Original Article

Application of drainage strategy with bi-pigtail catheters in patients undergoing lobectomy by uniportal video-assisted thoracic surgery

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Background: There are no standard guidelines regarding the number and size of chest tubes that should be selected after thoracic surgery. This study aimed to evaluate the effects of adopting a drainage strategy with bi-pigtail catheters (BPCs) on patients undergoing lobectomy by uniportal video-assisted thoracic surgery (VATS).

Methods: A retrospective study was performed of patients undergoing uniportal lobectomy at the Department of Thoracic Surgery of the Cancer Hospital of Dalian University of Technology between August 2021 and August 2022. The patients were divided into the following two groups according to the drainage strategy adopted: (I) a traditional chest tube (TCT) group; and (II) a BPC group. The outcomes measured included postoperative complications, as measured by the Clavien-Dindo method, and the visual analogue scale (VAS) pain scores of the patients after surgery.

Results: In total, 868 patients underwent lung resection during the study period, after exclusion, the data of 470 patients who underwent uniport lobectomy were reviewed (235 in the TCT group, and 235 in the BPC group). There were no statistically significant differences between the two groups in terms of baseline data (P>0.05). The incidence of postoperative complications (7.7% *vs.* 19.1%) and postoperative VAS pain scores at 7–24 hours (3.3±1.0 *vs.* 3.7±1.5) and 25–48 hours (3.1±0.8 *vs.* 3.6±1.5) were significantly lower in the BPC group than the TCT group (all P<0.001). Additionally, the postoperative length of stay (4.6±1.5 *vs.* 5.4±4.5 days) and the collapse rate of the residual lung (19.2%±9.1% *vs.* 20.9%±9.6%) of the BPC group were better than those of the TCT group (P<0.05). The results of univariable and multivariable analyses showed that a drainage strategy with a TCT was an independent risk factor for decreased postoperative complications, and reduced moderate or severe pain scores at 7–24 and 25–48 hours after surgery.

Conclusions: Our drainage strategy with BPCs decreased the incidence of postoperative complications and alleviated the postoperative pain of patients undergoing lobectomy by uniportal VATS and is safe and feasible.

Keywords: Lobectomy; bi-pigtail catheters (BPCs); postoperative complication; visual analogue scale pain score (VAS pain score)

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Introduction

Lung cancer is a major cause of cancer-related death worldwide, and surgery is the standard treatment for most patients with early-stage non-small cell lung cancer (NSCLC) and is part of the treatment strategy for patients with locally advanced NSCLC (1,2). Due to its advantages, which include less pain, a reduced hospital stay, a more satisfactory surgical incision, and a faster recovery, the use of uniportal video-assisted thoracic surgery (VATS) in minimally invasive thoracic surgery is supported by accumulating evidence (3-6). However, controversy continues as to which type of thoracic drainage strategy to adopt after uniportal VATS. Traditional large-bore chest tubes (usually 20–32 Fr) have advantages in terms of the drainage of both fluid and air, but can cause significant pain and discomfort. Conversely, small-bore tubes may obstruct drainage, which can result in loculated pleural effusion, severe subcutaneous emphysema, or the poor re-expansion of the residual lung (7).

A pigtail catheter (PC) is a small-bore tube that has been proven to be safe in the drainage of pneumothorax, traumatic hemothorax, and wedge resection of the lung (8-13). Recently, it was reported that a drainage strategy with bi-pigtail catheters (BPCs) in uniportal VATS lung surgery safely reduced the postoperative pain of patients, but the types of surgery in that study only included wedge resection, segmentectomy, or wedge resection combined with segmentectomy (14). To date, no reports have been published on the usage of drainage strategies with BPCs in patients undergoing lobectomy only by uniportal VATS.

In this retrospective study, we introduced a drainage strategy with BPCs in uniportal lobectomy to examine whether this strategy decreased the incidence of postoperative complications and whether the patients who received the BPC strategy had lower postoperative visual analogue scale (VAS) pain scores compared to those who received a drainage strategy that used traditional chest tubes (TCTs). We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-925/rc).

Highlight box

Key findings

- The drainage strategy with bi-pigtail catheters (BPCs) in patients undergoing lobectomy by uniportal video-assisted thoracic surgery (VATS) is safe and feasible.

What is known, and what is new?

- Controversy continues as to the type of thoracic drainage strategy that should be adopted after uniportal VATS. A drainage strategy with one large-bore chest tube has been confirmed to be safe and reliable in lung surgery by uniportal VATS.
- Our drainage strategy with BPCs decreased the incidence of postoperative complications in patients undergoing lobectomy by uniportal VATS. The drainage strategy with BPCs alleviated the postoperative pain in patients undergoing lobectomy by uniportal VATS.

What is the implication, and what should change now?

- A drainage strategy with BPCs in patients undergoing lobectomy by uniportal VATS is highly recommended.

Methods

Patients who underwent lung operations at the Department of Thoracic Surgery of the Cancer Hospital of Dalian University of Technology were enrolled in the study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Liaoning Cancer Hospital & Institute Ethics Committee (No. KY20240407). Individual consent for this retrospective analysis was waived. The patients were divided into the following two groups according to the postoperative drainage strategy adopted: (I) the TCT group; and (II) the BPC group. The choice of the specific drainage method was based on the surgeon's preference.

Baseline data, including gender, age, body mass index (BMI), hypertension, history of smoking, Charlson Comorbidity Index (CCI), the percentage of forced expiratory in 1 second (FEV1), the percentage of forced vital capacity (FVC), the percentage of diffusion lung capacity for carbon monoxide (DLCO), the lobe involved, the operative time, the drainage duration, the postoperative drainage volume, the postoperative hospital time, the collapse rate of the residual lung after surgery, and the cumulative consumption of analgesic drugs, were collected. Operative time was defined as the time from the start of the incision to the completion of wound suturing. Postoperative drainage time was defined as the time from the day after surgery to the day of chest tube extraction. Postoperative hospital time was defined as the time spent in the hospital from the day after operation to the last day of surgery. Kircher *et al.* (15) described the calculation method of the collapse rate of the residual lung after surgery.

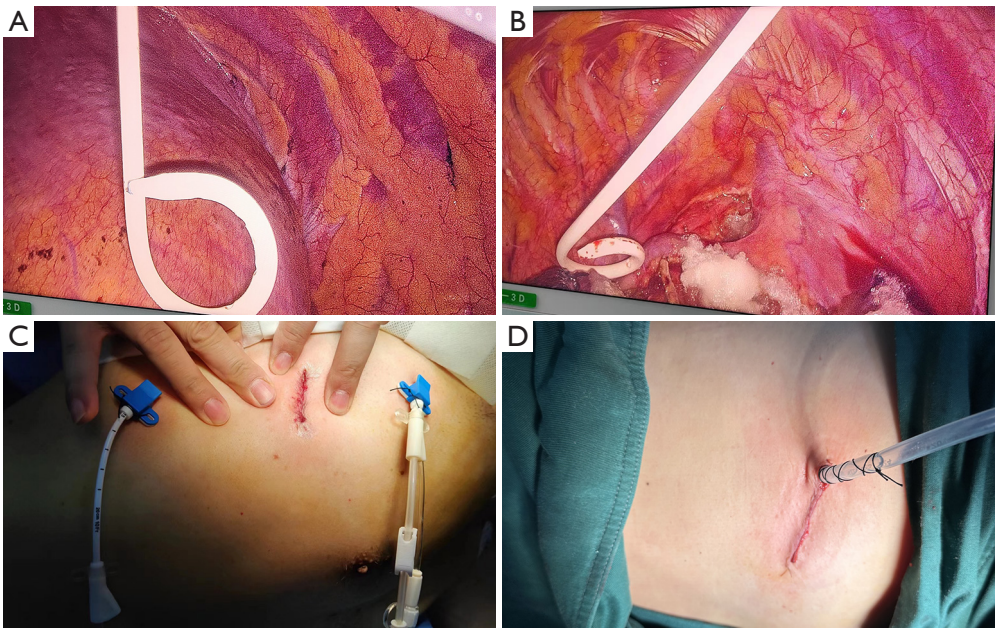

Figure 1 Drainage strategies after uniportal video-assisted thoracic lung surgery. (A) One 10-Fr × 20-cm pigtail catheter in the eighth intercostal space at the posterior axillary line. (B) One 12-Fr × 20-cm pigtail catheter in the third intercostal space at the anterior axillary line. (C) Two pigtail catheters and a surgical incision in the fifth intercostal space. (D) One 20-Fr chest tube through the surgical incision.

Inclusion and exclusion criteria

Patients who underwent lobectomy at the Department of Thoracic Surgery at Liaoning Cancer Hospital & Institute between August 2021 and August 2022 were included in the study. Patients were excluded from the study if they met any of the following exclusion criteria: (I) had undergone a previous chest surgery; (II) tuberculosis, pleurisy, or trauma on the surgical side; (III) had received neoadjuvant therapy; (IV) pleural adhesion was found during the surgery; (V) had to be converted to thoracotomy; (VI) had intraoperative bleeding; (VII) had incomplete data; and/or (VIII) underwent any of the following types of surgery: segmentectomy, wedge resection, bronchoplasty angioplasty, bilobectomy, or pneumonectomy.

Perioperative management measures

After general anesthesia with a double-lumen tube, the patients were placed in the lateral position. Intraoperative pain control strategies were implemented by the anesthesiologists. A 2.5–4-cm incision was made between the middle axillary and anterior axillary lines in the fourth or fifth intercostal space. In the BPC group, a 12-Fr × 20-cm PC was connected to a standard chest drain system, and was inserted in the third intercostal space in the anterior axillary line, and a 10-Fr × 20-cm PC which was connected to drainage bag was inserted in the seventh or eighth intercostal space at the posterior axillary line (*Figure 1A-1C*). The depth of the PC inserted to the thoracic cavity is 15 cm. In the TCT group, a 20-Fr chest tube was connected to a standard drainage system and was inserted in the posterior edge of the incision (*Figure 1D*). The depth of chest tube inserted to the thoracic cavity was 14 or 15 cm. The incisions were then closed with absorbable sutures.

All the patients received non-steroidal anti-inflammatory drugs for postoperative pain control, and the treatment was propacetamol hydrochloride by injection (2 grams, two times per day). Oral oxycodone was administered at a standard dose (with maximum dose of 20 mg per day). The VAS pain scores of the patients at 6 hours, and day 1 and day 2 following surgery were recorded. All the patients underwent chest radiography on day 1 after surgery (*Figure 2*), and as needed on subsequent days. The collapse rate was calculated according to the last chest X-ray obtained. The tubes were removed in accordance with our criteria that required the expansion of the residual lung, a drainage volume <300 mL per 24 hours, and no air leakage. The patients were discharged the day following the removal of

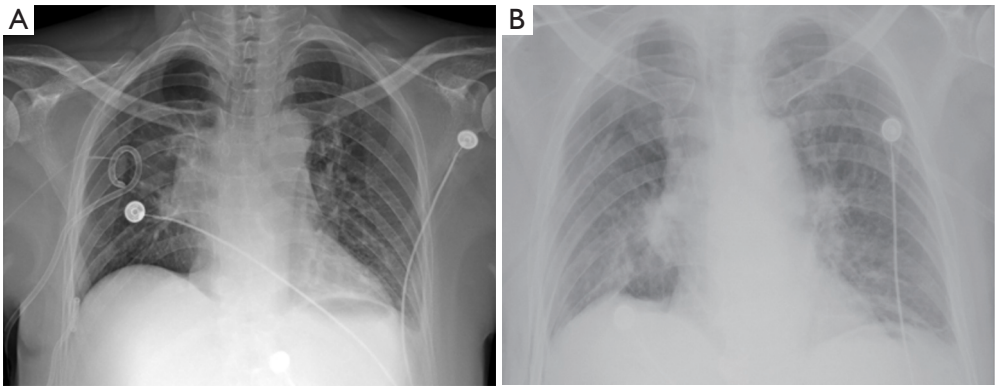

Figure 2 X-ray chest radiography on the first postoperative day. (A) Bi-pigtail catheter group. (B) Traditional chest tube group.

the drainage tubes.

Clinical outcomes

The primary outcome was postoperative complications. The postoperative complications were recorded using the Clavien-Dindo method. The secondary outcome was the VAS pain scores collected when the most severe pain occurred during 0–6, 7–24, and 25–28 hours after surgery, respectively. The VAS pain scores ranged from 0 (no pain) to 10 (the worst pain). The verbal categories of mild, moderate, and severe pain corresponded to values of 1–3, 4–6, and 7–10, respectively, on the VAS in the same patient (16).

Statistical analysis

The collected data are expressed as the number and percentage, and the mean ± standard deviation (SD). The continuous variables are expressed as the mean ± SD. The two-sample Student's *t*-test or the Mann-Whitney *U* test was used to compare the means between the continuous variables. The Chi-square test or Fisher's exact test was used to compare the categorical variables. Univariable and multivariable analyses were used to assess the predictors of postoperative complications, and moderate to severe postoperative pain. All the hypothesis tests were two-sided; a P value <0.05 was considered statistically significant.

Results

From August 2021 to August 2022, 868 patients underwent lung surgery at our department. After exclusion, a total of 470 patients remained, of whom 235 patients were allocated to the TCT group and 235 patients were allocated to the BPC group (*Figure 3*) according to the surgeon's preference.

The epidemiological and clinical characteristic data of the patients are shown in *Table 1*. No statistically significant differences were observed between the two groups in demographic characteristics (all P>0.05). In relation to the postoperative hospitalization time (4.6±1.5 *vs.* 5.4±4.5 days) and the collapse rate of the residual lung after operation (19.2%±9.1% *vs.* 20.9%±9.6%), the results of the BPC group were significantly better than those of the TCT group (all P<0.05).

The results of postoperative complications and VAS pain scores are set out in *Table 2*. The incidence of complications was significantly higher in the TCT group than the BPC group (19.1% *vs.* 7.7%, P<0.001), especially in terms of arrhythmia and hypertension. In relation to the postoperative VAS pain scores, the scores at 7–24 hours (3.3±1.0 *vs.* 3.7±1.5) and 25–48 hours (3.1±0.8 *vs.* 3.6±1.5) were significantly lower in the BPC group than the TCT group (P<0.001), but there was no difference in the scores at 0–6 hours between the two groups.

The results of the univariable analysis showed that age, the CCI, the operative time, and the drainage strategy were associated with occurrence of postoperative complications (*Table 3*), and the results of the multivariable analysis showed that the drainage strategy was the only independent risk factor of postoperative complications (*Table 4*).

We classified mild, moderate, and severe pain as corresponding to values of 1–3, 4–6, and 7–10, respectively, on the VAS, and compared the mild pain with the moderate or severe pain at 7–24 and 25–48 hours after surgery (*Tables 5-8*). The univariable and multivariable analyses showed that the lobe involved (i.e., the right lower lobe) and the drainage

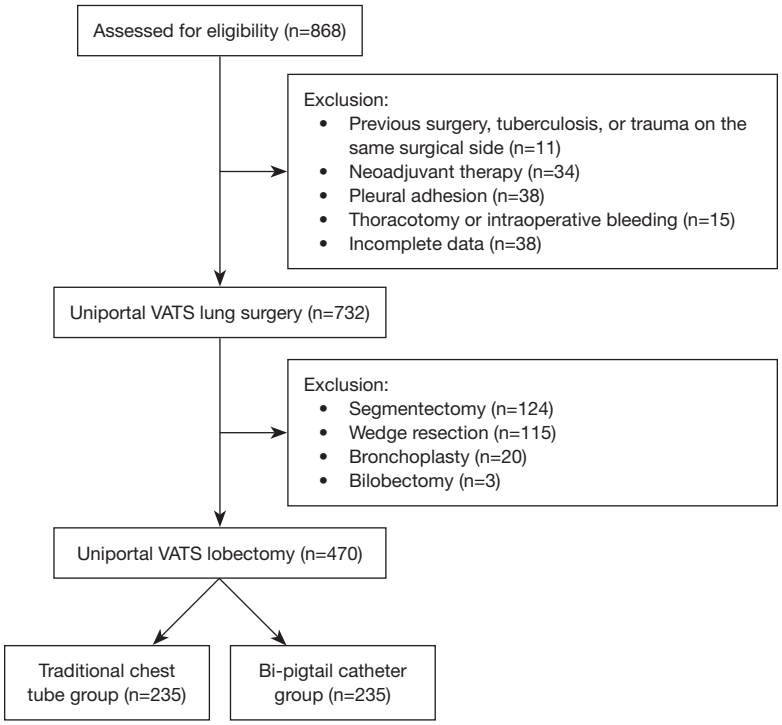

Figure 3 Flow diagram of patient enrollment. VATS, video-assisted thoracic surgery.

strategy were independent risk factors of moderate or severe pain at 7–24 hours after surgery (P<0.05), and the lobe involved (i.e., the right middle lobe) and the drainage strategy were independent risk factors of moderate or severe pain at 25–48 hours after surgery (P<0.05).

Discussion

There are no standard guidelines as to the number and sizes of the chest tubes that should be selected after thoracic surgery. In the past, thoracic surgery mainly comprised thoracotomy, and the use of two large-bore chest tubes was considered the routine and safe option (17). With the growing popularity of VATS surgery, a drainage strategy with one large-bore chest tube has been proven to be safe and is accepted by most surgeons (18), especially in uniportal VATS. Recently, the use of PCs has been reported to be effective in the drainage of pneumothorax, traumatic hemothorax, and wedge resection of the lung (8-13). It has also been reported that a drainage strategy that uses BPCs in uniportal VATS lung surgery reduces postoperative pain safely, but the type of surgery only included wedge resection, segmentectomy, or wedge resection combined with segmentectomy (14). Yang *et al.* (19) showed that a strategy that use one pleural catheter plus a single chest tube for drainage was safe in upper lobectomy by uniportal VATS. The present study was the first to examine the use of a drainage strategy with BPCs in patients undergoing lobectomy only by uniportal VATS, and the results showed that the drainage strategy with BPCs decreased the incidence of postoperative complications, and was accompanied by less pain at 7–24 and 25–48 hours after surgery.

Research has shown that larger-bore chest tubes cause more severe pain that negatively affects respiration, which in turn increases the risk of postoperative respiratory complications, impairs patients' early ambulation after surgery, and consequently increases the risk of a thromboembolic event (20). Xu *et al.* (21) reported that placing a 12-Fr PC alone was effective and safe after uniportal VATS lobectomy and extended lymphadenectomy. In our study, the BPC group had fewer postoperative complications and lower VAS pain scores at 7–24 and 25–48 hours after surgery than the TCT group, and there were no statistically significant differences in drainage duration and postoperative drainage volumes between the two groups, which suggests that the drainage strategy with BPCs is safe and effective. We conducted univariable and multivariable

Table 1 Baseline clinical characteristics of the patients

Variables	Traditional chest tube (n=235)	Bi-pigtail catheters (n=235)	P value
Gender			0.06
Men	74 (31.5)	93 (39.6)	
Women	161 (68.5)	142 (60.4)	
Age (years)	59.3±8.7	59.4±9.4	0.95
BMI (kg/m^2)	23.8±2.9	24.2±3.2	0.13
Hypertension			0.90
Yes	47 (20.0)	48 (20.4)	
No	188 (80.0)	187 (79.6)	
History of smoking			0.17
Yes	58 (24.7)	71 (30.2)	
No	177 (75.3)	164 (69.8)	
Charlson Comorbidity Index	2.6±1.3	2.8±1.3	0.27
FEV1%	94.4±17.2	93.3±15.6	0.49
FVC%	92.6±18.6	91.2±17.5	0.40
DLCO%	83.5±17.9	82.7±18.2	0.64
Lobe involved			0.64
RUL	85 (36.2)	77 (32.8)	
RML	23 (9.8)	19 (8.1)	
RLL	47 (20.0)	43 (18.3)	
LUL	52 (22.1)	60 (25.5)	
LLL	28 (11.9)	36 (15.3)	
Operating time (min)	147.6±45.8	141.8±46.8	0.17
Drainage duration (days)	3.5±1.7	3.7±1.6	0.16
Total drainage volume (mL)	748.1±469.7	752.8±485.4	0.91
Postoperative hospitalization (days)	5.4±4.5	4.6±1.5	0.01
Collapse rate of lung after operation (%)	20.9±9.6	19.2±9.1	0.047
Analgesic drug usage, per person (g)	14.6±3.2	15.1±3.0	0.15

Data are presented as n (%) or mean ± standard deviation. BMI, body mass index; FEV1, forced expiratory in 1 second; FVC, forced vital capacity; DLCO, diffusion lung capacity for carbon monoxide; RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LUL, left upper lobe; LLL, left lower lobe.

analyses to examine predictors of postoperative complications and moderate to severe postoperative pain, and found that the drainage strategy with TCT was the only predictive factor.

There was no difference between the two groups in terms of the postoperative VAS pain score at 0–6 hours. This might be because the postoperative time was too short, and not sufficient for the patients to completely metabolize the analgesic drugs during anesthesia. Additionally, the surgical patients were required to stay in bed for 6 hours postoperatively after returning to the ward, and their reduced activity might have reduced the stimulation of the drainage tube to the chest wall and the residual lung.

Several studies have reported that a drainage strategy

Table 2 Perioperative outcomes

Variables	Traditional chest tube (n=235)	Bi-pigtail catheters (n=235)	P value
Postoperative complications	45 (19.1)	18 (7.7)	<0.001
Pneumothorax and/or subcutaneous emphysema (Grade IIIa)	1 (2.1)	1 (5.0)	
Arrhythmia (Grade II)	7 (14.9)	1 (5.0)	
Atrial fibrillation (Grade IIIa)	21 (44.7)	15 (75.0)	
Air leakage (Grade I)	3 (6.4)	1 (5.0)	
Hypertension (Grade II)	9 (19.1)	2 (10.0)	
Pleural effusion (Grade IIIa)	3 (6.4)	0	
Chylothorax (Grade I)	2 (4.3)	0	
Cerebral infarction (Grade II)	1 (2.1)	0	
Pain VAS score			
0–6 hours after surgery	3.1±0.7	3.1±0.5	0.32
7–24 hours after surgery	3.7±1.5	3.3±1.0	<0.001
25–48 hours after surgery	3.6±1.5	3.1±0.8	<0.001

Data are presented as n (%) or mean ± standard deviation. VAS, visual analogue scale.

Table 3 Results of the univariable analysis of postoperative complications

Variables	Odds ratio	95% CI	P value
Gender	0.699	0.408–1.199	0.19
Age	2.193	1.267–3.797	0.005
BMI	1.532	0.889–2.637	0.12
Hypertension	1.030	0.534–1.987	0.92
History of smoking	1.166	0.652–2.084	0.60
Charlson Comorbidity Index	1.238	1.011–1.515	0.03
FEV1%	0.997	0.981–1.013	0.70
FVC%	0.991	0.976–1.006	0.22
DLCO%	1.009	0.995–1.022	0.21
Lobe involved	2.083	0.945–4.594	0.08
Operating time	1.006	1.001–1.012	0.03
Drainage strategy	0.350	0.196–0.626	<0.001

BMI, body mass index; FEV1, forced expiratory in 1 second; FVC, forced vital capacity; DLCO, diffusion lung capacity for carbon monoxide; CI, confidence interval.

Table 4 Results of the multivariable analysis of postoperative complications

Variables	Odds ratio	95% CI	P value
Age	1.046	0.994–1.101	0.08
Charlson Comorbidity Index	1.010	0.724–1.409	0.95
Operating time	1.005	0.999–1.011	0.08
Drainage strategy	2.885	1.598–5.208	<0.001

CI, confidence interval.

with PC improves the drainage of pleural effusion and air, but no studies have focused on the re-expansion of the residual lung (14,22,23). In our study, the collapse rate of the lung after operation in the BPC group was significantly better than that of the TCT group; thus, the re-expansion of the residual lung in the BPC group was better than that in the TCT group. The full drainage and reduced stimulation of the PCs to the lung or chest wall could reduce patients' pain, and such patients should be able to increase their activity and respiratory function exercise faster after surgery.

It has been reported that pain and discomfort after surgery caused by chest tubes might be one of the main obstacles to enhanced recovery after surgery (ERAS) (24). Chen *et al.* (25) also reported that postoperative pain is a primary obstacle to ERAS, as it leads to insufficient respiratory function exercise during the initial postoperative days. In our study, the postoperative hospitalization time of the BPC group

Table 5 Results of the univariable analysis of VAS pain score at 7–24 hours after surgery

Variables	Odds ratio	95% CI	P value
Gender	1.562	0.896–2.723	0.11
Age	0.935	0.539–1.624	0.81
BMI	0.840	0.473–1.491	0.55
Hypertension	0.623	0.333–1.164	0.13
History of smoking	0.574	0.323–1.019	0.058
Charlson Comorbidity Index	0.913	0.736–1.133	0.41
FEV1%	1.003	0.987–1.020	0.69
FVC%	1.004	0.989–1.019	0.63
DLCO%	0.992	0.976–1.009	0.37
Lobe involved (RLL)	3.121	1.144–8.516	0.02
Operating time	1.150	0.653–2.024	0.62
Drainage strategy	2.710	1.491–4.926	0.001

VAS, visual analogue scale; BMI, body mass index; FEV1, forced expiratory in 1 second; FVC, forced vital capacity; DLCO, diffusion lung capacity for carbon monoxide; RLL, right lower lobe; CI, confidence interval.

Table 6 Results of the multivariable analysis of VAS pain score at 7–24 hours after surgery

Variables	Odds ratio	95% CI	P value
Lobe involved (RLL)	2.971	1.075–8.212	0.03
Drainage strategy	2.583	1.410–4.731	0.002

VAS, visual analogue scale; RLL, right lower lobe; CI, confidence interval.

Table 7 Results of the univariable analysis of VAS pain score at 25–48 hours after surgery

Variables	Odds ratio	95% CI	P value
Gender	1.031	0.551–1.932	0.92
Age	2.238	1.164–4.302	0.01
BMI	1.044	0.547–1.992	0.89
Hypertension	2.947	1.032–8.424	0.04
History of smoking	1.266	0.624–2.570	0.51
Charlson Comorbidity Index	0.670	0.518–0.868	0.002
FEV1%	0.987	0.969–1.006	0.17
FVC%	0.988	0.971–1.005	0.15
DLCO%	0.996	0.978–1.013	0.63
Lobe involved (RML)	2.868	1.198–6.862	0.01
Operating time	1.020	0.552–1.884	0.95
Drainage strategy	5.646	2.577–12.370	<0.001

VAS, visual analogue scale; BMI, body mass index; FEV1, forced expiratory in 1 second; FVC, forced vital capacity; DLCO, diffusion lung capacity for carbon monoxide; RML, right middle lobe; CI, confidence interval.

Table 8 Results of the multivariable analysis of VAS pain score at 25–48 hours after surgery

Variables	Odds ratio	95% CI	P value
Age	1.282	0.528–3.110	0.58
Hypertension	2.208	0.717–6.801	0.16
Charlson Comorbidity Index	0.783	0.543–1.131	0.19
Lobe involved (RML)	2.833	1.149–6.983	0.02
Drainage strategy	5.634	2.535–12.525	<0.001

VAS, visual analogue scale; RML, right middle lobe; CI, confidence interval.

was significantly better than that of the TCT group, and patients in the BPC group also had less pain and a lower incidence of postoperative complications than those in the TCT group. Thus, a drainage strategy that uses BPCs is in accordance with the concept of ERAS.

This study had several limitations. First, it was a single-center retrospective study with a relatively small sample size and choice of the specific drainage method was based on the surgeon's preference, which inevitably led to selection bias. Thus, further international multi-center randomized controlled trials (RCTs) are needed to verify our results. Second, there are no standard guidelines for efficient drainage, and we used the 20-Fr chest tube, 12- and 10-Fr PC based only on our experience; thus, the adequate diameters of PCs still need to be determined. Third, we did not have any data on incision healing and cosmetic outcomes, and it is possible that the incision healing results and cosmetic outcomes could have been better in the BPC group than the TCT group. Fourth, long-term outcomes, such as chronic pain and quality of life, were not examined in the current study, but we intend to analyze these outcomes in a further report.

Conclusions

Our drainage strategy with BPCs decreased the incidence of

postoperative complications and alleviated the postoperative pain of patients undergoing lobectomy by uniportal VATS, and is safe and feasible. Thus, this type of drainage strategy is simply a viable option. Additionally, there's potential for initiating a RCT to explore and establish any causal relationships between factors such as pain, complications, and incision placement.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-925/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-925/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-925/coif). H.C.F. serves as an unpaid editorial board member of *Journal of Thoracic Disease* from April 2024 to June 2026. The other 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. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Liaoning Cancer Hospital & Institute Ethics Committee (No. KY20240407). Individual consent for this retrospective analysis was waived.

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