Staple Line Coverage After Bullectomy for Primary Spontaneous Pneumothorax: A Randomized Trial

Sungsoo Lee, MD, Hyeong Ryul Kim, MD, Sukki Cho, MD, Dong Myung Huh, MD, Eung Bae Lee, MD, Kyoung Min Ryu, MD, Deug Gon Cho, MD, Hyo Chae Paik, MD, Dong Kwan Kim, MD, Sung-Ho Lee, MD, Jeong Su Cho, MD, Jae Ik Lee, MD, Ho Choi, MD, Kwahanmien Kim, MD, and Sanghoon Jheon, MD, for the Korean Pneumothorax Study Group

Department of Thoracic and Cardiovascular Surgery, Ajou University Hospital, Suwon; Asan Medical Center, Seoul; Seoul National University Bundang Hospital, Seongnam; Daegu Fatima Hospital, Daegu; Kyungpook National University Hospital, Daegu; Dankook University Hospital, Cheonan; Catholic Saint Vincent Hospital, Suwon; Gangnam Severance Hospital, Seoul; Korea University Anam Hospital, Seoul; Pusan National University Hospital, Pusan; Gachon University Gil Hospital, Incheon; and Seoul National University College of Medicine, Seoul, Korea

Background. Thoracoscopic wedge resection is generally accepted as a standard surgical procedure for primary spontaneous pneumothorax. Because of the relatively high recurrence rate after surgery, additional procedures such as mechanical pleurodesis or visceral pleural coverage are usually applied to minimize recurrence, although mechanical pleurodesis has some potential disadvantages. The aim of this study was to clarify whether an additional coverage procedure on the staple line after thoracoscopic bullectomy prevents postoperative recurrence compared with additional pleurodesis.

Methods. A total of 1,414 patients in 11 hospitals with primary spontaneous pneumothorax undergoing thoracoscopic bullectomy were enrolled. After bullectomy with staplers, patients were randomly assigned to either the coverage group (n = 757) or the pleurodesis group (n = 657). In the coverage group, the staple line was covered with absorbable cellulose mesh and fibrin glue. The pleurodesis group underwent additional mechanical abrasion on the parietal pleura.

Results. The coverage group and the pleurodesis group showed comparable surgical outcomes. After a median follow-up of 19.5 months, the postoperative 1-year recurrence rate was 9.5% in the coverage group and 10.7% in the pleurodesis group. The 1-year recurrence rate requiring intervention was 5.8% in the coverage group and 7.8% in the pleurodesis group. The coverage group showed better recovery from pain.

Conclusions. In terms of postoperative recurrence rate, visceral pleural coverage after thoracoscopic bullectomy was not inferior to mechanical pleurodesis. Visceral pleural coverage may potentially replace mechanical pleurodesis, which has potential disadvantages such as disturbed normal pleural physiology.


Primary spontaneous pneumothorax (PSP) is not a serious disease but is troublesome because of its high rate of recurrence. Primary management is pleural drainage, and surgical intervention is needed in cases of persistent air leakage or recurrent pneumothorax [1]. With the introduction of video-assisted thoracic surgery (VATS), the surgical approach of PSP has changed. Video-assisted thoracic surgery probably represents the most commonly accepted surgical approach. However, wedge resection alone, performed using VATS, has been associated with high postoperative recurrence rates, ranging from 9.5% to 24.5% [2–5].

Many surgeons perform additional procedures such as parietal pleural abrasion or pleurectomy after wedge resection to minimize postoperative recurrence. However, pleural symphysis, regardless of method, may disturb normal pleural physiology [6, 7]. Because of this potential disadvantage for young patients with PSP originating from visceral pleura, we focused on additional procedures for the visceral pleura. Acceptable recurrence rates by covering the surgical pulmonary margins with absorbable mesh and fibrin glue to reinforce the visceral pleura are reported [3, 5]. Despite several small-scale and single-center studies on recurrence rates with various additional procedures for PSP, no large-scale, multicenter, prospective, controlled study has been reported [2, 5, 6, 8–11].

This prospective randomized multicenter study aimed to determine efficacy in preventing postoperative recurrence after thoracoscopic bullectomy with either an
additional staple line coverage procedure or an additional mechanical pleurodesis after thoracoscopic bullectomy.

**Material and Methods**

**Study Design**

Between October 2006 and July 2010, a total of 1,414 patients with PSP who underwent thoracoscopic bullectomy were enrolled in a prospective, multicenter, randomized, controlled study to investigate efficacy of coverage after thoracoscopic bullectomy. The minimum follow-up period was 1 year, and all except 16 patients who failed this requirement were followed up at least until June 2011. Eligibility criteria included ipsilateral or bilateral recurrent pneumothorax, history of previous contralateral pneumothorax, visible blebs on the initial plain chest film or computed tomography, persistent air leakage for at least 5 days, and age 15 to 35 years. The exclusion criteria were underlying pulmonary disease such as pulmonary tuberculosis, previous ipsilateral thoracic operation, and refusal of the study. After thoracoscopic bullectomy, patients were randomly assigned to either the coverage or mechanical pleurodesis groups. Our hypothesis was that coverage is not inferior to pleurodesis as an additional procedure. The primary end points were the rates of ipsilateral 1-year recurrence rate and recurrence requiring intervention (RRI), defined as a postoperative recurrent pneumothorax large enough to need closed thoracostomy or reoperation. This study was conducted at 11 hospitals in Korea and was approved by the institutional review boards at each hospital. Patients provided written informed consent, and the protocol was registered at ClinicalTrials.gov (NCT00615849).

**Surgical Procedures**

All procedures were under general anesthesia with double-lumen endotracheal tube intubation. Surgery was performed by board-certified thoracic surgeons. All surgeons involved in this study followed a standardized surgical procedure and postoperative management. We used the three-port technique of Cho and colleagues [6]. After a thorough examination of the entire visceral pleural surface, blebs were resected using an endoscopic stapling device (Autosuture GIA Universal; Covidien, Mansfield, MA; Echelon 60; Ethicon, Cincinnati, OH) according to the surgeon’s preference. After confirmation of no air leak, an envelope containing a random number was opened for each patient. For the coverage group, inflated lungs 3 cm all around the staple line were covered with absorbable cellulose mesh (Surgicel, Ethicon) and then fibrin glue (TISSEEL; Baxter, Deerfield, IL; Beriplast; CSL Bohrning, Marburg, Germany; Greenplast; Green Cross Corp, Yongin, Korea) was sprayed on the mesh. For the pleurodesis group, mechanical pleurodesis was performed by scrubbing the parietal pleura with sandpaper and gauze until uniform blood oozing of the pleura was confirmed. The pleural abrasion was limited from the apex down to the fifth intercostal space. We shared standardized manuals and video clips of coverage and pleural abrasion procedures for quality control. Patients were discharged on the day after removal of the chest tube.

**Follow-Up**

After discharge from the hospital, patients received outpatient follow-up care, including chest radiography at 1 week and at 6 and 12 months. Subsequently, patients received follow-up care annually at clinics or by telephone. Patients were instructed to visit a clinic or emergency room for any signs related to recurrent pneumothorax.

**Study End Points**

The primary end points of the study were ipsilateral 1-year recurrence rate and RRI rate. The secondary end points were possible differences in early surgical outcomes and postoperative pain.

**Statistical Analysis**

Continuous variables were expressed as mean ± standard deviation and analyzed by a two-sample Student’s t test. Categorical variables were expressed by frequency and analyzed by χ² test. Freedom from recurrence was analyzed by the Kaplan-Meier method, and comparisons were made by the log-rank test. Risk factors of 1 year and overall recurrence or RRI were analyzed by a logistic model. Risk factors of freedom from recurrence or RRI (1-, 2-, and 3-year) were analyzed by the Cox proportional hazard model. Study design was designed in consultation with the Medical Research Collaboration Center of Seoul National University Hospital, and statistical analysis was assisted by the Department of Clinical Epidemiology and Biostatistics of Asan Medical Center, Korea.

**Results**

**Patients**

The median age of the 1,414 patients (1,295 male; 91.6%) was 18 years (range, 15 to 35 years), and 990 patients were never-smokers. Operations were performed for right pneumothorax in 652 patients (46.1%) and left pneumothorax in 761 patients (53.8%), with no clinical differences between the two groups (Table 1).

**Operations**

All underwent the VATS procedure successfully without conversion or mortality. Causes of operation were recurrent PSP (567 patients; 40.1%), tension pneumothorax (93 patients; 6.6%), first attack with persistent air leakage greater than 5 days (205 patients; 14.5%), first attack with visible blebs (413 patients; 29.2%), first attack with visible blebs and history of contralateral pneumothorax (119 patients; 8.4%), and risk-related occupation (15 patients; 1.0%). A single bleb was found in 199 patients (14.1%), and multiple blebs, in 1,092 patients (77.2%). Definite blebs were not found in 123 patients (8.7%). An average of two staples was used intraoperatively (range, 1 to 10). Additional coverage procedure on the stapled line was
performed in 757 patients (covered group), and mechanical pleurodesis was performed in 657 patients (pleurodesis group). The mean operation time was 48.4 ± 19.2 minutes. There was no difference in operative indication, findings, and data between the two groups (Table 2).

### Hospital Course
Complications included postoperative bleeding (4 patients; 0.3%), air leakage greater than 5 days (58 patients; 4.1%), and minor wound problem (13 patients; 0.9%). Median chest tube drainage and hospitalization after operation were 3 days (range, 1 to 16 days) and 4 days (range, 2 to 22 days), respectively. Operative complications and hospital courses were similar in the two groups (Table 2).

### Residual Pain
Return to ordinary activity was possible by 5.2 ± 2.92 days after operation. At 1 week after discharge, 785 patients (55.5%) had no pain. 542 patients (38.3%) experienced occasional pain but needed no analgesics, and 87 patients (6.2%) needed an intermittent or daily medication for pain (Table 3). Patients in the mechanical pleurodesis group had significantly more severe pain ($p < 0.0001$).

#### Recurrence
Sixteen patients dropped out as they failed to meet the minimum requirement of at least 1-year follow-up, and the median follow-up duration of 1,414 patients was 19.5 months (range, 0.3 to 66.7 months). Of the 192 patients (13.6%) experiencing recurrence of ipsilateral pneumothorax, 63 patients (32.8%) fully recovered without treatment or with oxygen inhalation within several days. For initial treatment of recurrent pneumothorax, VATS reexplanation was performed in 63 patients (32.8%), and closed thoracostomy was performed in 64 patients. Among these 64 patients, reoperation was eventually performed in 12 patients because of a second recurrence, and chemical pleurodesis was performed in 1 patient because of prolonged air leakage. Thus, 75 patients underwent reoperation because of recurrence (Table 4). Recurrence requiring intervention such as closed thoracostomy or reoperation occurred in 95 patients (6.7%) at postoperative 1 year and in 128 patients (9.2%) throughout the study period. At 1 year, the recurrence rate was 9.5% in the coverage group and 10.7% in the mechanical pleurodesis group. The overall recurrence rate was 13.8% in the coverage group and 14.2% in the mechanical pleurodesis group (Table 4). Overall recurrence and RRI in the two groups were similar (Fig 1).

Concerning risk factors, younger patients, lower body mass index, less smoking, and fewer multiple blebs yielded a significantly higher overall recurrence and RRI after multivariate analysis (Tables 5, 6).

### Comment
We set out to compare the prevention of PSP recurrence after thoracoscopic bullectomy by additional staple line coverage or additional mechanical pleurodesis. Although primary management of PSP is closed thoracostomy, the surgical indications for PSP have been broadened by advances in minimally invasive surgery and perioperative care. Video-assisted thoracic surgery has shown many advantages, such as reduced operation time, reduced

### Table 1. Patient Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Coverage Group (n = 757)</th>
<th>Pleurodesis Group (n = 657)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>20.7 ± 5.21</td>
<td>20.9 ± 5.08</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>697 (92.1%)</td>
<td>598 (91.0%)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>19.3 ± 2.08</td>
<td>19.4 ± 2.00</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>537 (71.0%)</td>
<td>453 (68.9%)</td>
</tr>
<tr>
<td>Current</td>
<td>220 (29.1%)</td>
<td>202 (30.8%)</td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>0 (0.0%)</td>
<td>2 (0.3%)</td>
</tr>
<tr>
<td>Laterality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>339 (44.8%)</td>
<td>313 (47.7%)</td>
</tr>
<tr>
<td>Left</td>
<td>417 (55.1%)</td>
<td>344 (52.4%)</td>
</tr>
<tr>
<td>Bilateral</td>
<td>1 (0.1%)</td>
<td>0 (0.0%)</td>
</tr>
</tbody>
</table>

BMI = body mass index.

### Table 2. Operative Data According to Groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coverage Group (n = 757)</th>
<th>Pleurodesis Group (n = 657)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative indication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recur</td>
<td>305 (40.3%)</td>
<td>262 (39.9%)</td>
<td>0.86</td>
</tr>
<tr>
<td>Others</td>
<td>436 (57.6%)</td>
<td>380 (57.8%)</td>
<td>0.93</td>
</tr>
<tr>
<td>Operation time</td>
<td>47.6 ± 19.03</td>
<td>49.0 ± 19.95</td>
<td>0.17</td>
</tr>
<tr>
<td>Bleb characteristics</td>
<td></td>
<td></td>
<td>0.95</td>
</tr>
<tr>
<td>Suspected</td>
<td>67 (8.9%)</td>
<td>56 (8.5%)</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>108 (14.3%)</td>
<td>91 (13.9%)</td>
<td></td>
</tr>
<tr>
<td>Multiple</td>
<td>582 (76.9%)</td>
<td>510 (77.6%)</td>
<td></td>
</tr>
<tr>
<td>Complications</td>
<td></td>
<td></td>
<td>0.66</td>
</tr>
<tr>
<td>None</td>
<td>711 (93.9%)</td>
<td>612 (93.2%)</td>
<td></td>
</tr>
<tr>
<td>Bleeding</td>
<td>3 (0.4%)</td>
<td>1 (0.2%)</td>
<td></td>
</tr>
<tr>
<td>Air leakage &gt;5 days</td>
<td>30 (4.0%)</td>
<td>28 (4.2%)</td>
<td></td>
</tr>
<tr>
<td>Wound problem</td>
<td>5 (0.7%)</td>
<td>8 (1.2%)</td>
<td></td>
</tr>
<tr>
<td>Tube removal (days)</td>
<td>2.4 ± 1.64</td>
<td>2.4 ± 1.60</td>
<td>0.99</td>
</tr>
<tr>
<td>Postoperative stay (days)</td>
<td>3.4 ± 1.96</td>
<td>3.4 ± 1.75</td>
<td>0.92</td>
</tr>
</tbody>
</table>

### Table 3. Residual Pain

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coverage Group (n = 757)</th>
<th>Pleurodesis Group (n = 657)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return to ordinary activity (days)</td>
<td>5.1 ± 2.71</td>
<td>5.3 ± 3.11</td>
<td>0.07</td>
</tr>
<tr>
<td>Residual pain</td>
<td></td>
<td></td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pain free</td>
<td>465 (61.4%)</td>
<td>320 (48.5%)</td>
<td></td>
</tr>
<tr>
<td>Occasional</td>
<td>260 (34.4%)</td>
<td>282 (43.0%)</td>
<td></td>
</tr>
<tr>
<td>Intermittent medication</td>
<td>29 (4.6%)</td>
<td>34 (5.2%)</td>
<td></td>
</tr>
<tr>
<td>Daily medication</td>
<td>3 (0.4%)</td>
<td>21 (3.2%)</td>
<td></td>
</tr>
<tr>
<td>Recurrence</td>
<td>Coverage Group (n = 757)</td>
<td>Pleurodesis Group (n = 657)</td>
<td>Difference</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------</td>
<td>-----------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Binary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-year recurrence rate</td>
<td>72 (9.5%)</td>
<td>70 (10.7%)</td>
<td>−1.61</td>
</tr>
<tr>
<td>Overall recurrence rate</td>
<td>99 (13.8%)</td>
<td>93 (14.2%)</td>
<td>−1.25</td>
</tr>
<tr>
<td>1-year recurrence requiring intervention rate</td>
<td>44 (5.8%)</td>
<td>51 (7.8%)</td>
<td>−1.95</td>
</tr>
<tr>
<td>Overall recurrence requiring intervention rate</td>
<td>61 (8.1%)</td>
<td>67 (10.2%)</td>
<td>−2.14</td>
</tr>
<tr>
<td>KM base</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-year recurrence rate</td>
<td>9.44 ± 1.07</td>
<td>10.74 ± 1.21</td>
<td>−1.30</td>
</tr>
<tr>
<td>2-year recurrence rate</td>
<td>13.14 ± 1.29</td>
<td>13.89 ± 1.41</td>
<td>−0.75</td>
</tr>
<tr>
<td>3-year recurrence rate</td>
<td>14.94 ± 1.46</td>
<td>16.21 ± 1.67</td>
<td>−1.27</td>
</tr>
<tr>
<td>1-year recurrence requiring intervention rate</td>
<td>5.85 ± 0.86</td>
<td>7.38 ± 1.05</td>
<td>−1.53</td>
</tr>
<tr>
<td>2-year recurrence requiring intervention rate</td>
<td>8.05 ± 1.03</td>
<td>9.90 ± 1.20</td>
<td>−1.85</td>
</tr>
<tr>
<td>3-year recurrence requiring intervention rate</td>
<td>9.30 ± 1.20</td>
<td>11.42 ± 1.41</td>
<td>−2.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment for recurrence</th>
<th>Coverage</th>
<th>Pleurodesis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>8 (8.1%)</td>
<td>8 (9.7%)</td>
</tr>
<tr>
<td>Oxygen inhalation</td>
<td>29 (29.3%)</td>
<td>18 (19.4%)</td>
</tr>
<tr>
<td>Closed thoracostomy</td>
<td>22 (22.2%)</td>
<td>31 (33.3%)</td>
</tr>
<tr>
<td>Reoperation</td>
<td>40 (40.4%)</td>
<td>35 (37.6%)</td>
</tr>
</tbody>
</table>

CI = confidence interval; KM = Kaplan-Meier.

Fig 1. Kaplan-Meier curves for recurrence-free survival. There was no difference in (A) overall recurrence-free survival and (B) recurrence requiring intervention-free survival rate (log-rank 0.51, 0.16, respectively) between the coverage group (blue line) and the pleurodesis group (red line).
### Table 5. Risk Factor Analysis for Overall Recurrence

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>1-Year Rate Logistic Model</th>
<th></th>
<th>Overall Cox Proportional Hazard Model</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Univariate</td>
<td>Multivariate</td>
<td>Univariate</td>
<td>Multivariate</td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
<td>p Value</td>
<td>OR</td>
</tr>
<tr>
<td>Age</td>
<td>0.852</td>
<td>(0.806, 0.901)</td>
<td>&lt;0.0001</td>
<td>0.876</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>0.754</td>
<td>(0.426, 1.336)</td>
<td>0.3335</td>
<td>0.876</td>
</tr>
<tr>
<td>BMI</td>
<td>0.906</td>
<td>(0.828, 0.990)</td>
<td>0.0294</td>
<td>0.945</td>
</tr>
<tr>
<td>Smoking (yes)</td>
<td>3.696</td>
<td>(2.168, 5.301)</td>
<td>&lt;0.0001</td>
<td>1.946</td>
</tr>
<tr>
<td>Indication (recur)</td>
<td>0.969</td>
<td>(0.679, 1.381)</td>
<td>0.8598</td>
<td>0.892</td>
</tr>
<tr>
<td>Laterality (right)</td>
<td>0.897</td>
<td>(0.633, 1.273)</td>
<td>0.5436</td>
<td>0.932</td>
</tr>
<tr>
<td>Blebs Single</td>
<td>0.421</td>
<td>(0.187, 0.950)</td>
<td>0.0217</td>
<td>0.401</td>
</tr>
<tr>
<td>Blebs Multiple</td>
<td>0.857</td>
<td>(0.483, 1.520)</td>
<td>0.2268</td>
<td>0.897</td>
</tr>
<tr>
<td>Operation time</td>
<td>0.999</td>
<td>(0.990, 1.008)</td>
<td>0.7794</td>
<td>0.999</td>
</tr>
<tr>
<td>Tube removal</td>
<td>1.071</td>
<td>(0.972, 1.179)</td>
<td>0.1645</td>
<td>1.071</td>
</tr>
<tr>
<td>Postoperative stay (days)</td>
<td>1.065</td>
<td>(0.981, 1.156)</td>
<td>0.1329</td>
<td>1.098</td>
</tr>
</tbody>
</table>

BMI = body mass index; CI = confidence interval; HR = hazard ratio; OR = odds ratio.

### Table 6. Risk Factor Analysis for Recurrence Requiring Intervention

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>1-Year Rate Logistic Model</th>
<th></th>
<th>Overall Cox Proportional Hazard Model</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Univariate</td>
<td>Multivariate</td>
<td>Univariate</td>
<td>Multivariate</td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
<td>p Value</td>
<td>OR</td>
</tr>
<tr>
<td>Age</td>
<td>0.886</td>
<td>(0.835, 0.940)</td>
<td>&lt;0.0001</td>
<td>0.88</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>0.682</td>
<td>(0.353, 1.317)</td>
<td>0.2539</td>
<td>0.819</td>
</tr>
<tr>
<td>BMI</td>
<td>0.894</td>
<td>(0.802, 0.996)</td>
<td>0.0421</td>
<td>2.699</td>
</tr>
<tr>
<td>Smoking (yes)</td>
<td>2.837</td>
<td>(1.563, 5.152)</td>
<td>0.0006</td>
<td>0.903</td>
</tr>
<tr>
<td>Indication (recur)</td>
<td>0.994</td>
<td>(0.650, 1.521)</td>
<td>0.9791</td>
<td>0.932</td>
</tr>
<tr>
<td>Laterality (right)</td>
<td>0.842</td>
<td>(0.552, 1.283)</td>
<td>0.4224</td>
<td>0.885</td>
</tr>
<tr>
<td>Blebs Single</td>
<td>0.598</td>
<td>(0.241, 1.481)</td>
<td>0.2507</td>
<td>0.536</td>
</tr>
<tr>
<td>Blebs Multiple</td>
<td>0.834</td>
<td>(0.419, 1.659)</td>
<td>0.7709</td>
<td>1.001</td>
</tr>
<tr>
<td>Operation time</td>
<td>1.022</td>
<td>(0.991, 1.012)</td>
<td>0.7529</td>
<td>1.071</td>
</tr>
<tr>
<td>Tube removal</td>
<td>1.103</td>
<td>(0.990, 1.229)</td>
<td>0.076</td>
<td>1.06</td>
</tr>
<tr>
<td>Postoperative stay (days)</td>
<td>1.091</td>
<td>(0.995, 1.196)</td>
<td>0.0634</td>
<td>1.122</td>
</tr>
</tbody>
</table>

BMI = body mass index; CI = confidence interval; HR = hazard ratio; OR = odds ratio.
drainage time, reduced complication rates, lower inflammatory response, shorter hospital stay, better cosmesis, and a rapid return to normal daily activities [12–14]. Although postoperative recurrence rates after VATS are somewhat higher than those of thoracotomy [14–18], most surgeons prefer VATS for PSP [9, 10, 12, 13, 15, 19–21] because of its greater merits.

The relatively high postoperative recurrence rates of thoracoscopic bullectomy using endostaplers (9.2% to 20%) [2, 22, 23] cannot be explained only by technical inadequacy [24]. We speculated that VATS might have a lower adhesion rate than open surgery [5]. Therefore, various additional procedures to reduce recurrence rate have been performed: targeting the site of bullectomy with fleece-coated glue [3], the attachment of an absorbent sheet [5, 25], and the spraying of a fibrin glue solution [3]. Procedures targeting the parietal pleura include mechanical parietal pleural abrasion [26, 27], excision of the pleura corresponding to the pulmonary apical portion [28, 29], chemical pleural adhesions using minocycline (Minomycin) [30] and talc [31], and further ablation of the parietal pleura using a needle thoracoscopic laser [32] or argon beam [33].

Although mechanical pleurodesis is applied in both open thoracotomy and VATS [2, 34, 35], parietal pleural procedures have several disadvantages. First, symphysis of parietal and visceral pleura may negatively affect normal pleural physiology. It may also facilitate dissemination of cancer invading the chest wall. Third, it may cause pleural adhesion, negatively affecting future thoracic surgery. Lastly it causes more pain, as was clearly demonstrated in this study.

Kurihara and associates [36] reduced the recurrence rate by applying absorbable cellulose mesh with fibrin glue to the staple line. Postoperative recurrence is reported to result from the formation of new blebs near the staple line, as observed in patients undergoing reoperation [5]. Furthermore, postoperative air leaks occur mainly at the staple line owing to stapling problems, such as incomplete resection of blebs, emphysematous changes in the resected area, or crossing of the staple line [37]. We consider that additional procedures resulting in pleural symphysis have more disadvantages in spite of some reduction of recurrence in young individuals. Our previous studies suggested visceral pleural reinforcement to be better than replacement of pleural symphysis [6, 25]. Among various additional procedures, we focused on and compared two commonly applied procedures: mechanical abrasion of parietal pleura and coverage of visceral pleura. Previous papers regarding additional procedures were mostly small, single-center, short-term follow-up studies.

Our postoperative recurrence rate was higher than some published recurrence rates, which varied from 3.7% to 13.7% [8, 13, 38]. Our intense and long-term follow-up was probably one reason for the relatively high recurrence rate. We strictly defined even extremely small postoperative pneumothoraces as recurrence. Because PSP is not a serious disease, recurrences with minimal symptoms could be overlooked, and a considerable portion of recurrent cases could have transferred to other hospitals. Because all 1,414 patients, except 16, received follow-up care by clinic visits or telephone consultations more than once per year, we minimized the dropout rate and approached the actual recurrence rate. Among 192 cases of recurrence, 128 patients (9.1%) needed intervention, but 63 cases recovered without intervention. Our study revealed a high number of clinically insignificant postoperative pneumothorax cases.

The limitations of this study were a higher-than-expected recurrence rate and the fact that 1:1 matching randomization was difficult as a result of the unequal allocation ratio. However, the numbers of enrolled patients provided sufficient statistical power and show statistically significant differences between groups.

This is the first prospective, randomized, multicenter, large-scale, long-term follow-up study for surgical methods for PSP focused on whether visceral pleura coverage can replace mechanical pleurodesis. In conclusion, visceral pleura coverage was not inferior to mechanical pleurodesis after VATS wedge resection in terms of success rate and postoperative recurrence. Furthermore, the visceral pleural coverage group showed better recovery from pain.

We would like to thank Professor Emeritus J. Patrick Barron (Professor Emeritus, Tokyo Medical University and Adjunct Professor, Seoul National University Bundang Hospital) for manuscript editing, the Medical Research Collaboration Center, Seoul National University Hospital, Seoul, Korea) for the study design, Jung Bok Lee (Department of Clinical Epidemiology and Biostatistics, Asan Digestive Disease Research Institute, Asan Medical Center, Seoul) for data analysis, and Eun Hee Kang, Sangho Chung, Sun Hee Park, Young Seon Geon, Dong Uk Kim, and Misun Chun for data collection.

References


