Single-Incision Thoracoscopic Surgery for Spontaneous Pneumothorax Using Multi-Degrees of Freedom Forceps

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Purpose: The objective of this study was to assess the perioperative results of a single-incision approach using multi-DOF forceps for spontaneous pneumothorax, in comparison with the traditional 3-port approach.

Methods: Between May 2012 and June 2013, 44 patients with spontaneous pneumothorax underwent SITS, and their clinical characteristics and perioperative results were evaluated. We then compared those who had undergone SITS (SITS group) with those who had undergone traditional 3-port surgery before the study period (3-port group).

Results: The two groups were similar in terms of mean patient age and pneumothorax laterality (p = 0.81, 0.38), but the proportion of male patients was higher in the 3-port group than in the SITS group (p = 0.0026). Operation time in the SITS group (52.4 min) was longer than in the 3-port group (35.9 min, p < 0.0001). The duration of postoperative drainage and hospital stay did not differ significantly between the groups (p = 0.19, 0.075). Although 14 of the 56 SITS patients (25%) showed mild adhesion in the pleural cavity, none required conversion to a 3-port approach. The bullous region in two or three lobes was resected in 23 patients (41%).

Conclusions: SITS using multi-DOF forceps is a useful approach for treatment of spontaneous pneumothorax in selected patients.

Keywords: single-incision thoracoscopic surgery, spontaneous pneumothorax, multi-degrees of freedom forceps
contrast, only a few studies of single-incision thoracoscopic surgery (SITS) have been reported.11–13) Rocco, et al. reported the feasibility of wedge pulmonary resection using single-portal VATS with the aim of further reducing the invasiveness of VATS.11) Then, Salati, et al. demonstrated that single-portal VATS yielded better results in terms of postoperative hospitalization, complete physical recovery after the operation, and the postoperative paresthesia rate in comparison with the traditional three-port approach in patients with spontaneous pneumothorax.12) Additionally, in a prospective study, Chen, et al. found no significant difference in perioperative results, including operation time, length of hospitalization, and postoperative drainage, between the single-port and three-port approaches, and observed that a single-port approach was superior to the three-port approach in reducing the degree of postoperative pain.13)

On the basis of these encouraging reports, although their number has been small, we have modified the traditional three-port VATS approach for spontaneous pneumothorax to a single-incision approach, and employed it since May 2012. The objective of the present study was to assess the perioperative results of this single-incision VATS technique for treatment of spontaneous pneumothorax, in comparison with the traditional three-port approach.

Materials and Methods

This study was approved by the Institutional Review Board of Maebashi Red Cross Hospital. Primary spontaneous pneumothorax was defined as spontaneous air accumulation in the pleural cavity without evidence of clinical disease. Any pneumothorax in a patient was proved by chest X-ray or computed tomography on admission to the hospital.

Initially, between May 2012 and January 2013, 44 patients with spontaneous pneumothorax underwent SITS. The clinical characteristics and perioperative results for these patients were evaluated. During this period, any patients with spontaneous pneumothorax who were suspected to have severe adhesion on the basis of preoperative radiography were considered ineligible for this procedure, and instead underwent the traditional three-port approach.

In addition, we studied patients with spontaneous pneumothorax who underwent SITS or three-port surgery during different periods, and compared the results between them. The inclusion criteria were: (1) Age ≤40 years, (2) Absence of underlying pulmonary diseases such as chronic obstructive pulmonary disease, asthma, or pulmonary fibrosis, (3) No history of pulmonary surgery, including bullectomy for pneumothorax, and (4) Absence of hemothorax.

On the basis of these criteria, we selected 72 patients with spontaneous pneumothorax who underwent traditional three-port thoracoscopic surgery (3-port group) between April 2010 and April 2012, and 31 patients with spontaneous pneumothorax who underwent SITS (SITS group) between May 2012 and January 2013.

Both procedures were performed under general anesthesia using one-lung ventilation with the patient in lateral recumbency. For SITS, a 2.5–3.0-cm skin incision was made in the 5th or 6th intercostal space along the anterior axillary line, a S or XS size wound-retractor (Alexis Wound Retractor; Applied Medical, Rancho Santa Margarita, California, USA) was placed. All instruments including the thoracoscope, forceps and stapler were inserted through this access port.

![Fig. 1 Access port for the single-incision thoracoscopic surgery (SITS) approach. After a 2.5–3.0 cm skin incision had been made in the 5th or 6th intercostal space along the anterior axillary line, a S or XS size wound-retractor (Alexis Wound Retractor; Applied Medical, Rancho Santa Margarita, California, USA) was placed. All instruments including the thoracoscope, forceps and stapler were inserted through this access port.](image)
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Medicalnext Co., Ltd., Osaka, Japan) to manipulate the bullae or blebs, to avoid any possibility that a forceps, a stapler, and a thoracoscope inserted via the same incision would interfere with each other (Fig. 2).

For the three-port approach, an initial 1.5-cm skin incision for stapling was made in the 5th or 6th intercostal space along the anterior axillary line. Then, a 7-mm skin incision for a 5-mm thoracoscope was made in the 5th or 6th intercostal space along the posterior axillary line. Finally, a 5-mm skin incision for the forceps to manipulate bullae or blebs was made in the 3rd intercostal space along the mid axillary line.

In both groups, visceral blebs and bullae were excised using an endostapler. Then, polyglycolic acid felt (Neovail, sheet type; Igaki Medical Planning Co., Ltd., Kyoto, Japan) was applied to the staple lines using fibrin glue sealant (Bolheal; Chemo-Sero Therapeutic Institute, Kumamoto, Japan) to prevent any postoperative air leakage. At the end of the procedure, in each patient, a 19 Fr chest drain (19 Fr Blake Drain; Ethicon, Somerville, New Jersey, USA) was placed with the drain positioned anterior-to-posterior through the apex, in an inverted U shape. The chest tube was removed the day after cessation of air leakage, when chest X-ray demonstrated a well expanded lung.

Adhesion was defined as follows: (1) mild: adhesion between the thoracic wall and only one lobe; (2) severe: adhesion between the thoracic wall and two or three lobes. Categorical variables were expressed as percentages and continuous variables as median ± standard deviation. Continuous variables were compared by unpaired t test and categorical variables by χ² test or Fisher’s exact test. Calculations and statistical tests were performed using the Stat View 5.0 software package (SAS Institute, Inc., Cary, North Carolina, USA). Statistical significance was set at p < 0.05.

Results

Table 1 shows the characteristics and perioperative results for patients who underwent SITS. The median patient age at surgery was 30.5 ± 13.5 years (range: 15 to 65 years). There were 35 male patients (79.5%) and 9 female patients (20.5%). In the 9 female patients, cata menial pneumothorax was not evident clinically or surgically. Pneumothorax was located on the right side in 18 patients (40.9%) and on the left in 26 (59.1%). Operation time was 59.0 ± 18.3 minutes. One patient had a 250-g hematoma in the thorax, whereas the other patients had only minimal blood loss, which was not evaluable.
Mild adhesion was evident in 11 patients. Severe adhesion was found in only one patient, who required conversion to a three-port approach. We resected the bullous region from one lobe in 25 patients (56.8%, apical in 24, S6 in 1), and from two or three lobes in 19 (43.2%, upper and middle: 3, upper and lower: 15, upper, middle and lower: 1). The duration of postoperative drainage was 1.2 ± 0.4 days (range: 1 to 3 days).

Table 2 shows the differences between the SITS and 3-port groups in terms of patient characteristics and perioperative results. The median age at surgery was similar in the two groups (SITS: 23.8 ± 6.1 years, 3-port: 23.4 ± 6.2, p = 0.72). In the SITS group, there were 25 male (80.6%) and 6 female (19.4%) patients, whereas in the 3-port group there were 69 male (95.8%) and 3 female (4.2%) patients. The proportion of male patients in the 3-port group was higher than that in the SITS group (p = 0.012). None of the 9 female patients in the 2 groups showed any clinical or surgical evidence of catamenial pneumothorax. In the SITS group, pneumothorax was located on the right side in 11 patients (35.5%) and on the left side in 20 (64.5%), whereas in the 3-port group there were 35 right-sided (48.6%) and 37 left-sided (51.4%) cases. There was no significant difference in pneumothorax laterality between the groups (p = 0.22).

Operation time was longer in the SITS group than in the 3-port group (SITS: 55.2 ± 15.5 min, 3-port: 35.9 ± 14.0 min, p <0.0001). In both groups, blood loss was minimal, and therefore this parameter was not considered further. The duration of postoperative drainage showed no difference between the groups (SITS: 1.2 ± 0.5 days, 3-port: 1.1 ± 0.3, p = 0.10). Also, there was no significant difference in the postoperative hospital stay between the two groups (SITS: 2.4 ± 0.1 days, 3-port: 2.6 ± 0.1, p = 0.16).

**Discussion**

The purpose of the present study was to investigate the perioperative results of SITS for spontaneous pneumothorax in comparison with the traditional three-port approach. The perioperative results in the SITS group, including operative blood loss, duration of postoperative drainage and postoperative hospital stay, were not inferior to those in the 3-port group, with the exception of operation time, which was significantly longer in the SITS group. However, the median operation time of 55.2 minutes in the SITS group was not considered problematic in terms of invasiveness.

The major difficulty with SITS is the need for the surgeon to adapt to the required method of instrumentation. The SITS approach is not a naturally ergonomic technique, because the traditional thoracoscopic principles of triangulation are lost. Because both the operating instruments and thoracoscope are introduced through the same incision, and on the same axis, the operator and assistant often impede each other’s movements. This interference occurs not only within the pleural space but also outside the thorax. Additionally, it is difficult to recognize the top edge of the forceps or staple, which might result in erroneous resection or manipulation. We conclude that such interference might have been the main reason for the longer operation time in the SITS group. To overcome this problem of interference, we have used multi-DOF forceps for SITS.
In the field of laparoscopic surgery, several authors have reported the usefulness of multi-DOF forceps. As the indications for laparoscopic surgery expand, more complex techniques have evolved. The traditional instrument with a straight shaft is unsuitable for accomplishing difficult techniques within a limited working space. Usui, et al. reported that all clinical applications were successfully achieved by using multi-DOF forceps, and that only a few training sessions were required. The use of multi-DOF forceps allowed us to manipulate lung parenchyma on a different axis from the thoracoscope or other instruments through the same incision, and avoids interference among the instruments.

In the SITS group, only one patient required conversion to a three-port approach because of severe adhesion in the pleural space. However, the operation was completed using the SITS approach in the other 43 cases. Although 11 patients had mild adhesions, they were managed by diathermy or hemoclipping, and good hemostasis was obtained in all cases. Additionally, 43.2% of the patients underwent resection of multiple bullous lesions in two or three lobes. These results indicate that SITS is applicable to various conditions, except for severe adhesion or other situations such as massive bleeding, in surgery for spontaneous pneumothorax.

In this study, we did not investigate relapse of pneumothorax after surgery, because the observation period after SITS was too short (data was not shown). However, there was no difference in the duration of postoperative drainage between the 3-port group and the SITS group, suggesting that the prevention of postoperative air leakage during the perioperative period had been sufficient.

**Conclusions**

The present results suggest that SITS is a sufficiently useful approach for spontaneous pneumothorax in selected patients, even though the three-port thoracoscopic approach for spontaneous pneumothorax is well established. With regard to knacks and pitfalls, the use of multi-DOF forceps for SITS allows triangulation in the thorax equivalent to that in the conventional three-port approach, thus making SITS a safer and easier technique. Additionally, this change of axis in the pleural cavity reduces the degree of extrathoracic interference. Berlanga, et al. have reported another procedure using a SILS port for avoiding instrumental interference in SITS for spontaneous pneumothorax. They considered that the SILS port allowed appropriate aligning of the instruments along the intercostal space and adequate roticulated instrument maneuverability for stapling apical lung blebs because of its flexibility, and that there was no increased need to clean the thoracoscope lens during the procedure. On the other hand, we used a Wound Retractor rather than a SILS port. However, this did not prove inconvenient because the use of multi-DOF forceps did not impede the movement of each instrument.

**Disclosure Statement**

None declared.

**References**

2) Lang-Lazdunski L, Chapuis O, Bonnet PM, et al. Videothoracoscopic bleb excision and pleural abrasion for the treatment of primary spontaneous pneumothorax: