Original Article

SV-VATS exhibits dual intraoperative and postoperative advantages

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Background: The merits of spontaneous ventilation video-assisted thoracic surgery (SV-VATS) are still controversial. Our team retrospectively evaluated the intraoperative and postoperative advantages of this surgical approach, comparing with mechanical ventilation video-assisted thoracic surgery (MV-VATS).

Methods: We did a single center retrospective study at the First Affiliated Hospital of Yunnan Province. 244 patients were eventually assigned to the SV-group and MV-group, and their intraoperative indicators and thoracic surgery postoperative data were included in the comparison.

Results: The SV-group exhibited markedly less intraoperative bleeding and postoperative thoracic drainage, and the bleeding volume was correlated with the volume and duration of drainage. Further analysis showed that, patients undergoing SV-VATS had less activation of white blood cells and neutrophils after surgery, but they also had lower serum albumin concentrations. Risks of short-term postoperative complications, including inflammatory reactions, malignant arrhythmias, constipation, and moderate or more pleural effusions, were also significantly reduced in the SV-group. Additionally, hospitalization cost was lower in the SV-group than that in the MV-group.

Conclusions: SV-VATS is suitable for various types of thoracic surgery, and effectively reduce intraoperative bleeding and postoperative thoracic drainage. With less postoperative inflammatory response, it reduces the risk of short-term postoperative complications. It is also able to help to reduce the financial burden of patients.

Keywords: Spontaneous ventilation; mechanical ventilation; video-assisted thoracic surgery (VATS); feasible; advantageous

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Introduction

In recent years, with the promotion of the concept of Enhanced Recovery after Surgery (ERAS) (1), video-assisted thoracic surgery (VATS) has been developed rapidly, which has resulted in the emergence of spontaneous ventilation VATS (SV-VATS). Aided by artificial pneumothorax, SV-VATS is able to be performed successfully while avoiding

the tracheal injury caused by endotracheal intubation, and also reduces the use of neuromuscular blocking agents (NMBAs). There have been extensive reports on the applications of SV-VATS for treating pulmonary nodules (2,3), hemangiomatosis (4), tracheal stenosis (5) and pulmonary bullae (6). Xun *et al.* reported that SV-VATS involved shorter operative time, shorter hospital stay, fewer postoperative complications, a shorter hospital stay, and improved the entire postoperative recovery compared to mechanical ventilation VATS (MV-VATS) (7). However, whether SV-VATS could become a first-choice option for thoracic surgeons remains debatable. Our team conducted a retrospectively controlled trial at the First People's Hospital of Yunnan Province, in order to evaluate the universality and perioperative advantages of SV-VATS systematically. We present the following article in accordance with the STROBE reporting checklist (available at https://dx.doi.org/10.21037/atm-21-2297).

Methods

Data source

Comparative surgical trials between SV-VATS and MV-VATS were conducted from March of 2015 to October of 2020 at the First Affiliated Hospital of Yunnan Province. We collated information of patients receiving VATS which performed by our clinical team for treating either pulmonary or non-pulmonary diseases. In total, approximately 450 patients were recruited with their clinical data during the entire hospitalization, and ethical approval for the trial was granted by the Ethics Review Committee of the First People's Hospital of Yunnan Province. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Also, written informed consent was obtained from all patients for participation in the trial. After filtering out cases refer to the exclusion criteria, a total of 244 cases (including 124 patients who underwent SV-VATS and 120 patients who underwent MV-VATS) were included in the formal data analyses of this study, as explained below. Overall, the first 2–3 years of the trial were spent on devising the standard procedures for database design.

Exclusion criteria

(I) Patients with incomplete data or obvious logical errors;
(II) One case that was transferred to a thoracotomy;
(III) No unplanned reoperation was included;
(IV) Those with severe postoperative complications, including postoperative high fever, long postoperative drainage duration, and purulent thoracic drainage.

Procedures

The surgical procedure in the SV-group was performed as follows: In addition to normal general anesthesia, anesthesia of SV-VATS was combined with epidural anesthesia, vagus nerve block, intercostal nerve block, and local anesthesia on the surface of the lung. It is designed to reduce intraoperative lung sensitivity to traction and further reduce the use of opioids. Prior to induction of general anesthesia, an epidural anesthesia was performed at the level of the fourth thoracic vertebra, and Ropivacaine (7.5 mg/mL) 21 mL was injected. This period usually cost anesthetics an extra 15–30 min compared with MV-VATS. Then intravenous channels were established and intravenous administration of Etomidate 0.3 mg/kg + Midazolam 0.1 mg/kg + Dexamethasone 10 mg + atropine 0.5 mg was given. An intravenous pump (Smiths Medical Co., Ltd., Hangzhou, Zhejiang Province, China) with Propofol+ Remifentanil was then used to maintain anesthesia (the dose of remifentanil is usually half that of MV-VATS), meanwhile a laryngeal mask (Single cavity of common type, 4.0#, Jian qi Medical Equipment Co., Ltd., Chang yuan, Henan Province, China) was placed to maintain a 30–40% oxygen concentration and preserve spontaneous breathing. After opening the chest, the surgeon completed the vagus nerve block and intercostal nerve block with Ropivacaine (7.5 mg/mL) 14 mL and Lidocaine (0.2 mg/mL) 10 mL. Then Lidocaine (0.2 mg/mL) 10 mL was applied to the surface of the lung, and the operation was started after the lung collapsed. In cases of poor intraoperative lung tissue collapse and poor visual field, high frequency neap tidal ventilation or suspension of ventilation should be performed to continue the surgery. The thoracic cavity was explored, the free target domain was dissected, and the resection was performed with an endoscopic cleavage closure device (Victormedic Medical and Surgical Instruments Co., Ltd., Changzhou, Jiangsu Province, China). Surrounding lymph nodes were dissected by intraoperative observation of the resected lung tissue or by reference to intraoperative frozen pathology. Following the operation, normal saline was infused into the thoracic cavity. After the lung enlargement test confirmed that there was no air leakage at the broken end of the bronchus, the

thoracic drainage tube (Jiangsu Yu bang Medical Equipment Technology Co., Ltd., Taizhou, Jiangsu, China) was indwelt into the operation hole, and the thoracic cavity was closed. In the early postoperative period, getting out of bed, eating, and drinking water were encouraged.

The surgical procedure in the MV-group was performed as follows: Firstly, intravenous channels were established and the same intravenous administration of Etomidate 0.3 mg/kg + Midazolam 0.1 mg/kg + Dexamethasone 10 mg + atropine 0.5 mg was given. An intravenous pump with Propofol+ Remifentanil was then used to maintain anesthesia, meanwhile MV endotracheal intubation was performed, adjusting the oxygen concentration to control blood oxygen saturation at 97–100%. The surgical methods were the same as those in the SV group. After 6 h of observation, the patients were encouraged to get out of bed and consume food and water.

Gathering indicators

The operative data (operation time, intraoperative bleeding volume and types of surgeries), postoperative thoracic drainage (duration of thoracic drainage, total drainage volume, daily average drainage volume and drainage peak), perioperative laboratory indexes, perioperative X-ray expressions, postoperative complications and hospitalization-cost (economic and time costs) of the two groups undergoing different procedures were collected. We did no effort to address potential sources of bias.

Initially, we collected postoperative drainage data and operation data including operation time, intraoperative bleeding, and types of surgeries. We found a significant reduction in postoperative drainage with SV-VATS, but as shown as the results of multiple linear regression analysis for intraoperative indicators and postoperative thoracic drainage, the reduction in intraoperative blood loss is not sufficient to fully explain the advantage of SV-VATS in reducing postoperative effusion. Therefore, we then collected our patients' laboratory indexes related to inflammation (preoperative laboratory blood exploration being done within a week before surgery; postoperative laboratory blood exploration being done on the postoperative day 2) and X-ray expressions perioperatively (preoperative laboratory blood exploration being done within two weeks before surgery; postoperative laboratory blood exploration being done on the postoperative day 1), and compared postoperative indicators and changes in these indicators before and after surgery. All of these inflammation-related indicators suggest a significant perioperative advantage of SV-VATS. Subsequently, we further expanded the observation indexes and summarized the postoperative complications of the patients from the end of surgery to discharge. At last, the time cost and economic cost of patients receiving SV-VATS and MV-VATS were also summarized and compared.

Statistical analysis

U-test was used to compare the SV-VATS and MV-VATS in terms of operation indicators, postoperative thoracic drainage, laboratory indexes and cost. Results of postoperative X-ray expressions and complications were analyzed with chi-square test, and we performed a multiple linear regression for intraoperative indicators and postoperative thoracic drainage.

Results

About 450 patients were included and 244 were included refer to the exclusion criteria. No loss to follow-up. The two groups exhibited no significant differences in either sex [SV-group (female 66, male 58), MV-group (female 64, male 56), Pearson χ^2=0.987] or age (SV-group 50.1±14.2 years old, MV-group 51.4±12.1 years old, P value =0.600) distribution. There were 4 cases missing the data of laboratory indexes and X-ray images: the patients were transferred to our hospital for advanced treatment, and the data of preoperative laboratory indexes and X-ray images were not collected in our hospital.

Intraoperatively, there were no significant differences between the SV- and MV-groups in terms of operation time (SV-group 118.7±50.5 min, MV-group 133.3±57.2 min, P=0.581). However, the SV-group exhibited a markedly lower intraoperative bleeding volume (SV-group 41.4±34.7 mL, MV-group 78.2±83.1 mL, P<0.001) (*Table 1*). The majority types of surgeries in two groups were both resection of pulmonary nodules. Other surgeries were also completed successfully in two groups (*Table 2*).

SV-VATS showed advantages in reducing postoperative thoracic drainage (total drainage volume [SV-group 394.7±348.0 mL, MV-group 569.6±423.5 mL, P<0.001]; daily average drainage volume [SV-group 117.5±74.9 mL, MV-group 146.9±77.7 mL, P=0.001]; and drainage peak [SV-group 199.1±146.1 mL, MV-group 242.1±140.2 mL, P=0.003], while simultaneously shortening the duration of thoracic drainage (SV-group 3.1±1.4 d, MV-group 3.6±1.4 d,

Table 1 Results of the significance test (U-test) for comparing SV-VATS and MV-VATS in terms of operation time and intraoperative bleeding volume

Operation indicators	SV-VATS	MV-VATS	P value
Operation time (min)	118.7±50.5	133.3±57.2	0.581
Intraoperative bleeding (mL)	41.4±34.7	78.2±83.1	<0.001

SV-VATS, spontaneous ventilation video-assisted thoracic surgery; MV-VATS, mechanical ventilation video-assisted thoracic surgery.

Table 2 Summary of the types of surgeries of SV-VATS and MV-VATS

Types of surgeries	SV-VATS	MV-VATS	Total
Resection of pulmonary nodules	99	105	204
LVRS	14	11	25
*Resection of mediastinal mass	5	7	12
*Other	2	1	3
Total	124	120	244

*Including of the cases of mediastinal mass resection, a 71-year -old patient accepted the resection of trachea-cystectomy with spontaneous ventilation. The surgery was successful, with no postoperative complications except of the constipation. *Other types of surgeries included 1 repairment of diaphragmatic hernia (MV-VATS), 1 resection of chest wall mass (SV-VATS) and 1 thorax exploration (SV-VATS). SV-VATS, spontaneous ventilation video-assisted thoracic surgery; MV-VATS, mechanical ventilation video-assisted thoracic surgery; LVRS, lung volume reduction surgery.

Table 3 Results of the significant test (U-test) for comparing SV-VATS and MV-VATS in terms of thoracic drainage

Thoracic drainage	SV-VATS	MV-VATS	P value
Duration of thoracic drainage (d)	3.1±1.4	3.6±1.4	0.001
Total drainage volume (mL)	394.7±348.0	569.6±423.5	<0.001
Daily average drainage volume (mL)	117.5±74.9	146.9±77.7	0.001
Drainage peak (mL)	199.1±146.1	242.1±140.2	0.003

SV-VATS, spontaneous ventilation video-assisted thoracic surgery; MV-VATS, mechanical ventilation video-assisted thoracic surgery.

P=0.001) (*Table 3*).

In order to assess the influence of intraoperative indicators on postoperative thoracic drainage, we performed a multiple linear regression analysis. The operation time and intraoperative bleeding was significantly correlated with the volume of total postoperative drainage, average daily drainage, and drainage peak. However, intraoperative bleeding seemed to exert a greater impact on postoperative drainage than the duration of surgery, as its standardized beta was notably higher. According to the unsatisfactory R-square of each regression model (0.494, 0.510, 0.480, respectively), more indicators was required for precise regression model. In other words, other factors of peri-operation should influence postoperative drainage (*Table 4*).

No difference shown in preoperative laboratory indexes between the two groups, however, patients in the SV-group had significantly lower postoperative weight blood cells (WBC, SV-group 8.1±2.3 10^9/L, MV-group 10.5±3.8 10^9/L, P<0.001), NEUT (neutrophils ratio, SV-group 70.8%±7.1%, MV-group 77.9%±8.9%, P<0.001), and serum albumin concentration (SV-group 33.6±3.2 g/L, MV-group 35.1±3.4 g/L, P=0.001) than patients in the MV-group after operation. This change is more directly reflected in the calculation of variations of WBC (SV-group 1.6±3.0 10^9/L, MV-group 4.1±3.7 10^9/L, P<0.001), NEUT (neutrophils ratio, SV-group 8.7%±10.6%, MV-group 16.8%±12.1%, P<0.001), and serum albumin concentration (SV-group −7.6±4.0 g/L, MV-group −5.7±4.1 g/L, P=0.001) after surgery (*Table 5*). As to the postoperative X-ray expressions, there was little significant difference between the two groups, while SV-group suggested less risk of moderate or more pleural effusion [SV-group 3 (total 119), MV-group 13 (total 121), P=0.011] (*Table 6*).

SV-VATS also has an advantage over MV-VATS in reducing the short-term risk of postoperative complications. As mentioned above, the SV-group had a significantly reduced risk of postoperative inflammatory reaction and large postoperative thoracic effusion. On the other hand, the risk of postoperative malignant arrhythmias [SV-group 4 (total 119), MV-group 14 (total 121), P=0.016] and constipation after surgery [SV-group 23 (total 119), MV-group 38 (total 121), P=0.032] is significantly reduced, possibly due to restricted intraoperative opioid use and

Table 4 Results of the multiple linear regression analysis for intraoperative indicators and postoperative thoracic drainage

Thoracic drainage	R-square	Variable	Non-standardized		Standardized	t value	P value
			Beta	SE	Beta		
Total	0.494	(Constant)	143.020	55.798	–	2.563	0.011
		Operation time	1.579	0.434	0.218	3.637	0.000
		Bleeding	2.223	0.356	0.374	6.250	0.000
Average	0.510	(Constant)	57.306	10.651	–	5.380	0.000
		Operation time	0.401	0.083	0.287	4.840	0.000
		Bleeding	0.382	0.068	0.333	5.625	0.000
Peak	0.480	(Constant)	94.598	19.165	–	4.936	0.000
		Operation time	0.639	0.149	0.259	4.286	0.000
		Bleeding	0.656	0.122	0.324	5.366	0.000

Table 5 Results of the significant test (U-test) for comparing SV-VATS and MV-VATS in terms of laboratory indexes of inflammation and nutrition

Laboratory indexes	SV-VATS	MV-VATS	P value
Preoperative WBC (10^9/L)	6.5±2.3	6.3±1.9	0.578
Preoperative NEUT% (%)	62.1±10.1	61.1±9.2	0.616
Preoperative ALB (g/L)	41.3±3.6	40.8±4.2	0.649
Postoperative WBC (10^9/L)	8.1±2.3	10.5±3.8	<0.001
Postoperative NEUT% (%)	70.8±7.1	77.9±8.9	<0.001
Postoperative ALB (g/L)	33.6±3.2	35.1±3.4	0.001
*Variation of WBC (10^9/L)	1.6±3.0	4.1±3.7	<0.001
*Variation of NEUT% (%)	8.7±10.6	16.8±12.1	<0.001
*Variation of ALB (g/L)	(-7.6)±4.0	(-5.7)±4.1	0.001

*Variations of indexes = postoperative indexes – preoperative indexes. *4 missing cases: the patients were transferred to our hospital for advanced treatment, and the data of preoperative laboratory indexes and X-ray images were not collected in our hospital. SV-VATS, spontaneous ventilation video-assisted thoracic surgery; MV-VATS, mechanical ventilation video-assisted thoracic surgery; WBC, white blood cells; NEUT%, neutrophils ratio; ALB, serum albumin.

Table 6 Results of the significance test (chi-square test) for comparing SV-VATS and MV-VATS in terms of postoperative X-ray expressions

Postoperative X-ray expressions	SV-VATS	MV-VATS	P value
*Slight pleural effusion	63 [119]	61 [121]	0.695
Moderate or more pleural effusion	3 [119]	13 [121]	0.011
Atelectasis	24 [119]	14 [121]	0.072
Consolidation/lung exudation	53 [119]	68 [121]	0.071

*Slight pleural effusion was defined as a small amount of pleural effusion confined to the costophrenic angle and the superior margin of the diaphragm, without preventing lung re-expansion. *4 missing cases: the patients were transferred to our hospital for advanced treatment, and the data of preoperative laboratory indexes and X-ray images were not collected in our hospital. SV-VATS, spontaneous ventilation video-assisted thoracic surgery; MV-VATS, mechanical ventilation video-assisted thoracic surgery.

preservation of spontaneous breathing (*Table 7*).

All of the above results suggest that SV-VATS can provide good intraoperative lung protection and reduce the subjective uncomforted feeling and objective cost of postoperative recovery. Considering the influence of other factors in the clinical work, we did not directly observe the reduction of postoperative hospital stay (SV-group 6.6±2.0 d, MV-group 6.1±2.0 d, P=0.087) in the SV group. However, the shortened drainage time and the reduction of hospitalization cost (SV-group 31,858.9±11,574.5 yuan, MV-group 38,527.6±13,205.1 yuan, P<0.001) all suggest the potential of SV-VATS to accelerate postoperative recovery (*Table 8*).

Discussion

Thoracic surgeons have never stopped their search for improvements to VATS, leading to advanced devices or techniques such as harmonic scalpel (8), uniportal VATS (9),

Table 7 Results of the significant test (chi-square test) for comparing SV-VATS and MV-VATS in terms of postoperative complications

Postoperative complications	SV-VATS	MV-VATS	P value
Fever	42 [119]	37 [121]	0.437
Postoperative WBC >10×10^9	19 [119]	63 [121]	<0.001
Postoperative NEUT >75%	32 [119]	75 [121]	<0.001
*Pain	33 [119]	40 [121]	0.370
Malignant arrhythmia	4 [119]	14 [121]	0.016
Constipation	23 [119]	38 [121]	0.032
Moderate or more pleural effusion	3 [119]	13 [121]	0.011
Atelectasis	24 [119]	14 [121]	0.072

*Postoperative pain was defined as requirement of analgesic drugs more than 2 times/24 hours (Dezocine 10 mg i.v. or Tramadol 50 mg i.v. or Flurbiprofen axetil 100 mg/100 mL i.v.gtt.), on the basis of continuous postoperative analgesic pump analgesia (Sufentanil 100 μg/100 mL, 2 μg/h i.m.). *4 missing cases: the patients were transferred to our hospital for advanced treatment, and the data of preoperative laboratory indexes and X-ray images were not collected in our hospital. SV-VATS, spontaneous ventilation video-assisted thoracic surgery; MV-VATS, mechanical ventilation video-assisted thoracic surgery.

Table 8 Results of the significant test (U-test) for comparing SV-VATS and MV-VATS in terms of economic and time costs

Economic and time costs	SV-VATS	MV-VATS	P value
Economic cost (yuan)	31,858.9 ±11,574.5	38,527.6 ±13,205.1	<0.001
Postoperative hospital-stay (d)	6.6±2.0	6.1±2.0	0.087

SV-VATS, spontaneous ventilation video-assisted thoracic surgery; MV-VATS, mechanical ventilation video-assisted thoracic surgery.

and robotic thoracic surgery (10). With the emergency of SV-VATS, more and more thoracic surgeons began to try this new surgical mode, and the feasibility and advantages of the relevant studies are not rare. Wen *et al.* conducted a meta-analysis of 27 studies on SV-VATS and concluded that the advantages of SV-VATS in reducing postoperative complications and accelerating postoperative recovery compared to traditional MV-VATS (11). A meta-analysis of 14 RCTs of two VATS modes reported that SV-VATS reduced postoperative hospital stay and patients' subjective discomfort after surgery (12). A meta-analysis involving more than 1,600 patients reached similar conclusions (13). Overall, SV-VATS has shown unique advantages in both mediastinum (14) and pulmonary surgery (15). However, these studies were limited to evaluating hospital stay, thoracic drainage time, postoperative complications and other outcomes, lack of exploration of the factors that contribute to these outcomes. By the collection of preoperative and postoperative laboratory indexes and imaging data, this study found the objective evidence that SV-VATS reduced the inflammatory response caused by surgery and the risk of moderator or more thoracic effusion. We also preliminarily analyzed the possible relationship between these objective indicators and postoperative thoracic drainage and postoperative short-term complications. The next step for our team is to explore the underlying mechanisms of these connections.

In this study, we found that the operation time was not significantly different between the SV- and MV-groups (SV-VATS 118.7±50.5 min, MV-VATS 133.3±57.2 min, P>0.05). Although the pulmonary activity generated by spontaneous respiration was present throughout the operation, intraoperative bleeding in SV-VATS tended to decrease (SV-VATS 41.4±34.7 mL, MV-VATS 78.2±83.1 mL, P<0.001). SV-VATS is not only suitable for resection of pulmonary nodules. In fact, we have successfully performed several types of thoracic surgery, including resection of mediastinal masses, LVRS and etc. with spontaneous ventilation. Especially, a 71-year-old patient accepted the resection of trachea-cystectomy in SV-group. The surgery was successful, with less than 50ml of intraoperative bleeding. No postoperative complication was monitored expect of the constipation. After symptomatic treatment, the patient defecated normally and went back home to recuperate on the postoperative day 5. In our view, limiting the use of anesthetics might be one of the reasons of this phenomenon. Considering that anesthetics promote the formation of microcirculation congestion in the lung, the intraoperative bleeding in SV-VATS procedures was considerably less than that of MV-VATS, despite the plentiful use of anesthetics during dissection and devascularization. In short, SV-VATS exhibited a similar operation time to that of MV-VATS, while at the same time promoting reduced intraoperative bleeding.

Among factors used to evaluate postoperative recovery, thoracic drainage in SV-VATS exhibited the most beneficial effect. SV-VATS showed advantages in reducing postoperative thoracic drainage [total drainage volume (SV-group 394.7±348.0 mL, MV-group 569.6±423.5 mL, P<0.001); daily average drainage volume (SV-group 117.5±74.9 mL, MV-group 146.9±77.7 mL, P=0.001),

and drainage peak (SV-group 199.1±146.1 mL, MV-group 242.1±140.2 mL, P=0.003)], while simultaneously shortening the duration of thoracic drainage (SV-group 3.1±1.4 d, MV-group 3.6±1.4 d, P=0.001). By restoring the loss of fluid from the patient's body and alleviating their worries regarding postoperative recovery, SV-VATS improved patients' surgical experiences and accelerated postoperative recovery. The reduction of thoracic drainage, either the duration or volume, directly explains why numerous studies have claimed that SV-VATS can significantly shorten postoperative hospital stay (16,17). As the primary way of discharging lung tissue exudate, the reduction of thoracic drainage can reduce the loss of albumin and glucose. Good postoperative nutritional status is conducive to tissue healing and functional recovery of patients, and the dynamic balance of body fluids directly affects blood pressure, metabolism, and many other aspects.

Multiple linear regression analysis showed that operation time and intraoperative bleeding dramatically influenced postoperative thoracic drainage. However, interestingly, the unsatisfactory R-square of the model suggested that other factors are linked to postoperative thoracic drainage. Due to interest in factors which influence postoperative drainage, we analyzed preoperative and postoperative laboratory indexes and X-ray expressions of patients. Patients who received SV-VATS had less proliferation of WBC and NEUT after surgery, suggesting that SV-VATS induced less inflammatory response in the body. The proliferation of WBC and neutrophils is regulated by cytokines and is closely related to the activation degree of the body's inflammatory system (18). With regard to changes in serum albumin, we did not find an explanation for the low postoperative serum albumin concentration in patients with SV-VATS. However, serum albumin concentration played an important role in maintaining plasma osmotic pressure. In combination with the results in *Table 3*, patients who received SV-VATS showed less exudation despite low postoperative serum albumin, indirectly reflecting the inhibitory effect of SV-VATS on postoperative exudation. As to the postoperative X-ray expressions, SV-group suggested less risk of moderate or more pleural effusion. It was consistent with the reduced pleural and pulmonary exudation shown by thoracic drainage.

From the patient's perspective, the most intuitive result of SV-VATS was the reduction of short-term postoperative complications and the reduction of hospitalization costs. Smooth recovery process can effectively relieve the anxiety of patients after surgery. At the same time, the reduction of the overall economic cost of treatment not only improved the postoperative satisfaction of patients, but also brought the hope of surgical treatment for patients with financial constraints. In order to give full play to the advantages of postoperative recovery from SV-VATS, we required patients to receive preoperative education to help them overcome their fear of getting out of bed, eating and drinking water in the early post-operative period. Our nurses would also aid the patient to get out of bed early and resume eating and drinking water after surgery. There was no specific consideration for patients receiving SV-VATS additionally.

SV-VATS exhibits dual intraoperative and postoperative advantages. Unfortunately, we only retrospectively collected case data from our only medical group in recent years, in order to avoid the influence of different surgical skills of different surgeons on the experimental results. Therefore, this study has a limited sample size and is limited to a single-center retrospective study. We will continue to promote and research SV-VATS in the future, and look forward to cooperating with other clinical centers.

Conclusions

SV-VATS is suitable for various types of thoracic surgery, and effectively reduce intraoperative bleeding and postoperative thoracic drainage. With less postoperative inflammatory response, it reduces the risk of short-term postoperative complications. It is also able to help to reduce the financial burden of patients.SV-VATS has a promising future, and we hope that more thoracic surgeons will work together to accelerate the maturity and promotion of this technology.

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Footnote

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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. Ethical approval for the trial was granted by the Ethics Review Committee of the First People's Hospital of Yunnan Province. Also, written informed consent was obtained from all patients for participation in the trial. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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