Review Article

Feasibility of non-intubated uniportal video-assisted thoracic surgery for spontaneous pneumothorax: a mini-review

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Contributions: (I) Conception and design: Both authors; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: H Yamagishi; (V) Data analysis and interpretation: Both authors; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

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Abstract: Non-intubated uniportal video-assisted thoracic surgery (VATS) has become a treatment of choice for thoracic diseases in some institutions to reduce postoperative pain and avoid adverse events due to general anesthesia and endotracheal intubation. However, the outcomes of non-intubated uniportal VATS for spontaneous pneumothorax remain unclear. In September 2022, a search was performed in the PubMed and Google Scholar databases for clinical studies written in English comparing the outcomes of non-intubated uniportal VATS and those of intubated uniportal VATS or other management methods for spontaneous pneumothorax. Two randomized controlled studies and one retrospective cohort study evaluated outcomes of non-intubated uniportal VATS for primary spontaneous pneumothorax in comparison to those of intubated uniportal VATS. In these studies, non-intubated uniportal VATS significantly shortened the anesthesia time or postoperative recovery time. The incidence of postoperative complications was not significantly different between the two procedures. Non-intubated uniportal VATS was associated with significantly less postoperative pain than intubated uniportal VATS in the two studies, whereas there was no significant difference between the two groups in the other study. No study has compared the outcomes of non-intubated uniportal VATS with those of other surgical procedures or non-surgical management of secondary spontaneous pneumothorax. The short-term outcomes of non-intubated uniportal VATS for primary spontaneous pneumothorax appear to be more favorable than those of intubated uniportal VATS based on the limited amount of available literature. Further studies are required to determine the role of non-intubated uniportal VATS in the treatment of primary and secondary spontaneous pneumothorax, including the long-term efficacy of this procedure.

Keywords: Video-assisted thoracic surgery (VATS); pneumothorax; non-intubated VATS; awake VATS; uniportal VATS

Received: 21 November 2022; Accepted: 08 February 2023; Published online: 15 March 2023.

doi: 10.21037/vats-22-48

View this article at: https://dx.doi.org/10.21037/vats-22-48

Introduction

Video-assisted thoracic surgery (VATS) is commonly performed to treat various thoracic diseases, including spontaneous pneumothorax (1). Although VATS is associated with better recovery of physical function than open thoracotomy (2), this technique has been modified to be less invasive in two different ways. One method is to reduce the number of ports to minimize postoperative pain and improve cosmetic outcomes, which may be reflected in VATS through a single port (uniportal VATS or uVATS) in some institutions (3). The other way is to avoid general anesthesia and endotracheal intubation, which may be associated with several adverse events (4), including

postoperative pulmonary complications (5), sore throat, hoarseness, and a longer recovery period. To avoid these events, VATS without endotracheal intubation or non-intubated VATS (6) has been initiated in other institutions. In addition, these two modifications may be combined, resulting in non-intubated uVATS (7).

Although controversy exists regarding whether the role of surgery in the management of pneumothorax is clear, VATS may provide patients with better outcomes than non-surgical treatment. Daemen *et al.* performed a systematic review, which suggested that VATS may reduce the recurrence rate of pneumothorax and length of hospitalization compared with chest tube drainage alone in patients with the first episode of primary spontaneous pneumothorax (PSP) (8). Although literature has described the clinical experience of non-intubated uVATS, the feasibility of this procedure for spontaneous pneumothorax has been examined in a limited number of studies.

In this review, we aimed to examine outcomes of non-intubated uVATS for spontaneous pneumothorax in comparison with those of other surgical procedures, including multiportal VATS and intubated VATS, or those of non-surgical treatments.

Methods

On September 24, 2022, we searched PubMed and Google Scholar for English language literature on the feasibility of non-intubated uVATS for spontaneous pneumothorax. The following search terms were used: "spontaneous pneumothorax" AND ("awake" OR "non intubated" OR "local anesthesia" OR "spontaneous ventilation") AND ("surgery" OR "bullectomy"). Eligible studies met the following criteria: (I) studies that compared outcomes between non-intubated uVATS and other management strategies for spontaneous pneumothorax; (II) included data on patients' characteristics, operative time, chest tube duration, postoperative hospital stay, perioperative complications, mortality, or recurrence of pneumothorax; (III) original studies that included more than 30 cases; and (IV) articles published in English. The risk of bias was assessed using the Jadad scale for randomized controlled studies (9) and the Newcastle-Ottawa scale for non-randomized studies (10).

Results

We found two randomized controlled studies (11,12) and one retrospective cohort study (13) that assessed the outcomes of non-intubated uVATS for PSP in comparison with intubated uVATS (*Table 1*). No study has compared the outcomes of non-intubated uVATS for secondary spontaneous pneumothorax (SSP) with those of other surgical procedures or non-surgical management.

The first randomized controlled trial, published in 2018, was conducted by Hwang *et al.* in Korea to compare postoperative short-term outcomes between non-intubated uVATS and intubated uVATS for PSP (11). In this trial, 41 patients were randomly assigned to either the non-intubated uVATS (n=21) or the intubated uVATS (n=20) group.

Jung *et al.* assessed the outcomes of non-intubated uVATS bullectomy for PSP in comparison with those of intubated uVATS in a retrospective cohort study using propensity score matching in Korea in 2019 (13). During the inclusion period, 52 and 183 patients underwent non-intubated uVATS and intubated uVATS, respectively. After propensity score matching using age, sex, number of pneumothorax episodes, and history of previous operations as matching parameters, 52 patients in the intubated uVATS group were matched for comparison with 52 patients in the non-intubated uVATS group.

A multi-institutional randomized controlled trial, published in 2022, was conducted in China by Liu *et al.* to assess the perioperative outcomes of non-intubated uVATS for PSP compared with those of intubated uVATS (12). Three hundred twenty-five patients were included; 162 and 163 patients were assigned to the non-intubated uVATS and the intubated uVATS groups, respectively.

Information obtained from the three studies are summarized below and in *Table 1*.

Risk of bias assessment

The three studies were considered to have acceptable quality because they scored three or more points on the Jadad scale or seven or more points on the Newcastle-Ottawa scale (*Tables 2*,*3*).

Indications and patients' characteristics

Patients with PSP scheduled for VATS bullectomy were included in the studies. Patients with pleural adhesions were excluded in one study (12). There was no significant difference in patients' characteristics between the non-intubated uVATS group and the intubated uVATS group in

Table 1 Summarized results of the studies

	Hwang *et al.* 2018 (11)			Jung *et al.* 2019 (13)			Liu *et al.* 2022 (12)		
	Non-intubated uVATS (n=21)	Intubated uVATS (n=20)	P	Non-intubated uVATS (N=52)	Intubated uVATS (n=52)	P	Non-intubated uVATS (n=162)	Intubated uVATS (n=163)	P
Age (years)	17[†]	18[†]		20.4	19.3		22.6	23.1	
Gender (male)	18 (86%)	20 (100%)		50 (96%)	50 (96%)		152 (94%)	155 (95%)	
Anesthesia time (min)	75.0	89.5	*	16.4[‡]	46.4[‡]	*	99.2	101.4	
Operative time (min)	30.8	36.3		57.5	56.6		54.5	52.4	
Arousal time (min)	8.4	12.6	*	36.0[§]	58.1[§]	*	12.4	15.2	
PACU recovery time (min)	74.9	63.2	*				25.4	30.7	*
Conversion to multiportal VATS				4 (7.7%)	5 (9.6%)				
Conversion to intubated VATS	0			0			1 (0.6%)		
Postoperative pain in VAS									
1 h after surgery	1.43	4.35	*						
24 h after surgery	1.57	2.60		1.56	2.06	*	2.39	2.36	
48 h after surgery				1.50	1.91	*	1.81	1.64	
1 day after the removal of chest tube				1.23	1.40				
Incidence of postoperative complications							16.7%	20.9%	
Prolonged air leak				5 (9.6%)	4 (7.7%)		4 (2.5%)	5 (3.1%)	
Postoperative drainage (d)				3.6	4.4				
Postoperative hospital stay (d)				4.0	5.0		2.7	2.7	
Recurrence of pneumothorax				1 (1.9%)	3 (5.8%)		5 (3.1%)	1 (0.6%)	
Follow-up duration (months)				24.6	50.1	*	1	1	

*, statistically significant difference between groups; [†], median; [‡], time from arrival at operation room to skin incision; [§], time from end of surgery to arrival at general ward; PACU, post-anesthesia care unit; VATS, video-assisted thoracic surgery; VAS, visual analog scale; uVATS, uniportal video-assisted thoracic surgery.

any of the studies. The average (mean or median) age of the patients ranged from 17 to 23 years. More than 90% of the included patients were male.

Intraoperative management and surgical procedures

A double-lumen endotracheal tube was used for patients in the intubated uVATS group. Patients in the non-intubated uVATS group were sedated using midazolam plus remifentanil (13), dexmedetomidine plus ketamine (11), or dexmedetomidine plus propofol and sufentanil, which was switched to remifentanil (12). Patients in non-intubated uVATS group were oxygenated intraoperatively using a non-rebreather mask (11), high-flow nasal cannula (13), or laryngeal mask airway (12) depending on the study protocol. The use of muscle relaxants was avoided in the non-intubated uVATS group in all the studies. Intercostal or local anesthesia with lidocaine or ropivacaine was administered prior to incision in the non-intubated uVATS group alone in two studies (12,13) and in both groups in one study (11). Of interest, visceral pleural surface anesthesia and intrathoracic vagal nerve block were used in the non-intubated uVATS group in one study (12). Intrathoracic vagal nerve block was used in both groups in another study (11). In one study involving use of a laryngeal mask for the non-intubated uVATS group, the anesthetic depth was intraoperatively maintained at the same level in both groups (12). In the other two studies, the anesthetic depth in

Table 2 Risk of bias assessment using Jadad scale for randomized controlled trials

Study	Randomization (maximum 2)	Blinding (maximum 2)	Withdrawal and dropout (maximum 1)	Total (maximum 5)
Hwang *et al.* (11)	2	1	0	3
Liu *et al.* (12)	2	2	1	5

Table 3 Risk of bias assessment using Newcastle-Ottawa scale for non-randomized study

Study	Selection (maximum 4)	Comparability (maximum 2)	Outcome (maximum 3)	Total (maximum 9)
Jung *et al.* (13)	4	2	1	7

one (11) or both groups (13) was not described. All patients underwent VATS bullectomy in the lateral decubitus position. The surgical procedure in the non-intubated uVATS group was identical to that in the intubated uVATS group in two studies (11,12). In the other study (13), the bulla was pulled with a traction suture before resection in the intubated uVATS group, whereas that in the non-intubated uVATS group was resected without a traction suture. In addition, the skin incision was greater in the non-intubated uVATS group than that in the intubated uVATS group (2.5 *vs.* 2 cm) (13). In this study, the staple line was reinforced using fibrin glue and polyglycolic acid sheets in both groups (13). Reinforcement of the staple line was not described in the other two studies. The number of resected bullae was not reported in any study.

Seventy percent of the operations were performed by a surgeon with less than two years of clinical experience in one study (13). In the other two studies, there was no description of the surgeons' clinical experience.

Operative outcomes

Among the 235 patients who underwent non-intubated uVATS in the three studies, only one patient underwent endotracheal intubation without changing position due to intraoperative migration of the laryngeal mask airway. The rate of conversion to multiportal VATS, as described in one study (13), was not significantly different between the non-intubated uVATS group and the intubated uVATS group (7.7% *vs.* 9.6%). The reasons for the conversion were not documented.

There was no significant difference in operative time between the two groups in all three studies (30.8–57.5 min in the non-intubated uVATS group *vs.* 36.3–56.6 min in the intubated uVATS group). However, anesthesia time, arousal time, or recovery time in the post-anesthesia care unit was significantly shorter in the non-intubated uVATS group than in the intubated uVATS group, according to the three studies.

Intraoperative arterial blood gas analysis was performed in two studies (11,12). However, specific values were reported in only one study (12). There were some discrepancies in the changes in the partial pressures of arterial oxygen (PaO_2) and carbon dioxide ($PaCO_2$) between studies. Intraoperative PaO_2 in the non-intubated uVATS group was significantly higher in one study (12) and lower in another study (11) than in the intubated uVATS group. The postoperative PaO_2 was not significantly different between the groups in the studies. The non-intubated uVATS group showed a significantly higher $PaCO_2$ during surgery than the intubated uVATS group in the studies. $PaCO_2$ decreased after surgery in the non-intubated uVATS group, and in one study, there was no statistically significant difference between the groups (11).

Postoperative complications and short-term outcomes

The incidence of any postoperative complications, including prolonged air leak, recurrent pneumothorax, pleural effusion, incision pain, and fever, was not significantly different between the non-intubated uVATS group (16.7%) and the intubated uVATS group (20.9%) (12).

Postoperative pain was evaluated using the visual analog scale in all three studies. In one study, there was no significant difference in pain scores at any point in time (12). In the two other studies (11,13), non-intubated uVATS showed significantly lower pain scores at 1, 24, or 48 h after surgery than intubated uVATS. However, the significant difference between the groups disappeared 24 h after surgery or one day before and after chest tube removal.

Prolonged air leak, duration of chest tube drainage, and postoperative hospital stay were assessed in two studies (12,13). Quantitative evaluation of air leaks was not described in any of the studies.

There was no significant difference in the incidence of prolonged air leak between the non-intubated uVATS and intubated uVATS groups (2.5–9.6% *vs.* 3.1–7.7%) (12,13).

Postoperative duration of chest tube drainage was not significantly different between the groups in one study (3.6 days in the non-intubated uVATS group *vs.* 4.4 days in the intubated uVATS group) (13). In another study (12), in which the chest tube was removed within 4 h postoperatively when there was no air leak, active bleeding, or incomplete expansion of the lung, the rate of chest tube removal within 4 h of surgery was not significantly different between the groups (81% in the non-intubated uVATS group *vs.* 89% in the intubated uVATS group).

Postoperative hospital stay was not significantly different between the two groups (2.7–4.0 days in the non-intubated uVATS group *vs.* 2.7–5.0 days in the intubated uVATS group) (12,13).

The recurrence of pneumothorax within 1 month of discharge from the hospital was not significantly different between the groups (3.1% in the non-intubated uVATS group *vs.* 0.6% in the intubated uVATS group) (12).

Postoperative follow-up and long-term outcomes

Information on follow-up for >1 month after surgery was available in one study (13). The follow-up period was significantly shorter in the non-intubated uVATS group than that in the intubated uVATS group in this study (24.6 *vs.* 50.1 months, P<0.001). In this context, the rate of pneumothorax recurrence was not significantly different between the groups (1.9% in the non-intubated uVATS group *vs.* 5.8% in the intubated uVATS group). A follow-up survey for more than five years in average was not performed in any study.

Discussion

The short-term outcomes of previous studies appeared favorable for patients undergoing non-intubated uVATS for PSP compared to intubated uVATS. Three studies demonstrated several features of non-intubated uVATS compared to intubated uVATS. First, non-intubated uVATS may shorten anesthesia time, arousal time, or postoperative recovery time, but not the operative time. Second, the incidence of perioperative complications in non-intubated uVATS was not significantly different from that in intubated uVATS. Third, although non-intubated uVATS may cause less postoperative pain than intubated uVATS, this advantage seems to last only a couple of days. Fourth, hypercapnia likely occurs during non-intubated uVATS but resolves postoperatively. These findings are consistent with those of a previous study investigating the outcomes of non-intubated multiportal VATS for PSP compared to intubated multiportal VATS (14) which suggests the feasibility of non-intubated multiportal VATS. Regarding the single-port technique, the efficacy of uVATS under general anesthesia for spontaneous pneumothorax has been previously demonstrated in a meta-analysis (15). In this study, intubated uVATS was associated with significantly less postoperative pain, lower paresthesia rate, and shorter hospital stay than intubated multiportal VATS, whereas operative time, duration of postoperative drainage, and incidence of complications were not significantly different between the two procedures (15). On the other hand, it is unknown whether non-intubated uVATS has a similar advantage of less pain and shorter hospital stay than non-intubated multiportal VATS because no study has compared the outcomes of these procedures. Furthermore, indications for the single-port technique in non-intubated VATS have not been defined. For example, pleural adhesion was reported to be the most common factor that required conversion from uVATS to multiportal VATS in intubated VATS for PSP (16,17). Although one of the three studies excluded patients with pleural adhesions from the analysis (12), the other two studies did not. The role and indication of the single-port technique in non-intubated VATS should be further investigated in future studies.

Whether non-intubated uVATS is associated with less postoperative pain than intubated uVATS remains controversial. Two of the three reviewed studies concluded that non-intubated uVATS was associated with transiently but significantly less postoperative pain than intubated uVATS (11,13). However, neither study identified the factors that contributed to the significant difference in postoperative pain. One of the potential explanations, as mentioned in one study (11), is the difference in the protocol of anesthesia and analgesia.

Our review was focused on PSP, because we were not able to find studies on non-intubated uVATS for SSP with a reasonable sample size. Although a few case reports have described experiences of non-intubated uVATS for SSP (18,19), there have been no studies comparing outcomes

between this surgery and other treatment options, including surgical and non-surgical treatment. Patients with SSP, unlike most patients with PSP, often do not tolerate surgery under general anesthesia due to their factors, such as high ages, comorbidities, poor cardiopulmonary reserve, and low performance status (20,21). Therefore, a randomized trial similar to the reviewed studies may be challenging. Non-intubated VATS is the only surgical procedure for patients who are unfit for surgery under general anesthesia. Owing to its less invasive nature, non-intubated uVATS may be an important treatment option for SSP. Further studies are warranted to assess the role of non-intubated uVATS in patients with SSP.

New strategies have recently been proposed to reduce the invasiveness of VATS. Some surgeons avoid the insertion of a chest tube at the end of surgery (22,23), which has been reported to reduce postoperative pain and length of hospital stay (23,24). In a retrospective cohort study investigating the outcomes of the drainless strategy in non-intubated uVATS bullectomy for PSP, all patients with intrapleural adhesions exhibited incomplete expansion of the ipsilateral lung on postoperative day 1 (22), which suggested that this strategy is feasible but can be risky without careful patient selection. Further studies are required to investigate the feasibility of these new strategies.

This study had several limitations. First, this mini-review was based on data from only three studies, which varied in study design. Randomized controlled studies with larger sample sizes are required to establish further evidence on the feasibility of non-intubated uVATS for spontaneous pneumothorax. Second, the literature search may not have been sufficient. We searched for studies written in English using only two databases (PubMed and Google Scholar). No librarians were involved in this search. Third, anesthetic management differed between non-intubated and intubated uVATS, which may have influenced postoperative outcomes, including pain and recovery time. Fourth, all three studies lacked sufficient data on pneumothorax recurrence. Postoperative follow-up information was not available in one study (11). In the other studies, the follow-up period was no more than one month after surgery (12) or inconsistent between the intubated and non-intubated uVATS groups (13). Further studies are required to assess the long-term outcomes of the procedure.

Conclusions

In conclusion, the short-term outcomes of non-intubated uVATS for PSP appear more favorable than those of intubated uVATS, based on the limited amount of available literature. Further studies are required to determine the role of non-intubated uVATS in the treatment of PSP and SSP, including its long-term efficacy.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editor (Kenji Tsuboshima) for the series "Single-Port VATS for Pneumothorax" published in *Video-Assisted Thoracic Surgery*. The article has undergone external peer review.

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://vats.amegroups.com/article/view/10.21037/vats-22-48/coif). The series "Single-Port VATS for Pneumothorax" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/vats-22-48
Cite this article as: Yamagishi H, Hamaji M. Feasibility of non-intubated uniportal video-assisted thoracic surgery for spontaneous pneumothorax: a mini-review. Video-assist Thorac Surg 2023;8:8.