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Outcomes of the Tower Crane Technique with a 15-mm Trocar in Primary Spontaneous Pneumothorax

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Background: Video-assisted thoracoscopic surgery (VATS) pulmonary wedge resection has emerged as the standard treatment for primary spontaneous pneumothorax. Recently, single-port VATS has been introduced and is now widely performed. This study aimed to evaluate the outcomes of the Tower crane technique as novel technique using a 15-mm trocar and anchoring suture in primary spontaneous pneumothorax. ***Methods:*** Patients who underwent single-port VATS wedge resection in Chungnam National University Hospital from April 2012 to March 2014 were enrolled. The medical records of the enrolled patients were reviewed retrospectively. ***Results:*** A total of 1,251 patients were diagnosed with pneumothorax during this period, 270 of whom underwent VATS wedge resection. Fifty-two of those operations were single-port VATS wedge resections for primary spontaneous pneumothorax performed by a single surgeon. The median age of the patients was 19.3±11.5 years old, and 43 of the patients were male. The median duration of chest tube drainage following the operation was 2.3±1.3 days, and mean postoperative hospital stay was 3.2±1.3 days. Prolonged air leakage for more than three days following the operation was observed in one patient. The mean duration of follow-up was 18.7±6.1 months, with a recurrence rate of 3.8%. ***Conclusion:*** The tower crane technique with a 15-mm trocar may be a promising treatment modality for patients presenting with primary spontaneous pneumothorax.

Key words: 1. Pneumothorax
2. Video-assisted thoracic surgery

INTRODUCTION

Pneumothorax refers to the abnormal collection of air in the pleural space, resulting in collapse of the lung through its uncoupling from the chest wall. Three types of pneumothorax have been identified: primary spontaneous pneumothorax, secondary pneumothorax, and iatrogenic pneumothorax [1,2].

Primary spontaneous pneumothorax tends to occur in young adults, particularly males, without underlying lung disease. Secondary pneumothorax occurs in patients with significant underlying lung disease, and iatrogenic pneumothorax is caused by complications of a medical procedure [1,3].

The treatment of primary spontaneous pneumothorax is determined by the patient's condition. When pneumothorax first occurs, closed thoracostomy is generally performed in order to decompress the pleural space. However, if prolonged air leakage or large visible bullae on a plain chest radiograph are observed, or a second attack occurs, the treatment of choice

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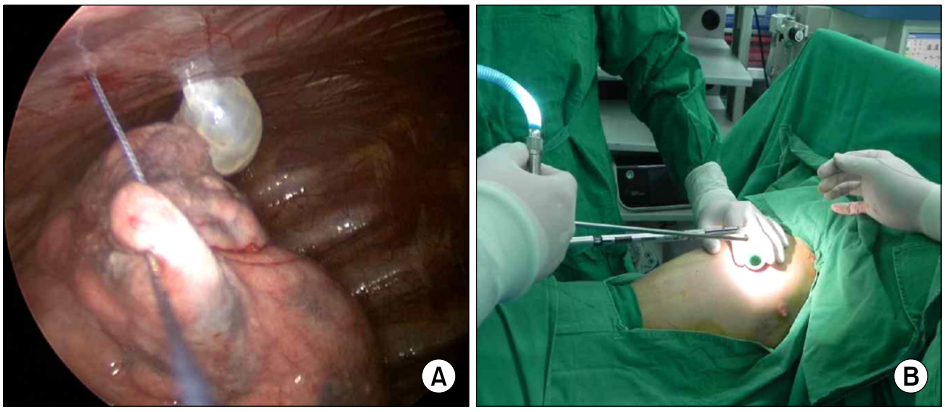

Fig. 1. Operative procedures of the Tower crane technique. (A) Shows an anchoring suture located in front of bullae to move the lung. (B) Shows locations of a 15-mm Thoracoport for a 5-mm thoracoscope and an endoscopic stapler and an anchoring suture.

is surgical excision [4].

Video-assisted thoracoscopic surgery (VATS) is the most common surgical procedure for primary spontaneous pneumothorax. Conventional VATS requires one camera port and two or three working ports [3,4]. Recently, single incision, single-port VATS has been introduced and gradually adopted worldwide [5-7]. Chen et al. [8] reported a case using a single 35-mm incision, Gigirey Castro et al. [9] reported a case in which single-port VATS was used with a single 20–25-mm incision for laparoscopic surgery, and Kang et al. [10] reported the use of single-port VATS with a 20-mm incision and a small wound protector.

The present study describes the single-port technique and reports the early outcomes of single-port VATS wedge resection with a 15-mm Thoracoport (Covidien, Mansfield, MA, USA) using the tower crane technique.

METHODS

We retrospectively reviewed the medical records of patients treated for primary spontaneous pneumothorax from April 2012 to March 2014 at Chungnam National University Hospital and enrolled those who had undergone single-port VATS pulmonary wedge resection with a 15-mm Thoracoport (Covidien). We evaluated the outcomes of this procedure, including operative time, duration of chest tube drainage, the length of the hospital stay, and the incidence of prolonged air leakage, wound problems, and recurrence.

A single surgeon operated on all the patients enrolled in this study, using the same perioperative management protocols. The location and the number of bullae were identified using preoperative chest X-rays and computed tomography. All patients had undergone a closed thoracostomy with a 24-Fr or 28-Fr chest tube preoperatively.

The surgical indications were visible bullae larger than 1 cm in diameter on the chest X-ray, air leakage for more than three days after the closed thoracostomy, and recurrent ipsilateral pneumothorax. If severe pleural adhesion was suspected during the preoperative radiologic evaluation, the patients were excluded from the single-port VATS procedure. If mild adhesions were found during the thoracoscopic evaluation, adhesiolysis was performed by electrocautery.

Wedge resection was performed under general anesthesia. Double-lumen endotracheal intubation was placed for one-lung ventilation. The patient was placed in the lateral decubitus position and aseptic draping was performed. A 15-mm Thoracoport (Covidien) was inserted in the sixth or seventh intercostal space at the midaxillary line, and a 5-mm 30^{o} scope was inserted to identify the target lesion. A 0–0 Vicryl suture (Ethicon, Somerville, NJ, USA) was inserted into the thoracic space through the second or third intercostal space, above the port site in the direction of the target lesion. Subsequently, an anchoring suture was made in front of the bullae with an endoscopic needle-holder through the trocar. The needle was pulled out through the trocar, and following this anchoring suture, the target lung was able to be mobilized for resection using the tower crane technique. Through the 15-mm trocar, an endoscopic stapler and a 5-mm scope were inserted simultaneously and wedge resection was performed (Fig. 1). A saline air leakage test was carried out to

Table 1. Results of the single ports VATS wedge resection

Variable	Value
Operation time (from intubation to extubation, min)	34.3±11.5
Length of chest tube drainage (day)	2.3±1.3
Hospital stay (day)	3.2±1.3
Complications	
Prolonged air leakage (more than 3 days)	1 (1.9)
Bleeding	0
Wound problem	0
Conversion to conventional VATS or thoracotomy	0
Follow-up duration (mo)	18.3±6.0 (range, 10–34)
Recurrence	2 (3.8)

Values are presented as mean±standard deviation or number (%). VATS, video-assisted thoracoscopic surgery.

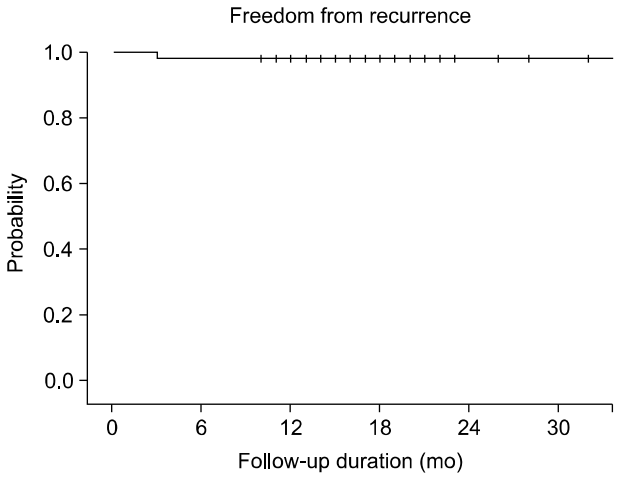

Fig. 2. Kaplan-Meier curves for recurrence-free survival after performance of the tower crane technique with a 15-mm trocar.

assess the presence of air leakage. A 28-Fr chest tube was placed via the trocar site.

The patients were monitored at an outpatient clinic with chest X-rays at one week, one month, six months, and 12 months after discharge, and follow-up by telephone was performed at the time of the present study. All patients were asked about their symptoms and the recurrence of pneumothorax over the course of their follow-up.

RESULTS

A total of 1,251 patients were diagnosed with pneumothorax in Chungnam National University Hospital over the course of the study period. Of these patients, 1,021 had primary pneumothorax and 230 had secondary pneumothorax. Of the primary spontaneous pneumothorax patients, 270 (26.4%) were candidates for surgery, and 52 of those patients underwent single-port VATS pulmonary wedge resection performed by a single surgeon. The remaining surgical patients underwent conventional VATS pulmonary wedge resection performed by other surgeons.

Fifty-two patients who underwent single-port VATS pulmonary wedge resection performed by a single surgeon were enrolled in this study. The median age of the patients was 19.3±11.5 years old. Forty-three of the patients were male and nine were female. The site of the pneumothorax was the left lung in 25 cases and the right lung in 27 cases. Forty-eight patients had experienced recurrent ipsilateral pneumothorax, two had exhibited prolonged air leakage for more than three days, and two showed an apical bulla on the initial chest X-ray and total lung collapse.

No operations were converted to conventional VATS or thoracotomy after thoracoscopic evaluation in the 52 patients who underwent surgery using the tower crane technique. Seven patients had mild adhesions, and adhesiolysis was performed using the single port without complications. All patients exhibited blebs in the apical segment of the upper lobe. In five patients, we found multiple bullae in another lobe upon thoracoscopic evaluation. In three patients, the bullae were in the superior segment of the lower lobe and in two patients, they were in the anterior segment of the upper lobe. These patients underwent multiple wedge resection with multiple anchoring sutures using the same trocar.

Table 1 shows the results of the single port VATS pulmonary wedge resection using the Tower crane technique. The mean operative time was 34.3±11.5 minutes and the median duration of chest tube drainage was 2.3±1.3 days. The mean postoperative hospital stay was 3.2±1.3 days, and the mean pain score on the first postoperative day was 2.3±0.8. One patient (1.9%) experienced prolonged air leakage for more than three days after the operation. The mean follow-up duration was 18.3±6.1 months (range, 10 to 34 months). No bleeding complications or wound problems occurred. Pneumothor-

ax recurred in two patients (3.8%) during the follow-up period, at three and 34 months post-surgery, respectively (Fig. 2). In these patients, multiple small bullae were found in another lobe, and were not visible in the initial chest computed tomography or in the operative findings. We performed single-port VATS surgical pulmonary wedge resection again in these patients. After the second operation, no recurrence of pneumothorax was observed over the remaining course of their follow-up (30 months and three months, respectively).

DISCUSSION

The treatment of primary spontaneous pneumothorax involves the evacuation of air from the pleural space with the aim of preventing recurrence [2-4]. The choice of the treatment modality depends on the size of the pneumothorax, the severity of symptoms, the presence of persistent air leakage, and whether the pneumothorax is primary, secondary, or recurrent [4]. In the past, surgical excision was performed via axillary thoracotomy or anterior thoracotomy. However, with the introduction of VATS, three-port VATS has become the standard procedure for the surgical excision of pulmonary bullae.

Several reports have evaluated the use of conventional VATS for primary spontaneous pneumothorax. Gomez-Caro et al. [11] reported the results of pulmonary wedge resection in primary spontaneous pneumothorax using conventional VATS. The complications of VATS were bleeding (3.6%), prolonged air leakage (2.1%), and recurrence (3.6%), as evaluated at a mean of 40 months after the initial procedure. A similar morbidity rate was found in both the VATS and thoracotomy groups, but the VATS group had a shorter hospital stay.

Kim et al. [12] reported the outcomes of conventional VATS for primary spontaneous pneumothorax, with an overall recurrence rate of 7% during 12.9 months (mean) of follow-up. Lee et al. [13] also reported the outcomes of VATS for primary spontaneous pneumothorax, with a complication rate of 6.4% and an overall recurrence rate of 13.6% during 19.5 months (mean) of follow-up. In our present study, the complication rate was 1.9% and the overall recurrence rate was 3.84%, which are both significantly lower values than those that have been previously reported.

Recently, single-port VATS has been introduced, and some authors have reported it to be associated with less paresthesia and more positive cosmetic outcomes [14]. Beginning in 2004, many techniques for single-port VATS resection have been reported. Rocco et al. [15] reported single-port VATS pulmonary wedge resection with a 20–25-mm incision, and concluded that the results of single-portal VATS were comparable to those of conventional VATS. However, they also concluded that it was essential to use a wide range of roticulating instruments for single-port VATS and that the procedure was difficult to perform due to the presence of many instruments in the same port simultaneously. Gigirey Castro et al. [9] reported single-port thoracoscopic surgery using a multistation flexible instrument (Covidien SILS, Covidien) with a 20–25-mm incision in the sixth intercostal space at the midaxillary line. They likewise reported that the disadvantages of the single-port procedure were the need for articulated instruments and the difficultly in handling them in the same port. Chen et al. [8] reported single-port thoracoscopic surgery with an incision of less than 35 mm. In the present study, we performed single-port VATS wedge resection with a 15-mm trocar, the smallest incision that has been reported in the literature. Using this procedure (the tower crane technique), no additional instruments were required. Conventional VATS instruments, an endoscopic grasper, an endoscopic needle holder, a 5-mm scope, and a 15-mm trocar were needed. Furthermore, the use of an anchoring suture made the procedures much easier due to the fact that only two instruments were inserted at the same time during the procedure: a scope and a stapler.

Kang et al. [10] reported single-port VATS with a 2-cm incision with a small wound retractor. They applied the wound retractor at the port site to protect the intercostal neuromuscular bundle. In the present study, we used the flexible 15-mm Thoracoport (Covidien), which may have allowed us to achieve the same protection with a smaller incision.

In conclusion, the tower crane technique with a flexible 15-mm Thoracoport (Covidien) is a good treatment modality for primary spontaneous pneumothorax without severe pleural adhesion, even if multiple bullae are present. However, this study does have limitations, as it was performed retrospectively with a short mean follow-up period and a small

population of patients.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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