgery (A-VATS) enables the surgeon to penetrate the tissue via a small incision and with less contact between the lung and atmospheric pressure; postoperative respiratory functions are also less affected than in open surgery. A-VATS is a safer technique than traditional VATS and non-intubated video-assisted thoracoscopic surgery (NI-VATS) because it does not require muscle relaxants and sedoanalgesics. In particular, diagnostic VATS for pleural effusions can be easily performed over a single port using only local anaesthetic. Anaesthesia-related risks increase even more for elderly patients and those with severe comorbidities. Although there are long and risky operations in thoracic surgery, general anaesthesia is not required for some thoracic surgery procedures. However, A-VATS is limited to minor procedures. Due to regional anaesthesia and sedation, NI-VATS is a safe and effective method for many indications. The results show that this method can be applied with low mortality and morbidity.

Key words: *awake video-assisted thoracic surgery, intubation, thoracic, anaesthesia.*

Introduction

In 1910, with the help of Jacobsen's local anaesthesia-assisted urological intervention tool, cystoscope thoracoscopy procedures were initiated as a diagnostic tool in the pleural cavity and effusions. Vishnevski used local anaesthesia and thoracoscopic surgery in the treatment in the 1950s, and Buchingam conducted the first awake thoracoscopic applications with the epidural anaesthesia method. Rusch reported that they performed awake thoracoscopy using a local intercostal nerve blocking method [1–3].

With the increase in image resolution and the development of endoscopic surgical instruments and staplers, thoracoscopy has become a diagnostic and treatment method. In the early 1990s, video-assisted thoracoscopic surgery (VATS) became standard in many operations, such as lung and pleural biopsy, bulla resection, mediastinal cyst, and mass excision. In some centres, this approach has become a viable method of lung cancer surgery with the development of appropriate patient selection and surgical experience over time [4, 5].

With the introduction of the epidural catheter in the field of anaesthesia, developments in thoracoscopic surgery have encouraged the discussion of methods without invasive monitoring (central venous, blood pressure, urinary catheter) and general anaesthesia [6–8].

With the use of this method, low morbidity and mortality, minimal blood loss, less postoperative pain, and short hospital stay have been achieved. This resulted in questioning other alternatives and methods of protection from anaesthesia risks [9]. First, VATS applications were performed with sedation and local anaesthesia in pleural effusion and pneumothorax, and later in thoracic sympathectomy applications, thus avoiding the risks of laryngotracheal injury

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of both general anaesthesia and double-lumen intubation, which is generally preferred in VATS [10].

Before 2010, there was no discussion about optimal anaesthesia management for thoracoscopic lung resections. These procedures were conducted under general anaesthesia and single-lung ventilation using a double-lumen endotracheal tube, and thoracic epidural analgesia was a standard technique [11].

VATS is a minimally invasive procedure in thoracic surgery and is applied endoscopically through ports. This technique is preferred in more than half of thoracic surgery cases due to evolving technology in recent years. Hence, VATS is applied more extensively and widely, especially in specialized and experienced thoracic surgery centres [12].

The use of deep sedation and muscle relaxants in diagnosing and treating elderly patients with high risk for general anaesthesia has become controversial. Pain, delayed effective use of the diaphragm, and postoperative problems such as atelectasis are the disadvantages of anaesthesia for thoracic surgery operations. For these reasons, non-intubated video-assisted thoracoscopic surgery (NI-VATS) has become a more widely used and increasingly popular intervention in the last decade [13]. Anaesthesia-related risks increase even more for elderly patients and those with severe comorbidities. Although there are long and risky operations in thoracic surgery, general anaesthesia is not required for some thoracic surgery procedures [14].

NI-VATS provides better respiratory function, less morbidity, and lower costs. The NI-VATS technique is applied in combination with intravenous sedoanalgesics. Awake VATS (A-VATS) was performed in a fully awake patient without the utilization of sedoanalgesics [15].

Aim

This review aims to elucidate the use of the awake NI-VATS technique in thoracic surgery and discusses its advantages, such as shorter length of hospital stay, or contraindications such as airway difficulties. Additionally, it summarizes current evidence and identifies areas that warrant further discussion.

Material and methods

The English language literature was reviewed to identify studies and reports describing the A-VATS and NI-VATS techniques in thoracic surgery. We used the Medical Literature Analysis and Retrieval System Online (Medline), Web of Science Core Collection (WOS), Excerpta Medica Database (EMBASE), Cochrane Central Register of Controlled Trials (CENTRAL), and other sources if relevant. Search strategies were created using MeSH terms, subject headings, and keywords to obtain the maximum number of articles.

Indications and contraindications of the awake NI-VATS procedure

VATS is a minimally invasive surgical procedure due to less pain, fewer complications, shorter hospital stay, and faster recovery time. Additionally, it is well known in the current literature that the NI-VATS technique can be successfully applied in many thoracic surgical operations [16].

NI-VATS requiring sedoanalgesia or general anaesthesia pose the same risks as surgeries completed under general anaesthesia. In addition, another diagnostic procedure known as pulmonologists perform medical thoracoscopy by applying local anaesthesia and sedoanalgesia in non-intubated patients [17]. In this procedure, sedoanalgesia is applied. Single-port A-VATS is performed using only local anaesthetic, with no need for general anaesthesia and intubation except for surgical complications. This is an essential advantage of A-VATS [18].

The American Society of Anesthesiologists (ASA) classification allows risk estimation by determining some basic categories before surgery. It enables evaluation according to age, comorbidity, type and duration of surgery, anaesthesia technique, blood product requirement, and postoperative intensive care need. A healthy normal patient is classified as ASA-I, while a patient with a life-threatening disease is classified as ASA-IV [19].

If fluid accumulation in the pleural space increases and respiratory complaints occur, the approach includes evacuation of the effusion and treatment of the underlying cause. Single-port VATS is a safe and widely accepted technique for most thoracic surgical procedures using general anaesthesia. Single-port VATS indications include thoracic sympathectomy, pleural biopsy, mediastinal or hilar LAP biopsy, and haemothorax [20].

Indications of awake video-assisted thoracoscopic surgery can be elaborated as follows [21]: man-

agement of simple pleural processes, evacuation of pleural and pericardial effusions of critically ill patients, spontaneous pneumothorax, bullous emphysema, resection of pulmonary nodules, lung volume reduction operations (LVRS), biopsy of anterior mediastinal masses, cases with high risk for general anaesthesia.

Patient selection is the most critical stage of surgery planning and preparation; it is an essential stage that requires careful and collaborative work by an experienced surgical and anaesthesia team [17, 20].

Contraindications of awake video-assisted thoracoscopic surgery can be elaborated as follows [21]: cases difficult to intubate, patients at risk of aspiration, type 2 respiratory failure, cases with high intracranial pressure, contralateral diaphragmatic paralysis, the patient does not accept the awake procedure, large and central masses (> 6 cm) for which resection is planned due to tumour, inexperience and lack of communication among the surgical team, cases with thoracic spinal deformity (epidural catheter cannot be placed) [21].

Relative contraindications of awake video-assisted thoracoscopic surgery can be elaborated as follows [21]: haemodynamic instability, bleeding disorders (deviations in thromboplastin time, prothrombin time, platelet count, or coagulopathy), obesity (BMI > 30 kg/m^2), patients with persistent severe cough and secretion, neurological disorders (dementia, epileptic attack), resting hypoxia and hypercarbia, cases with severe intrathoracic and pleural adhesions secondary to previous operations [21].

Advantages and disadvantages of NI-VATS

Video-assisted thoracoscopic surgery is a diagnostic and therapeutic tool for treating pleural, parenchymal, and mediastinal diseases. Although the risks of general anaesthesia are minimized, awake VATS has been reported to have advantages such as short average hospital stay, fast recovery time, lower mortality, and lower hospital cost, primarily for patients with poor tolerance to general anaesthesia. The published results confirm that this method can be applied confidently, offering a valuable alternative [22].

Considering the haemodynamic consequences of deep anaesthesia, the deterioration of cardiac performance, the need for muscle paralysis, delayed recovery, increased risk of pneumonia, and the inherent risks of intubation, an operation with sedoanalgesia should be considered as an option [23]. Because intubation is not required in thoracoscopic procedures performed with sedation and local anaesthesia, possible fatal complications are avoided [24].

With increasing interest, non-intubation techniques applied under minimal sedation with the help of regional anaesthesia and spontaneous breathing have been used actively. The most important point is creating a spontaneous pneumothorax as the surgeon enters the thorax. In this way, excellent lung isolation can be achieved without requiring positive pressure ventilation in the contralateral lung. Pompeo *et al.* stated that patients with a primary spontaneous pneumothorax who underwent pleural abrasion with awake NI-VATS wedge had a shorter hospital stay and lower cost than local and general anaesthesia method preferences [25]. In a similar study, Lesser *et al.* suggested that pulmonary nodule operations resected with the awake thoracoscopic approach had a significantly shorter duration of anaesthesia, total surgery, and hospital stay. This also brought about less invasive and more cosmetic results in limited patient groups [26].

Providing local anaesthesia and sedation together is reported to be the main advantage of allowing the patient's physical condition to be followed up while maintaining communication, as well as the fact that the patient has fewer respiratory complications during the procedure, it does not cause any adverse effects to the immune system with high postoperative lymphocyte and natural killer cell counts, and it provides a shorter recovery time [27].

The disadvantages of A-VATS operations are minimal. The absence of total lung collapse may not provide a calm surgical environment in stressed and anxious groups because they provide spontaneous breathing for the patients. Awake VATS procedures are a simple and effective method for diagnosing and treating thoracic pathologies [3].

Katlic *et al.* [28] performed VATS on 343 cases with a mean age of 67 years. Pleural biopsy, empyema drainage, and talc pleurodesis were performed in 244 patients, lung biopsy in 74 patients, haematoma evacuation in 40 patients, pericardial window opening in 13 patients, lung abscess drainage in 2 patients, chylothorax in 2 patients, pneumothorax in 1 patient, and mediastinal mass biopsy in 1 patient. No operation-related mortality was observed in

any of the cases, and they reported that the subjects tolerated VATS with sedation and local anaesthesia.

Pompeo *et al.* [25] conducted a randomized trial in 60 patients with solitary pulmonary nodules. General anaesthesia and intubation were applied to 30 patients, and awake epidural anaesthesia to the other 30. They stated that in postoperative recovery, the requirement for nurse care was lower in the group administered epidural anaesthesia. Additionally, they admitted that surgery could be performed safely under awake thoracic epidural anaesthesia, and this approach was superior to VATS applied under general anaesthesia.

A meta-analysis of 47 clinical trials included 4736 patients with thoracoscopic intervention; major complications (empyema, bleeding, port site metastasis, bronchopleural fistula, postoperative pneumothorax, prolonged air leak, and pneumonia) were reported in 86 patients. A meta-analysis of 31 studies with 2411 patients performed under local anaesthesia reported minor complications in 177 patients, such as emphysema, minor bleeding, surgical site infection, intraoperative hypotension, fever, and atrial fibrillation [2].

Although dense pleural adhesions are contraindicated in the literature, some publications report that the transition rate to general anaesthesia is 1–10% depending on whether the surgical procedure is simple or complex [29].

Anaesthesia process

Awake NI-VATS includes thoracoscopic interventions performed under regional anaesthesia techniques in breathing patients. Regional anaesthesia techniques consist of local anaesthesia, intercostal nerve blocks, intrapleural blocks, paravertebral blocks, or thoracic epidural anaesthesia [29].

In the preoperative period, anaesthesia should include routine evaluations and patients' cardiovascular and pulmonary risk status; also, electrocardiography (ECG), peripheral oxygen saturation, blood pressure, and end-tidal carbon dioxide levels should be evaluated and comprehensively elucidated. Extra attention is required for surgical success in awake VATS anaesthesia cases and the patient's safety. Anaesthesiologists should have information about the procedure and be in a joint decision with the surgeon on the method to be selected [28].

Thoracic epidural analgesia, with or without premedication, is one of the most frequently used methods. The anaesthetist places the thoracic epidural needle between the T4 and T6 levels, causing somatosensory and motor block in the T1-T9 range, and its maintenance can be provided by adding intermittent local anaesthesia infusion [30]. Thoracic epidural anaesthesia meta-analyses have shown that cardiac morbidity and mortality are very low after non-cardiac surgeries [31]. A meta-analysis study suggested that pulmonary complications decreased after epidural analgesia, possibly due to the decrease in the need for opioids due to early mobilization and reduced cough-related pain. The intact bowel functions in thoracic epidural analgesia contributed to systemic recovery [32].

In many cases, sedation of the patient may be beneficial, especially in anxious patients, while losing communication with the patient can be a disadvantage; according to the anaesthesiologist's choice, midazolam, fentanyl, propofol, or ketamine can be utilized for the patient. In the postoperative period, patients often take just non-steroidal anti-inflammatory drugs. Local anaesthetic infiltration or intercostal space nerve block before incision can be used as an adjunct to thoracic epidural anaesthesia (TEA) [32].

Because pain due to unsuccessful or incomplete analgesia may cause cardiopulmonary hazards, general anaesthesia should be reserved as an alternative. In addition, oxygen can be administered by nasal route, face mask, or both. Bi-level positive airway pressure (BIPAP) should be added during its transport and throughout the operation, and if necessary the patient should be taken to the whole side position [33] (Table I).

Depending on the surgeon's preference and underlying pathology, local anaesthesia can be infiltrated into the incision site, and only a Thoracar is inserted into the camera port.

The reasons for conversion to conventional anaesthesia can be elaborated as follows [22, 34]: surgical complications (major bleeding, strong adhesions, large tumours, failure to progress during the intervention regarding the surgeon's thoracoscopic experience), severe hypoxemia (PaO_2 < 60 hypercapnia ($PaCO_2$ > 80) acidosis (pH < 7.1), haemodynamic instability, severe hypotension, arrhythmias, right ventricular failure, persistent coughs that prevent surgery, excessive diaphragm and mediastinal movements, failed regional blocks, non-collapse of the lung [22, 34].

Table I. Advantages and disadvantages of general anaesthesia in video-assisted thoracoscopic surgery (VATS)

Advantages of VATS with general anaesthesia	Disadvantages of general anaesthesia VATS
Providing the surgeon with a safe surgical time	Long hospital stay
Having enough collapse in the lungs	Complications related to intubation
Better palpation of the lung parenchyma	Pneumonia risk
	Low hospital costs
	Contrasting lung continuous positive pressure exposure
	Long recovery time
	Long anaesthesia time
	Impairment of cognitive functions

Current status and future perspective of the awake NI-VATS procedure

The ideal patient position involves balancing surgical comfort against the risks associated with the patient's position. The choice of position is the joint responsibility of the surgeon and the anaesthesiologist. Surgical table weight limits should be strictly followed in A-VATS surgeries. The weight limit is usually much lower when the patient is tilted sideways or from top to bottom. Although the lateral thoracotomy position is generally preferred in awake VATS operations, it can be in a semi-sitting position for patient comfort and better airway management. Therefore, the patient's position during the surgery should be considered during the preoperative evaluation [35].

While A-VATS is performed with multiple incisions in simple procedures (diagnostic pleural interventions, pericardial window opening, recurrent spontaneous pneumothorax, interstitial lung diseases, simple mediastinal masses) according to its initial definitions, there are transitions to more minimally invasive techniques (uniport) within the framework of the experience developed in clinics where the procedures are used extensively. However, a standard approach has yet to be developed for complex surgeries (resection and extended surgeries) [36].

It can be used for pleural surgery operations (chronic effusion, haemothorax with empyema, and pleurodesis), and recently single-port interventions have been used more frequently. However, spare ports can be opened during the procedure [37].

For lung biopsy, using a total of 3 ports, a camera is placed in the eighth intercostal space along the middle axillary line, and additional ports can be opened from the front and back by using 1-cm incisions according to the other 2 port locations. After determining the biopsy area radiologically and macroscopically for diagnosis, 2 or 3 wedge resections are performed with the help of staplers [38].

When a pericardial window opening is required, the patient is placed in the entire lateral position. The lung can easily deflate with accompanying pleural effusion, and 2 port sites will be sufficient. The pericardium should be retained to accompany a Gresper telescope parallel to it. After opening with a tissue scalpel, the procedure is terminated by removing a 1-cm pericardium under direct vision with the help of endoscopic scissors [39].

For bulloplasty surgery, the patient is placed in the entire lateral decubitus position. One camera and 3 port accesses are sufficient despite surgical induction of pneumothorax. The bulla can be deflated by cutting with an endo-dissector to create hyperinflation and space to work there. Then, after the lung is grasped ventrally and dorsally, engulfing the bulla's base and the lesion's midsection, a single ring forceps and an endo stapler are applied to the base of both lungs. The bulla and suture line on the lung area where the stapler will be applied should contain a limited amount of healthy tissue. After leakage control is done by coughing, the procedure is terminated by placing a chest tube up to the top of the chest [40].

Pulmonary metastasectomy surgery begins by placing the patient in the entire lateral decubitus position with 3-flexible thoracoscopic-trocar access. Begin using the bimanual finger palpation method, starting at the apex, and moving towards the basal segments to allow full lung palpation. To identify smaller nodules, the lung should be deflated. To remove the nodules, the relevant tissue should be re-

Table II. Advantages and disadvantages of awake video-assisted thoracoscopic surgery (A-VATS)

Advantages of A-VATS	Disadvantages of A-VATS
Short hospital stay	Lack of adequate lung collapse
Absence of intubation-related complications	Poor image opportunity due to the inability to provide safe surgery in stressful and anxious patient groups
Low hospital costs	Hypercapnia
Short recovery time	Cough
Short anaesthesia time	
Fewer respiratory complications	
Maintaining communication with the patient	
More physiological (no V/Q deterioration)	

A-VATS – awake video-assisted thoracoscopic surgery, V/Q – pulmonary ventilation and perfusion.

moved with the help of an endoscopic stapler while the surgeon cooperates with the patient to check their well-being [41].

It is known that single lung ventilation requiring general anaesthesia increases the risk of pneumonia due to sedation and muscle relaxation, decreases cardiac performance, and causes neuromuscular problems. It is possible to avoid these problems with A-VATS performed with spontaneous breathing. Karadayı *et al.* reported that A-VATS applied with sedoanalgesia in 80 cases with pleural effusion was a reliable method in diagnosing and treating pleural pathologies [42]. Chen *et al.* [43] performed lobectomy in 137 cases, wedge resection in 132 cases, and segmentectomy in 16 cases with the A-VATS method, in a total of 285 patients. They needed intubation in only 14 cases, 1 case was opened due to bleeding, and no mortality was observed. The authors also reported applying vagal blockade in selected patients to suppress the cough reflex. They stated that intraoperative iatrogenic pneumothorax caused sufficient lung collapse in most of the cases.

A-VATS enables the surgeon to penetrate the tissue via a small incision, with less lung contact with atmospheric pressure, postoperative respiratory functions are also less affected than open surgery, and morbidity is lower even if a bilateral approach is applied in a single session [44].

A-VATS is a safer technique than traditional VATS and NI-VATS because it does not require muscle relaxants and sedoanalgesics. In particular, diagnostic VATS for pleural effusions can be easily performed over a single port using only local anaesthesia. However, the scope of A-VATS is limited to minor procedures. Another area for improvement is that this technique has a learning curve. Only expert surgeons and experienced units can perform A-VATS. It is recommended that those new to the A-VATS procedure should gain experience with cases of pleural effusion [45] (Table II). Also, patients who undergo VATS or awake NI-VATS frequently experience moderate to severe postoperative pain. Deep or superficial serratus anterior plane block and paravertebral nerve block can be used to overcome the pain [46]. Awake NI-VATS can be included in the gold standard treatment algorithm in the future in pleural biopsy and PSP surgery. This minimally invasive method may be preferred in more indications and by more centres in the future, considering the disadvantages and advantages of the procedure.

Conclusions

A-VATS with regional anaesthesia and sedation is safe and effective for many indications. The results show that this method can be applied with low mortality and morbidity. Patient selection, surgery planning, and preparation is the most critical stage and requires careful and collaborative work by an experienced surgical and anaesthesia team. The use of this minimally invasive technique with careful patient selection and in the right indication can be used increasingly in many indications and by many centres in the future.

Conflict of interest

The author declares no conflict of interest.

References

1. Jacobaeus HC. Ueber die moglichkeit die zystoskopie bei untersuchung seroser Honlungen anzuwenden. Münch Medi Wochen 1910; 57: 2090-2.
2. Rahman NM, Ali NJ, Brown G, et al. Local anaesthetic thoracoscopy: British Thoracic Society Pleural Disease Guideline 2010. Thorax 2010; 65: 54-60.
3. Gonzalez DR, Aymerich H, Bonome C, et al. From open operations to nonintubated uniportal video-assisted thoracoscopic lobectomy: minimizing the trauma to the patient. Ann Thorac Surg 2015; 100: 2003-5.
4. Rocco G, Martucci N, La Manna C, et al. Ten year experience on 644 patients undergoing single port (uniportal) video-assisted thoracoscopic surgery. Ann Thorac Surg 2013; 96: 434-8.
5. Hameed F, Raza A, Saleem J, et al. VATS without general anesthesia: initial experience of 18 cases. Anaesth Pain Intensive Care 2016; 20: 150-3.
6. Defosse JM, Wappler F, Schieren M. Anästhesie bei nicht intubierter videoassistierter Thoraxchirurgie (NiVATS) [Anaesthetic Management of Non-intubated Video-assisted Thoracic Surgery]. Anasth Intensiv Notfall Schmerzt 2022; 57: 405-16.
7. Alagoz A, Findik G, Sazak H, et al. Non-intubated video-assisted thoracoscopic surgery under combination of erector spinae plane block and thoracic paravertebral block. BMC Anesthesiol 2022; 22: 99-104.
8. Chen PH, Chuang JH, Lu TP, et al. Non-intubated versus intubated video-assisted thoracic surgery in patients aged 75 years and older: a propensity matching study. Front Surg 2022; 2: 880-7.
9. Anile M, Vannucci J, Ferrante F, et al.; NIVATS Interest Group. Non-intubated thoracic surgery: standpoints and perspectives. Front Surg 2022; 1: 937-43.
10. Pathonsamit C, Tantraworasin A, Poopipatpab S, et al. Perioperative outcomes of non-intubated versus intubated video-assisted thoracoscopic surgery in different thoracic procedures: a propensity score-matched analysis. BMC Anesthesiol 2022; 22: 154-8.
11. Furák J, Tosi D. Editorial: non-intubated thoracic surgery: from concepts to clinical reality. Front Surg 2022; 9: 94-9.
12. Alwatari Y, Simmonds A, Ayalew D, et al. Early video-assisted thoracoscopic surgery (VATS) for non-emergent thoracic trauma remains underutilized in trauma accredited centers despite evidence of improved patient outcomes. Eur J Trauma Emerg Surg 2022; 48: 3211-9.
13. Grott M, Eichhorn M, Eichhorn F, et al. Thoracic surgery in the non-intubated spontaneously breathing patient. Respir Res 2022; 23: 379-85.
14. Tsukamoto Y, Odaka M, Nakada T, et al. Comparative study of local vs. general anesthesia in video-assisted thoracoscopic surgery for empyema. Asian J Surg 2022; 8: 1015-24.
15. Steinberg I, Bisciaio A, Rosboch GL, et al. Impact of intubated vs. non-intubated anesthesia on postoperative diaphragmatic function: results from a prospective observational study. Front Physiol 2022; 8: 395-400.
16. Bellini R, Salandini MC, Granieri S, et al. Erector spine plane block as single loco-regional anesthesia in non-intubated video-assisted thoracic surgery for unfit patients: a case-match study. Updates Surg 2023 Feb 23. doi: 10.1007/s13304-023-01464-0.
17. Lin WY, Lin FS, Shih CC, et al. Comparisons on the intraoperative desaturation and postoperative outcomes in non-intubated video-assisted thoracic surgery with supraglottic airway devices or high-flow nasal oxygen: a retrospective study. J Formos Med Assoc 2023; 122: 309-16.
18. Wang P, Wang Q, Zhang W, et al. A simple and practical intraoperative ventilation technique for uniportal video-assisted thoracoscopic tracheal reconstruction: a case report. Ann Transl Med 2022; 10: 529-34.
19. Szabo Z, Fabo C, Oszlanyi A, et al. Anesthetic (r)evolution from the conventional concept to the minimally invasive techniques in thoracic surgery-narrative review. J Thorac Dis 2022; 14: 3045-60.
20. Wang R, Jiang Y, He J, et al. Electromagnetic navigation bronchoscopy integrated non-intubated uniportal VATS in localization and resection of pulmonary nodules. Front Surg 2022; 5: 872-8.
21. Zheng H, Hu XF, Jiang GN, et al. Nonintubated-awake anesthesia for uniportal video-assisted thoracic surgery procedures. Thorac Surg Clin 2017; 27: 399-406.
22. Gonzalez-Rivas D, Bonome C, Fieira E, et al. Non-intubated video-assisted thoracoscopic lung resections: the future of thoracic surgery? Eur J Cardiothorac Surg 2016; 49: 721-31.
23. Kösek V, Thiel B, Nikolova K, et al. Lung volume reduction surgery: from National Emphysema Treatment Trial to non-intubated awake video-assisted thoracoscopic surgery. Ann Transl Med 2020; 8: 146-53.
24. Cajozzo M, Lo Iacono G, Raffaele F, et al. Thoracoscopy in pleural effusion--two techniques: awake single-access video-assisted thoracic surgery versus 2-ports video-assisted thoracic surgery under general anesthesia. Future Oncol 2015; 11 (24 Suppl): 39-41.
25. Pompeo E, Mineo D, Rogliani P, et al. Feasibility and results of awake thoracoscopic resection of solitary pulmonary nodules. Ann Thorac Surg 2004; 78: 176-82.
26. Lesser T, Doenst T, Lehmann T, et al. Lung bioposy without pleural drainage. Dtsch Arztebl Int 2019; 116: 329-34.
27. Mineo TC. Epidural anesthesia in awake thoracic surgery. Eur J Cardiothorac Surg 2007; 32: 13-9.
28. Katlic MR, Facktor MA. Video-assisted thoracic surgery utilizing local anesthesia and sedation: 384 consecutive cases. Ann Thorac Surg 2010; 90: 240-5.
29. Batchelor TJP, Rasburn NJ, Abdelnour-Berchtold E, et al. Guidelines for enhanced recovery after lung surgery: recommendations of the Enhanced Recovery After Surgery (ERAS®) Society and the European Society of Thoracic Surgeons (ESTS). Eur J Cardiothorac Surg 2019; 55: 91-115.
30. Phelps JR, Lizi H, Murphy BA. Anesthesia for global general thoracic surgery. Thorac Surg Clin 2022; 32: 307-15.
31. Raft J, Richebé P. Anesthesia for thoracic ambulatory surgery. Curr Opin Anaesthesiol 2019; 32: 735-42.
32. Xu ZZ, Li HJ, Li MH, et al. Epidural anesthesia-analgesia and recurrence-free survival after lung cancer surgery: a randomized trial. Anesthesiology 2021; 135: 419-32.

33. Sunaga H, Blasberg JD, Heerdt PM. Anesthesia for nonintubated video-assisted thoracic surgery. Curr Opin Anaesthesiol 2017; 30: 1-6.
34. Sagiroglu G, Yanik F, Karamustafaoglı YA, et al. May awake video-assisted thoracoscopic surgery with thoracic epidural anesthesia use routinely for minimaly invasive thoracic surgery procedures in the future? Int Surg J 2018; 5: 1602-9.
35. Yu Y, Liu RS, Bo Y, et al. Comparison of two preoperative positioning techniques and unpositioning methods in non-intubated video-assisted thoracoscopic surgery. J Thorac Dis 2022; 14: 464-73.
36. Aymerich H, Bonome C, González-Rivas D. Non intubated video-assisted thoracoscopic lung resections (NI-VATS) in COVID times. Saudi J Anaesth 2021; 15: 362-7.
37. Kong XL, Lu J, Li PJ, et al. Technical aspects and early results of uniportal video-assisted thoracoscopic complex segmentectomy: a 30 case-series study. J Cardiothorac Surg 2022; 17: 63-9.
38. Yang F, Zhang X, Wang J, et al. The short-term outcomes of non-intubated anesthesia compared with intubated anesthesia in single-port video-assisted lung surgery in enhanced recovery after thoracic surgery: results from a single-center retrospective study. J Thorac Dis 2022; 14: 4951-65.
39. Luo G, Tao J, Zhu J, et al. Comparison of analgesic effects of different regional blocks in video-assisted thoracic and breast surgeries: a network meta-analysis and systematic review. Pain Physician 2022; 25: 339-54.
40. Elkhouly AG, Karamustafaoglu YA, Galvez C, et al. Nonintubated versus intubated thoracoscopic bullectomy for primary spontaneous pneumothorax: a multicenter propensity-matched analysis. Asian Cardiovasc Thorac Ann 2022; 30: 1010-6.
41. AlGhamdi ZM, Lynhiavu L, Moon YK, et al. Comparison of non-intubated versus intubated video-assisted thoracoscopic lobectomy for lung cancer. J Thorac Dis 2018; 10: 4236-43.
42. Karadayı Ş, Fındıkçıoğlu A, Kılıç D, et al. Plevral efüzyonların tanı ve tedavisinde uyanık hastada yapılan VATS'ın Rolü. Turk Toraks Derg 2013; 14:103-5.
43. Chen KC, Cheng YJ, Hung MH, et al. Nonintubated thoracoscopic lung resection: a 3-year experience with 285 cases in a single institution. J Thorac Dis 2012; 4: 347-51.
44. Kim TH, Cho JH. Nonintubated video-assisted thoracoscopic surgery lung biopsy for interstitial lung disease. Thorac Surg Clin 2020; 30: 41-8.
45. Gálvez C, Bolufer S, Gálvez E, et al. Anatomic segmentectomy in nonintubated video-assisted thoracoscopic surgery. Thorac Surg Clin 2020; 30: 61-72.
46. Zhang Y, Fu Z, Fang T, et al. A comparison of the analgesic efficacy of serratus anterior plane block vs paravertebral nerve block for video-assisted thoracic surgery: a randomized controlled trial. Videosurgery Miniinv 2022; 17: 134-42.

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