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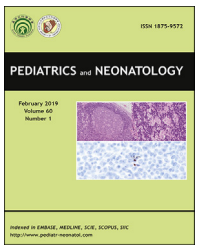

Original Article

Fixation of lung apex in spontaneous pneumothorax is safe and efficient in decrease recurrences

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Key Words
spontaneous pneumothorax;
thoracoscopic bullectomy;
video-assisted thoracoscopic surgery (VATS);
lung apex fixation

Abstract *Background:* Video-assisted thoracoscopic bullectomy with pleurodesis is widely used to treat spontaneous pneumothorax. However, 1%—3% of patients experience postoperative complications that may require reoperation, such as bleeding or prolonged air leaks, and 3%—7% of patients require a repeat thoracoscopic bullectomy due to recurrence. Therefore, a modified procedure with improved outcomes is required.
Methods: Between January 1, 2011 and December 31, 2015, 196 patients with spontaneous pneumothorax underwent thoracoscopic bullectomy and pleurodesis with or without fixation of the lung apex to the chest wall. In patients in the fixation group, the lung apex was fixed to the chest wall with two non-absorbable sutures after bullectomy and pleurodesis. The treatment of each lung was considered an independent operation in patients with bilateral spontaneous pneumothorax.
Results: The patients in each group had comparable backgrounds. In the fixation group, 67 patients underwent 87 operations, four of which (in three patients) led to recurrences (recurrence rate, 4.60%). There were no readmissions or reoperations within 30 days in this group. In the non-fixation group, 128 patients underwent 161 operations, 14 of which (in nine patients) led to recurrences (recurrence rate, 8.7%). In addition, three patients in this group required reoperation and two were readmitted within 30 days.
Conclusions: Modified thoracoscopic bullectomy with fixation of the lung apex is a safe procedure that provides better outcomes with lower complication rates.

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1. Introduction

Primary spontaneous pneumothorax (PSP) occurs most frequently in young, tall, thin males, with an incidence of 7.4—18 cases per 100,000 population per year in males and 1.2—6 cases per 100,000 population per year in females.[1] However, the recurrence of PSP, which ranges from 20% to 60%,[2,3] is higher in females, as well as smokers, individuals with a low body mass index (BMI),[2,4] and patients with cystic fibrosis, chronic obstructive pulmonary disease, or Marfan syndrome.[5,6]

Treatments for spontaneous pneumothorax include observation, aspiration, intercostal drainage, and surgery,[7] with the latter reducing the recurrence rate to 1%—10%. Operation procedures usually include resection of visible lung blebs with pleurodesis, which most commonly involves gauze abrasion, the instillation of talc or other sclerotic chemicals, electrocoagulation, and partial pleurectomy.[7] However, 1%—3% of patients experience postoperative complications that may require reoperation within 1 month of the first operation, such as bleeding or prolonged air leaks, and 3%—7% of patients require repeat thoracoscopic bullectomy due to recurrence.[8] Therefore, a modified procedure with improved outcomes is required.

2. Methods

We conducted a retrospective review of patients of <25 years of age who underwent video-assisted thoracoscopic bullectomy for PSP at the Chang Gung Memorial Hospital, Linkou, Taiwan, China, between January 1, 2011 and December 31, 2015. All of the surgeons were well-trained, specialist thoracic or pediatric surgeons. Data were collected using a modified version of the American College of Surgeons National Surgical Quality Improvement Program (ACS NCQIP) pediatric form, to which we added fields for the recurrence status before and after the operation. Patients who were lost to follow-up were excluded from our data. This project was approved by our Institutional Review Board (No. 201601280B0) and sponsored by the Health and Welfare Surcharge of Tobacco Products, Ministry of Health and Welfare, Taiwan.

2.1. Surgical procedures

Each patient was placed in a lateral position after single-lung ventilation had been confirmed. A 1.5-cm incision was made at the sixth intercostal space in the midaxillary line and two 5-mm trocars were inserted using a camera specifically designed for instruments such as graspers and diathermy. A liner stapler was then used to resect visible blebs or bullae or, where these were not found, scarring or adhesion at the lung apex. Following this, pleurodesis was performed by gauze abrasion or electrocoagulation. Finally, additional fixation of the lung apex was carried out in some instances according to the surgeon's preference, which involved fixing the lung apex, usually along the stapler line, to the second or third intercostal space with two non-absorbable sutures (2-0 Ethibond) (Fig. 1). Care was taken to ensure that the fixation was performed without tension to ensure that the lung tissue was not cut through, which would cause an air leak, and to prevent any adverse effect on lung expansion. At the end of the procedure, a chest tube was inserted and connected to an underwater-seal suction system with a negative pressure of 10 cm H_2O. Once no air leak had been detected for 24 h, the chest tube was removed and the patient was discharged with arrangements for their return to the outpatient clinic 1 week after discharge and then annually for post-operative follow-up.

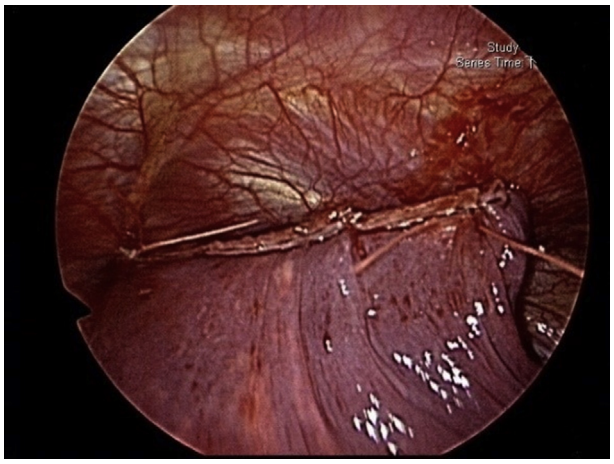

Figure 1 Two non-absorbable sutures were placed along the stapler line to fix the lung apex to the chest wall.

2.2. Statistical analysis

The patients were divided into two groups according to whether lung apex fixation was performed during the operation: the fixation group and the non-fixation group. The treatment of each lung in patients with bilateral spontaneous pneumothorax was counted as an independent operation. Demographic variables were obtained from the ACS NSQIP pediatric form and outcome variables included operation time, 30-day reoperation rate, 30-day readmission rate, wound infection rate, and recurrence rate up until December 31, 2015.

Data from the two groups were compared using the two-tailed Student's *t*-test for continuous variables and the χ^2 test for discrete variables. All statistical analyses were conducted in SPSS v.20 with a significance level of $P < 0.05$ (two-tailed test). Continuous variables are presented as means ± standard errors.

3. Results

Initially, 196 patients were included in this study; however, three of these were subsequently excluded due to loss of follow-up. A total of 248 operations were performed on the remaining 193 patients. There was no significant difference between the two treatment groups for most of the demographic data, including weight and height (Table 1). However, patients in the fixation group were significantly younger than those in the non-fixation group.

More patients had undergone previous cardiac surgery in the fixation group than in the non-fixation group, and

Table 1 Demographic data and outcomes for patients who underwent thoracoscopic bullectomy and pleurodesis with or without fixation of the lung apex.

	Fixation of lung apex (*n*)	Mean	*P* value
Age at OP (years)	Y (87)	16.37 ± 1.04	0.000
	N (161)	20.71 ± 3.91	
Height (cm)	Y (86)	173.37 ± 6.72	0.287
	N (124)	170.39 ± 25.33	
Weight (kg)	Y (87)	54.18 ± 8.07	0.821
	N (125)	53.77 ± 15.58	
BMI (kg/m^2)	Y (86)	18.00 ± 2.00	0.123
	N (123)	18.41 ± 1.79	
OP time (minutes)	Y (87)	118.56 ± 37.41	0.024
	N (161)	107.00 ± 38.75	
Admission time before OP (days)	Y (87)	3.10 ± 2.50	0.008
	N (161)	2.08 ± 3.04	
Admission time after OP (days)	Y (87)	4.59 ± 2.70	0.04
	N (161)	5.36 ± 2.89	
Hospital stay (days)	Y (87)	7.69 ± 3.60	0.668
	N (161)	7.45 ± 4.40	

Y, patients received fixation of the lung apex; N, patients did not receive fixation of the lung apex; OP, operation procedure; BMI, body mass index.

patients in the fixation group also had higher cardiac risk factors. Furthermore, more patients in the fixation group suffered from pectus excavatum and Marfan syndrome, and underwent bilateral surgery. With respect to operative indications, more patients in the fixation group experienced recurrence or a prolonged air leak for more than 5 days, while more patients in the non-fixation group underwent the operation at the first attack with no evidence of a prolonged air leak (Table 2).

The mean follow-up period across both groups was 28.35 months. There were four recurrences (in three patients) in the fixation group and 14 recurrences (in nine patients) in the non-fixation group, corresponding with recurrence rates of 4.6% and 8.7%, respectively. Recurrences were noted 1–31 months postoperatively (mean = 12.5 months), with more than 80% occurring within 24 months. Three patients in the non-fixation group also underwent unplanned operations, representing a reoperation rate of 0.025%: two due to prolonged air leaks after the operation and one due to contralateral pneumothorax immediately after the first operation. One patient experienced a prolonged air leak after chest tube insertion while in the operating theater, forcing a thoracoscopic bullectomy to be performed during the same admission. In addition, one patient required reoperation due to a persistent air leak even after undergoing surgery twice in 1 week. One patient in the non-fixation group also had an unplanned readmission within 30 days of the initial operation due to

Table 2 Demographic data for patients who underwent thoracoscopic bullectomy and pleurodesis with or without fixation of the lung apex.

		Fixation of lung apex (*n*)		*P* value
		Yes (87)	No (161)	
Male		92.0% (80)	91.3% (147)	0.861
Cystic fibrosis		0.0% (0)	1.2% (2)	0.543
Asthma		1.1% (1)	3.1% (5)	0.668
Cardiac risk factors	None	89.7% (78)	96.9% (156)	0.039
	Low	10.0% (9)	3.1% (5)	
Previous cardiac surgery		5.7% (5)	0.0% (0)	0.005
Steroid use		0.0% (0)	1.2% (2)	0.543
Pectus excavatum		9.2% (8)	1.2% (2)	0.004
Marfan syndrome		8.0% (7)	1.9% (3)	0.036
Childhood malignancy		1.1% (1)	0.0% (0)	0.351
Bilateral operation		16.1% (14)	7.5% (12)	0.034
Operation indications	Recurrent	56.3% (49)	48.4% (78)	0.002
	Sequential	12.6% (11)	12.4% (20)	
	Air leak[1]	26.4% (23)	16.8% (27)	
	Other[2]	4.6% (4)	22.4% (36)	

recurrent spontaneous pneumothorax. By contrast, there were no unplanned operations or readmissions in the fixation group. Furthermore, although the operation time was significantly longer in the fixation group, the number of postoperative admission days was shorter (Table 1). No mortality occurred in either group.

4. Discussion

To our knowledge, an optimal treatment for spontaneous pneumothorax has not yet been determined. Although most surgeons agree that thoracoscopic bullectomy with pleurodesis is indicated when a patient has suffered from recurrent spontaneous pneumothorax, a prolonged air leak after drainage, or sequential attacks,[3,7] others believe that this treatment should be applied at the first attack, particularly in patients suffering from secondary pneumothorax, such as those with Marfan syndrome.[5] There has also been debate around operative timing and variation in the pleurodesis procedures used to decrease the incidence of postoperative air leaks and recurrence, both of which occur more frequently in patients who are young, tall, and experiencing secondary spontaneous pneumothorax. Furthermore, the 30-day reoperation rate after a video-assisted thoracoscopic bullectomy procedure for spontaneous pneumothorax can be as high as 5.8%,[8,9] indicating the need for a modified procedure with improved outcomes.

In our study, the recurrence rates ranged from 4.6% to 8.7%, which are comparable to the results of previous studies. The overall outcome was better in the fixation group than in the non-fixation group because the patients were younger. Furthermore, although more patients suffered from Marfan syndrome in the fixation group, the recurrence rate was lower than in the non-fixation group, likely due to fixation enabling us to secure the adhesion between the lung apex and the chest wall— all other types of mechanical pleurodesis require lung expansion for the lung apex and chest wall to attach and adhere to each other.

Patients in the fixation group also had fewer postoperative admission days than those in the non-fixation group and did not undergo any reoperations due to prolonged air leaks, providing additional evidence for this group having a better outcome. Although the operation time was longer in the fixation group, more patients underwent bilateral operations in this group, and so this time difference may have been due to a combination of the suture procedure and the need to change the patient's position and prepare them for the contralateral operation.

This study was limited by the relatively small number of cases included. Therefore, further randomized studies should be conducted that include a larger number of patients to confirm the results.

5. Conclusion

Modified thoracoscopic bullectomy with pleurodesis and lung apex fixation is a safe and efficient procedure that provides improved outcomes for patients with spontaneous pneumothorax, including a reduced number of recurrences, postoperative complications, and postoperative admission days.

Conflicts of interest statement

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.pedneo.2018.04.009.