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A retrospective cross-sectional study of therapeutic results of single port thoracoscopy in patients with lung collapse due to trauma: comparison of entirely recovered and re-thoracoscopy needed patients

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Abstract

Introduction Lung collapse can occur for various reasons, especially trauma. Single-port thoracoscopy is a treatment method that has not been discussed in detail. This study aimed to investigate the results of single-port thoracoscopy as a treatment for trauma-induced lung collapse.

Methods This descriptive retrospective cross-sectional study included 100 patients with lung collapse following trauma who were referred to the Madani Hospital. Demographic data, underlying causes and injuries, respiratory and consciousness state, pain level, recurrence rate, hospitalization period, complications, and narcotic and non-narcotic analgesics, re-thoracoscopy, and thoracotomy requirements were evaluated.

Results The mean age of patients was 38 ± 16 years, and 65% were male. Single port thoracoscopy has suitable therapeutic effects, low complications, less pain, and reduced need for painkillers. Patients with more concomitant injuries, longer duration from trauma to performing thoracoscopy, intubation requirement, bilateral lung involvement, and lower GCS, required re-thoracoscopy, which has been associated with more extended hospitalization, suffering from more pain, need to receive narcotics and thoracotomy, and frequency of narcotic and non-narcotic agents. These results demonstrate the efficacy of the single port thoracoscopy in uncomplicated and initially completely recovered patients, and the re-thoracoscopy requirement and complications are based on the underlying cause and medical circumstances.

Conclusion Single port thoracoscopy is practical for improving the quality of management of patients with lung collapse following trauma. Future studies should compare different methods.

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Keywords Thoracoscopy, Lung collapse, Trauma, Single port, VATS

Introduction

Pulmonary segmental/lobar collapse is critical in patients with traumatic injuries and chest wall disorders. Following trauma, lung collapse can occur, and in this situation, the collapsed part of the lung requires a procedure to restore the lung to its original state [1].

Video-assisted thoracic surgery (VATS) has been one of the most critical developments and minimally invasive procedures with accurate and sensitive outcomes in thoracic surgery and respiratory interventions. Compared to open thoracotomy, VATS significantly reduces pain, accelerates recovery, minimizes complications, and improves the postoperative quality of life. The increased use of single-port surgery is a recent advancement in VATS [2]. Single-port VATS was initially reported for the diagnosis and treatment of noncomplex pleural diseases in 2003 [3]. Involvement of only one intercostal space and, as a result, reduced postoperative pain are the advantages of single-port VATS [4]. The adaptability, feasibility, and success of the single-port access technique in managing various chest diseases have made this technique famous and practical worldwide.

Angled double-hinged and narrow-shaft instruments and flexible endo staplers have become part of the essential armamentarium for VATS single-port access. These tools improve space availability and reduce access to trauma. Nowadays, scopes have become thinner and have greater versatility and visual clarity to improve access through smaller surgical incisions and less interference with other instruments in the operation field [5]. A combination of thoracoscope and more specialized instruments will be considered a key to facilitating the advancement of single-port VATS [6].

The main diagnostic and therapeutic indications for medical thoracoscopy are localized chest wall and lung lesions, diffuse lung diseases, pleural effusions of indeterminate origin, staging of lung cancer with pleural effusion, staging of diffuse malignant mesothelioma, staging of pneumothorax, hormone receptor determination in breast cancer and culture in tuberculous pleurisy, and talc poudrage in pleural effusions, empyema and pneumothorax [7]. Technological advances help customize instruments for thoracoscopic surgery, which will be equally decisive in facilitating the single-port technique under topical, local, or general anesthesia or even conscious sedation [8].

Since few studies evaluated the effectiveness of using single-port thoracoscopy in various lung injuries, this study aimed to investigate the feasibility, safety, and therapeutic results of single-port thoracoscopy for patients with trauma-induced lung collapse with an assessment of chest CT scan.

Methods

This is a descriptive retrospective cross-sectional study conducted through the SROBE checklist (Supplementary Material Table 1) [9] in which 100 patients with chest trauma leading to lung collapse were referred to Shahid Madani Hospital in Karaj in 2021. This study protocol was reviewed and approved by Alborz University of Medical Sciences research ethics committee, approval number [IR.ABZUMS.REC.1400.146]. Written informed consent was obtained from the patients.

Sampling method

The inclusion criteria for this study were as follows: (1) patients with chest trauma leading to lung collapse, (2) mastery of speech and ability to understand and read Persian language, (3) consent to participate in the study, (4) age over 18 years. Exclusion criteria included: (1) disagreement to participate in the study, absolute and relative contraindications for thoracoscopic treatment such as the lack of pleural space due to extensive adhesions of the pleural layers in pleural fibrosis, infections, or previous pleurodesis, coagulopathies, impossible lateral decubitus position, unstable hemodynamic status, uncorrectable hypoxamia, pulmonary arterial hypertension, refractory cough, drug hypersensitivity, and short suspected survival [7], (2) indications for thoracotomy treatment including shock, arrest at presentation, blunt or penetrating thoracic injuries, and ongoing hemorrhage [10], and (3) the presence of chronic lung diseases inducing chronic hypoxemia, hypercapnia, and cough [11].

The number of available cases in the area during the study period determined the sample size.

Procedure

Before the operation, a chest CT scan was taken and interpreted by the surgeon to determine the target lesion location, anatomical formation, and deformities which is provided for all the patients and none of them underwent the procedure without a CT scan. Patients were positioned in lateral decubitus on the healthy side or supine. Gaetano Rocco clearly explains the general rules of VATS [12]. The scapular angle line (longitude) is the dividing line between the anterior and posterior incisions to identify anterior and posterior lesions. The intercostal space for incision in a plane (latitude) based on providing sufficient space for accessing the target lesion is selected to avoid mutual interference of the thoracoscopic surgical instrument set. After that, a surgical incision (3.5–4.5 cm

long) is performed in the fourth or fifth intercostal space through the anterior axillary line on the affected side of the chest (Fig. 1). Access to the intercostal plane is possible with a blunt procedure similar to the placing chest drain technique. The operator stands on the abdomen side of the patient and only uses endoscopic tools. A 10-mm 30-degree video thoracoscope is inserted into the incision's upper part and used for visualization, whereas articulating instruments facilitate operative support into the chest [13]. Several instruments can be inserted parallel to the video thoracoscope through the same incision, and their mutual position can be changed during the procedure if needed [14]. The assistant holding the camera should stand on the side of the operator's feet on the same side to have the same level view. The head of the camera is often placed at one end of the incision, especially the superior edge, in order to minimize its interference with utilizing surgical instruments. The towel clip can fix the camera's body, increase the camera's stability, and decrease the fatigue of the assistant holding the

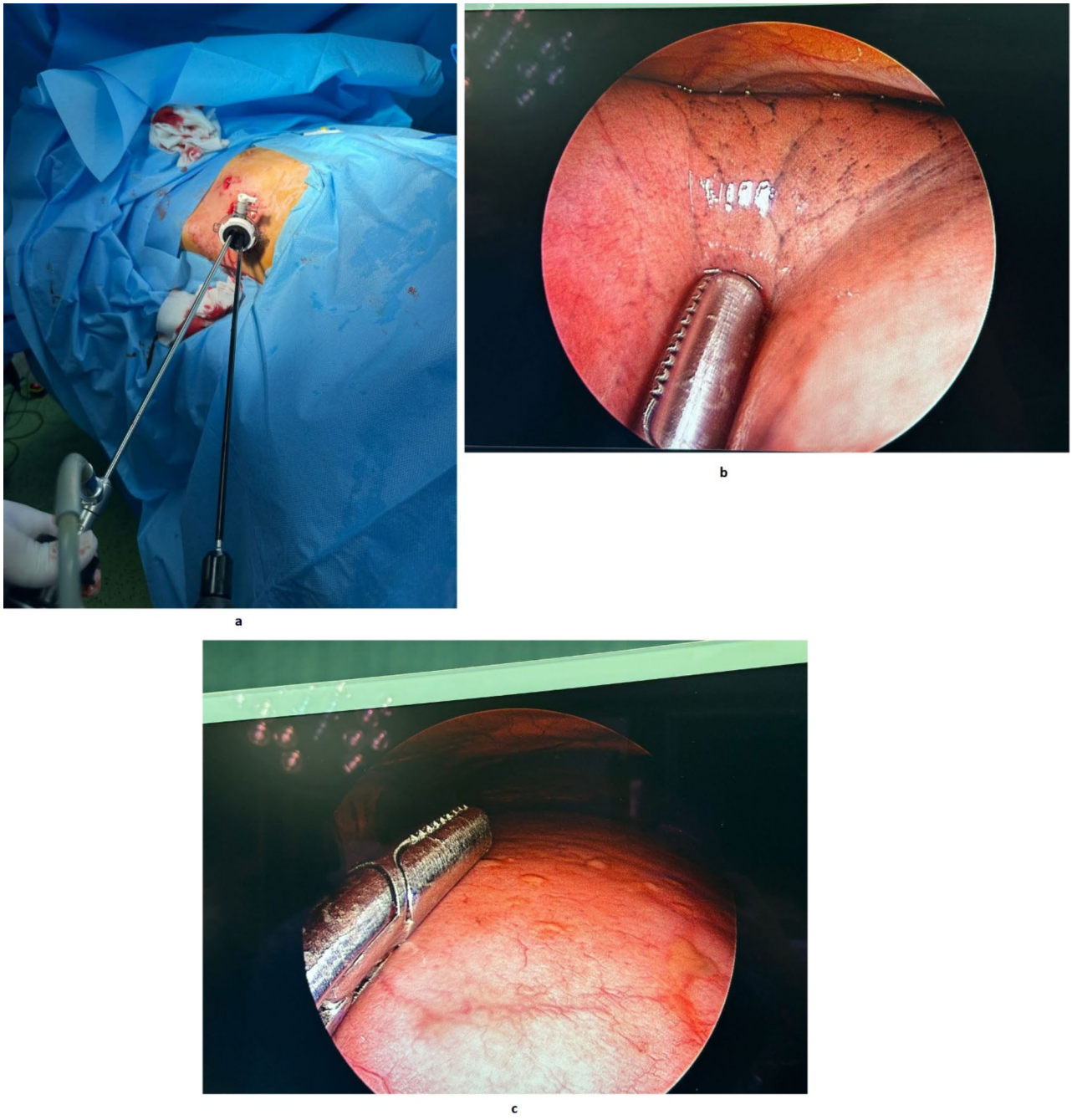

Fig. 1 A surgical incision (3.5–4.5 cm long) in the fourth or fifth intercostal space through the anterior axillary line on the affected side of the chest

camera [15]. At the end of the procedure, a 28 French chest tube is inserted, and if there is no air leakage and the drainage volume is less than 200 cc per day, this tube is removed [16]. Sometimes, during single-port VATS, the operator may face difficulties visualizing and dissecting the structures and identifying the correct angles to establish the instruments and staplers. Repositioning the instruments through a single-port incision facilitates this process without enlarging the incision or applying force to the ribs. Rapid advances in instrument design have occurred to improve ergonomics and prevent interference between inserted instruments along the small single-port VATS incision [17].

A computed tomography (CT) scan was performed after thoracoscopy to investigate the full, relative, or lack of response to treatment, and the requirement to re-thoracoscopy management.

After the intervention, patients were evaluated based on demographic data, underlying causes and injuries, respiratory and consciousness state, pain level, recurrence rate, hospitalization period, complications, and narcotic and non-narcotic analgesics, re-thoracoscopy, and thoracotomy requirements. The VAS questionnaire was also used to evaluate postoperative pain.

Statistical analysis

Analyses were performed using SPSS 25.0 statistical software. Percentage and frequency were employed to describe qualitative data, whereas mean, median, range, and standard deviation were utilized for quantitative data. The T-test was used to compare quantitative variables, and Fisher's exact test and chi-square were used to compare qualitative variables. A P-value less than 0.05 was considered statistically significant.

Results

The purpose of this study is to investigate the therapeutic results of single port thoracoscopy in patients with lung collapse due to trauma by assessing the chest CT scan before and after thoracoscopy in Karaj Madani Hospital in 2021. 100 case of chest trauma leading to lung collapse referred to Shahid Madani Hospital, who needed thoracoscopic treatment, were included in the study, and their characteristics were summarized in Table 1.

A total of 166 patients were enrolled and the participants' mean age was 38 ± 16, ranging from 18 to 75 years. 65 (65%) patients were men, and 35 (35%) of them were women. 9 patients (9%) had a history of illnesses and 36 (36%) had associated injuries. Lung involvement was unilaterally and bilaterally in 85 (85%) and 15 (15%) patients, respectively. 8 (8%) patients required intubation, and 92 (92%) of them had spontaneous breathing. The mean level of consciousness was 14 ± 2 and the mean pain level was 3 ± 2. Of these, 41 patients (41%) received narcotic painkillers and 73 patients (73%) received non-narcotic ones. 3 patients (3%) needed thoracotomy and postoperative wound infection occurred in 2 patients (2%). The mean duration of hospitalization was 8 ± 6.

89 patients (89%) were completely recovered after single-port thoracoscopy. The mean age was 38 ± 17, ranging from 18 to 75 years. 55 (61.8%) patients were men, and 34 (38.2%) of them were women. 7 patients (7.9%) had a history of illnesses and 25 (28.1%) had associated injuries. Lung involvement was unilaterally and bilaterally in 79 (88.8%) and 10 (11.2%) patients, respectively. 1 (1.1%) patients required intubation, and 88 (98.9%) of them had spontaneous breathing. Thoracoscopy was performed due to hemothorax, pneumothorax, and hemopneumothorax in 39 (43.8%), 32 (36%), and 18 (20.2%) of the patients, respectively. 1 patient (1.1%) needed thoracotomy and postoperative wound infection occurred in 2 patients (2.2%).

11 patients (11%) required re-thoracoscopy after single-port thoracoscopy. The mean age was 39 ± 15, ranging from 21 to 62 years. 10 (90.9%) patients were men, and 1 (9.1%) of them were women. 2 patients (18.2%) had a history of illnesses and 11 (100%) had associated injuries. Lung involvement was unilaterally and bilaterally in 6 (54.5%) and 5 (45.5%) patients, respectively. 7 (63.6%) patients required intubation, and 4 (36.4%) of them had spontaneous breathing. Thoracoscopy was performed due to hemothorax, pneumothorax, and hemopneumothorax in 3 (27.3%), 2 (18.2%), and 6 (54.5%) of the patients, respectively. 2 patients (18.2%) needed thoracotomy and postoperative wound infection occurred in none of the patients. The mean duration of hospitalization was 24 ± 7.

- **Evaluating the etiology of the performing thoracoscopy**.

Among the total number of patients, 25 patients (25%) had penetrating trauma, and 75 (75%) had blunt trauma. The primary pathology cause leading to lung collapse was also investigated. Thoracoscopy was performed due to hemothorax, pneumothorax, and hemopneumothorax in 42 (42%), 34 (34%), and 24 (24%) of the patients, respectively. The most common cause in complete recovery patients after the first thoracoscopy operation was hemothorax, which was observed in 39 patients (43.8%), and the most common cause for patients requiring re-thoracoscopy was hemopneumothorax demonstrated in 6 patients (54.5%) (P-value = 0.043).

Only 33 patients (37.1%) in complete recovery after the first thoracoscopy operation needed simultaneous bronchoscopy, whereas it was performed in all of the 11 re-thoracoscopy needed patients (100%) (P-value < 0.05). A patient who needed a thoracotomy due to aortic rupture

Table 1 Clinical characteristics of the patients and comparison of the complete recovered and re-thoracoscopy needed patients

Characteristics	Total (*n*=100)	Complete Recovered (*n*=89)	Re-thoracoscopy Needed (*n*=11)	*P*-value
Age	38 ± 16 (18– 75)	38 ± 17 (18– 75)	39 ± 15 (21– 62)	0.846
Gender				
Male	65 (65)	55 (61.8)	10 (90.9)	
Female	35 (35)	34 (38.2)	1 (9.1)	
History of illness				0.257**
Yes	9 (9)	7 (7.9)	2 (18.2)	
No	91 (91)	82 (92.1)	9 (81.8)	
Associated injuries				<0.001**
Yes	36 (36)	25 (28.1)	11 (100)	
No	64 (64)	64 (71.9)	0 (0)	
Lung involvement				0.011**
Unilateral	85 (85)	79 (88.8)	6 (54.5)	
Bilateral	15 (15)	10 (11.2)	5 (45.5)	
Breathing				<0.001**
Spontaneous	92 (92)	88 (98.9)	4 (36.4)	
Intubated	8 (8)	1 (1.1)	7 (63.6)	
Level of consciousness	14 ± 2	15 ± 1	10 ± 4	<0.001*
Pain level	3 ± 2	3 ± 2	6 ± 3	<0.001*
Receiving narcotic painkillers				<0.001**
Yes	41 (41)	30 (33.7)	11 (100)	
No	59 (59)	59 (66.3)	0 (0)	
Narcotic frequency	2 ± 1	2 ± 1	3 ± 2	0.005*
Receiving non-narcotic painkillers				0.722**
Yes	73 (73)	64 (71.9)	2 (18.2)	
No	27 (27)	25 (28.1)	9 (81.8)	
Non-narcotic frequency	3 ± 2	2 ± 1	5 ± 2	<0.001*
The days from trauma to performing thoracoscopy	4 ± 2	3 ± 1	9 ± 2	<0.001*
Duration of hospitalization (days)	8 ± 6	6 ± 2	24 ± 7	<0.001*
Type of trauma				0.061**
Blunt	75 (75)	64 (71.9%)	11 (100)	
Penetrating	25 (25)	25 (28.1)	0 (0)	
Cause of thoracoscopy				
Hemothorax	42 (42)	39 (43.8)	3 (27.3)	0.043**
Pneumothorax	34 (34)	32 (36)	2 (18.2)	
Hemopneumothorax	24 (24)	18 (20.2)	6 (54.5)	<0.001**
VATS frequency				
1	89 (89)	89 (100)	0 (0)	
2	8 (8)	0 (0)	8 (72.7)	
3	3 (3)	0 (0)	3 (27.3)	
Simultaneous bronchoscopy				<0.001**
Yes	44 (44)	33 (37.1)	11 (100)	
No	56 (56)	56 (62.9)	0 (0)	
Need for thoracotomy				0.031**
Yes	3 (3)	1 (1.1)	2 (18.2)	
No	97 (97)	88 (98.9)	9 (81.8)	
Postoperative wound infection				
Yes	2 (2)	2 (2.2)	0 (0)	
No	98 (98)	87 (97.8)	11 (100)	

***Based on T-test**

****Based on Chi-square**

Table 2 Evaluating the intubated patients required second and third thoracoscopy or thoracotomy compared to patients with spontaneous breathing

		Intubated patients require a second and third thoracoscopy or thoracotomy	Patients with spontaneous breathing	*P*-value
VATS frequency	**1**	2 (18.2%)	87 (97.8%)	<0.001
	2	6 (54.5%)	2 (2.2%)	
	3	3 (27.3%)	0 (0.0%)	
Associated injury	**No**	0 (0.0%)	64 (71.9%)	<0.001
	Yes	11 (100.0%)	25 (28.1%)	
Previous medical history	**No**	9 (81.8%)	82 (92.1%)	0.257
	Yes	2 (18.2%)	7 (7.9%)	
Lung involvement	**No**	7 (63.6%)	78 (87.6%)	0.058
	Yes	4 (36.4%)	11 (12.4%)	
Simultaneous bronchoscopy	**No**	1 (9.1%)	55 (61.8%)	0.001
	Yes	10 (90.9%)	34 (38.2%)	

underwent a thoracotomy, and then a thoracoscopy was performed due to lung collapse, and recovery was achieved in the first visit.

- **Evaluating the pain level and analgesic consumption among the patients**.

The patients' average level of consciousness (LOS) was 14 ± 2, which was higher in patients with complete recovery after the first thoracoscopy (15 ± 1) in comparison with patients who required re-thoracoscopy (10 ± 4).

The pain level in complete recovery patients after the first thoracoscopy procedure was 3 ± 2. In patients who required re-thoracoscopy, it was 6 ± 3 (P-value < 0.001). 30 patients with complete recovery after the first thoracoscopy operation (33.7%) received narcotic sedation, and the mean frequency of narcotic sedation was 2 ± 1 times. Narcotic sedation was required in all the patients who needed re-thoracoscopy, and the mean frequency was 3 ± 2 times (P-value < 0.001). Non-narcotic agents were used in 64 (71.9%) of the fully recovered patients and in 2 (18.2%) of the re-thoracoscopy-needed patients.

- **Evaluation of intubated patients required second and third thoracoscopy or thoracotomy compared to patients with spontaneous breathing**.

Among 11 (11%) intubated patients who required second and third thoracoscopy or thoracotomy, 11 (100%) patients had associated injuries, 2 patients (18.2%) also had a previous medical history, and 4 patients (36.4%) had bilateral lung involvement. Finally, 10 patients (90.9%) required simultaneous bronchoscopy. In addition, patients with spontaneous breathing had also been evaluated (Table 2).

Discussion

Single port thoracoscopy has suitable therapeutic effects, low complications, less pain, and reduced need for painkillers. Patients with more concomitant injuries, longer duration from trauma to performing thoracoscopy, intubation requirement, bilateral lung involvement, and lower GCS, required re-thoracoscopy, which has been associated with more extended hospitalization, suffering from more pain, need to receive narcotics and thoracotomy, and frequency of narcotic and non-narcotic agents. These results demonstrate the efficacy of the single port thoracoscopy in uncomplicated and initially completely recovered patients, and the re-thoracoscopy requirement and complications are based on the underlying cause and medical circumstances. Complete recovery was achieved significantly in patients who did not have associated injuries, and continued thoracoscopy was required in patients with associated injuries and intubation. Furthermore, patients with unilateral lung involvement mostly achieved full recovery. Analysis of non-narcotic pain relievers did not demonstrate a significant difference between the two groups (P value = 0.722). As a result, non-narcotic analgesics were used in a similar proportion among patients in the two groups, while all patients requiring re-thoracoscopy received narcotic analgesics. The time from trauma to thoracoscopy, hospitalization period, need to receive narcotics, pain level, and frequency of narcotic and non-narcotic agents were more in patients who required re-thoracoscopy.

Single port thoracoscopy reduces access trauma, clear surgical vision, and compression of the intercostal nerves and vessels, causing complications including incision pain and hemorrhage, and provides quick postoperative recovery [18, 19]. Compared with multi-port thoracoscopy, single-port thoracoscopy has less complications such as postoperative pain and surgical site infection, and facilitates wound healing [20]. The single port approach was initially described by Rocco et al. for wedge

pulmonary resection to reduce access trauma, which was later developed by Gonzalez-Rivas et al. for major resections [21, 22].

Han et al. concluded that single-port thoracoscopic is a safe and feasible approach for removing pulmonary bullae because it is the least invasive surgical option with the innate advantages of reduced operative time, single-lung ventilation, better surgical outcomes, and fewer complications [23]. In Han's study, after thoracoscopy, patients were discharged after 4.8 ± 1.5 days without complications, and 5 cases of recurrence (3.8%) were reported. In the current study, patients were discharged 8 ± 6 days after thoracoscopy. This difference may be due to the etiology of the thoracoscopy. In the current study, patients underwent single port thoracoscopy due to lung collapse following trauma, whereas in the mentioned study, this procedure was performed to remove pulmonary blebs. Furthermore, in our study, 11 patients needed re-thoracoscopy, which was more than Han's study.

In 2021, Puri et al. reported VATS as an effective and safe management in primary spontaneous pneumothorax (PSP) patients with a low recurrence rate and a high level of satisfaction [24]. The mean duration of hospitalization was 3.83 days. There was no postoperative death. The mean follow-up period was 25.05 months. The overall rate of complications was 3.6%, and recurrence occurred in 2.7%. In the current study, the mean duration of hospitalization was 8 ± 6 days, without mortality. Wound infection and relapse occurred in 2% and 11%, respectively. The differences between the current study and Puri's study might be due to the differences between the examined patients. In the study of Puri, patients with primary spontaneous pneumothorax were examined, which are often young people, while our cases were trauma patients. This issue can justify the inconsistency in the mean age and the mean duration of hospitalization. In addition, the disease type also impresses other parameters. As mentioned in our study, all the patients who required repeating single port thoracoscopy had pneumothorax, hemothorax, and hemopneumothorax. This issue indicates that relapses and complications might be more common in these patients, which was also investigated in the study conducted by Puri et al. Based on our results, patients also benefited from less postoperative pain, less need for painkillers, and early discharge, which are considered advantages of single-port thoracoscopy.

A study conducted by Mazzella et al. concluded that pathology did not influence the outcomes after VATS lobectomy, and VATS was introduced as a safe choice in evaluating patients with benign diseases requiring lobectomy. From the point of view of our study, this conclusion was not correct because, according to our findings, in trauma-induced lung collapse, the recurrence rate, the need for repeating the procedure, and complications were higher according to the etiology and accompanying injury. However, the pathology of the patients evaluated by Mazzella et al. was cancer, while our patients had trauma, and this difference should be investigated in future studies [25]. The most common complications of the VATS are prolonged air leaks, bleeding, infections, and postoperative pain [26–28].

Kutluk et al. compared the results of single-port, two-port, and three-port thoracoscopic surgery [29]. The amount of drainage ($p = 0.03$) was the only statistically significant factor. The single-portal VATS approach was less painful and had better aesthetic results. In addition, it was as efficient as the two- or three-port VATS approach. In the current study, according to the VAS criteria, the mean pain level of patients who underwent single port thoracoscopy was 3, which indicates that the procedure was appropriate and less painful. Since this procedure was performed with one port, it had better aesthetic results and less pain than performing the same procedure with more ports.

In the study of Daman et al., which compared the effect of chest tube drainage and VATS as the first-line treatment of an initial occurrence of primary spontaneous pneumothorax, it was reported that VATS could be a suitable substitute for standard chest tube drainage, reducing the ipsilateral recurrence rate and duration of hospitalization [30].

A limitation in the single-port VATS approach can be the interference between instruments since both endoscope and operational instruments pass from the same port. Since single-port VATS is performed through the sagittal plane, the eyes and hands are used at the same level during the surgery in the caudal-to-cranial direction. Therefore, a reverse observation design should be avoided. The impact of camera holding quality on VATS encompasses many aspects of the entire process, including ergonomics, operating time, accuracy, and safety issues. A qualified assistant should have flexible camera handling skills, be familiar with precise surgical procedures, understand and support the surgeon's operating habits, and have extensive and long-term teamwork experiences [31, 32].

The current study has limitations, including (1) no comparison was performed with multiple port procedures, (2) a single-centered and retrospective design with a limited sample size, and (3) no subgroup analysis. However, the findings demonstrated the single-port thoracoscopic procedure as a useful, practical, effective, and low-complication method for patients with trauma-induced lung collapse, further prospective randomized, large-scale studies comparing single-port thoracoscopy to other interventions are needed to confirm these findings and compare different methods.

Conclusion

The single-port thoracoscopy is a valuable, practical, and effective method as a treatment in patients with lung collapse due to trauma. This approach has suitable therapeutic effects, less pain, and reduced need for painkillers. Patients with lung collapse after trauma who had more concomitant injuries, intubation requirement, bilateral lung involvement, and lower GCS, required re-thoracoscopy, which has been associated with more extended hospitalization, suffering from more pain, and the need for more narcotics and thoracotomy.

Supplementary Information

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Supplementary Material 1

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Author contributions
M.A. J.Z.B. was actively involved in patients' follow-up and the acquisition, analysis and interpretation of data. M.A., J.Z.B., M.F and I.A. designed and organized the study. H.S., N.Y. and H.M. wrote the manuscript. All authors edited and approved the final manuscript.

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The datasets used or analyzed are available from the corresponding author on request.

Declarations

Consent for publication
Not Applicable.

Competing interests
The authors declare no competing interests.

Statement of ethics
This study protocol was reviewed and approved by Alborz University of Medical Sciences research ethics committee, approval number [IR.ABZUMS.REC.1400.146] and is adhered to the Declaration of Helsinki [33].

Conflict of interest
The authors have no conflicts of interest to declare.

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