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ORIGINAL ARTICLE

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Subxiphoid versus intercostal uniportal video-assisted thoracoscopic surgery for bilateral lung resections: a single-institution experience

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Key question

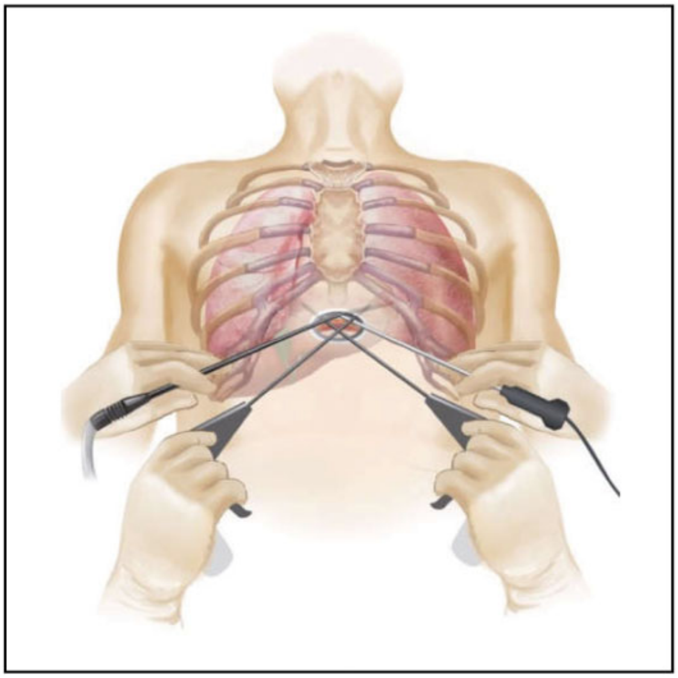
Is the perioperative outcome of subxiphoid uniportal VATS comparable with that of intercostal uniportal VATS in synchronous treatment of bilateral lung lesions?

Key findings

Compared with intercostal uniportal VATS, subxiphoid uniportal VATS does not increase the risk of complications and has an advantage in pain control.

Take-home message

Subxiphoid uniportal VATS is a safe surgical procedure and worth trying in selected patients with bilateral lung lesions.



Abstract

OBJECTIVES: Subxiphoid uniportal video-assisted thoracoscopic surgery (SUVATS) is a technically difficult and challenging operation that can help decrease pain around the incision after traditional intercostal uniportal video-assisted thoracoscopic surgery (IUVATS), and can also treat bilateral lesions through the same incision. We aimed to compare perioperative outcomes and pain scores after SUVATS and IUVATS in patients receiving synchronous treatment of bilateral lung lesions.

METHODS: Patients who received SUVATS and IUVATS bilateral lung resections from September 2014 to February 2018 were analysed. Ultimately a total of 381 cases were analysed after using one-to-one propensity score matching to match baseline characteristics between the 2 groups.

RESULTS: The 381 patients included 56 with SUVATS and 325 with IUVATS. After matching, 54 SUVATS and 54 IUVATS cases were analysed. The 2 groups had similar preoperative factors and did not differ with respect to duration of chest tube placement, length of stay in hospital and incidence of postoperative complications. SUVATS was associated with a significantly longer operative time (212.3 vs 154.6 min, $P < 0.001$) and more blood loss (190.9 vs 72.7 ml, $P < 0.001$), lower pain score on the first day after operation (2.6 vs 3.0, $P = 0.03$) and before discharge (0.8 vs 1.4, $P < 0.001$). Furthermore, less patients in group SUVATS requested for additional analgesic therapy ($P = 0.03$).

CONCLUSIONS: Compared with IUVATS, despite the longer operative time and greater blood loss, SUVATS for bilateral lung lesions is a safe surgical procedure associated with significantly less postoperative pain and a similar incidence of postoperative complications in selected patients.

Keywords: Subxiphoid • Video-assisted thoracoscopic surgery • Uniportal

INTRODUCTION

Video-assisted thoracoscopic surgery (VATS) has been widely utilized by thoracic surgeons because of the associated reduced trauma, quicker recovery and recognized therapeutic effects [1]. Nevertheless, although the VATS approach has evolved through 5-port to 3-port, 2-port, and even recently single-port, associated with smaller and fewer incisions and obviously higher acceptability for patients, no strong evidence has indicated that fewer incisions lead to significantly less postoperative pain. In 2014, subxiphoid uniportal VATS (SUVATS) lobectomy was first reported by Liu *et al*. [2]. This novel VATS approach was quickly accepted and was adopted worldwide. SUVATS avoids injury to the intercostal nerve and has been proven to significantly reduce postoperative pain, leading to quicker recovery [3, 4]. Furthermore, this approach can be applied to resect bilateral lesions via only 1 subxiphoid incision, which causes less trauma and sometimes could save needed to change positions.

Since September 2014, our group has performed SUVATS surgery in more than 1000 cases, more than 50 of which involved bilateral lesions. Therefore, the purpose of this study was to evaluate the advantages and disadvantages of both SUVATS and traditional intercostal uniportal VATS (IUVATS) in synchronous bilateral lung resections, including assessment of the indications, safety and perioperative complications.

METHODS

Patients

Initially, 401 patients who underwent bilateral lung resections by bilateral IUVATS or SUVATS between September 2014 and February 2018 in Shanghai Pulmonary Hospital were enrolled. The inclusion criteria were the diagnoses of benign, malignant or metastasis nodules in bilateral lungs whereby lung wedge or major resection was performed for biopsy or treatment. The exclusion criteria were as follows: (i) history of thoracic surgery or radiotherapy, (ii) patients with incomplete preoperative data and (iii) synchronous bilateral lobectomy. Ultimately, 381 patients were included in this study, 56 cases in the SUVATS group and 325 cases in the IUVATS group. The reason why we ruled out synchronous bilateral lobectomy was that this operation is often associated with extensive damage and a high risk of postoperative complications. We planned to balance the difference in patients' characteristics by 1:1 matching. Finally, 54 patients in the SUVATS group were matched with 54 in the IUVATS group (Fig. 1).

Preoperative preparation

Before surgery, high-resolution computed tomography was performed to assess whether the patients were good candidates for uniportal VATS. Meanwhile every patient had to undergo a preoperative routine examination including a blood test, electrocardiogram, pulmonary function and so forth. One-stage bilateral lung resection was only considered in patients with adequate lung function. Our criteria are the percentage of the forced expiratory volume in 1 s on the predicted value (FEV1%) >60% and the predicted postoperative FEV1 value >1.0l. Based on our initial experience, we often selected the candidate for SUVATS in patients with metastatic or benign tumour, or suspected primary lung cancer without enlarged or calcificated lymph node. Patients who had undergone S2, S6, S9 or S10 segmentectomy were more suitable for IUVATS than for SUVATS because their posterior anatomy was much more technically demanding. For patients with potential cardiovascular risks, bilateral SUVATS was also generally not considered.

Surgical procedure

All surgeries were performed by 2 senior surgeons who both have experience in performing more than 2000 IUVATS and 300 SUVATS surgeries. After administration of general anaesthesia, all patients were intubated by double-lumen endotracheal tube; therefore, single-lung ventilation was applied during the intervention. Patients undergoing SUVATS were placed in a supine position. If necessary, the operating table could be adapted to accommodate 30° of visualization (the operating side 30° higher than the healthy side) to make the operation easier for the surgeon (Fig. 2A). The details about SUVATS have been described in our previous publication [4]. An ∼4-cm semi-curved incision, lying just below the costal margin, was made under a fingerbreadth distance of the subxiphoid area (Fig. 2B). If the infrasternal angle is too narrow, a midline 4-cm incision just below the xiphoid should be recommended. Skin and subcutaneous fat was separated layer by layer, exposing the costal margin. The rectus abdominis muscle was separated along the costal margin. After fully separating the subxiphoid area, the subcutaneous fat and rectus abdominis were bluntly separated by the fingers clinging to the inner side of the costal arch, forming a subcostal tunnel up to the mediastinal pleura. During the operation, the diaphragm in the cardiophrenic angle should be pushed outward from the inside to avoid damage to the diaphragm in subsequent manoeuvres. The mediastinal pleura was opened and the thoracic cavity accessed. The assistant holding the camera and helping the exposure stood at the back of the patient (Fig. 3A). Longer VATS instruments dedicated for SUVATS should be used for fine dissection (Fig. 3B). Patients undergoing conventional IUVATS were placed in the 90° lying position. The incision was ∼3–4 cm. An incision of the 4th intercostal space in the midaxillary line was performed for right upper lobectomy, left upper lobe trisegmentectomy and bilateral upper apical or anterior lobectomy. An incision of the 5th intercostal space in the midaxillary line was performed for other anatomical major resections. The selection of wedge resection incision was flexible, depending on the precise location of the lesion. The lobectomy and segmentectomy methods under SUVATS and IUVATS have been described in the literature [5–7]. Routine frozen pathological examinations were performed for preoperatively unspecified lesions. If pathological reports suggested primary invasive malignancies, lymph

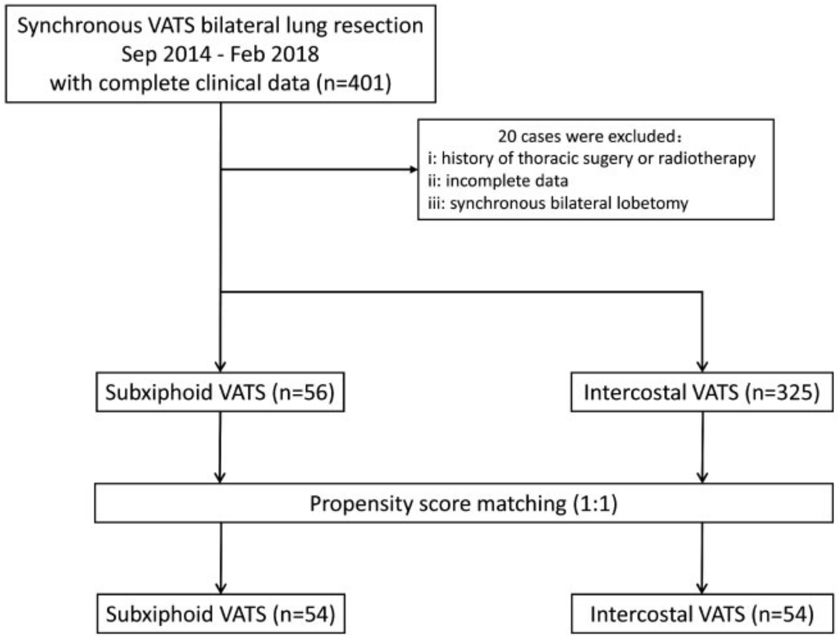


Figure 1: Patient selection. VATS: video-assisted thoracoscopic surgery.

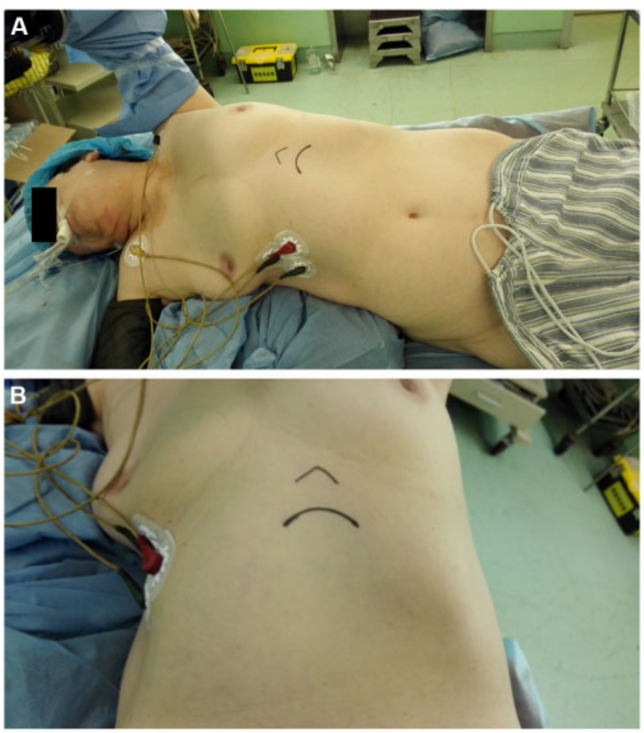


Figure 2: (**A**) The patient's position during subxiphoid uniportal video-assisted thoracoscopic surgery: supine position and 30° elevated on the surgical side, and (**B**) semi-curved subxiphoid incision for bilateral surgery.

node dissection was routinely performed in stations 2, 4, 7, 8, 9, 10 and 11 on the right side and stations 4, 5, 6, 7, 8, 9, 10 and 11 on the left side. Pathological examination of station 12 lymph node, if necessary, was performed at segmentectomy. If the result was positive, a lobectomy was performed. After the operation, both sides were indwelled with a 28-Fr chest tube drain to the upper part of the chest (Fig. 3C). For lobectomy or multisegmentectomy, which we consider to result in larger residual space than wedge resection, a central venous catheter using for draining thoracic fluid would be placed at the 7th to 8th intercostal space on the lateral chest wall (Video 1).

Postoperative therapy

If there was no noticeable increase in the amount of drainage (<500 ml), patients who met the standard (Caprini score ≥ 3 [8]) were administered preventive anticoagulant therapy. The chest radiograph was examined on the first postoperative day. Postoperative pain was managed using a patient-controlled analgesia pump at first 24 h after operation, with sufentanil citrate 1 ml: 50 μg, and regular medication was followed with ibuprofen 0.4 g every 8 h. Pain was evaluated by using the verbal Likert scale model (0–10 point), and pain score was recorded at 1 day after surgery and before discharge for the 2 groups. We also factored in additional analgesia (analgesia drugs not from the standard postoperative protocol, e.g. tramadol, pethidine or fentanyl) usage for the patients as an indicator of pain outcome. Additional analgesia was provided based on patient's request. Patients with intestinal function recovery, restoration of preoperative status and no occurrence of significant surgical complications could be discharged. If a small amount of leakage was sustained but the physical condition was generally good, the patient could be discharged while wearing the chest tube until leakage ceased.

Statistical analysis

The nature of our study is a non-randomized retrospective comparative analysis. To make these 2 groups more comparable, we used a propensity score matching method to balance the preoperative data of the 2 groups (1:1 matching). The propensity score was calculated by a logistic regression model including the variables which were considered to be associated with undergoing either SUVATS or IUVATS, such as age, gender, American Society of Anesthesiologists score, body mass index, comorbidities (hypertension, diabetes

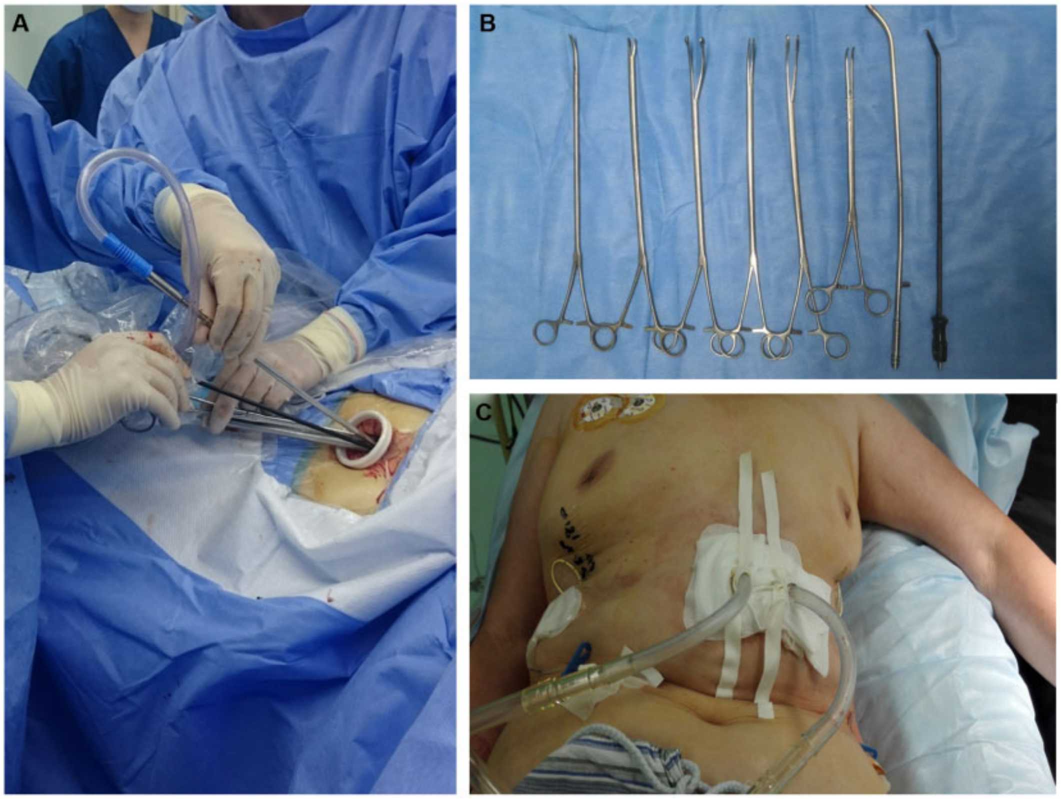
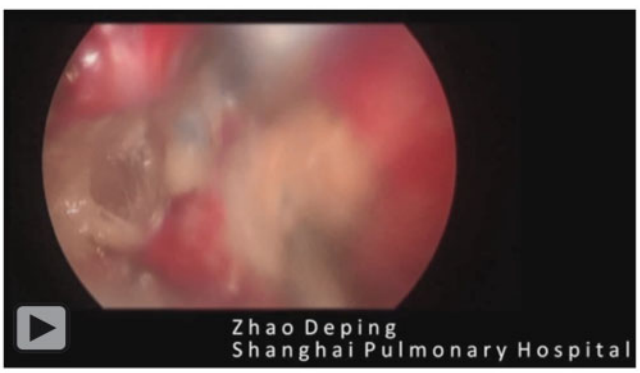


Figure 3: (**A**) Insertion of the instruments through the subxiphoid port, the assistant stands on the opposite side of the surgeon. (**B**) Long instrument dedicated for subxiphoid uniportal video-assisted thoracoscopic surgery. (**C**) Both sides are inserted with 28-Fr chest tubes through a subxiphoid incision and a central venous catheter is selectively placed at the lateral chest wall to help in draining thoracic fluid.



Video 1: Subxiphoid uniportal video-assisted thoracoscopic surgery right upper lobe wedge resection and left trisegmentectomy.

mellitus and cardiopathy), FEV1%, surgical method and the highest pathological stage. The patients in 2 groups were matched by '1:1 nearest neighbour matching' based on propensity score with a calliper width of 0.2. Data are described using mean and standard deviation. Comparison of continuous variables between groups was performed with Student's *t*-test when quantitative data were normally distributed and the Mann–Whitney rank-sum test when data were not normally distributed. Categorical variables were compared by the χ^2 or the Fisher's exact test. Paired *t*-test or Wilcoxon signed-rank test was used for comparing the continuous numeric variables of matched paired sample. Statistical significance was considered at $P < 0.05$ and no correction for multiple testing was performed. All analyses were performed by Stata 12.0.

RESULTS

Patient characteristics

SUVATS was performed in 56 patients while 325 patients underwent IUVATS. The characteristics of the patients in the 2 groups are shown in Table 1. There was a significant difference between the distribution of American Society of Anesthesiologists score ($P = 0.007$) and FEV1% (90.5% vs 96.4%, $P = 0.009$) of patients in the 2 groups. The incidences of common comorbidities, including hypertension ($P = 0.01$), diabetes mellitus ($P = 0.03$) and cardiopathy ($P = 0.01$), were all significantly different between 2 groups. Furthermore, for each patient, the highest stage of pathological outcome was recorded and it was also obviously different ($P = 0.04$). The reliability was low if the results were directly compared. Therefore, propensity score matching was carried out according to the patients' gender, age, American Society of Anesthesiologists score, body mass index, comorbidities, FEV1%, surgical method and the highest pathological stage. The results showed that there was no significant difference in preoperative indicators between the 2 groups after matching (Table 2).

Surgical outcome

There was no significant difference in duration of chest tube placement, length of stay in hospital and complication rate between the 2 groups after matching (Table 3). Operation time in the SUVATS group was longer than that in the IUVATS group (212.3 vs 154.6 min, $P < 0.001$). Blood loss under SUVATS was also

Table 1: Patient characteristics of the overall cohort

Characteristics	SUVATS (n = 56)	IUVATS (n = 325)	P-value
Age, mean ± SD	53.5 ± 13.5	55.4 ± 11.0	0.47
Sex, n (%)			
Male	24 (42.9)	140 (43.1)	0.98
Female	32 (57.1)	185 (56.9)	
ASA score, n (%)			
I	43 (76.8)	291 (89.5)	0.007
II	13 (23.2)	34 (10.5)	
Hypertension, n (%)	9 (16.1)	21 (6.5)	0.01
Diabetes mellitus, n (%)	8 (14.3)	20 (6.1)	0.03
Cardiopathy, n (%)	6 (10.7)	11 (3.4)	0.01
BMI (kg/m^2), mean ± SD	22.8 ± 2.7	23.4 ± 2.8	0.29
FEV1% preoperative	90.5 ± 12.8	96.4 ± 14.0	0.009
Surgical procedure, n (%)			0.21
Lobectomy + segmentectomy	12 (21.4)	42 (12.9)	
Lobectomy + wedge resection	16 (28.6)	90 (27.7)	
Bilateral segmentectomy	4 (7.1)	20 (6.1)	
Segmentectomy + wedge resection	6 (10.7)	74 (22.8)	
Bilateral wedge resection	18 (32.1)	99 (30.5)	
Pathological outcome (the highest stage)			0.04
Primary tumour, n (%)			
AIS	11 (19.6)	103 (31.7)	
TNM stage I	29 (51.8)	176 (54.1)	
TNM stage II or III	4 (7.1)	11 (3.4)	
Others (benign or metastatic tumours), n (%)	12 (21.4)	35 (10.8)	

AIS: adenocarcinoma *in situ;* ASA: American Society of Anesthesiologists; BMI: body mass index; FEV1%: forced expiratory volume in 1 s; IUVATS: intercostal uniportal video-assisted thoracoscopic surgery; SD: standard deviation; SUVATS: subxiphoid uniportal video-assisted thoracoscopic surgery.

more than in intercostal VATS (190.9 vs 72.7 ml, $P < 0.001$). Three SUVATS cases were converted to add another intercostal small incision to facilitate the operation. In all 381 patients, there were 2 deaths in the IUVATS group, which resulted from pulmonary embolism during the perioperative period, but no death in the cohort after matching. There was no difference in complication rate between the groups (14.8 vs 9.3%, $P = 0.37$). Two patients in the SUVATS group suffered from major complications (grade III or more in Clavien–Dindo classification system). One suffered from massive postoperative bleeding (1100 ml) at first day after operation and received a secondary surgery which revealed that the bleeding was from small vessels around the incision. Another received the treatment of mechanical ventilation because of severe lung infection. Pain score on the first day after surgery (2.6 vs 3.0, $P = 0.005$) and before discharge (0.8 vs 1.4, $P < 0.001$) in the SUVATS group was better than that in the IUVATS group. Fifteen patients in the IUVATS group received additional analgesic therapy except ibuprofen whereas only 6 patients in the SUVATS group demanded for it ($P = 0.03$).

In the SUVATS group, a total of 118 lesions were resected, including 40 benign lesions such as atypical adenomatous hyperplasia or bullae, 33 adenocarcinoma *in situ*, 9 minimally invasive adenocarcinoma, 30 invasive adenocarcinoma, in which 27 cases with TNM stage I, 1 with stage II and 2 with stage III; 1 TNM stage I squamous carcinoma, 1 lymphoma and 4 pathologically proven metastatic tumours. In the IUVATS group, 144 lesions were resected, including 37 benign lesions, 58 adenocarcinoma *in situ*, 21 minimally invasive adenocarcinoma, 25 invasive adenocarcinoma in which 20 cases with TNM stage I, 2 with stage II and 3 with stage III, 1 TNM stage I squamous carcinoma and 2 metastatic malignant tumours.

DISCUSSION

The subxiphoid procedure has evolved over nearly 40 years with the aims of mediastinal exploration, pericardial window, bilateral lung metastasectomy and extended thymectomy [9–12]. However, in the VATS procedure, for a long time the subxiphoid incision was only applied as an auxiliary operating or camera port. SUVATS is a major innovation, combining the advantages of subxiphoid incision and uniportal VATS, which can be considered as 'painless uniportal VATS'. The experience of SUVATS lung resection in our hospital has been reported previously in case series [3, 4]. Given that this technique was applied in the thoracic domain for over 4 years, to our knowledge, this study is the first to compare SUVATS with IUVATS in the treatment of bilateral lesions.

As mentioned earlier, the introduction of the subxiphoid pathway to the field of uniportal VATS was aimed at reducing postoperative pain. To date, 2 retrospective studies on subxiphoid uniportal thoracoscopic surgery have been conducted in our centre [3, 4]. Studies have shown that there are significant pain score advantages in patients undergoing SUVATS at each postoperative stage than in those undergoing conventional IUVATS. The conclusions reached in our study were similar to those reported previously. The discomfort of patients undergoing bilateral subxiphoid surgery was significantly relieved after removal of the chest tube. Avoiding intercostal nerve injury significantly relieved perioperative pain around the incision while preventing discomfort at the long-term postoperative incision, such as peripheral nerve pain, numbness and local skin laxity and swelling. These manifestations were the most common long-term complications but the least likely to be alleviated in patients undergoing conventional thoracotomy and intercostal VATS [13]. Unfortunately, due to the limited follow-up time, the long-term quality of life of the patients in both groups is difficult to quantify. A prospective follow-up study is required to address this issue.

Another advantage of SUVATS is that the bilateral lesions can be treated through the same incision. In 1999, Mineo *et al.* [11] performed subxiphoid hand-assisted incision with the use of VATS in surgery for bilateral pulmonary metastases for a biopsy examination, which provided convenience for the exploration of bilateral pulmonary metastatic nodules. This represented the initial application of the subxiphoid approach in the treatment of bilateral pulmonary disease. Later Hsu *et al.*, [12] as pioneers in subxiphoid VATS total thymectomy, proposed that both sides of the thymus edge and phrenic nerve could be well exposed through the subxiphoid incision as an intraoperative observation port. After the introduction of subxiphoid incision to the field of anatomical lung resection, we successfully attempted to use it for bilateral surgery. The incision we made was an ~4-cm subxiphoid transverse incision, ~1 cm longer than that in unilateral surgery. The exposure in the bilateral incision was no less than that in the unilateral incision for each lobe of the lungs, including hilar structures. If the surgical view was inappropriate because of cardiac blockage and elevation of the diaphragm, an ~1- to 2-cm surgical incision along the costal arch could be appropriately extended and the view partly improved. If the operative view

Table 2: Patient characteristics after matching

Characteristics	SUVATS (*n* = 54)	IUVATS (*n* = 54)	*P*-value
Age, mean ± SD	53.3 ± 13.7	54.5 ± 13.2	0.64
Sex, *n* (%)			
Male	22 (40.7)	26 (48.1)	0.44
Female	32 (59.3)	28 (51.9)	
ASA score, *n* (%)			
I	43 (79.6)	42 (77.8)	0.81
II	11 (20.4)	12 (22.2)	
Hypertension, *n* (%)	7 (13.0)	6 (11.1)	0.77
Diabetes mellitus, *n* (%)	7 (13.0)	8 (14.8)	0.78
Cardiopathy, *n* (%)	4 (7.4)	6 (11.1)	0.51
BMI (kg/m^2), mean±SD	22.9 ± 2.6	22.6 ± 2.7	0.57
FEV1% preoperative, mean ± SD	90.9 ± 12.7	90.9 ± 13.7	0.71
Surgical procedure, *n* (%)			0.88
Lobectomy + segmentectomy	10 (18.5)	11 (20.4)	
Lobectomy + wedge resection	16 (29.6)	19 (35.2)	
Bilateral segmentectomy	4 (7.4)	4 (7.4)	
Segmentectomy + wedge resection	6 (11.1)	7 (13.0)	
Bilateral wedge resection	18 (33.3)	13 (24.1)	
Pathological outcome (the highest stage)			0.77
Primary tumour, *n* (%)			
AIS	11 (20.4)	13 (24.1)	
TNM stage I	28 (51.8)	27 (50.0)	
TNM stage II or III	3 (5.6)	5 (9.3)	
Others (benign or metastatic tumours), *n* (%)	12 (22.2)	9 (16.7)	

AIS: adenocarcinoma *in situ;* ASA: American Society of Anesthesiologists; BMI: body mass index; FEV1%: forced expiratory volume in 1 s; IUVATS: intercostal uniportal video-assisted thoracoscopic surgery; SD: standard deviation; SUVATS: subxiphoid uniportal video-assisted thoracoscopic surgery.

Table 3: Comparison of surgical result after matching

	SUVATS (*n* = 54)	IUVATS (*n* = 54)	*P*-value
Operative time (min), mean ± SD	212.3 ± 76.3	154.6 ± 60.6	<0.001
Blood loss (ml), mean ± SD	190.9 ± 401.8	72.7 ± 47.1	<0.001
Transfusion rate (%), *n* (%)	3 (5.5)	0 (0.0)	/
Duration of chest tube use (days), mean ± SD	5.5 ± 5.4	4.5 ± 2.1	0.42
Length of stay (days), mean ± SD	6.4 ± 5.5	5.0 ± 2.4	0.17
Complications, *n* (%)	8 (14.8)	5 (9.3)	0.37
Clavien–Dindo classification system			
No complication	46	49	
Grade I or II	6	5	
Grade III or more	2	0	
Prolonged air leak (>7 days)	1	2	
Atrial fibrillation	2	1	
Wound problems	2	0	
Pulmonary infection	2	2	
Postoperative massive bleeding	1	0	
Pain score, mean ± SD			
1 day after surgery	2.6 ± 0.9	3.0 ± 1.0	0.03
Before discharge	0.8 ± 0.6	1.4 ± 0.6	<0.001
Additional analgesic therapy, *n* (%)	6 (11.1)	15 (27.8)	0.03

IUVATS: intercostal uniportal video-assisted thoracoscopic surgery; SD: standard deviation; SUVATS: subxiphoid uniportal video-assisted thoracoscopic surgery.

was still poor, we recommended increasing the intercostal incisions or conversion to conventional IUVATS.

A disadvantage of subxiphoid surgery is that the treatment of massive haemorrhage is not as simple as when using the intercostal procedure. With the conventional lateral position, various haemostasis, clamping and suturing operations can be conveniently performed during massive haemorrhage. If necessary, expanding the port and conversion to thoracotomy can be easily performed. Addressing massive haemorrhage in SUVATS is challenging. The difficulty in getting access to deep areas is the main limitation. Even with additional intercostal port, this does not give good access to the area of interest [14]. On the one hand, patients requiring relatively simple surgical procedures can be scheduled for bilateral SUVATS. On the other hand, even high-volume surgeons often have to apply greater effort in performing SUVATS.

As the results in this study show, there was no statistical difference in the incidence of total complications between SUVATS and IUVATS groups. Common complications included postoperative haemorrhage, fever, arrhythmia, pulmonary infection, prolonged air leak and pulmonary embolism. Among these, pulmonary embolism was the leading cause of death among the 2 groups of patients. Both deaths in the entire cohort resulted from pulmonary embolism. Although pulmonary embolism is rare among Asian populations, its prevalence during the perioperative time of lung cancer surgery is ∼2%, with dangerous circumstances and a high fatality rate [15]. Nonetheless, patients at high risk of pulmonary embolism before surgery (Caprini score ≥ 3) and postoperative chest drainage volume not exceeding 500 ml would receive low-molecular-weight heparin anticoagulant immediately postoperatively, whereby in our experience, the incidence of perioperative pulmonary embolism and the mortality rate were significantly decreased.

Another prominent complication of patients in this group was postoperative pulmonary infection. Patients with bilateral VATS had limited respiratory activity on both sides. Loss of pulmonary function after unilateral or bilateral anatomical lung resection was high, together with pain, leading to postoperative weakness and fatigue. The risk of pulmonary infection was higher in patients with bilateral VATS than in those undergoing unilateral VATS [16]. The reduction of postoperative pain in patients undergoing SUVATS could theoretically promote active sputum excretion and reduce the incidence of pulmonary infection. However, in the present study, the incidence of pulmonary infection is the same in both groups (3.7 vs 3.7%, $P = 1.0$).

Synchronous bilateral surgery for multiple pulmonary lesions is considered more effective but associated with higher risk. There are few reports on 1-stage bilateral surgery, and the criteria for selecting patients for 1-stage bilateral surgery are not uniform [17, 18]. Due to the potential for increased risk of postoperative complications, the requirements for pulmonary function are more stringent than that for staging surgery. Our standard usually requires that the FEV1% should be above 60%, and the predicted postoperative FEV1 value should be above 1.0l. However, in clinical practice, we are still cautious about single-stage bilateral surgery. Not all patients meeting the above criteria will receive synchronous bilateral resections, so the FEV1% of patients in both groups in this study is above 90%.

During the same period, we also performed 7 cases of synchronous bilateral lobectomy by SUVATS or IUVATS. We excluded these cases from this study because the number of patients undergoing bilateral lobectomy was small, and the balance after matching between the 2 groups was not guaranteed. On the other hand, the current opinion showed that the requirement of preoperative pulmonary function in bilateral lobectomy was high and the rate of surgical trauma was large. The risk of postoperative complications was noticeably higher than that of other patients undergoing bilateral surgery. In our experience, 2 of the 3 patients who underwent SUVATS faced severe respiratory failure after surgery. Therefore, we believe that surgeons should be cautious in their choice of synchronous bilateral lobectomy, whether using SUVATS or not. Bilateral lobectomy can be performed only in patients with good heart and lung function and an expected short operation.

Limitations

The main limitations of this study are as follows. Firstly, it was a retrospective controlled study. So although we matched many factors that may affect perioperative outcomes, we may have overlooked some other factors that may lead to selection bias. Appropriate cases for subxiphoid surgery were included in this study, such as nodules in the anterior position, a clear split of the lungs, and no significant changes in hilar structures, pure ground-glass opacity or mixed ground-glass opacity. Intercostal conventional VATS was performed for patients with speculated lymph node metastases. Therefore, a suitable prospective well-controlled study is needed to further validate our results. Secondly, SUVATS is more difficult than IUVATS, requiring experienced surgeons to successfully complete the operation. Given the high volume of surgery in our centre, the time to complete the learning curve was short. However, subxiphoid surgery may not be carried out as smoothly in a low-volume institution, and the results may differ from those in this study. Thirdly, for sublobar resections, although there were no cases with positive surgical margin in this study, due to the lack of detailed margin, we could not prove that SUVATS had the same surgical efficacy as IUVATS. This would be fully considered in our further prospective study. Fourthly, SUVATS is a fairly innovative thoracic surgical procedure whose clinical application currently runs to only 4 years. Although there was no significant difference in perioperative outcome between patients undergoing SUVATS and IUVATS, the results of long-term follow-up were unavailable. For these reasons above, further exploration of the surgical outcome is strongly warranted.

CONCLUSION

In conclusion, the perioperative indicators and short-term follow-up outcomes were compared between SUVATS and IUVATS. The results indicated that subxiphoid uniportal VATS reduced the number of incisions and improved the postoperative discomfort and pain of patients. In addition, the incidence of postoperative complications did not increase in patients undergoing SUVATS in comparison with IUVATS.

Conflict of interest: none declared.

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