

# Global development and current evidence of uniportal thoracoscopic surgery

Cheng-Che Tu<sup>1</sup>, Po-Kuei Hsu<sup>2,3</sup>

<sup>1</sup>Division of Thoracic Surgery, Department of Surgery, Chang Bing Show Chwan Memorial Hospital, Changhua, Taiwan; <sup>2</sup>Division of Thoracic Surgery, Department of Surgery, Taipei Veterans General Hospital, Taipei, Taiwan; <sup>3</sup>School of Medicine, National Yang-Ming University, Taipei, Taiwan

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**Correspondence to:** Po-Kuei Hsu, MD, PhD. Division of Thoracic Surgery, Department of Surgery, Taipei-Veterans General Hospital, No. 201, Sec. 2, Shih-Pai Road, Taipei, Taiwan. Email: hsupokuei@yahoo.com.tw.

**Abstract:** In the era of video-assisted thoracoscopic surgery (VATS), uniportal and single incision thoracoscopic surgeries are gaining popularity. The spectrum of uniportal VATS indications is now almost equal to that of conventional VATS. For example, successful uniportal sleeve lobectomy, rib segmental resection, and management of intraoperative bleeding have all been reported. According to published data in the English-language literature, more than 9,545 uniportal VATS have been performed to date, including 1,293 lobectomies, 1,024 procedures for pneumothorax, and 6,845 sympathectomies. Of the 192 articles discussing this topic, 35 were conducted in Spain, and there were an increasing number of publications from China, Korea, and other Asian countries. There were 41 technical and review articles, all of which provided an excellent foundation of surgical concept and skill learning. The benefits of uniportal VATS include better surgical geometry and cosmetics. Regarding postoperative outcomes, thirteen out of the 15 articles reviewed showed that uniportal VATS has similar or superior outcomes to conventional VATS. Most studies demonstrated that uniportal VATS produced less postoperative pain and paresthesia. In conclusion, uniportal VATS can produce excellent operative outcome, which is becoming a mature surgical approach in thoracic disease, supported by fast-accumulating and abundant experience.

**Keywords:** Uniportal; single-port; thoracoscopic; video-assisted thoracoscopic surgery (VATS)

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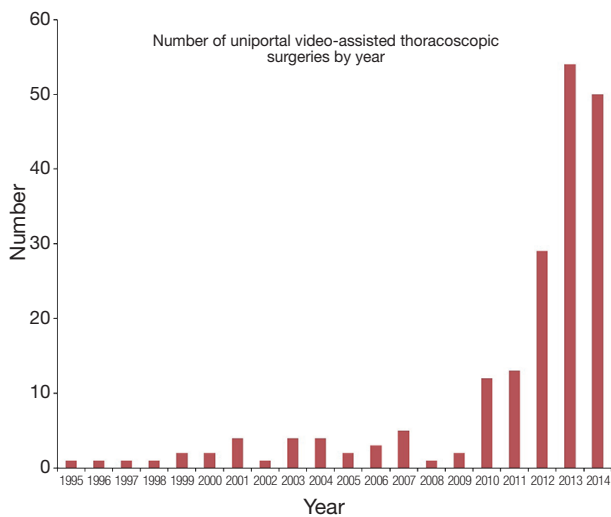
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## Introduction

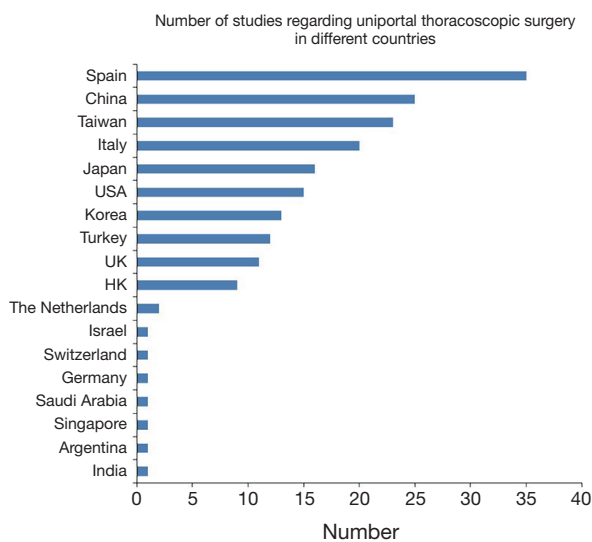
Video-assisted thoracoscopic surgery (VATS) has been used in almost all surgical indications for thoracic disease, including pneumothorax, infectious disease, and malignancy (1). The benefits of VATS include shorter hospital stay, reduced postoperative pain, and superior postoperative quality of life compared to open thoracotomy. Multiple variants of the VATS technique exist, including those that use different port numbers, positions, and entry styles. Most surgeons perform VATS with one utility port plus one or two more

assistant ports (2).

Uniportal VATS, also known as single incision thoracoscopic surgery (SITS), has gained popularity in the past decade. Rocco *et al.* published the first case series of uniportal VATS pulmonary wedge resection in 2004 (3). Since then, uniportal VATS has been successfully performed for numerous indications. When performing thoracic endoscopic surgery with all instruments in a single incision, the collision of instruments is inevitable and might compromise the operative outcome. However, with the advent of specialized surgical instruments and the



**Figure 1** Number of uniportal video-assisted thoracoscopic surgeries performed worldwide each year.



**Figure 2** Number of uniportal video-assisted thoracoscopic surgeries performed in different countries. HK, Hong Kong; UK, United Kingdom; USA, United States of America.

improvement of surgical technique, we can safely perform not only simple operations, such as diagnostic procedures or sympathectomy, but also more complication procedures, such as anatomic resection of the lung (4).

The number of patients who have undergone uniportal VATS and the number of published studies regarding this procedure are increased rapidly. Interestingly, with the increasing number of patients undergoing this operation,

surgeons in Asian countries seem more inclined to practice uniportal VATS. Some authors reported various additional benefits of the uniportal approach versus its multi portal counterpart, while others demonstrated no difference between the procedures. The aim of this review was to provide a clear picture of the current achievements associated with uniportal VATS, its development and geographic distribution, accumulated evidence of its actual benefits, and educational resources.

## Methods

An electronic search was performed in databases including PubMed, The Cochrane Library, and Embase. The search terms were “single port” or “single incision” or “uniportal”, and “VATS”. We sought controlled trials, observational studies, case series, case reports, and review articles. The searches were limited to English-language articles published before November 2015. Only articles that provided full text were included.

From these articles, we included those that described surgery attempted with only one incision. The following characteristics were recorded: number of each type of procedure, operative time, blood loss, complications and mortality, length of incision, hospital stay, and rate of conversion. With respect to surgery for cancer treatment, we also collected data regarding oncological outcomes, such as overall survival (OS) and recurrence-free survival (RFS).

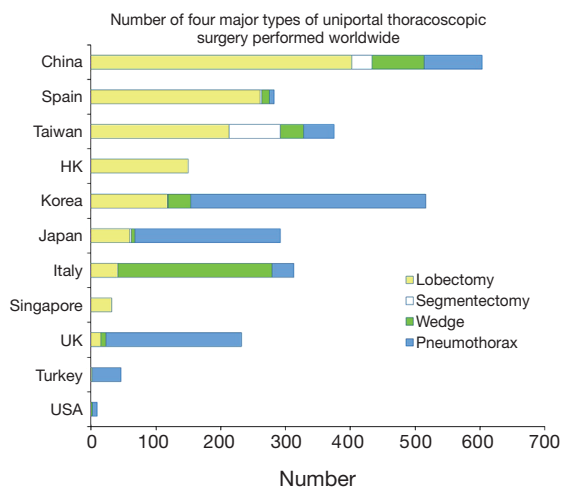
## Results

### Current publications

A total of 240 articles were found using the search criteria. After excluding articles without complete data, articles not written in English, and letters or replying commentaries, 192 articles remained: 102 original articles, 49 case reports, and 41 review or technical articles mentioning SITS or uniportal VATS.

Before 2010, there were generally fewer than 10 articles published each year. In the past half-decade, there was a sharp increase in number; there were 54 publications in 2014 and 50 in 2015. The number of publications by year is presented in *Figure 1*.

The top three countries with the highest number of publications were Spain with 35 articles; China, 25; and Taiwan, 23. The complete list is shown in *Figure 2*. Overall, authors from Asian countries published more articles



**Figure 3** The numbers of four major types of uniportal thoroscopic surgery performed in different countries. The four major types of surgery include: lobectomy, segmentectomy, wedge resection and surgery for pneumothorax. HK, Hong Kong; UK, United Kingdom; USA, United States of America.

regarding uniportal VATS. Among the European countries, Spain, Italy, Turkey, and the UK were those that had more interest in uniportal VATS than the others. In addition, of the 35 articles from Spain, 26 of them were the works of one group: Gonzalez-Rivas *et al.*

From a total of 9,545 operations attempted in the fashion of uniportal VATS, 61 (0.61%) were converted to either 2- or 3-port VATS, or thoracotomy. Sympathectomy was the most common operation, with 6,845 procedures. Other popular operations included 1,293 lobectomies and 1,024 uniportal VATS for spontaneous pneumothorax. In *Figure 3*, we compare the four main types of surgery by country. The four types of surgery included two types of major lung resection, lobectomy and segmentectomy, and two types of VATS surgery involving primarily minor lung resection, and wedge and pneumothorax surgery. China, Spain, and Taiwan published the most uniportal lobectomy cases, while most of the pneumothorax surgeries were published by authors from Korea, Japan, and the UK.

### **Perioperative outcome of uniportal versus conventional VATS**

Many authors have reported large series of uniportal VATS operations, with low morbidity and low 30-day mortality. However, perioperative parameters varied greatly between centers. For example, the operative time for lobectomy

ranged from 80 to 230 minutes (5,6). Hsu *et al.* (7) reported the first multi-institutional study for perioperative outcome of uniportal VATS and demonstrated that in experienced centers there is a general decline in the rate of conversion and complication after 2–4 years of practice, but that great differences in operative time and the numbers of harvested lymph nodes exist between hospitals. Thus, we focused on those publications that compared uniportal and conventional VATS. These studies mainly included surgery for pneumothorax and lung anatomic resection. The comparison of perioperative outcomes is listed in *Tables 1,2*. *Table 1* shows the seven articles in which the authors compared outcomes of anatomic resection with uniportal and conventional VATS in their own institutes. Three of the articles found no significant differences between the two VATS approaches. Two showed that uniportal VATS had a mildly increased operative time, while other outcomes were similar. In Liu's series, uniportal VATS surpassed conventional VATS in many aspects, such as less blood loss, shorter operative time and hospital stay, and a greater number of harvested lymph nodes (14). In that article, the author provided figures that demonstrated improved operative results year by year. Wang and Shen *et al.* compared anatomic resections in uni- or multi portal VATS with propensity score matching (9,13). In Shen's series, the operative time was longer during lymph node dissection, but shorter during lobectomy. In Wang's study, 35 lobectomies and 15 segmentectomy were performed in a uniportal fashion. The uniportal group had shorter operative time, less blood loss, and a greater number of harvested lymph nodes. The comparison of surgery for pneumothorax revealed similar or superior results associated with uniportal VATS in seven of 8 articles (*Table 2*). Morbidity and recurrence rates after uniportal VATS are generally low. In Salati and Chen's studies, patients who received uniportal VATS had shorter hospital stays.

In conclusion, in either anatomic resection or pneumothorax operations, most studies show that uniportal VATS is not inferior to multi portal VATS. Several authors also demonstrated better results in the uniportal group; two studies of pneumothorax surgery showed uniportal VATS was associated with shorter hospital stays, and two studies of anatomic resection showed numerous benefits, such as shorter hospital stay, less blood loss, smaller wound size, and a larger number of retrieved lymph nodes. Only one study in each surgical type showed that conventional VATS was superior to uniportal VATS with respect to operative time, which could be overcome with practice.

**Table 1** Comparison of perioperative outcomes of anatomic resection between uniportal and conventional video-assisted thoracoscopic surgeries

Outcomes	Author						
	c-VATS better	Similar or controversial results			Uniportal VATS better		
	Zhu (8)	Shen <sup>*,§</sup> (9)	Ibrahim (10)	Hirai (11)	Chung (12)	Wang <sup>§</sup> (13)	Liu (14)
Patients (n)	33	100	15	60	90	50	Lob: 100 Seg: 50
Operative time (minutes)	181.3±27.5 vs. 149.5±30.9 P=0.007	LND: 29.6±16.7 vs. 17.4±13.3 P<0.001	112.6 [70–200]	168 [95–276]	159.2±53.14	169.9±39.58 vs. 191.2±51.82 P=0.029	2.99±0.87 vs. 3.34±0.93 (hour) 3.47±1.06 (hour) P<0.001
Blood loss (mL)	90.6±49.3	Lob: 65.7±14.8 vs. 81.3±13.6 P<0.001	55.1±9.0	95 [15–475]	53.04±47.09 vs. 95.33±107.0 P=0.017	55.68±52.81 vs. 78.28±84.99 P=0.001	63.88±79.60
Incision length (cm)	4	3.5	3.2	5	7.2 [5–14]	5.83±1.83	3.66±0.77 vs. 4.50±0.56 P<0.001
Hospital stay (days)	6.9±4.0	4.7±1.2	3.2	7.2 [5–14]	6.78±3.37	5.83±1.83	5.76±1.98 vs. 6.83±2.21 P=0.014
Lymph nodes harvested, N	23.6±11.2	21.4±5.6	13.6 [6–24]	13.59±7.18	27.39±12.28 vs. 22.07±11.18 P=0.032	28.47±11.77 vs. 25.23±11.30 P=0.013	19.47±10.79
Conversion, N (%)	0	1 (1%)	1 (1.7%)	32 (35.5%)			
Complications, N (%)	3 (9.1%)	4 (4%)	10 (16.7%)	18 (20%)	4 (8.70%)		

<sup>\*</sup>, In this article, LND time was longer in uniportal VATS, but the lobectomy time was shorter in uniportal VATS; <sup>§</sup>, Propensity score matching. Outcomes with significant difference are shown with grey shading, and the p-values are listed. In Zhu's study, the operative time is longer in the uniportal group. In Wang & Liu's study, uniportal video-assisted thoracoscopic surgeries (VATS) has a shorter operative time and hospital stay, less blood loss, smaller incision length and more lymph nodes harvested. In Shen's article, the uniportal VATS group won over conventional VATS on lymph node dissection time, but slower on lobectomy time. In the three other studies, no significant differences were found. In all articles, complications and the rate of conversion to thoracotomy were low and did not differ significantly. c-VATS, conventional VATS, has more than 1 incision; LND, lymph node dissection; Lob, lobectomy; Seg, segmentectomy; VATS, video-assisted thoracoscopic surgeries.

**Table 2** Comparison of perioperative outcomes of pneumothorax surgery between uniportal and conventional video-assisted thoracoscopic surgeries

Outcomes	Author							
	c-VATS better		Similar results				Uniportal VATS better	
	Igai (15)	Yang (16)	Chen (17)	Ocakciogl (18)	Song (19)	Jutley (20)	Salati (21)	Chen (22)
Patients (n)	44	27	10	37	37	16	28	36
Operative time (minutes)	55.2±15.5 vs. 35.9±14.0 P<0.001	74.6±22.8	80.5±20.74	61.7	57.1±18.6		72.3±31.8	59.3
Incision length (cm)	2.5–3.0	2.5	2.5		2.5	2–2.5	2.5	1.5
Hospital stay after surgery (days)	2.4±0.1	2.3±0.7			5.0±1.8	4.6±2.1	3.8±1.8 vs. 4.9±2.9 P=0.03	4.1 vs. 6.2 P<0.001
Conversion, N (%)	1 (2.3)			0	0	0	0	0
Complications, N (%)	0	1 (3.7)		0	0	3 (18.75)	1 (3.5)	0
Recurrence, N (%)	0	1 (3.7)			0	0	3 (10)	1 (2.8)

Outcomes with significant difference are shown with grey shading, and P values are listed. c-VATS, conventional VATS, has more than 1 incision; VATS, video-assisted thoracoscopic surgeries.

### Pain and paresthesia issue

Pain reduction is an important goal for many surgeons who attempt uniportal VATS. However, does applying the uniportal technique actually reduce patient's suffering? In the current study, of the 192 articles identified in our search, 14 focused on the evaluation of pain score. Those 14 articles are summarized in *Tables 3,4*. Three of these articles included the evaluation of patients with NSCLC, with a total of 108 lobectomies performed. Two articles that focused on mediastinal surgery included seven patients with spontaneous pneumothorax. The remaining two studies had a mixture of patients. Tamura *et al.* reported the results of operations on 19 patients, including 5 wedge resections, 10 pneumothorax operations, and 4 mediastinal operations. Mier *et al.* analyzed a group of patients who underwent lung biopsies, the pneumothorax procedure, and mediastinal cyst excisions.

From these reports, we concluded that uniportal VATS caused no more pain than conventional VATS and, apart from one study, all investigations showed that uniportal VATS was superior to its conventional counterpart for at least one pain-related parameter. In most studies, a 0–10 numeric visual analog pain scale was used, and many authors recorded pain scores on each day after the operation. Suda *et al.*

recorded the amount and duration of oral analgesics used after the operation (24). Wu *et al.* evaluated the pain score on the day of discharge, and their uniportal VATS patients were discharged 3.75±1.53 days postoperatively, which is significantly shorter than that for conventional VATS (28). In McElnay's article, the first day pain score, median days of patient-controlled anesthesia use, and median amount of morphine used were compared (23). The pain score was zero in both uni- and multiportal groups, and the two other parameters were also similar. Young *et al.* recently reported a best-evidence topic: "Is uniportal thoracoscopic surgery less painful than multiple port approaches?" (29). That article, which commented on the very issue that is the focus of the present review, included 10 papers and 2 abstracts. In one of the two abstracts, Byun *et al.* showed significant lower median pain score associated with uniportal VATS, while in the other Soggi *et al.* reported no statistical differences in postoperative pain between uni- and multiportal groups (30,31). In most articles, the level of evidence was highest in level IIb, while in all of them the case number was small. The author concluded that uniportal VATS might have a small effect on early postoperative pain because only half of the studies showed significant reduction of postoperative pain, and most reported differences in pain score of only 1 or 2 points.

**Table 3** Comparing postoperative pain and paresthesia of uni- versus multiportal video-assisted thoracoscopic operation, including lobectomy, mediastinal surgery and mixed different type of surgeries

Outcomes	Author						
	Lobectomy			Mediastinal		Mixed	
	Hirai (11)	Zhu (8)	McElnay (23)	Suda* <sup>α</sup> (24)	Wu* (25)	Tamura (26)	Mier (27)
Number	60	33	15	46	29	19	10
VAS on							
Operation day (first 24 h)		3.6±0.7 vs. 5.5±1.0 P<0.000	0 (0–0) Median morphine in 24 h: 19 (18.0–29.4)	Oral analgesics: 28 [21–40] vs. 41 [21–53] P=0.0092		4.95±0.3 vs. 6.44±0.39 P=0.012	
POD 1			Median duration of PCA days: 1 [1, 1]		1.45±0.87 vs. 3.69±1.22 P<0.001	2.74±0.3 vs. 3.78±0.35 P=0.039	4.4±1.7 vs. 6.2±1.4 P=0.035
POD 2		2.7±1.0		Duration of drugs: 10 [7–13] vs. 14 [7–26.8] P=0.0312	Discharge day: 0.24±0.51 vs. 0.86±1.43 P=0.035	1.32±0.2 vs. 1.94±0.21 P=0.037	
POD 3 or later days	2.4±0.4 vs. 4.2±0.3 P=0.041						

\*, record pain score at time intervals different from other studies; <sup>α</sup>, subxiphoid approach. Pain scores are demonstrated as video-assisted thoracoscopic surgeries (VAS) from 0–10 if not mentioned otherwise. The columns are shaded grey to indicate significant differences between uni- and multi portal VATS, and P value is shown if provided. Thirteen of the 14 studies comparing postoperative pain show that uniportal VATS has at least one parameter superior to conventional VATS, except for McElnay's study where there are no differences. POD, postoperative day; VAS, visual analog scale.

**Table 4** Comparing postoperative pain and paresthesia of uni- to multiportal video-assisted thoracoscopic surgeries treating pneumothorax

Outcomes	Author						
	Chen (17)	Ocakcioglu <sup>°</sup> (18)	Song (19)	Chen (22)	Yang (16)	Salati* (21)	Jutley* <sup>§</sup> (20)
Patients (n)	10	37	37	36	27	28	16
VAS on							
Operation day (first 24 h)					4.1±1.7	Chronic pain after 6 months	Inpatient max pain: 0.4±0.5
POD 1	4.50±0.70 vs. 4.95±0.39 P=0.032	3.42±0.94 vs. 4.23±0.92 P=0.011	3.9±1.2 vs. 5.2±1.3, P=0.022	4	1.4±1.4	Using McGill pain questionnaire (0–5 points), no difference	Inpatient median pain: 1.4±0.9 vs. 2.6±0.9 P<0.001
POD 2	4.20±0.78	2.46±0.81 vs. 3.60±0.87 P=0.014		3.2	2.7±1.0		
POD 3 or later days	3.30±0.60	1.96±0.59 vs. 2.55±0.78 P=0.042	2.5±1.5 vs. 3.9±1.8 P=0.03	2.5 vs. 2.9 P=0.008			
Paresthesia, N (%)					9 (33.3%) vs. 10 (76.9%), P=0.01	35% vs. 94%, P<0.003	2 (14%) vs. 12 (58%) <sup>‡</sup>

\*, record pain score at time intervals different from other studies; <sup>°</sup>, in this study, uniportal, 2- and 3-port VATS were all performed. The data shown compare uniportal vs. 3-port VATS; <sup>‡</sup>, P value not provided, but a notable clinical difference was found; <sup>§</sup>, using 0–4 points VAS score. Pain scores are demonstrated as VAS from 0–10 if not mentioned otherwise. Columns shaded grey indicate significant differences between uni- and multiportal VATS, and P value is shown if provided. POD, postoperative day; VAS, visual analog scale.

Paresthesia is also an important complication after thoracic surgery; however, this issue was not addressed in the study conducted by Young *et al.* Three of the 14 articles compared postoperative paresthesia in uni- versus multiportal VATS, and recorded the patient's neurological complications or paresthesia. In Yang and Salati's studies, the incidence of paresthesia was significantly lower among patients in the uniportal group. According to the study of Jutley *et al.*, 86% of patients with multi-port VATS developed paresthesia, compared to just 58% of patients with uniportal VATS (20). Although the P value was not provided, the clinical difference was evident. Neurological symptoms or paresthesia is a distinct complaint in VATS patients. Sihoe *et al.*, described as many as 52.8% of patients having such complaints, and as many as 21% of patients having symptoms that last more than a year (32). These neurological symptoms can be very troublesome, and are often not amendable to oral analgesics. Reducing the number of ports also reduces the chance of intercostal nerve damage, and lowers the risk for paresthesia. The results presented in tables underscores this theory.

In conclusion, most of the studies reviewed showed that uniportal VATS produces less pain than does conventional VATS, but that there is generally a small difference in the degree of pain score difference. All three studies showed that uniportal VATS was associated with significant lower incidence of paresthesia. Reducing the number of ports used in the surgery might be crucial to reduce the chance of developing intercostal nerve injury.

#### ***Technical instructions for anatomic lung resection***

One of the most challenging tasks in the SITS operation is anatomic lung resection. Thus, in the articles reviewed many surgeons have provided suggestions and tips for surgical procedures. The articles listed in *Table 5* describe the technical issues of specific operations. Uniportal VATS for the management of pneumothorax, lobectomy, segmentectomy, pneumonectomy, and even detailed techniques on chest wall reconstruction and lymph node dissection has been described. Of all the types of surgery that involve VATS, anatomic resection remains the most complex. Gonzalez-Rivas *et al.* reviewed a comprehensive array of techniques for anatomic lung resection, covering every important aspect encountered in lung cancer surgery, including lobectomy (33,34), segmentectomy (40), pneumonectomy (42), and lobectomy with bronchovascular reconstruction (42). These valuable publications provide

many videos and useful suggestions on surgical techniques. Liu's review of uniportal VATS for lung cancer included a detailed discussion on important aspects of surgical planning, such as incision placing, instrument handling, anesthesia, and patient positioning (37). With respect to lymph node dissection, Liu's group found that single port surgery led to the harvesting of a higher number of lymph nodes, and shorter operative time and hospital stay (14). That article outlined the number of operations and perioperative outcomes by year, and obvious improvement was observed after several years of skill refinement. A specialized technique, called Liu's maneuver, was also described to facilitate lymph node dissection.

To conclude, resources for surgeons interested in uniportal VATS, and literature regarding techniques and helpful suggestions are abundant, especially from the excellent works by Gonzalez-Rivas and Liu. With these resources and several years of practice, thoracic surgeons have an excellent opportunity to grasp the uniportal VATS technique.

#### ***Other indications of uniportal video-assisted thoracoscopic surgeries***

Apart from lung and mediastinal surgery, many different types of surgery, such as those of the diaphragm and chest wall, are also performed with single port VATS. As shown in *Table 6*, Wu *et al.* performed 10 uniportal diaphragm plications (50). For chest wall surgery, Furukawa and Clark used the Nuss procedure in a uniportal fashion (51,52). In addition, Huang reported a single port rib resection (57) where they delivered a gigli saw via single incision into the thoracic cavity, and controlled the saw with instruments. Apart from common anatomic resection, Gonzalez-Rivas reported several complex surgeries, such as uniportal lobectomy with pulmonary artery reconstruction and bronchovascular reconstruction.

In conclusion, many other indications are now also possible in a uniportal setting, including diaphragm and chest wall surgeries.

#### ***Subxiphoid approach***

Subxiphoid uniportal VATS is yet another variant of VATS. It allows the surgeon to approach both hemithorax from the anterior side using the unusual entry point of the thorax. In contrast, the posterior surface of the pleural cavity is covered by the lungs, making it a more difficult point of access. This incision would be suitable for wedge resection

**Table 5** Technical or review articles of uniportal video-assisted thoracoscopic surgeries

Topic	Author	Journal	Year
Lobectomy	Gonzalez-Rivas (33)	<i>Scientific World Journal</i>	2012
	Gonzalez-Rivas (34)	<i>Multimed Man Cardiothorac Surg</i>	2012
	Chen (35)	<i>J Cardiothorac Surg</i>	2012
	Gonzalez-Rivas (36)	<i>J Thorac Dis</i>	2013
	Liu (37)	<i>J Thorac Dis</i>	2014
	Guerra (38)	<i>Rev Port Cir Cardiothorac Vasc</i>	2014
	Fieira Costa (39)	<i>J Thorac Dis</i>	2014
Segmentectomy	Gonzalez-Rivas (40)	<i>J Thorac Dis</i>	2013
	Gonzalez-Rivas (41)	<i>Ann Cardiothorac Surg</i>	2014
	Wang (13)	<i>Ann Thorac Surg</i>	2013
Pneumonectomy	Gonzalez-Rivas (42)	<i>J Thorac Dis</i>	2013
Geometry	Rocco (3)	<i>Ann Thorac Surg</i>	2004
	Bertolaccini (43)	<i>J Thorac Dis</i>	2013
Sleeve and bronchoplasty	Gonzalez-Rivas (44)	<i>J Thorac Dis</i>	2014
Management of complication	Gonzalez-Rivas (45)	<i>Eur J Cardiothorac Surg</i>	2015
	Fernández Prado (46)	<i>J Thorac Dis</i>	2014
Chest wall reconstruction	Gonzalez-Rivas (47)	<i>Innovations</i>	2013
Lymph node dissection	Delgado Roel (48)	<i>J Thorac Dis</i>	2014
Pneumothorax	Rocco (3)	<i>Ann Thorac Surg</i>	2004
	Chen (17)	<i>J Cardiothorac Surg</i>	2011
	Salati (21)	<i>J Thorac Dis</i>	2013
	Yang (16)	<i>Surg Endosc</i>	2013

**Table 6** Uncommon case reports and series of uniportal video-assisted thoracoscopic surgeries

Author	N	Year	Operation type
Case series			
Rocco (49)	4	2006	Pericardial window
Wu (50)	10	2013	Diaphragm plication
Furukawa (51)	32	2007	Nuss procedure
Clark (52)	14	2011	Nuss procedure
Lee (53)	16	2015	Esophagectomy
Case reports			
Gonzalez-Rivas (54)	1	2012	Pneumonectomy
Gonzalez-Rivas (6)	1	2013	Lobectomy with pulmonary artery reconstruction
Gonzalez-Rivas (55)	1	2014	Lobectomy with pulmonary artery & bronchial reconstruction
Gonzalez-Rivas (56)	1	2014	Lobectomy with double sleeve resection
Huang (57)	1	2014	Rib resection
Santini (58)	1	2015	Costal exostosis



located at the anterior or apical parts of the lungs, anterior mediastinal tumor resection, or thymectomy. Nevertheless, this type of uniportal VATS may not be the best option for operations requiring subcarinal lymph node dissection or treating esophageal cancer. Five studies reported a total of 51 operations that were performed in a subxiphoid uniportal setting. The main study was reported by Suda *et al.*, in which 46 patients underwent uniportal subxiphoid thymectomy for anterior mediastinal tumor or extended thymectomy for those with myasthenia gravis, compared to 35 patients who received 3-port VATS (24). The subxiphoid group had great surgical results, with less blood loss and shorter hospital stay. The author also reported that the uniportal group required less oral analgesics after the operation and used these drugs over a shorter duration. Another reason why the author proposed the subxiphoid approach for anterior mediastinal dissection during thymectomy is that this approach offers the convenience to simultaneously view the bilateral phrenic nerve, instead of performing the VATS bilaterally. With respect to pain reduction, if reducing the number of intercostal ports proportionally reduces paresthesia, then theoretically the subxiphoid incision would eliminate the possibility of intercostal neurological symptoms. Further investigation of long-term postoperative symptoms and satisfaction comparing this modality to other forms of VATS are required to confirm this possible advantage. Other authors have reported subxiphoid single port VATS as case reports, in which they performed lobectomy, bilateral metastasectomy, bilateral sympathectomy, or operations for pneumothorax (59-62).

Therefore, uniportal VATS has a variant—subxiphoid uniportal VATS—that allows assessment of the bilateral pleural cavity with one incision from the anterior aspect and most likely provides an excellent solution to postoperative paresthesia.

## Conclusions

Uniportal VATS is a mature variant of VATS, development of which continues to flourish worldwide. During the past 12 years, this approach was practiced in exponentially greater number each year. The surgical quality of this procedure is excellent and has been shown to be superior to conventional VATS in many studies, especially with respect to hospital stay and pain/paresthesia. Many uncommon types of surgery were also reported possible with only a single incision. The resources of education and learning regarding uniportal VATS are abundant and have covered all major aspects of thoracic surgery.

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## Footnote

*Conflict of Interest:* The authors have no conflicts of interest to declare.

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