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Current perspective on uniportal and multiportal video-assisted thoracic surgery during lobectomy for lung cancer

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Abstract

Non-small cell lung cancer (NSCLC) is the most typical type of lung cancer, and it is the leading cancer-related mortality globally. Lobectomy for early-stage NSCLC has been characterized in the previous decade using a wide range of methodologies. The development of video-assisted thoracoscopic surgery (VATS) allowed surgeons first to reduce the thoracotomy size, which is generally anterior, limiting it to trocar incisions or a single portal approach. This review aimed to describe current perspectives on operative outcomes, lymph node removal, oncologic outcomes, and advantages for surgeons performing uniportal VATS (uVATS) and multiportal (mVATS) lobectomy. The advantages of uVATS include comfortable operating for surgeons with a direct view and safety, and for patients more favourable operative outcomes. Also, the uVATS approach has previously been demonstrated to be effective and safe, with positive outcomes not just with respect to cosmetics but also in terms of a speedy recovery. Oncological uVATS clearance is comparable to multiportal VATS with respect to early mid-term survivability as well as nodal staging, as per retrospective comparison studies. However, the interpretation of outcomes must be made cautiously due to selection bias as well as lack of long-term follow-up; the choice of which VATS approach to utilize for patients' treatment following pulmonary resection is largely based on the preferences of the surgeon. As a result, it is difficult to say if one VATS method is better than another.

Key words: lobectomy, video-assisted thoracoscopic surgery (VATS), uniportal VATS, multiportal VATS, pain, oncology.

Introduction

Non-small cell lung cancer (NSCLC) is the most typical type of lung cancer, which is the primary cancer-related cause of mortality globally. Lung cancer ranked highest as it was the leading cancer-related cause of death in 2012, accounting for 12.09% of all newly reported malignancies [1, 2]. In spite of breakthroughs in multimodality approaches such as immunotherapy and target therapy, the long-term survivability of subjects with advanced-stage lung cancer has remained depressing [3]. In a national cost-effectiveness investigation, lung cancer has ranked first in terms of cost per quality-adjusted life-year [4]. Even though lung cancer of an advanced stage continues to account for the majority of newly diagnosed cases, the incidence of early-stage lung cancer, identified as clinical T1-2N0M0 disease, has increased significantly in recent years as a result of LDCT (low-dose CT) screening, which aided in detecting, treating, as well as curing many early-stage lung cancers [5].

Lobectomy for early-stage NSCLC has been characterized throughout the previous decade in several methods [6]. An axillary, posterolateral or anterior incision can be used for open surgical procedures. To reduce thoracic damage, muscle-sparing procedures have been recently implemented. The development of video-assisted thoracoscopic surgery (VATS) allowed surgeons to minimize the thoracotomy size, generally anterior, confined to trocar incisions or a single portal approach [7, 8]. Video-assisted thoracoscopic surgery lobectomy, which was proposed first over 25 years ago, is a well-established strategy for treating NSCLC of an early stage that was given the recommendation of 'grade 2C' by the American College of Chest Physicians proof-based guidelines in 2013 as a preferable option over open surgery [9, 10]. In comparison to open surgery, video-assisted thoracoscopic surgery lobectomy is considered to result in less discomfort, fewer complications, as well as a faster return to normal functioning; these claims are supported by trial meta-analyses, despite the fact that most of the trials were not randomized [11, 12].

To be accurate, 'video-assisted thoracoscopic surgery lobectomy' refers to a group of surgical procedures that considerably vary in the number of incisions, the utility incision's width, as well as how the pulmonary hilum is

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addressed. Furthermore, some innovative methodologies were characterized, such as the transcervical [13] or subxiphoid uniportal approaches [14] and microlobectomy [15]. Nonetheless, the most widely used technique is Hansen and Petersen's 3-portal anterior approach [16]. However, if video-assisted thoracoscopic surgery lobectomy is superior to open thoracotomy because of reduced surgical access trauma, a further decrease in surgical access trauma ought to result in improved results. Diego Gonzales Rivas proposed his uniportal VATS (uVATS) lobectomy in the year 2010 as a result of this consideration [17]. The uniportal approach has gained great significance, notably in Asian countries, despite initial scepticism. Those supporting the procedure claim that uVATS can reduce morbidity and post-operative pain while also speeding up functional recovery [18]. In spite of publishing certain retrospective studies where there is a comparison of uniportal to "multiportal" video-assisted thoracoscopic surgery lobectomy, there is still insufficient information to indicate which procedure must be favoured, particularly in preference to reducing post-operative pain [19–22].

Furthermore, the perioperative outcome of uVATS is equivalent to those of multiportal VATS (mVATS) technique, mainly in relation to lesser access trauma as well as intra-operative loss of blood, according to increasing evidence, and uVATS has been progressively used globally [23]. Also, according to recent research, uniportal VATS wedge resection might improve surgeon ergonomics by enabling them to stand straight and face the monitor with a much more neutral body posture [24]. Furthermore, according to a prior study research review, ergonomic variables can affect the performance of surgery during laparoscopies [25].

This narrative review aimed to describe current perspectives on operative outcomes, lymph node removal, oncologic outcomes, and advantages for surgeons performing uVATS and mVATS lobectomy.

Transition from mVATS TO uVATS

In the minimally invasive surgery era, all future techniques of surgery will strive to achieve the same oncological radicality with much less invasiveness, resulting in improved cosmetic results outcomes, reduced post-operative pain, as well as speedy patient recovery. In the last 6 years, thoracic surgeons have become increasingly interested in VATS, which promises better outcomes than conventional multiportal VATS [26, 27]. As a result, a rising number of centres around the world have begun to successfully execute uVATS. The main factor which influences the decision to change mVATS to uVATS is described here.

Triportal VATS (tVATS)

Kirby *et al.* reported their initial experience with VATS lobectomy in the early 1990s [28], followed soon by Lewis in 1995 [29]. Since then, the number of VATS procedures has rapidly multiplied. Triportal VATS is nowadays a well-established method and is demonstrated widely to be effective and safe [30]. In the tVATS technique, 2 ports, as well as a 3–4 cm service incision, are included. Hence, compared to muscle-sparing thoracotomy, it provides the same demonstrated oncological efficiency as open surgery but with reduced post-operative pain, improved cosmetic outcomes and speedy patient recovery. It is also inexpensive compared to other minimally invasive procedures, such as robotic surgery, which achieves the same results for subjects at a greater expense.

Moreover, there seems to be a number of complaints that can be raised against this technique, the most serious of which concerns technological issues which may jeopardize the comfort of operators. Certainly, the trapezoidal design of tVATS interferes with the optical source, resulting in a new optical plane that produces a torsion angle that is not favourable for standard 2-dimensional monitors [31, 32]. The surgeon's position can be bothersome as he has to turn his neck and frequently work with his shoulders lifted to handle the equipment. Standing on the opposite side, with a different visual axis, can also be much more inconvenient for assistance [24]. Moreover, lung palpation with this technique might be difficult or impossible at times.

Biportal VATS (bVATS)

The whole method, which some surgeons refer to as "a bridge to uVATS", was established in an effort to decrease the number of incisions in comparison to standard tVATS. As a result, while uVATS does have some benefits, it also has some unfavourable factors acquired from tVATS. The key advantages include the ability to use the same anterior approach as open surgery with the added benefit of magnification provided by the thoracoscope, effective lung palpation and reduced post-operative discomfort compared to muscle-sparing thoracotomy [31, 32].

Moreover, unlike open surgery, the surgeon with this approach has a different visual axis, and there is a greater danger of fencing between the equipment and camera shank if the surgeon does not have strong fluency in using typical straight endoscopic equipments [31, 32].

Uniportal VATS (uVATS)

In 1998, uVATS was first used as a diagnostic method for pulmonary nodules [33]. But due to its low invasiveness, it has grown in popularity and is currently used for more complex techniques such as pulmonary lobectomies and bronchoplasties [34–36].

The fundamental benefit of this method is that it uses the same anterior approach for open surgery, allowing a direct view of the target area and efficient lung palpation as well as mobilization. Only one 3–4 cm incision is necessary (4^{th} or 5^{th} intercostal space), with no disruption of muscle, no spreading of ribs, and no need for trocars [37]. A 10 mm 30° thoracoscope is used, held in the upper part of the incision, and all the other tools can be inserted in the lower part of the same instruments through the same incision. Because of its curved design, uVATS makes it possible to introduce multiple tools through small incisions and to handle them with comfort.

Table I. Summary of perioperative outcomes in all studies comparing uVATS and mVATS

Reference	Operative time [min]		Length of say [days]		Blood loss [ml]		Duration of postoperative drainage [days]		Conversion to thoracotomy		Overall morbidity		Mortality	
	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi	Uni	Multi
Chung *et al.* [23]	159.2 ±53.1	166.2 ±49.5	6.8 ±3.4	8.6 ±8.3	NR	NR	5.04 ±2.9	6.3 ±5.7	10/90 (11%)	9/60 (15%)	18/90 (20%)	17/60 (28%)	0/90 (0%)	1/60 (2%)
Hirai [59]	168 [95–276]	155 [105–225]	7.2 [5–14]	7.4 [5–15]	95 [15–475]	85 [14–435]	NR	NR	1/60 (2%)	0/20 (0%)	10/60 (17%)	5/20 (25%)	0/60 (0%)	0/20 (0%)
Chang *et al.* [60]	151.0 ±26.0	156.3 ±26.5	7.2 ±2.0	7.9 ±2.0	188.6 ±47.0	156.3 ±26.5	3.9 ±1.2	4.4 ±1.4	NR	NR	18/87 (21%)	21/75 (28%)	NR	NR
Liu *et al.* [58]	179.4 ±52.2	208.2 ±63.6	6.0 ±1.7	6.8 ±3.6	55.7 ±52.8	78.3 ±85.0	NR	NR	NR	NR	8/100 (8%)	47/342 (14%)	NR	NR
Mu *et al.* [41]	138.8 ±63.6	135.6 ±55.5	6.5 ±3.8	6.3 ±2.6	73.6 ±51.5	74.1 ±64.5	5.0 ±1.9	5.3 ±2.2	2/58 (3%)	8/347 (2%)	6/58 (10%)	33/347 (10%)	0/58 (0%)	0/347 (0%)
Shen *et al.* [43]	95.3 ±16.9	98.8 ±15.3	4.7 ±1.2	5.3 ±1.4	55.1 ±9.0	58.7 ±7.1	NR	NR	1/100 (1%)	2/100 (2%)	4/100 (4%)	7/100 (7%)	0/100 (0%)	0/100 (0%)
Wang *et al.* [20]	165.9 ±41.7	192.5 ±55.2	5.9 ±1.8	6.7 ±2.5	50.8 ±45.9	87.4 ±85.4	NR	NR	0/50 (0%)	1/183 (1%)	5/50 (10%)	25/183 (14%)	0/50 (0%)	0/183 (0%)
Zhu *et al.* [55]	181.3 ±27.5	149.5 ±30.9	6.9 ±4.0	7.2 ±3.5	90.6 ±49.3	79.5 ±45.2	4.0 ±1.5	5.4 ±3.7	0/33 (0%)	0/49 (0%)	3/33 (9%)	5/49 (10%)	0/33 (0%)	0/49 (0%)
Mean	155.8 ±53.8	167.9 ±64.6	6.2 ±2.6	6.7 ±3.4	86.3 ±76.2	82.4 ±74.0	4.5 ±2.2	5.3 ±2.9	3.6%	2.6%	12.0%	13.7%	0.0%	0.1%
P-value	0.69	< 0.0001	0.63	0.0006	0.83	0.009	NA	*P*-value	0.69	< 0.0001	0.63	0.0006	0.83	0.009

^Data presented are for lobectomy patients. Continuous variables are presented as mean ± SD or median (range). Uni – uniportal, Multi – multiportal, NR – not reported.Adapted from Harris *et al.* 2016.

The uniportal method, unlike tVATS, works on a sagittal plane from a caudo-cranial perspective. All equipment is positioned parallel to this plane, keeping the operative fulcrum inside the chest as well as maintaining visualization depth [31, 32]. Moreover, uVATS is far more ergonomic, allowing surgeons to get better eye-hand coordination naturally. All surgeons look at the same screen on the opposite side of them, which enhances their body posture as well as reducing movements of the neck [24]. This method appears to have a reasonably short learning curve for major resections of the lung, especially after undergoing masterclasses, proctored cases as well as dedicated courses, for the reasons described above [38, 39]. But the technique's greatest strength is the prospective benefits for subjects, such as reduced post-operative pain in comparison to other multiportal approaches, speedy patient recovery, short duration of post-operative stay in the hospital, as well as improved clinical cosmetic outcomes. This minimally invasive technique costs less than robotic surgery and appears to have similar oncological efficiency and safety as all the other techniques [40]. Day after day, a considerable and growing number of publications in the literature demonstrate the efficiency as well as safety of uVATS [20, 38, 41–43]. This discussion between opponents and proponents of uVATS could be fruitful and stimulating, resulting in newer clinical proof of greater quality in the future years.

Operative outcomes

Harris *et al.* reported in their systematic review and meta-analysis study that in comparison to the multiportal technique, subjects who underwent uVATS lobectomy had a statistically significantly shorter stay in hospital (6.20 ±2.60 vs. 6.70 ±3.40 days, $p < 0.0001$). The post-operative drainage duration decreased in the uniportal group by a statistically significant amount (4.50 ±2.20 vs. 5.40 ±2.90 days, $p = 0.0006$). Concerning overall morbidity, a statistically significant reduction was seen in the overall morbidity incidence for subjects following uVATS lobectomy in comparison to multiportal technique, as revealed by relevant research studies (12.00% vs. 13.70%, $p = 0.009$) [42].

No considerable discrepancies between uVATS and mVATS were seen with regards to operative time (155.80 ±53.80 vs. 167.00 ±64.60 minutes, $p = 0.69$), perioperative loss of blood (86.30 ±76.20 vs. 82.40 ±74 ml, $p = 0.63$) or conversion rate to open thoracotomy (3.60% vs. 2.60%, $p = 0.83$). No perioperative deaths occurred in any patients who underwent uVATS and only 1 subject who underwent the multiportal approach [23].

No statistically significant changes were seen in hospital stay length, operation time, post-operative drainage duration, perioperative loss of blood, conversion rate to thoracotomy, or overall morbidity when propensity-matched data were evaluated. A summary of perioperative outcomes in all research comparing multiportal and uniportal VATS is summarized in Table I [42].

Tosi *et al.* recently published a retrospective, observational, multi-centre study on data gathered in the Italian

VATS Group Database, assessing lobectomies conducted for clinical stage I–II NSCLC by uVATS and tVATS. Their findings revealed that uVATS lobectomy seems to involve a higher severe/moderate pain risk on post-operative days 2 and 3 [44].

A single site trial reported by Perna *et al.* has been the only randomized comparative research study that compared mVATS with uVATS lobectomy. With respect to post-operative pain, there was no statistically significant difference between the 2 groups [45].

Oncological outcomes

Video-assisted thoracoscopic surgery refers to comprehensive thoracic procedures conducted through small incisions with the exclusively endoscopic vision of the intrathoracic viscera. Open lobectomy, on the other hand, is performed under direct visualization via a large thoracotomy. The open approach involves the splitting of muscle, cutting of ribs, and spreading to gain access to the pleural cavity, typically leading to disability, shoulder dysfunction and severe pain [46]. The resultant systemic inflammatory response syndrome (SIRS) and the access trauma experienced are typically severe. Video-assisted thoracoscopic surgery not only helps in reducing disability and pain but also has the ability to limit SIRS magnitude. This is hypothesized to minimize post-operative humoral and cellular immune disturbances as well as aiding in preventing an environment conducive to tumour micrometastases [47–49]. As a result, minimizing the length of incision might assist in lessening not just the pain but also immunological dysfunction as well as possible disease recurrence risks. To benefit from this kind of access trauma reduction, shifting from multiportal to uVATS might be a possible approach. Early evidence suggests that in comparison to multiportal, uVATS is related to an attenuated post-operative immunochemokine response. However, more research is required to validate this and to explore its clinical implications [48].

Lim *et al.* searched EMBASE, as well as Medline with the use of the tactic, noted in the ISMICS (International Society for Minimally Invasive Cardiac Surgery) expert consensus statement on an "Optimal Approach to Lobectomy for Non-Small Cell Lung Cancer: Systematic Review and Meta-Analysis" to determine the current state of evidence for oncological efficiency of uniportal VATS [50]. Twenty-three publications were identified that compared uVATS and mVATS between January 2000 and October 2019. Two cases were removed from the current discussion as they did not provide any oncological results. The remaining 21 trials, which involved 2,165 uVATS and 3,737 mVATS subjects, were all retrospective in nature [51].

The early post-operative complication rate was documented in 16 studies. Furthermore, there was a lot of heterogeneity in how problems were defined as well as categorized. Generally, in terms of complications, there is no substantial difference between the 2 groups. Bourdages-Pageau *et al.* found that the uVATS group had less pneumonia compared to the mVATS group; however, the reason for this is unknown.

The number of dissected lymph nodes collected was compared in 18 investigations. The radiological nodal staging was commonly reported partially or was not reported at all. Routine lymphadenectomy was conducted in 13 studies, lymph node sampling in 2, and in 3 studies the strategy is not clear. The completeness of lymphadenectomy or the boundaries of lymph node stations were not stated in any of the publications. Only 1 research study recorded the number of lymph nodes removed separately from N1 and N2 stations. In every study, uniportal VATS was superior to multiportal VATS with regards to sampling of the number of lymph node stations and the number of lymph nodes extracted [51]. Song *et al.* found that the uniportal VATS team extracted many more lymph nodes in their propensity-matched trial; nevertheless, the explanation for this is unknown [52]. The pathological upstaging rate reported from 4 articles showed no considerable disparity [51].

Only 2 retrospective investigations provided information on short-term to mid-term survivability. Han *et al.* from South Korea reported four hundred and thirty-nine video-assisted thoracoscopic surgery lobectomies for stage I and II disease from 2006 to 2015, during the transition of the group from triportal to biportal and then to uniportal. The 3-year overall survival was 87.3% (median follow-up of 75.7 months) for the triportal group, in comparison to 93.7% (median follow-up of 56.5 months) for biportal and 93.2% (median follow-up 27.5 months) for uniportal. Among the 3 categories, no difference in disease-free survival as well as overall survival was seen [53]. Outcomes of 191 lobectomies conducted on T1a and T1b patients between 2013 and 2015 were reviewed retrospectively by Zhao *et al.* in China. 3-year overall survival did not differ between the uniportal, thoracotomy and multiportal groups (p = 0.327) [54]. However, the particular percentage of subjects in each team who survived 3 years was not disclosed.

None of the studies provided an explanation for why the video-assisted thoracoscopic surgery technique was chosen. The surgeon's discretion was a large part of the decision. "The selection criteria between triple-ports and single-port weren't special or different," as one report stated frankly [55]. The selection bias risk was considered high with even propensity score matching since only 3 out of 10 studies revealed the factors included in propensity score calculation.

Surgeon's experience and learning curve

It is challenging to master uniportal VATS. At high-volume centres, focused as well as dedicated training is essential, along with close supervision by experienced surgeons. Moreover, oncological clearance has been demonstrated to be affected by the surgeon as well as institutional experience. An inspection of 500 successive video-assisted thoracoscopic surgery lobectomies at New York-Presbyterian Hospital revealed that the latter half of the cohort had considerably more lymph nodes removed. Further examination of an individual surgeon's learning curve in VATS lymphadenectomy revealed that after the first 50 cases, a plateau

in the number of lymph nodes extracted was attained [56]. Gonzalez *et al.* assessed their first 3 years of video-assisted thoracoscopic surgery lobectomies experienced at Coruna when the group was transitioning from triportal to biportal VATS. From 2007 to 2010, 200 cases were separated into 3 cohorts by year, with each year showing an improvement in nodal harvesting due to improved experience [57].

Despite the fact that both research studies used multiportal VATS, the findings can be inferred to be relevant to uniportal VATS. From 2013 to 2014, the learning curve of the first 120 uniportal VATS lobectomies was studied by Zhongshan University, which was carried out by a group of experienced multiportal VATS surgeons [58]. After the first 30 cases, the skin-to-skin time reached a plateau. In addition, the first quartile of the cohort had significantly more conversions and failed efforts at passing the stapler. Before shifting to uniportal instrumentation, trainees are asked to get experience with biportal instrumentation first as per the advice from an experienced surgeon. In the event of technical issues, switching to a biportal method can usually provide an expedient and safe operation in most cases by enabling more equipment into the operating field, increasing stapling angles, and lowering instrument fencing.

Conclusions

The advantages of uVATS include a comfortable operation for surgeons with a direct view and safety, and for patients more favourable operative outcomes. Furthermore, the uVATS approach has previously been proved to be feasible as well as safe, with positive outcomes not just with respect to cosmetics but also in terms of a quick recovery. Moreover, in an era when hospitals are concerned about their own finances, it should be emphasized that such a procedure offers an excellent benefit-to-cost ratio, with no need of technologies that are expensive and with a rather short learning curve for operators' training.

Even though the uniportal technique has no intrinsic limitations that limit oncological efficiency, the use of uniportal VATS for lung cancer continues to remain controversial. Oncological clearance of uniportal VATS is similar to multiportal VATS with regards to nodal staging as well as early mid-term survivability, as per retrospective comparison studies. However, the interpretation of their findings must be made with care due to the lack of long-term follow-up and selection bias.

Moreover, the decision of which video-assisted thoracoscopic surgery method to use for treating subjects having pulmonary resection is more a matter of the surgeon's preferences, as it is difficult to say how one video-assisted thoracoscopic surgery technique is better than the other. Furthermore, post-operative analgesic procedures consistently vary from one centre to the next. Only a few studies have assessed the impact of the most used video-assisted thoracoscopic surgery procedures to date. With regards to post-operative pain, there is no evidence to suggest that uVATS and mVATS differ. Therefore, we are in accordance with the recommendation of Dr. Gonzalez-Rivas that there is a resurgence of high-quality investigation in this discipline to ensure the true value of uVATS in the armamentarium of modern minimally invasive thoracic surgery.

Disclosure

The authors report no conflict of interest.

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