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Impact of Single-Port Thoracoscopic Surgery on Postoperative Pain and Pulmonary Function in Patients with Chest Trauma

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Abstract: *Objective*: To study the therapeutic effect of single-port thoracoscopic surgery for patients with chest trauma, and explore its influences on postoperative pain, pulmonary function and postoperative complications, so as to provide clinical references for minimally invasive treatment of chest trauma. *Methods*: A total of 54 patients with chest trauma admitted to our hospital from January 2024 to August 2026 were selected and divided into an observation group (single-port thoracoscopic surgery, 27 cases) and a control group (conventional multi-port thoracoscopic surgery, 27 cases). The visual analogue scale (VAS) scores at postoperative day 1, day 3 and day 7, pulmonary-function indicators including forced expiratory volume in one second (FEV_1), forced vital capacity (FVC) and peak expiratory flow (PEF) before and after surgery, as well as the incidence of postoperative complications were compared between the two groups. *Results*: There were no statistically-significant differences in baseline general data and preoperative pulmonary-function indicators between the two groups ($P>0.05$). The VAS pain scores of the observation group were lower than those of the control group at postoperative day 1, day 3 and day 7 ($P<0.05$). Seven days after surgery, pulmonary-function indicators of both groups were significantly improved compared with preoperative values; FEV_1, FVC and PEF in the observation group were higher than those in the control group ($P<0.05$). The incidence of postoperative complications in the observation group was 7.41 %, lower than 22.22 % in the control group ($P<0.05$). *Conclusion*: Single-port thoracoscopic surgery for chest trauma brings less surgical trauma, can significantly relieve postoperative pain, promote pulmonary-function recovery and reduce the risk of postoperative complications. It features high safety and possesses high value for clinical promotion.

Keywords: Single-port thoracoscopic surgery; Chest trauma; Postoperative pain; Pulmonary function; Complications

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1. Introduction

Chest trauma is a common emergency in clinical emergency departments and thoracic-surgery departments. It is mostly caused by external forces such as traffic accidents, falls from heights and heavy-object impacts, and may manifest as rib fractures, hemopneumothorax, pulmonary contusion and other conditions. The

disease progresses rapidly; without timely and effective management, severe complications such as respiratory failure, thoracic infection and hemorrhagic shock may be aggravated, endangering patients' lives [1]. With the continuous development of minimally-invasive surgical techniques, thoracoscopic surgery has gradually replaced conventional thoracotomy and become the major minimally-invasive procedure for chest trauma. Single-port thoracoscopic surgery is a novel minimally-invasive technique improved on the basis of multi-port thoracoscopic surgery. It only requires one small incision, which can minimize injuries to chest-wall tissues, intercostal nerves and blood vessels, and conforms to the concept of enhanced recovery after surgery [2]. Therefore, this paper compares the clinical curative effects of single-port and multi-port thoracoscopic surgery, aiming to provide clinical evidence for minimally-invasive treatment of chest trauma.

2. Materials and methods

2.1. General data

Fifty-four patients hospitalized for chest-trauma treatment in the Department of Thoracic Surgery of our hospital from January 2024 to August 2026 were enrolled as research subjects. They were divided into an observation group and a control group, with 27 cases in each group.

Inclusion criteria: Patients with closed chest injuries confirmed by chest CT and X-ray, complicated with rib fractures, hemopneumothorax or pulmonary contusion; time interval from trauma to surgery within 24 hours; patients with surgical indications for thoracoscopy and without surgical contraindications; patients and their family members provided informed consent and voluntarily participated in this study.

Exclusion criteria: Combined open chest trauma, severe craniocerebral injury and abdominal-visceral injury; previous pulmonary diseases, thoracic-wall deformity and history of chest-wall surgery; coagulation-disorder and immunodeficiency; complicated severe cardiac, hepatic or renal failure; incomplete clinical data and inability to cooperate with follow-up observation.

In the observation group: 19 males and 8 females; aged 22-65 years, mean (43.26 ± 8.52) years old. Trauma types: 13 cases of multiple rib fractures, 8 cases of hemopneumothorax, 5 cases of pulmonary contusion. Causes of injury: 22 cases of traffic-accident injury, 13 cases of fall-from-height injury, 8 cases of heavy-object-impact injury. In the control group: 19 males and 8 females; aged 21-64 years, mean (42.89 ± 8.37) years old. Trauma types included multiple rib fractures, hemopneumothorax and pulmonary contusion. Causes of injury: 13 cases of traffic-accident injury, 9 cases of fall-from-height injury, 5 cases of heavy-object-impact injury. There were no statistically-significant inter-group differences in general data such as gender, age, trauma type and cause of injury (P>0.05), indicating comparability. This study was approved by the Medical Ethics Committee of our hospital.

2.2. Surgical methods

All patients in both groups received preoperative routine examinations to assess physical status, correct shock and electrolyte disturbances, and complete preoperative preparation. General anesthesia and double-lumen endotracheal intubation were adopted. Intraoperative one-lung ventilation was performed on the healthy side, patients were placed in the lateral decubitus position of the uninjured side, and routine disinfection and draping were carried out [3].

The control group underwent conventional multi-port thoracoscopic surgery. According to the trauma site, a 1.0 cm observation port was made at the 7th intercostal space on the mid-axillary line of the affected

side. A thoracoscope was inserted for intrathoracic exploration to identify trauma locations, bleeding, hemothorax and pneumothorax. Two 1.5 cm operating ports were made respectively at the 4th intercostal space on the anterior-axillary line and the 6th intercostal space on the posterior-axillary line to establish a three-port working channel. Under direct thoracoscopic vision, intrathoracic hematocele, effusion and fractured lung tissues were cleared. Fractured ribs were reduced and internally fixed; lacerated pleura were repaired. After hemostasis, the thoracic cavity was irrigated. After confirming no active bleeding or air leakage, a closed thoracic-drainage tube was placed, and the incision was sutured layer by layer.

The observation group received single-port thoracoscopic surgery. A single 2.5-3.0 cm surgical incision was made at the 4th intercostal space on the anterior-axillary line of the affected side according to the trauma site, serving as a shared channel for observation and manipulation. Skin, subcutaneous tissues and chest-wall muscles were incised layer by layer, and the thoracoscope and operating instruments were inserted [4]. Comprehensive intrathoracic exploration was performed under direct vision to define the scope of traumatic lesions. Intrathoracic hematocele, effusion and necrotic tissues were precisely cleared; rib reduction and internal fixation, pleural repair and hemostasis were completed. Surgical procedures were consistent with those of the control group. At the end of surgery, the closed thoracic-drainage tube was placed through this single incision, and the incision was sutured in layers without additional port-making [5].

Postoperatively, patients in both groups received anti-infection, analgesia, antitussive, atomized-oxygen-inhalation and symptomatic treatments. When patients were capable of active activities, guidance was given for activity modes and effective cough-and-sputum-expectoration. Chest CT re-examinations were performed regularly, and drainage tubes were removed in good time according to drainage conditions.

2.3. Observation indicators

(1) Postoperative pain score: The visual analogue scale (VAS) was adopted to assess pain intensity on postoperative day 1, day 3, and day 7. The total score ranged from 0 to 10 points: 0 points indicated pain-free status; 1-3 points for mild pain; 4-7 points for moderate pain; 8-10 points for severe pain. Higher scores represented more intense pain.

(2) Pulmonary-function indicators: A pulmonary-function tester was used to measure FEV_1, FVC, and PEF before surgery and on postoperative day 7. Postoperative changes in pulmonary function were compared between the two groups.

(3) Incidence of postoperative complications: The occurrence of postoperative complications, including pulmonary infection, atelectasis, pleural effusion, incision infection, and persistent chest pain, in the two groups was counted, and the total incidence of complications was calculated.

2.4. Statistical methods

SPSS 26.0 statistical software was used for data analysis. Measurement data were expressed as mean ± standard deviation (SD). Paired *t*-test was applied for intra-group pre-post-surgery comparison, and independent-samples *t*-test for inter-group comparison. Count data were expressed as [n(%)], and the χ^2 test was adopted. $P<0.05$ was regarded as statistically significant.

3. Results

3.1. Comparison of VAS pain scores at different postoperative time points between the two groups

Postoperative pain of patients in both groups gradually alleviated over time. The VAS pain scores of the observation group were significantly lower than those of the control group at postoperative day 1, day 3 and day 7, with statistically-significant inter-group differences ($P < 0.05$).

Table 1. Comparison of VAS pain scores at different postoperative time points between the two groups (mean ± SD, points)

Group	Post-op Day 1	Post-op Day 3	Post-op Day 7
Observation Group (n=27)	4.12 ± 0.85	2.65 ± 0.62	1.23 ± 0.41
Control Group (n=27)	5.86 ± 0.93	3.92 ± 0.75	2.15 ± 0.53

3.2. Comparison of pulmonary-function indicators before and after surgery between the two groups

There was no significant difference in preoperative FEV_1, FVC and PEF pulmonary-function indicators between the two groups ($P > 0.05$). At postoperative day 7, all pulmonary-function indicators of both groups were markedly improved compared with preoperative levels, and the improvement was more prominent in the observation group, with statistically-significant inter-group differences ($P < 0.05$).

Table 2. Comparison of pulmonary-function indicators before and after surgery between the two groups (mean ± SD)

Group	Time	FEV_1(L)	FVC(L)	PEF(L/s)
Observation Group (n=27)	Pre-operation	2.15±0.32	2.86±0.41	4.23±0.56
	Post-op Day 7	2.89±0.45	3.65±0.52	5.86±0.63
Control Group (n=27)	Pre-operation	2.13±0.30	2.84±0.39	4.21±0.54
	Post-op Day 7	2.51±0.41	3.22±0.48	5.12±0.59

Note: Compared with preoperative status within the same group, $P<0.05$.

3.3. Comparison of the incidence of postoperative complications between the two groups

In the observation group, there was 1 case of pulmonary infection and 1 case of persistent chest pain; the total complication incidence was 7.41 %. In the control group, there were 3 cases of pulmonary infection, 1 case of atelectasis, 1 case of pleural effusion and 1 case of incision infection, with 0 case of persistent chest pain; the total complication incidence was 22.22 %. The incidence of postoperative complications in the observation group was significantly lower than that in the control group, and the difference was statistically significant.

Table 3. Comparison of the incidence of postoperative complications between the two groups [n(%)]

Group		Atelectasis	Pleural Effusion	Incision Infection	Persistent Chest Pain	Total Incidence
Observation Group (n=27)	1(3.70)	0(0.00)	0(0.00)	0(0.00)	1(3.70)	2(7.41)
Control Group (n=27)	3(11.11)	1(3.70)	1(3.70)	1(3.70)	0(0.00)	6(22.22)

4. Discussion

Chest trauma features acute onset and complex conditions. It is often accompanied by destruction of thoracic-cage structures and intrathoracic-tissue injuries, which directly affect patients' respiratory and circulatory functions. Without timely treatment, various postoperative complications are likely to occur and prognosis will be severely impaired. Surgery constitutes the major therapeutic modality for chest trauma. Greater surgical trauma brings more severe postoperative pain, slower pulmonary-function recovery and poorer overall therapeutic outcomes. Conventional thoracotomy causes heavy trauma, massive bleeding and severe postoperative pain. Patients tend to inhibit respiration and suppress cough due to pain, resulting in sputum retention and poor pulmonary re-expansion, which greatly increases the incidence of pulmonary complications and impedes pulmonary-function recovery [6]. With iterative updates of minimally-invasive techniques, multi-port thoracoscopic surgery has gradually replaced thoracotomy for its advantages of minimal trauma, high safety and good visual field. Nevertheless, clinical practice reveals that multiple operating ports of multi-port surgery repeatedly injure chest-wall muscles and intercostal nerves. Postoperative pain remains prominent, which imposes certain restrictions on early respiratory-function rehabilitation exercises [7].

Single-port thoracoscopic surgery represents an important innovation in minimally-invasive thoracic surgery. All surgical manipulations can be completed via only one incision, which minimizes chest-wall trauma compared with conventional multi-port procedures. The results showed that the VAS pain scores of the observation group at postoperative day 1, day 3 and day 7 were lower than those of the control group, indicating that the single-port approach can effectively relieve postoperative pain. The underlying reasons are analyzed as follows: multi-port thoracoscopic surgery requires multiple intercostal operating ports; intraoperative traction and injuries to intercostal nerves and chest-wall muscles are extensive. Postoperative nerve irritation and tissue edema trigger persistent pain. Single-port surgery adopts only one incision for manipulation, avoids multiple chest-wall injuries, maximally preserves chest-wall integrity, reduces traction and damage to intercostal nerves, and alleviates postoperative pain from the source, with faster pain relief than multi-port surgery. This finding is consistent with conclusions of existing clinical studies [8].

Pulmonary-function impairment is one of the major pathological changes in patients with chest trauma. Pulmonary contusion, thoracic-cage deformity, intrathoracic hematocele and pneumothorax induced by trauma, together with surgical trauma and postoperative pain and other factors, all impair patients' ventilation and gas-exchange functions. In this study, there were no significant inter-group differences in preoperative pulmonary-function indicators. Pulmonary function of both groups improved on postoperative day 7, while FEV_1, FVC, and PEF levels in the observation group were obviously superior to those in the control group, demonstrating better postoperative pulmonary-function recovery after single-port thoracoscopic surgery. On the one hand, single-port surgery causes slight trauma and mild postoperative pain, which enables patients to carry out rehabilitation training such as deep-breathing exercises, effective coughing and early ambulation as early as possible, facilitating pulmonary expansion and airway sputum clearance and promoting the recovery of pulmonary-ventilation function [9]. On the other hand, single-port surgery exerts little influence on chest-wall muscles and thoracic-cage stability, maintains normal thoracic-cage movement rhythm, prevents dyspnea caused by chest-wall injury, and creates favorable conditions for rapid pulmonary-function recovery [10].

Postoperative complications are influencing factors for rehabilitation of chest-trauma patients, among which pulmonary infection, atelectasis and pleural effusion are the most common [11]. The above results

show that the incidence of postoperative complications was lower in the observation group, proving the clinical-safety advantages of single-port thoracoscopic surgery. Single-port surgery features fewer incisions and less trauma, shorter intraoperative thoracic-cavity exposure time and reduced risk of intrathoracic infection. Meanwhile, favorable postoperative recovery permits early respiratory-function training for patients to prevent complications such as sputum retention and atelectasis. The single incision achieves rapid healing with low infection risk [12]. Multiple incisions in multi-port surgery aggravate the body's stress response, reduce patients' willingness for postoperative activities, cause accumulation of pulmonary secretions and raise the incidence of various complications [13].

From the perspective of clinical practice, although single-port thoracoscopic surgery possesses prominent strengths, it imposes high technical requirements on surgical operators. The instrument-operating space under a single incision is narrow; surgeons must be proficient in minimally-invasive skills to avoid mutual interference among instruments [14]. Clinicians shall strictly comply with surgical indications, formulate individualized surgical plans according to patients' injury conditions, and implement postoperative analgesia and respiratory-tract nursing to accelerate recovery. The present study is a single-center, small-sample observational study with a relatively short follow-up duration. Future research can expand sample sizes, adopt multi-center designs and prolong follow-up time to observe long-term changes in patients' pain and pulmonary function [15].

5. Conclusion

Compared with conventional multi-port thoracoscopic surgery, single-port thoracoscopic surgery for chest trauma has remarkable advantages, including less trauma, milder postoperative pain, and fewer complications. It can effectively relieve patients' pain symptoms at different postoperative stages, accelerate pulmonary-function recovery and shorten rehabilitation cycles, with higher clinical safety and effectiveness. It conforms to the concept of enhanced recovery after surgery and serves as a preferred minimally-invasive therapeutic option for chest trauma, possessing high clinical-promotion-and-application value.

Disclosure statement

The authors declare no conflict of interest.

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