



# Cross-sectional survey on Chinese surgeons' practice patterns and views on video-assisted thoracoscopic surgery

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**Background:** Surgeons' opinions on video-assisted thoracoscopic surgery (VATS) may influence VATS adoption. This study aims to understand Chinese surgeons' view on VATS.

**Methods:** A questionnaire was developed to collect surgeons' opinions on the benefits of VATS over open procedures, potential obstacles to adopt VATS, and possible indications and contraindications of VATS to treat lung cancer.

**Results:** Ninety-six surgeons from  $\geq 75$  hospitals in  $\geq 23$  provinces completed the questionnaire. Of them, 95.8% were thoracic surgeons; 38.5%, 30.2%, and 28.1% were chief, associate chief, and attending surgeons, respectively. The chief and associate chief surgeons had significantly more years of experiences in VATS and higher monthly VATS volume than the attending surgeons (All  $P < 0.05$ ). Notably, compared with only 32.4% of the chief surgeons, 55.6% of the attending and 55.2% of the associate chief surgeons answered a proportion of VATS  $> 75\%$  in their practice. The top three mostly agreed (96.9–92.7%) benefits of VATS were shortening hospital stay, reducing postoperative pain, and decreasing the incidence of postoperative complications. In addition, 81% of the 96 surgeons agreed that VATS could reduce drug fee. The mostly agreed (70.8%) potential obstacle for VATS adoption was insufficient training for surgeons. The opinions on the benefit of VATS and hurdles to adopt VATS were consistent across the three professional titles. The mostly agreed indication (91.7%) and contraindication (80.2%) were stage I and II non-small cell lung cancer and inability to tolerate single lung ventilation, respectively.

**Conclusions:** Chinese thoracic surgeons consistently agreed on clinical benefits and indications of VATS and believed insufficient training as a key obstacle to adopt VATS.

**Keywords:** Benefits; Chinese surgeons; questionnaire; obstacles; video-assisted thoracoscopic surgery (VATS)

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## Introduction

Since the early 1990s, video-assisted thoracoscopic surgery (VATS) has been widely adopted to diagnose and treat diseases in the chest, such as spontaneous pneumothorax and lung cancer, especially the stage I and II non-small cell lung cancer (1). Substantially improved optical and surgical equipment and better anesthesia partially contribute to the

widespread of VATS in recent years (2). Numerous previous studies have shown that VATS is as safe as open procedures and is associated with substantial benefits over open procedures in terms of simpler perioperative management, faster patient recovery, and better cost effectiveness (3-7). In particular, compared with open procedures, VATS can shorten the length of hospital stay, reduce intraoperative blood loss and the need of blood transfusion, decrease the

incidence of surgical site infection, shorten the duration of chest tube drainage, and reduce postoperative pain (3-7).

VATS was introduced to China almost three decades ago (8). Although large scale multi-center studies to compare the clinical and health economic outcomes of VATS versus open procedures in Chinese patients are still lacking, single-center investigations with a relatively small sample size have shown an equal safety and surgical effectiveness of VATS and open procedures (9-11). VATS adoption rate in Chinese surgeons and hospitals remains unknown. Surgeons' opinions could influence VATS adoption. To understand Chinese surgeons' views on VATS and their VATS practice patterns, we developed a questionnaire to collect and analyze their opinions on the benefits of VATS over open procedures, the potential obstacles to adopt VATS, and the possible indications and contraindications of VATS to treat lung cancer. The current study may shed light on strategies to increase VATS adoption.

## Methods

### Participants

All Chinese surgeons attending the 5<sup>th</sup> Asian Masters of Minimally Invasive Thoracic Surgery event on June 3<sup>rd</sup>-4<sup>th</sup>, 2017 could participate. The event aimed to engage Chinese surgeons to discuss the technique of challenging minimally invasive procedures and to share experience in difficult surgical cases with international experts. A survey questionnaire was provided to attendees at on-site meeting registration on June 2<sup>nd</sup>, 2017. Attendees completed the questionnaire either at the on-site registration or on their convenient time during the event.

### Questionnaire

The survey questionnaire included four sections: (I) general information; (II) opinions on the advantages of VATS over open procedure; (III) VATS practice pattern and opinions on potential hurdles to adopt VATS; (IV) opinions on possible indications and contraindications of VATS to treat lung cancer. The survey was anonymous. Each section contained 7-20 questions. The questions in the general information section were to collect participants' practice geographic location, professional title, experiences in thoracic surgery and VATS, and monthly VATS volume. Seventeen questions were used to collect participants' opinions on the advantages of VATS over open procedures

in terms of perioperative management, postoperative patient recovery, and healthcare economics. The questions on VATS practice patterns included the proportion of VATS, learning curve, and VATS-to-open conversion rate. The questionnaire also collected participants' opinions on 7 possible concerns regarding VATS that could inhibit VATS adoption. In the last section of the questionnaire, opinions on possible indications and contraindications of VATS to treat lung cancer were collected. Incomplete questionnaires were excluded from data analysis. The survey questionnaire is presented in the supplementary file (*Figure S1*).

### Statistical analysis

Categorical data are presented as percentage and number of cases. The statistical analysis software SPSS v21.0 was used. Chi-square test was used to compare the proportions of surgeons with different professional titles.  $P < 0.05$  was considered significantly different.

## Results

### General information

A total of 96 Chinese surgeons from  $\geq 75$  hospitals in  $\geq 23$  provinces completed the survey questionnaire. Of them, the majority (95.8%, 92/96) were thoracic surgeons; 3 (3.1%, 3/96) were clinical oncologists; only one (1.0%, 1/96) was a general surgeon (*Table 1*). Their professional titles were chief surgeons (38.5%, 37/96), associate chief surgeons (30.2%, 29/96), attending surgeons (28.1%, 27/96), and resident surgeons (3.1%, 3/96). Consistent with their professional titles, 97.3% of the chief surgeons and 89.7% of the associate chief surgeons had  $>10$  years of experience in thoracic surgery, whereas only 14.8% of the attending surgeons had such long experience ( $P < 0.0001$  *vs.* the chief and *vs.* the associate chief surgeons, *Table 1*). Similar to their experience in thoracic surgery, significantly greater proportions of the chief surgeons (40.5%) and associate chief surgeons (24.1%) than the attending surgeons (0.0%, all  $P < 0.05$ ) had  $>10$  years of experience in VATS (*Table 1*). The majority of the attending surgeons (74.0%) had performed VATS for  $<5$  years (*Table 1*). Notably, higher percentage of the chief surgeons (40.5%) than the associate chief surgeons (24.1%) had  $>10$  years of experience in VATS (*Table 1*). These results indicate that a senior professional title appears to be associated with longer years of experiences in VATS.

**Table 1** Respondents' general information

Variables	<5 years, n (%)	5–10 years, n (%)	>10 years, n (%)
Specialty			
Total	96 (100.0)		
Thoracic surgeons	92 (95.8)		
Clinical oncologist	3 (3.1)		
General surgeon	1 (1.0)		
Professional title			
Total	96 (100.0)		
Chief surgeon	37 (38.5)		
Associate chief surgeon	29 (30.2)		
Attending surgeon	27 (28.1)		
Resident surgeon	3 (3.1)		
Experience in thoracic surgery			
Total, N=96	11 (11.4)	19 (19.8)	66 (68.8)
Chief surgeon, N=37	0 (0.0)	1 (2.7)	36 (97.3)
Associate chief surgeon, N=29	1 (3.4)	2 (6.9)	26 (89.7)
Attending surgeon, N=27	7 (25.9)	16 (59.3)	4 (14.8)*
Resident surgeon, N=3	3 (100.0)	0 (0.0)	0 (0.0)
Experience in VATS			
Total, N=96	36 (37.5)	38 (39.6)	22 (22.9)
Chief surgeon, N=37	5 (13.5)	17 (45.9)	15 (40.5)
Associate chief surgeon, N=29	8 (27.6)	14 (48.3)	7 (24.1)
Attending surgeon, N=27	20 (74.1)	7 (25.9)	0 (0.0) <sup>#</sup>
Resident surgeon, N=3	3 (100.0)	0 (0.0)	0 (0.0)

\*Represent significantly different versus the associate chief surgeons ( $P<0.0001$ ) and versus the chief surgeons ( $P<0.0001$ ); <sup>#</sup> represent significantly different versus the associate chief surgeons ( $P=0.0063$ ) and versus the chief surgeons ( $P=0.00016$ ). Chi-square test was used for the comparisons. The statistical analysis software SPSS v21.0 was used.

### VATS practice patterns

Of the chief surgeons and associate chief surgeons, 45.9% and 44.8%, respectively, answered that they performed >20 VATS procedures per month, whereas only 14.8% of the attending surgeons answered such a monthly VATS volume ( $P=0.0088$  *vs.* the chief and  $P=0.0147$  *vs.* the associate chief surgeons) and most of them (70.3%) had <10 VATS procedures per month (*Table 2*). Although the attending surgeons answered a lower VATS volume, the proportion of VATS in their practice was high. Of the attending surgeons, 55.6% answered a proportion of VATS >75% in their practice; the proportion

was similar to that of the associate chief surgeons (55.2%) but was higher than that of the chief surgeons (32.4%,  $P=0.064$  *vs.* the attending surgeons) (*Table 2*). The attending surgeons appeared to believe they could learn VATS quickly. Compare to only 13.5% of the chief surgeons answering a learning curve of 10–25 VATS procedures, 25.9% of the attending surgeons believed their VATS skill could become stable after 10–25 VATS procedures (*Table 2*). Most of the participants (84.4%) answered that their VATS-to-open conversion rate was <10% (*Table 2*). Higher proportions of the chief surgeons (10.8%) and associate chief surgeons (6.9%) than the attending surgeons (0.0%,  $P=0.0776$  *vs.* the chief surgeons)

**Table 2** VATS practice patterns of the respondents

Variables	Chief surgeon (N=37), n (%)	Associate chief surgeon (N=29), n (%)	Attending surgeon (N=27), n (%)	Total (N=96), n (%)
Monthly volume				
<10 VATS	9 (24.3)	5 (17.2)	19 (70.4)	36 (37.5)
10–20 VATS	11 (29.7)	11 (37.9)	4 (14.8)	26 (27.1)
>20 VATS	17 (45.9)	13 (44.8)	4 (14.8)*	34 (35.4)
Proportion of VATS				
<25%	3 (8.1)	0 (0.0)	2 (7.4)	5 (5.2)
25–50%	5 (13.5)	2 (6.9)	4 (14.8)	11 (11.5)
50–75%	15 (40.5)	9 (31.0)	6 (22.2)	33 (34.4)
>75%	12 (32.4)	16 (55.2)	15 (55.6)	43 (44.8)
Do not know	2 (5.4)	2 (6.9)	0 (0.0)	4 (4.2)
Learning curve				
10–25 VATSs	5 (13.5)	5 (17.2)	7 (25.9)	19 (19.8)
>25 VATSs	30 (81.1)	20 (69.0)	15 (55.6)	66 (68.8)
Do not know	2 (5.4)	4 (13.8)	5 (18.5)	11 (11.5)
VATS-to-open conversion rate				
<5%	17 (45.9)	22 (75.9)	19 (70.4)	59 (61.5)
5–10%	14 (37.8)	2 (6.9)	5 (18.5)	22 (22.9)
>10%	4 (10.8)	2 (6.9)	0 (0.0)	7 (7.3)
Do not know	2 (5.4)	3 (10.3)	3 (11.1)	8 (8.3)
Preference for the number of incisions				
One incision	4 (10.8)	8 (27.6)	5 (18.5)	18 (18.8)
Multiple incisions or based on lesion characteristics	33 (89.2)	21 (72.4)	22 (81.5)	78 (81.3)

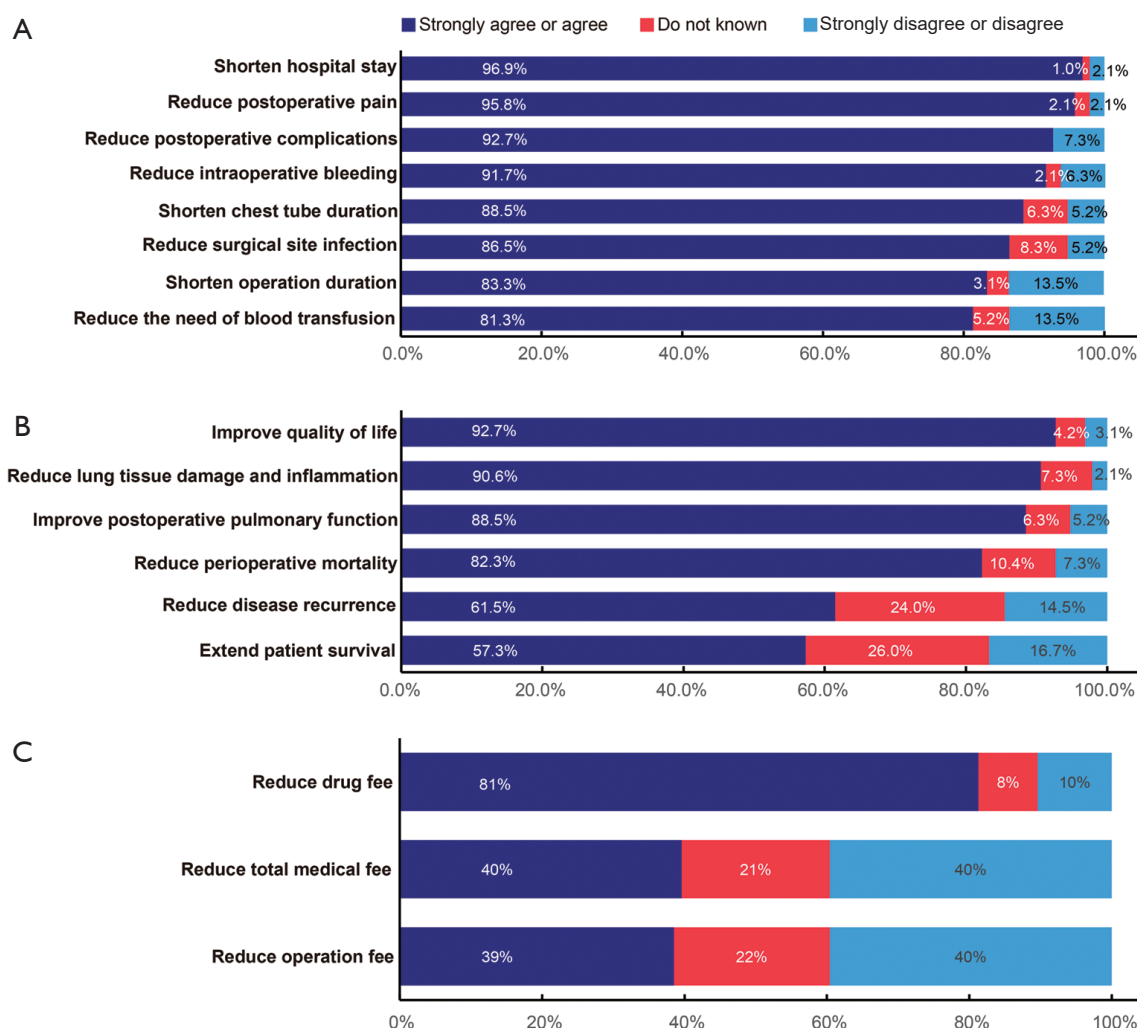
\*Represent significantly different versus the associate chief surgeons ( $P=0.0147$ ) and versus the chief surgeons ( $P=0.0088$ ). Chi-square test was used for the comparisons. The statistical analysis software SPSS v21.0 was used. VATS, video-assisted thoracoscopic surgery.

answered a VATS-to-open conversion rate of >10% in their practice (Table 2). Most of the 96 surgeons (81.3%) preferred either multiple incisions or determining the number of incisions based on lesion characteristics (Table 2). Only 10.8% of the chief surgeons used one incision in VATS, whereas higher proportions of associate chief surgeons (27.6%) and attending surgeons (18.5%) used one incision in VATS (Table 2).

### ***Opinions on the benefits of VATS and potential hurdles to adopt VATS***

The 96 surgeons' opinions on the advantages of VATS

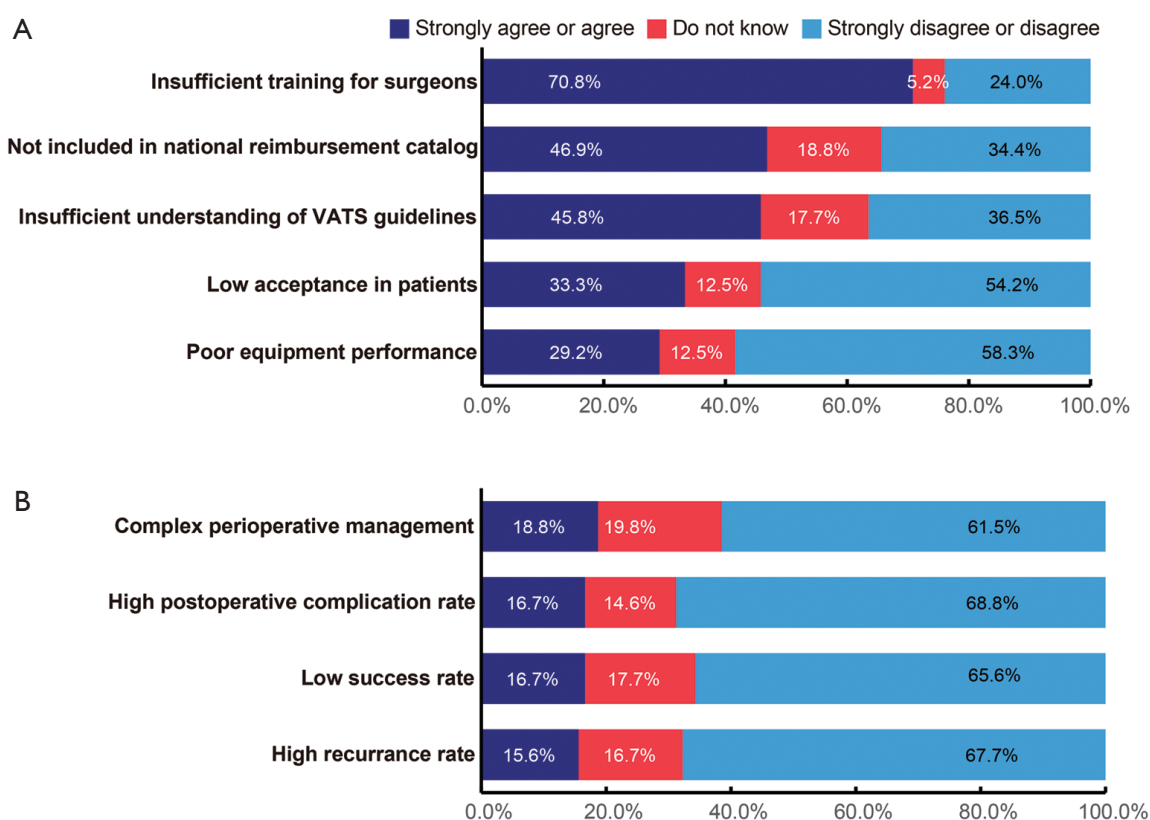
over open procedures in perioperative management appeared quite consistent (Figure 1A). The top four mostly agreed VATS benefits in perioperative management were shortening hospital stay (96.9%), reducing postoperative pain (95.8%), reducing postoperative complications (92.7%), and reducing intraoperative bleeding (91.7%) (Figure 1A). The majority of the surgeons also strongly agreed or agreed that VATS could shorten chest tube duration (88.5%), reduce surgical site infection (86.5%), shorten operation duration (83.3%), and reduce the need of blood transfusion (81.3%) (Figure 1A). Most of the surgeons also strongly agreed or agreed that VATS could improve postoperative patient recovery compared with



**Figure 1** Participants' opinions on the benefits of VATS over open procedures. (A) Perioperative benefits of VATS. Shortening hospital stay (96.9%), reducing postoperative pain (96.8%), reducing postoperative complications (92.7%), and reducing intraoperative bleeding (91.7%) were the top 4 mostly agreed VATS benefits in perioperative management. (B) Benefits of VATS in patient recovery. Most of the surgeons strongly agreed or agreed that VATS could improve quality of life (92.7%) and reducing lung tissue damage and inflammation (90.6%), but lower proportions of them believed that VATS could reduce disease recurrence (61.5%) and extend patient survival (57.3%) compared with open procedures. (C) Health economic benefits of VATS. Although most of the 96 surgeons (81%) strongly agreed or agreed that VATS could reduce drug fee, large proportions of them did not think that VATS could reduce total medical fee (40%) and operation fee (40%). VATS, video-assisted thoracoscopic surgery.

open procedures (*Figure 1B*), such as improving quality of life (92.7%), reducing lung tissue damage and inflammation (90.6%), improving postoperative pulmonary function (88.5%), and reducing perioperative mortality (82.3%). However, relatively lower proportions strongly agreed or agreed that VATS could reduce disease recurrence (61.5%) and extend patient survival (57.3%) compared with open procedures (*Figure 1B*). The participants' opinions on

economic advantages of VATS over open procedures varied greatly. Although most of the 96 surgeons (81%) strongly agreed or agreed that VATS could reduce drug fee, large proportions of them disagreed that VATS could reduce total medical fee (40%) and operation fee (39%) (*Figure 1C*). The surgeons' opinions on the advantages of VATS over open procedures were similar across the three professional titles (*Table S1*).



**Figure 2** Participants' opinions on the possible concerns on VATS that could be potential obstacles to adopt VATS. (A) Possible concerns that are not related with VATS procedures. The mostly agreed potential hurdle to adopt VATS was insufficient training for surgeons (70.8%), while other factors, such as not-being included in the national reimbursement catalog and insufficient understanding of VATS guidelines, were not considered as potential major hurdles. (B) Possible concerns that are related with VATS procedures. The majority of the surgeons did not believe potential concerns associated with VATS procedures or disease, such as complex perioperative management (61.5%) and high postoperative complication rate (68.8%), could be potential hurdles to adopt VATS. VATS, video-assisted thoracoscopic surgery.

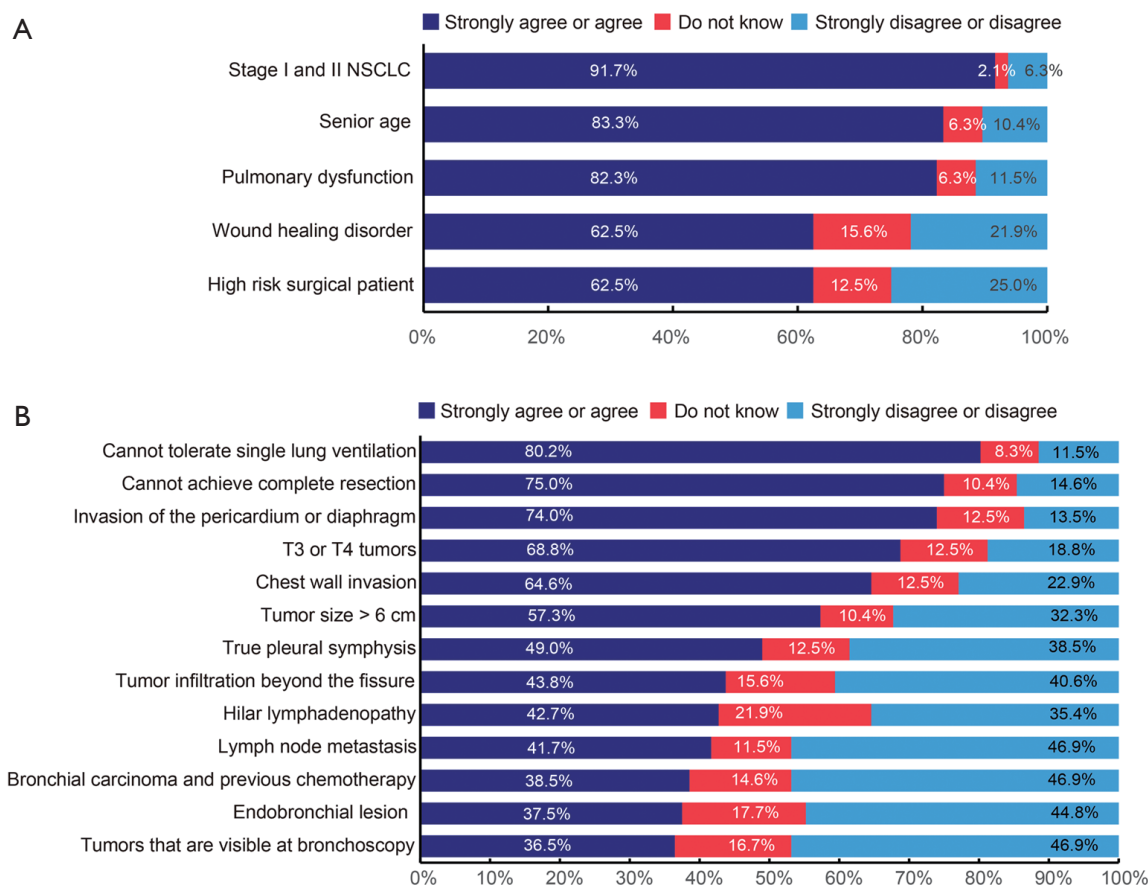
The mostly agreed potential hurdle to adopt VATS was insufficient training for surgeons (70.8%, *Figure 2A*). Less than 50% of the 96 surgeons strongly agreed or agreed that not-being included in the national reimbursement catalog and insufficient understanding of VATS guidelines could be potential hurdles (*Figure 2A*). The majority of the participants strongly disagreed or disagreed that low acceptance in patients (54.2%, *Figure 2A*) and poor equipment performance (58.3%, *Figure 2A*) could be hurdles to adopt VATS. In addition, the majority of the surgeons strongly disagreed or disagreed that potential concerns associated with VATS procedures or disease, such as complex perioperative management (61.5%), high postoperative complication rate (68.8%), low success rate (65.6%), and high recurrence rate (67.7%) could be potential hurdles to adopt VATS (*Figure 2B*). These

opinions were similar in the chief surgeons, associate chief surgeons, and attending surgeons (*Table S2*).

#### *Opinions on the indications and contraindications of VATS to treat lung cancer*

Most of the 96 participants strongly agreed or agreed that VATS should be performed on lung cancer patients with stage I and II non-small cell lung cancer (91.7%), advanced age (83.3%), or/and pulmonary dysfunction (82.3%) (*Figure 3A*), and 62.5% agreed that patients with wound healing disorder or/and high risk for surgery may be suitable for VATS (*Figure 3A*). The top 4 mostly agreed possible contraindications of VATS were being unable to tolerate single lung ventilation (80.2%), unable to achieve complete resection by VATS (75.0%), lesions invading





**Figure 3** Participants opinions on the possible indications and contraindications of VATS to treat lung cancer. (A) Indications. Stage I and II non-small cell lung cancer (91.7%) was the mostly agreed indication among the surgeons. (B) Contraindications. The mostly agreed possible contraindications of VATS included being unable to tolerate single lung ventilation (80.2%), unable to achieve complete resection by VATS (75.0%) and lesions invading the pericardium or diaphragm (74.0%). The surgeons' views on possible contraindications of VATS were very diverse. VATS, video-assisted thoracoscopic surgery.

the pericardium or diaphragm (74.0%), and T3 or T4 tumors (68.8%) (Figure 3B). For technically challenging lesions such as chest wall invasion and large tumor (>6 cm in diameter), 57.3–64.6% of the participants agreed that VATS may not be suitable (Figure 3B). Notably, <50% of the surgeon strongly agreed or agreed the following possible contraindications of VATS: true pleural symphysis (49.0%), tumor infiltration beyond the fissure (43.8%), hilar lymphadenopathy (42.7%), lymph node metastasis (41.7%), bronchial carcinoma and previous chemotherapy (38.5%), endobronchial lesion (37.5%), and tumors that are visible under bronchoscopy (36.5%) (Figure 3B). These results indicate Chinese surgeons' views on possible contraindications of VATS appear very diverse.

The surgeons with different professional titles shared

similar opinions on most of the possible indications and contraindications of VATS. However, more associate chief surgeons (69.0%) and attending surgeons (70.4%) than the chief surgeons (51.4%) strongly agreed or agreed that VATS could be performed on patients with high surgical risk (Table S3). This result indicates that young surgeons may be less conservative on the possible indications of VATS compared with senior ones. In addition, more attending surgeons (44.4%) than chief surgeons (27.0%) and associate chief surgeons (27.6%) disagreed that a tumor with a diameter >6 cm should be a contraindication. Furthermore, more associate chief surgeons (55.2%,  $P=0.0248$  vs. chief surgeons) and attending surgeons (40.7%) than the chief surgeons (27.0%) disagreed that true pleural symphysis should be a contraindication. Similarly, greater percentages

of the associate chief surgeons (44.8%) and the attending surgeons (40.7%) than the chief surgeons (24.3%) disagreed that hilar lymphadenopathy could be a contraindication (*Table S3*). These findings suggest that Chinese thoracic surgeons at the junior or middle career levels appear more likely to perform VATS on anatomically and/or clinically challenging cases than senior surgeons.

## Discussion

The current study collected 96 Chinese surgeons' practice patterns and opinions on VATS. The 96 surgeons were from all the 6 geographic regions (North, Northeast, East, South Central, Southwest, and Northwest) in China and across all of the 3 professional titles (chief, associate chief, and attending surgeons) of thoracic surgery. Each of the 3 professional titles included approximately one third of the 96 surgeons. Thus, their opinions may more likely reflect the views of whole Chinese thoracic surgeon community rather than the opinions of thoracic surgeons at a certain professional level.

The surgeons' experiences in VATS were consistent with their professional titles. The chief and associate chief surgeons had performed VATS for significantly longer years and had significantly higher monthly volume than the attending surgeons, indicating that the surgeons' answers to the questionnaire may be reliable. Notable, although most of the attending surgeons (junior surgeons) had <5 years of experience in VATS and <10 VATS procedures per month, the percentage of them (55.6%) answering a proportion of VATS >75% was as high as the associate chief surgeons (55.2%) and even higher than the chief surgeons (32.4%). These findings suggest that Chinese young thoracic surgeons appear more likely to perform VATS than established surgeons. In addition, our study also indicated that Chinese young thoracic surgeons seem very confident in performing VATS because more attending surgeons answered a short learning curve (10–25 VATS procedures) and fewer of them answered a >10% VATS-to-open conversion rate compared with the senior and established surgeons (chief and associate chief surgeons). Furthermore, the result showing a higher proportion of the attending surgeons (18.5%) than the chief surgeons (10.8%) choosing one portal VATS support that Chinese young thoracic surgeons may be more likely adopt new VATS technique.

Our survey found that the benefits of VATS over open procedures in perioperative management and patient recovery were uniformly agreed in the 96 participants

(81.3–96.9% agreement rate). These benefits of VATS are consistently supported by the results from numerous previous studies (3–7). However, the 96 surgeons' opinions on the economic benefits of VATS appear different from the findings of previous studies that were conducted in other countries. In this survey, although the majority of the 96 surgeons (81.0%) agreed that VATS could reduce drug fee, most of them disagreed that VATS might reduce total medical fee and operation fee. In contrast, previous studies conducted in US and Europe consistently support that VATS lung resection is associated with lower total hospital cost compared with open procedures (12–15). Similar to the opinions of the current survey on total medical fee, in a single-center retrospective observational study, Li and colleagues found significantly increased total hospital cost of VATS compared with open lobectomy in China (10). Therefore, VATS may be associated with higher total hospital and operation costs in China but lower in US and Europe. The opposite effects of VATS on the medical costs in China and US may be explained by the very different national pricing and reimbursement policies for healthcare in the two countries. For example, the fees for surgeons and other health care professionals are much lower in China than in US, whereas the fees for VATS equipment and supplies are substantially higher in China. Although VATS may cause higher total hospital and operation costs than open procedures in China, VATS could be associated with better cost-effectiveness than open procedures when the VATS-associated clinical benefits were considered.

In our survey, insufficient training for surgeons was the mostly agreed potential obstacle to adopt VATS, whereas all of the other possible concerns on VATS that could discourage VATS adoption were disagreed by most of the participants. Thus, based on Chinese thoracic surgeons' opinion, VATS may be commonly accepted by patients although VATS could be more expensive than open procedures and VATS appears not technically too challenging to be operated. Similar to our study, Cao and colleagues conducted a cross-sectional survey on lobectomy approach (X-SOLA study) (16). In the X-SOLA study, Cao and colleagues investigated the attitudes of 838 thoracic surgeons worldwide toward VATS lobectomy and found that a need for VATS lobectomy training was agreed by both the surgeons who only performed open lobectomy and the surgeons who only perform VATS lobectomy (16).

Our survey showed that stage I and II NSCLC was the mostly agreed indication for VATS, suggesting that Chinese thoracic surgeons' opinions on the indications



for VATS appear to be consistent with the international guidelines on VATS (17,18), which recommend VATS for patients with stage I and II non-small cell lung cancer. Inability to tolerate single lung ventilation, inability to achieve complete resection, and T3 or T4 tumors have been considered as absolute contraindication to VATS lobectomy (19). Our survey showed that these contraindications were also agreed widely in the Chinese surgeons. In contrast to the more consistent views on clinical benefits of VATS, such as the benefits in perioperative management and postoperative recovery, the survey respondents' views on the contraindications of VATS were less consistent and varied widely, particularly on anatomically and/or clinically challenging cases. Notably, our results showed that more attending surgeons than the well-established surgeons (chief surgeons) did not consider challenging clinical and tumor characteristics, such as large tumors with a diameter >6 cm, true pleural symphysis, and hilar lymphadenopathy, as contraindications of VATS to treat lung cancer. These data indicate that junior Chinese thoracic surgeons may hold less conservative views toward VATS and appear more likely to perform VATS on anatomically and/or clinically challenging cases than senior surgeons. These attending surgeons' views on less strict contraindications may also reflect the evolution of indications and contraindications of VATS. As the equipment and technique of VATS advance continuously, one would expect that the contraindications of VATS will be increasingly narrowed. Thus, the results of this survey suggest that Chinese thoracic surgeons might not reach a consensus on contraindications of VATS.

The limitation of this study is that the number of respondent is relatively small. Nevertheless, the practice locations of the 96 surgeons were cross the entire country and the 96 surgeons were distributed evenly at the three professional titles. Thus, their opinions may be representative among Chinese thoracic surgeons. These opinions are subjective. Objective clinical investigations are required to confirm the findings. Moreover, although the current study only collected opinions of Chinese surgeons, the findings could shed light on the strategies to improve VATS adoption.

## Conclusions

The benefits of VATS over open procedures in perioperative management and patient recovery were commonly agreed in Chinese thoracic surgeons. Chinese thoracic surgeons also consistently agreed on the early stage lung cancer as the

indication of VATS. Insufficient training may be a potential obstacle to adopt VATS. Training workshops may broaden VATS adoption.

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## Footnote

*Conflicts of Interest:* Both authors have completed the ICMJE uniform disclosure form (available at <http://dx.doi.org/10.21037/vats.2018.10.02>). The authors have no 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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Section 1: General information

1. Your hospital name and location: \_\_\_\_\_
2. Your specialty: ☐ Thoracic Surgery   ☐ General Surgery   ☐ Clinical Oncology
3. Your professional title:  
☐ Chief Surgeon   ☐ Associate Chief Surgeon   ☐ Attending Surgeon   ☐ Resident Surgeon
4. How many years have you have been practicing thoracic surgery:  
☐ ≤ 5 years   ☐ 5-10 years   ☐ ≥ 10 years
5. How many years have you been practicing VATS:  
☐ ≤ 5 years   ☐ 5-10 years   ☐ ≥ 10 years
6. What is your monthly VATS volume:  
☐ < 10 VATS   ☐ 10-20 VATS   ☐ > 20 VATS
7. During VATS, you prefer:  
☐ One incision   ☐ Multiple incisions   ☐ Depend on lesion

Section 2: What are your opinions on the advantages of VATS over open procedure?

	Strongly agree	Agree	Do not know	Disagree	Strongly disagree
1. Perioperative management					
Reduce postoperative complications	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce postoperative pain	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shorten chest tube duration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce surgical site infection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shorten operation duration	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce intraoperative bleeding	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce the need of blood transfusion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Shorten hospital stay	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Patient postoperative recovery and survival					
Improve postoperative pulmonary function	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce lung tissue damages and inflammation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce disease recurrence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Improve quality of life	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Extend patient survival	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce perioperative mortality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Healthcare economics					
Reduce total medical fee	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce operation fee	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Reduce drug fee	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 3: What are your current VATS practice pattern and your opinion on the potential hurdles to adopt VATS

1. Current VATS practice patterns					
Your VATS rate	<input type="checkbox"/> < 25%	<input type="checkbox"/> 25%-50%	<input type="checkbox"/> 50%-75%	<input type="checkbox"/> >75%	<input type="checkbox"/> do not know
Your VATS learning curve	<input type="checkbox"/> 10-25	<input type="checkbox"/> 25-40	<input type="checkbox"/> 40-50	<input type="checkbox"/> ≥ 50	<input type="checkbox"/> do not know
VATS-to-open conversion rate	<input type="checkbox"/> ≤5%	<input type="checkbox"/> 5%-10%	<input type="checkbox"/> 10%-25%	<input type="checkbox"/> ≥25%	<input type="checkbox"/> do not know
2. Possible concerns on VATS that could be potential hurdles to adopt VATS					
	Strongly agree	Agree	Do not know	Disagree	Strongly disagree
Insufficient training for surgeons	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Insufficient understanding of VATS guidelines	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Low acceptance in patients	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Complex perioperative management	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Not included in national reimbursement catalog	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Poor equipment performance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Low success rate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
High recurrence rate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
High postoperative complication	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Section 4: What are your opinions on the clinical characteristics that could be suitable or unsuitable for VATS procedure for surgical treatment of lung cancer?

1. Clinical characteristics that could be suitable for VATS procedure					
	Strongly agree	Agree	Do not know	Disagree	Strongly disagree
High-risk surgical patients	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Senior age	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lung dysfunction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wound healing disorder	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Stage I and II non-small cell lung cancer	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Clinical characteristics that could be unsuitable for VATS procedure					
Unable to tolerate single lung ventilation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bronchial carcinoma with prior chemotherapy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Endobronchial lesions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tumor size > 6 cm in diameter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Unable to achieve complete resection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
T3 or T4 tumors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lymph node metastasis)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
True pleural symphysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tumors that are visible at bronchoscopy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hilar lymphadenopathy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Chest wall invasion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tumor infiltration beyond the fissure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Invasion of the pericardium or diaphragm	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure S1 Questionnaire.

**Table S1** Opinions on the benefits of VATS over open procedures

Variables	Chief surgeon (N=37), n (%)	Associate chief surgeon (N=29), n (%)	Attending surgeon (N=27), n (%)
Perioperative management			
Reduce the need of blood transfusion			
Agree	27 (73.0)	27 (93.1)	21 (77.8)
No opinions	1 (2.7)	1 (3.4)	3 (11.1)
Disagree	9 (24.3)	1 (3.4)	3 (11.1)
Shorten operation duration			
Agree	32 (86.5)	24 (82.8)	21 (77.8)
No opinions	0 (0.0)	2 (6.9)	1 (3.7)
Disagree	5 (13.5)	3 (10.3)	5 (18.5)
Reduce surgical site infection			
Agree	30 (81.1)	27 (93.1)	23 (85.2)
No opinions	4 (10.8)	2 (6.9)	2 (7.4)
Disagree	3 (8.1)	0 (0.0)	2 (7.4)
Shorten chest tube duration			
Agree	30 (81.1)	29 (100.0)	23 (85.2)
No opinions	4 (10.8)	0 (0.0)	2 (7.4)
Disagree	3 (8.1)	0 (0.0)	2 (7.4)
Reduce intraoperative bleeding			
Agree	33 (89.2)	28 (96.6)	24 (88.9)
No opinions	0 (0.0)	0 (0.0)	2 (7.4)
Disagree	4 (10.8)	1 (3.4)	1 (3.7)
Reduce postoperative complications			
Agree	33 (89.2)	28 (96.6)	25 (92.6)
No opinions	0 (0.0)	0 (0.0)	0 (0.0)
Disagree	4 (10.8)	1 (3.4)	2 (7.4)
Reduce postoperative pain			
Agree	35 (94.6)	27 (93.1)	27 (100.0)
No opinions	0 (0.0)	2 (6.9)	0 (0.0)
Disagree	2 (5.4)	0 (0.0)	0 (0.0)
Shorten hospital stay			
Agree	36 (97.3)	29 (100.0)	25 (92.6)
No opinions	0 (0.0)	0 (0.0)	1 (3.7)
Disagree	1 (2.7)	0 (0.0)	1 (3.7)
Patient recovery and patient survival			
Extend patient survival			
Agree	17 (45.9)	16 (55.2)	19 (70.4)
No opinions	10 (27.0)	9 (31.0)	6 (22.2)
Disagree	10 (27.0)	4 (13.8)	2 (7.4)
Reduce disease recurrence			
Agree	19 (51.4)	18 (62.1)	19 (70.4)
No opinions	10 (27.0)	9 (31.0)	4 (14.8)
Disagree	8 (21.6)	2 (6.9)	4 (14.8)
Reduce perioperative mortality			
Agree	32 (86.5)	24 (82.8)	20 (74.1)
No opinions	2 (5.4)	3 (10.3)	5 (18.5)
Disagree	3 (8.1)	2 (6.9)	2 (7.4)
Improve postoperative pulmonary function			
Agree	32 (86.5)	26 (89.7)	24 (88.9)
No opinions	3 (8.1)	1 (3.4)	2 (7.4)
Disagree	2 (5.4)	2 (6.9)	1 (3.7)
Reduce lung tissue damage and inflammation			
Agree	33 (89.2)	28 (96.6)	23 (85.2)
No opinions	3 (8.1)	1 (3.4)	3 (11.1)
Disagree	1 (2.7)	0 (0.0)	1 (3.7)
Improve quality of life			
Agree	32 (86.5)	28 (96.6)	26 (96.3)
No opinions	3 (8.1)	0 (0.0)	1 (3.7)
Disagree	2 (5.4)	1 (3.4)	0 (0.0)
Health economic values			
Reduce operation fee			
Agree	13 (35.1)	10 (34.5)	11 (40.7)
No opinions	8 (21.6)	9 (31.0)	4 (14.8)
Disagree	16 (43.2)	10 (34.5)	12 (44.4)
Reduce total medical fee			
Agree	12 (32.4)	11 (37.9)	12 (44.4)
No opinions	7 (18.9)	9 (31.0)	4 (14.8)
Disagree	18 (48.6)	9 (31.0)	11 (40.7)
Reduce drug fee			
Agree	32 (86.5)	26 (89.7)	18 (66.7)
No opinions	2 (5.4)	1 (3.4)	5 (18.5)
Disagree	3 (8.1)	2 (6.9)	4 (14.8)

Agree: including strongly agree and agree; disagree: including strongly disagree and disagree. VATS, video-assisted thoracoscopic surgery.



**Table S2** Opinions on potential obstacles to adopt VATS

Variables	Chief surgeon (N=37), n (%)	Associate chief surgeon (N=29), n (%)	Attending surgeon (N=27), n (%)
Possible concerns that are not related with VATS procedures			
Insufficient training for surgeons			
Agree	26 (70.3)	20 (69.0)	20 (74.1)
No opinions	3 (8.1)	2 (6.9)	0 (0.0)
Disagree	8 (21.6)	7 (24.1)	7 (25.9)
Not included in national reimbursement catalog			
Agree	18 (48.6)	13 (44.8)	14 (51.9)
No opinions	6 (16.2)	4 (13.8)	6 (22.2)
Disagree	13 (35.1)	12 (41.4)	7 (25.9)
Insufficient understanding of VATS guidelines			
Agree	14 (37.8)	14 (48.3)	16 (59.3)
No opinions	9 (24.3)	5 (17.2)	2 (7.4)
Disagree	14 (37.8)	10 (34.5)	9 (33.3)
Low acceptance in patients			
Agree	13 (35.1)	9 (31.0)	10 (37.0)
No opinions	7 (18.9)	3 (10.3)	2 (7.4)
Disagree	17 (45.9)	17 (58.6)	15 (55.6)
Poor equipment performance			
Agree	10 (27.0)	9 (31.0)	9 (33.3)
No opinions	7 (18.9)	2 (6.9)	3 (11.1)
Disagree	20 (54.1)	18 (62.1)	15 (55.6)
Possible concerns that are related with VATS procedures			
Complex perioperative management			
Agree	5 (13.5)	7 (24.1)	5 (18.5)
No opinions	8 (21.6)	6 (20.7)	5 (18.5)
Disagree	24 (64.9)	16 (55.2)	17 (63.0)
High postoperative complication rate			
Agree	6 (16.2)	5 (17.2)	4 (14.8)
No opinions	5 (13.5)	4 (13.8)	5 (18.5)
Disagree	26 (70.3)	20 (69.0)	18 (66.7)
Low success rate			
Agree	5 (13.5)	5 (17.2)	5 (18.5)
No opinions	7 (18.9)	5 (17.2)	5 (18.5)
Disagree	25 (67.6)	19 (65.5)	17 (63.0)
High recurrence rate			
Agree	6 (16.2)	5 (17.2)	4 (14.8)
No opinions	6 (16.2)	4 (13.8)	5 (18.5)
Disagree	25 (67.6)	20 (69.0)	18 (66.7)

Agree: including strongly agree and agree; disagree: including strongly disagree and disagree. VATS, video-assisted thoracoscopic surgery.



**Table S3** Opinions on indications and contraindications for VATS to treat lung cancer

Variables	Chief surgeon (N=37), n (%)	Associate chief surgeon (N=29), n (%)	Attending surgeon (N=27), n (%)
Indications			
Stage I and II non-small cell lung cancer			
Agree	33 (89.2)	28 (96.6)	25 (92.6)
No opinions	0 (0.0)	1 (3.4)	1 (3.7)
Disagree	4 (10.8)	0 (0.0)	1 (3.7)
Advanced age			
Agree	32 (86.5)	23 (79.3)	23 (85.2)
No opinions	1 (2.7)	3 (10.3)	2 (7.4)
Disagree	4 (10.8)	3 (10.3)	2 (7.4)
Pulmonary dysfunction			
Agree	29 (78.4)	28 (96.6)	20 (74.1)
No opinions	2 (5.4)	1 (3.4)	3 (11.1)
Disagree	6 (16.2)	0 (0.0)	4 (14.8)
Wound healing disorder			
Agree	20 (54.1)	19 (65.5)	19 (70.4)
No opinions	7 (18.9)	5 (17.2)	3 (11.1)
Disagree	10 (27.0)	5 (17.2)	5 (18.5)
High risk for surgery			
Agree	19 (51.4)	20 (69.0)	19 (70.4)
No opinions	5 (13.5)	4 (13.8)	3 (11.1)
Disagree	13 (35.1)	5 (17.2)	5 (18.5)
Contraindications			
Unable to tolerate single lung ventilation			
Agree	30 (81.1)	23 (79.3)	22 (81.5)
No opinions	1 (2.7)	4 (13.8)	2 (7.4)
Disagree	6 (16.2)	2 (6.9)	3 (11.1)
Unable to achieve complete resection by VATS			
Agree	30 (81.1)	22 (75.9)	18 (66.7)
No opinions	3 (8.1)	2 (6.9)	5 (18.5)
Disagree	4 (10.8)	5 (17.2)	4 (14.8)
Lesions invading the pericardium or diaphragm			
Agree	28 (75.7)	22 (75.9)	20 (74.1)
No opinions	4 (10.8)	4 (13.8)	4 (14.8)
Disagree	5 (13.5)	3 (10.3)	3 (11.1)
T3 or T4 tumors			
Agree	28 (75.7)	21 (72.4)	16 (59.3)
No opinions	3 (8.1)	3 (10.3)	5 (18.5)
Disagree	6 (16.2)	5 (17.2)	6 (22.2)
Chest wall invasion			
Agree	27 (73.0)	14 (48.3)	19 (70.4)
No opinions	6 (16.2)	4 (13.8)	2 (7.4)
Disagree	4 (10.8)	11 (37.9)	6 (22.2)
Large tumor (>6 cm in diameter)			
Agree	25 (67.6)	16 (55.2)	12 (44.4)
No opinions	2 (5.4)	5 (17.2)	3 (11.1)
Disagree	10 (27.0)	8 (27.6)	12 (44.4)
True pleural symphysis			
Agree	23 (62.2)	10 (34.5)	12 (44.4)
No opinions	4 (10.8)	3 (10.3)	4 (14.8)
Disagree	10 (27.0)	16 (55.2)*	11 (40.7)
Tumor infiltration beyond the fissure			
Agree	18 (48.6)	12 (41.4)	11 (40.7)
No opinions	7 (18.9)	4 (13.8)	3 (11.1)
Disagree	12 (32.4)	13 (44.8)	13 (48.1)
Hilar lymphadenopathy			
Agree	18 (48.6)	10 (34.5)	11 (40.7)
No opinions	10 (27.0)	6 (20.7)	5 (18.5)
Disagree	9 (24.3)	13 (44.8)	11 (40.7)
Lymph node metastasis			
Agree	16 (43.2)	11 (37.9)	12 (44.4)
No opinions	3 (8.1)	5 (17.2)	2 (7.4)
Disagree	18 (48.6)	13 (44.8)	13 (48.1)
Bronchial carcinoma and previous chemotherapy			
Agree	16 (43.2)	10 (34.5)	10 (37.0)
No opinions	5 (13.5)	4 (13.8)	4 (14.8)
Disagree	16 (43.2)	15 (51.7)	13 (48.1)
Endobronchial lesion			
Agree	16 (43.2)	12 (41.4)	6 (22.2)
No opinions	4 (10.8)	5 (17.2)	7 (25.9)
Disagree	17 (45.9)	12 (41.4)	14 (51.9)
Tumors that are visible under bronchoscopy			
Agree	14 (37.8)	8 (27.6)	11 (40.7)
No opinions	5 (13.5)	5 (17.2)	5 (18.5)
Disagree	18 (48.6)	16 (55.2)	11 (40.7)

Agree: including strongly agree and agree; disagree: including strongly disagree and disagree. \*Represent significantly different versus the chief surgeons (P=0.0248). Chi-square test was used for the comparisons. The statistical analysis software SPSS v21.0 was used. VATS, video-assisted thoracoscopic surgery.