Original Article

# Evaluation of the nonstapling bullectomy by manual suturing for young men with primary spontaneous pneumothorax

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**Background:** Currently, surgery for primary spontaneous pneumothorax (PSP) is performed by bullectomy using a stapler with complete video-assisted thoracic surgery (cVATS). However, the postoperative recurrence rate (RR) of PSP is high in young men. The factors of postoperative PSP recurrence are the formation of postoperative bulla neogenesis (POBN) around the staple line, pleural injury caused by forceps for VATS, and bulla overlooked with a thoracoscope. We attempted nonstapling bullectomy with one-port–one-window (1p–1w) by using hybrid VATS (hVATS) to reduce postoperative RR. This study aimed to evaluate nonstapling bullectomy by manual suturing for young male patients with PSP compared with bullectomy by cVATS.

**Methods:** From January 2012 to December 2022, we retrospectively reviewed the medical records of 259 male patients aged ≤25 years who underwent initial surgery for PSP and compared them between two groups, with staple use (S+) or by manual suturing without staple use (S–). RR, operative time, blood loss, and postoperative hospitalization period were examined in both groups.

**Results:** The median operative time was 81 and 63 min in the S– and S+ groups, respectively (P<0.001), with the S– group tending to be statistically significantly longer. The mean intraoperative blood loss was 1.61 and 2.11 mL in the S– and S+ groups, respectively (P=0.003). The median postoperative hospitalization period was 4 days in both groups (P=0.32). Recurrences occurred in 8 (7.1%) and 14 patients (12.2%) in the S– and S+ groups, respectively [odds ratio (OR) =0.55; 95% confidence interval (CI): 0.22–1.37; P=0.19]. In patients aged <20 years, 5 (6.6%) and 10 (14.1%) patients had a recurrence in the S– and S+ groups, respectively (OR =0.42; 95% CI: 0.13–1.32; P=0.13).

**Conclusions:** Compared with stapling bullectomy, nonstapling bullectomy with small thoracotomy for young male patients with PSP had lesser RR. This procedure is beneficial in reducing postoperative recurrence and is one of the surgical choices for young male patients with PSP.

**Keywords:** Pneumothorax; nonstapling; manual suture; postoperative recurrence; hybrid video-assisted thoracic surgery (hVATS)

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## Introduction

Primary spontaneous pneumothorax (PSP) is a condition where air is retained in the chest cavity, without evidence of trauma, emphysema, interstitial lung disease, malignancy, or any known underlying lung disease. The disruption of the bulla or bleb often causes PSP. The admission rate per 100,000 population of PSP was 15.5 in male and 3.1 in female patients aged 15–34 years, as well as 4.1 and 2.9 in both sexes combined for those aged 35–49 and ≥50 years, respectively (1), with PSP occurring more commonly in young male patients.

The typical symptoms of PSP are chest pain and dyspnea, which may be minimal or absent. Although PSP is initially treated with needle aspiration or chest drainage, observation is the treatment of choice for patients with small PSP without significant symptoms conservative management of PSP in selected cases with minimally symptoms and clinical and radiological stability, regardless of size of pneumothorax. in European Respiratory Society (ERS)/European Association for Cardio-Thoracic Surgery (EACTS)/European Society of Thoracic Surgeons (ESTS) guidelines (2).

Large and severe PSP often requires chest decompression; such as needle aspiration or chest drainage. Recently, a study reported that conservative management of moderate to large PSP is not inferior to interventional management (3).

Surgery is the treatment of choice for the first occurrence of hemopneumothorax, simultaneous bilateral PSP, signs of severity, persistent air leaks despite initial chest decompression, risky occupation or leisure activity, PSP occurring during pregnancy (after birth), and second PSP episode (4). Currently, bullectomy is performed for PSP by using a stapling instrument with complete video-assisted thoracic surgery (cVATS). The cVATS approach is favorable to thoracotomy in terms of pain, hospital stay, and cosmetics (5,6), but it is inferior to thoracotomy in terms of recurrence rate (RR). In a systematic review, the RR of pneumothorax (including secondary spontaneous pneumothorax) treated with VATS was four times higher than that with thoracotomy (7). Postoperatively, the RR is high in young patients with PSP, and PSP recurrence can significantly affect the life events of patients, such as examinations or job hunts. There are many discussions on reducing RR. The factors of postoperative PSP recurrence include the formation of postoperative bulla neogenesis (POBN) around the staple line, pleural injury caused by forceps for VATS (8), and bulla overlooked with a thoracoscope.

To prevent the occurrence of these factors, we attempted nonstapling bullectomy with one-port–one-window (1p–1w) by using hybrid VATS (hVATS) to reduce postoperative RR in 2012. We aimed to evaluate nonstapling bullectomy for young male patients with PSP compared with bullectomy by cVATS. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-693/rc).

### Highlight box

**Key findings**

- Nonstapling bullectomy by manual suturing with small thoracotomy for young male patients with primary spontaneous pneumothorax (PSP) showed a tendency for less recurrence rate (RR) to be lesser than stapling bullectomy.

**What is known and what is new?**

- Currently, surgery for PSP is performed by bullectomy using a stapler with complete video-assisted thoracic surgery (VATS). However, the postoperative RR of PSP is high in young men.
- We attempted nonstapling bullectomy with one-port–one-window by using hybrid VATS (hVATS) to reduce postoperative RR.

**What is the implication, and what should change now?**

- Nonstapling bullectomy by manual suturing with hVATS is beneficial in reducing postoperative recurrence and is one of the choices for surgery for young male patients with PSP.

## Methods

### *Materials and methods*

From January 2012 to December 2022, 569 patients with pneumothorax underwent surgery at our institution. In our institution, the indications for surgery for PSP were recurrent cases, cases of uncontrolled air leakage or cases with patient preference.

We retrospectively reviewed the medical records of the initial 259 male patients with PSP aged ≤25 years and compared the two groups: with staple use (S+) or manual suturing without staple use (S–) (*Figure 1*). Additionally, we analyzed the data of patients <20 years, who were considered to have a higher postoperative RR.

The surgery was performed using either three-port or 1p–1w VATS. The patients were informed about the advantages and disadvantages of each procedure and instructed to choose one of the two methods.

Three-port VATS was performed by bullectomy with

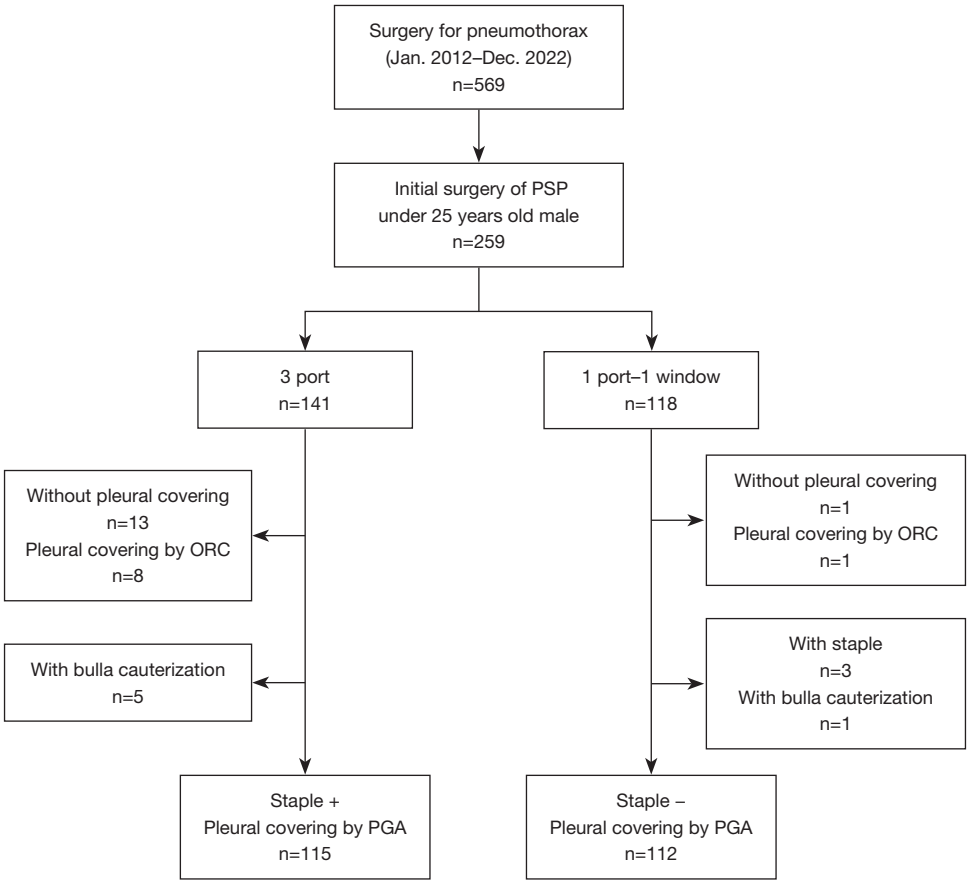


**Figure 1** Flowchart of patient selection. PSP, primary spontaneous pneumothorax; ORC, oxidized regenerated cellulose; PGA, polyglycolic acid.

stapling instrument access form the three ports (two 5 mm ports and one 12 mm port). After bullectomy, the pleura was covered mainly with a polyglycolic acid (PGA) sheet without fibrin glue or thread fixation.

The 1p–1w bullectomy was performed with manual suturing from the window by a 3-cm skin incision on the third intercostal midaxillary line with wound protection device and a 5 mm camera port on the fifth intercostal anterior axillary line or site of chest tube extraction between the fifth and eighth intercostal anterior axillary line. The base of the bulla was grasped with forceps, then a continuous horizontal mattress suture was placed on the central side of the forceps. Subsequently, the bulla was resected on the peripheral side of the forceps, followed by forceps removal, return with an over-and-over suture, and ligation. We used 4-0 monofilament absorbable thread (4-0 PDSII®) for suturing. The reason for bullectomy was to ensure that the bulla base was grasped and to evaluate its histology. The pleura was covered mainly with the PGA sheet, which was secured using a ligature thread (*Figure 2*).

The surgeries were performed in both groups by respiratory surgeons belonging to our department.

In our clinical pathway, the drain was removed on the second postoperative day, and the patient was discharged on the fourth postoperative day regardless of whether three-port or 1p–1w was performed.

We excluded patients without pleural covering (14 patients) or using oxidized regenerated cellulose (ORC) sheet as covering (9 patients), and who received bulla cauterization (6 patients). In 1p–1w, we excluded those using a staple (3 patients).

The maximum observation period was 5 years, which was terminated in March 2023 for those observed <5 years. The medical records were reviewed to determine recurrence.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study

 

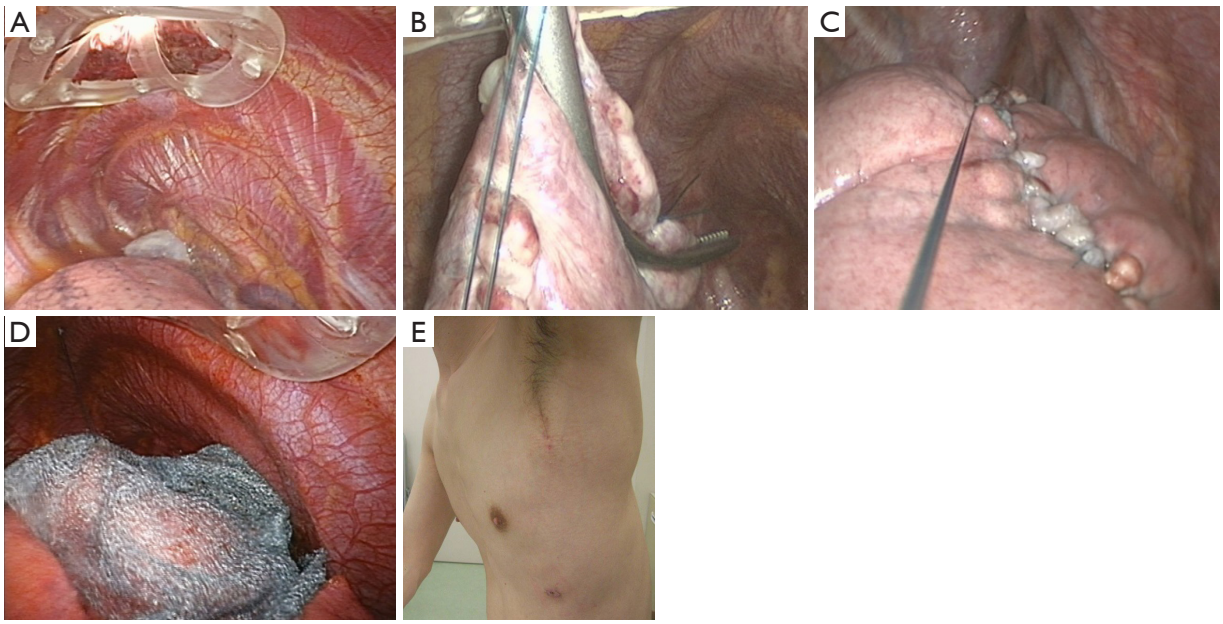


**Figure 2** Procedure for one-port–one-window bullectomy. (A) Small thoracotomy at the third intercostal space and camera port at the fifth intercostal space. (B) The bulla base was grasped with forceps, and a continuous horizontal mattress suture was placed on the central side of the forceps. (C) The bulla was resected on the peripheral side of the forceps. The forceps were removed, returned with an over-and-over suture, and ligated. (D) The pleura was covered was using PGA sheet, which was secured using ligature thread. (E) Surgical wound at 3 months postoperatively. PGA, polyglycolic acid.

**Table 1** Patient characteristics in two groups

| Characteristics | S– | S+ |
|---|---|---|
| N | 112 | 115 |
| Age (years) | 18 [14–25] | 19 [14–25] |
| Age <20 years old | 76 | 71 |
| Right | 54 | 64 |
| Left | 58 | 51 |

Data are presented as n or median [range]. S–, without staple use; S+, with staple use.

was approved by the institutional ethics board of the Showa University Research Administration Center Ethics Committee (approval No. 2023-174-A) and individual consent for this retrospective analysis was waived.

### *Statistical analysis*

RR, operative time, blood loss, and postoperative hospitalization period were examined in the S+ and S– groups. The odds ratios (ORs) were calculated for the RR. The Kaplan-Meier method was used to examine the 5-year cumulative RR, and the log-rank test was used to compare between the two groups. Hazard ratios (HRs) were calculated using logistic regression analysis. The Wilcoxon rank sum test was used to compare blood loss, operative time, postoperative drainage period, and postoperative hospitalization period between the two groups. Significance was set at $P \leq 0.05$.

JMP Pro software (version 16.0.0; SAS Institute Inc., Cary, NC, USA) was used for statistical evaluation.

## Results

Of the 259 patients, 112 and 115 were in the S– and S+ groups, respectively. Of these, 76 and 71 patients were aged <20 years in the S– and S+ groups, respectively. The median age was 18 (range, 14–25) and 19 (range, 14–25) years in the S– and S+ groups, respectively. The affected side was left/right in 54/58 and 64/51 in the S– and S+ groups, respectively (*Table 1*).

The median operative time was 81 (range, 43–164) and 63 (range, 36–124) min in the S– and S+ groups, respectively ($P<0.001$), with group S– tending to be

**Table 2** Operative outcomes

| Outcomes | S– | S+ | P value |
|---|---|---|---|
| Operating time (min) | 81 [43–164] | 63 [36–124] | <0.001 |
| Blood loss (mL) | 1.61 [0–62] | 2.11 [0–50] | 0.003 |
| Post operative drainage period (days) | 2 [2–11] | 2 [1–9] | 0.98 |
| Post operative hospitalization (days) | 4 [3–22] | 4 [3–12] | 0.32 |
| Post operative complication | 4 | 4 | 0.96 |

Data are presented as median [range] or n. S–, without staple use; S+, with staple use.

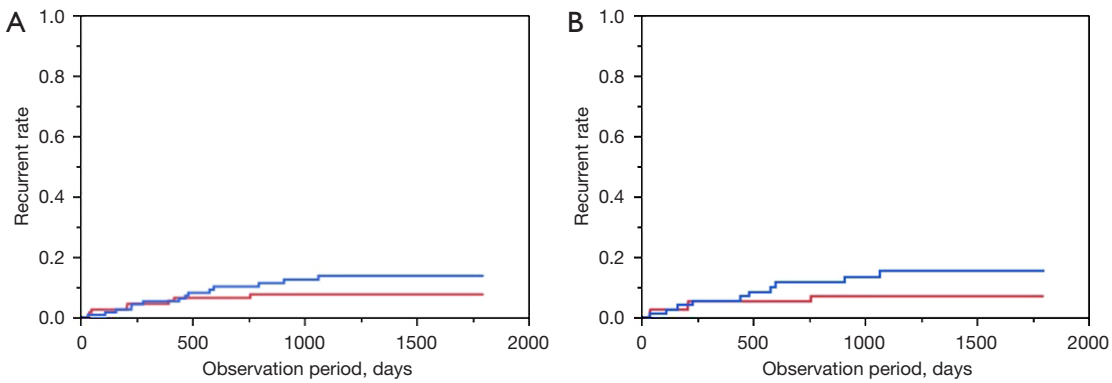


**Figure 3** Kaplan-Meier curve of all patients (A) and of patients aged <20 years (B).

statistically significantly longer. The mean intraoperative blood loss was 1.61 (range, 0–62) and 2.11 (range, 0–50) mL in the S– and S+ groups, respectively (P=0.003), with a statistically significant trend toward more blood loss in the S+ group. The median postoperative drainage period was 2 days in both groups (P=0.98). The median postoperative hospitalization period was 4 days in both groups (P=0.32). Postoperative complications were prolonged air leaks in six patients (two and four in the S– and S+, respectively, with one in the S+ group requiring reoperation) and postoperative hemorrhage in one patient in the S– group, which required reoperation. In the S– group, one patient with atopic dermatitis had a surgical site infection (*Table 2*).

Recurrences occurred in 8 (7.1%) and 14 patients (12.2%) in the S– and S+ groups, respectively [OR =0.55; 95% confidence interval (CI): 0.22–1.37; P=0.19] (*Figure 3*). Of the recurrent cases, 6 and 11 patients received conservative treatment, and 2 (1.8%) and 3 patients (2.6%) required additional treatment, such as thoracic drainage or surgery, in the S– and S+ groups, respectively. In patients aged <20 years who were considered to have a higher postoperative RR, recurrences occurred in 5 (6.6%) and 10 (14.1%) patients in the S– and S+ groups, respectively (OR =0.42; 95% CI: 0.13–1.32; P=0.13). The median time to recurrence was 209 (range, 37–759) and 455 (range, 35–1,063) days (P=0.10), but it was 208 (range, 37–759) and 461 (range, 13–1,063) days in patients aged <20 years in the S– and S+ groups, respectively (P=0.27) (*Table 3*). The 5-year cumulative postoperative RR using the Kaplan-Meier method was 7.6% and 13.8% (HR =0.57; 95% CI: 0.24–1.38; P=0.28; *Figure 3A*), but it was 7% and 15.6% in patients aged <20 years in the S– and S+ groups, respectively (HR =0.45; 95% CI: 0.15–1.34; P=0.14; *Figure 3B*). The median observation period was 1,427 (range, 37–1,800) days and 1,302 (range, 111–1,800) days in the S– and S+ groups, respectively.

## Discussion

Currently, the most common surgical approach for PSP is cVATS, which is associated with less pain and cosmetic benefits. However, the RR of cVATS is significantly higher than that of thoracotomy. The RR of young patients with PSP who underwent cVATS was particularly high, and Fujiwara *et al.* (9). reported that the risk factor of PSP

**Table 3** Summary of recurrent cases

| Characteristics | S– | S+ | OR (95% CI) | P value |
|---|---|---|---|---|
| N | 112 | 115 | – | – |
| Recurrent cases | 8 (7.1) | 14 (12.2) | 0.55 (0.22–1.37) | 0.19 |
| Time to recurrence (days) | 209 [37–759] | 455 [35–1,063] | – | 0.10 |
| Recurrent cases under 20 years old | 5 (6.6) | 10 (14.1) | 0.42 (0.13–1.32) | 0.13 |
| Time to recurrence under 20 years old (days) | 208 [37–759] | 461 [13–1,063] | – | 0.27 |

Data are presented as n, n (%) or median [range]. S–, without staple use; S+, with staple use; OR, odds ratio; CI, confidence interval.

was age <30 years, with some studies reporting a higher incidence of recurrence in patients aged <20 years than in those aged >20 years (10,11). We applied coverage material, such as PGA sheet or ORC mesh, to prevent postoperative recurrence and mechanical pleural abrasion. In the prospective, randomized, controlled trial by Min *et al.* (12), mechanical pleural abrasions did not significantly decrease PSP recurrence compared with simple wedge resection, and intraoperative bleeding and postoperative pleural drainage rates were higher. Mao *et al.* (13) reported the benefits of covering with a PGA sheet. Woo *et al.* (14) reported that postoperative pneumothorax recurrence did not significantly differ between PGA and ORC as the coverage material. However, Kabuto *et al.* (15) reported that covering with a PGA sheet was more effective than covering with the ORC mesh in early postoperative recurrence.

The postoperative recurrence of PSP may be caused by a missed bulla with thoracoscopic vision, POBN from the pleura near the staple line, or damage caused by forceps (16,17). Choi *et al.* (18) reported that 65% of new bullae following first-line VATS in PSP were found in the staple line, and the group with POBN in the staple lines had RR more than two-folds higher than the group without POBN in the staple lines. In our experience, when reoperating on a recurrent pneumothorax, a new bulla is expected to be found near the staple line or in the area that may have been grasped with forceps during the previous surgery. Kadokura *et al.* (8) reported the pleural histological change of subpleural hemorrhage, cutting of the elastic membrane, and mesothelial damage of the lung specimen which was held with forceps.

Furthermore, we encountered several cases of intraoperative influx of air under the pleura through the needle hole in the staple line, resulting in bulla neoformation. Bulla disruption in the pleura causes PSP, which indicates pleural fragility or other abnormalities. Ayed *et al.* (19) reported that the pathological findings of resected lung apices of patients with PSP showed subpleural emphysematous changes with bulla/bleb formation, lymphocytic infiltration or mixed lymphocytic and plasma cell infiltration, pleural fibrosis, and pleural fibrosis with mesothelial thickening and hyperplasia. We speculate that new bullae are formed by the numerous needle holes created in the pleura by the stapler during VATS bullectomy and the excessive pressure applied on the pleura around the staple line due to tight metal closure. Tsuboshima *et al.* (20) reported that the resected large volume of the lung is a significant risk factor for developing POBN, which causes increased pressure on the suture line.

Based on the high RR with or without pleural coverage in VATS at our institution and our experience, we reconsidered our surgical approach to young patients with PSP and started bullectomy with 1p–1w in 2012. The 1p–1w method aimed to minimize the risk of missing the bulla by using a combination of thoracoscopic and direct views, inserting tools through a small window, avoiding grasping with a settling instrument except for the resected area, and dynamically unfolding the lung with cotton, and not using a stapler to reduce the risk of POBN near the staple line. We thought needle-and-thread suturing reduces the risk of POBN because the number of needle holes is fewer than that with a stapler that closes the resection with a set of dots, whereas hand suturing closes it with a line. We performed a hand-stitched partial resection with forceps to ensure that the bulla base was grasped, and we evaluated its histology.

We investigated whether the use of a stapler makes a difference in the RR in patients aged <25 years with pneumothorax. Both groups included cases covered with PGA sheets. Several reports showed that pleural covering with PGA plus fibrin glue effectively reduced postoperative recurrence (21-23). However, Kawamura *et al.* (24) reported the risk of human parvovirus infection caused by fibrin sealant used during thoracic surgery. Oda *et al.* (25) reported

 

that the high cost of PGA plus fibrin glue may not be significantly different from the total cost of treating PSP in the follow-up period, including the treatment cost of postoperative recurrent pneumothorax. Blood products are a valuable medical resource, and we should be cautious in their use. Thus, we did not use fibrin glue as a pleural covering.

The median operative time tended to be longer in the S– group, which may be due to the longer time required for resection and wound closure with manual suturing compared with the stapler, but the increase in operative time was not drastic, and we considered it acceptable. The mean blood loss was higher in the S+ group with a statistically significant, but the difference was not clinically significant.

The postoperative hospital stay was not different between the two groups, but two and three patients had prolonged postoperative air leaks in the S– and S+ groups, respectively, and one patient with postoperative bleeding required reoperation in the S– group. However, the risks of both techniques were considered comparable when intraoperative blood loss and length of hospital stay were included in the analysis.

Postoperative RR tended to be lower at 7.1% in the S– group compared with 12.2% in the S+ group, but the difference was not statistically significant. The 5-year cumulative RR using the Kaplan-Meier method also tended to be lower at 7.6% in the S– group compared with 13.8% in the S+ group, but the difference was not statistical significance. The study in patients aged <20 years also showed no statistically significant difference, but the difference in postoperative RR was more pronounced, with 6.6% and 14.1% in the S– and S+ groups, respectively. The cumulative 5-year RR was 7.6% and 13.8% in the S– and S+ groups, respectively. The trend toward lower RRs in the S– group may be due to not using staplers, which prevented POBN, or the presence of adhesions between the surgical wound in the third intercostal space and the lung apex. Furthermore, the PGA sheet in the S+ group is spread and affixed near the staple line, but not fixed. Conversely, the PGA sheet in the S– group is fixed by sutures, which may have influenced this result because the sheet is less displaced.

The median time to recurrence was 209 days in the S– group and 208 days in patients aged <20 years in the S– group. Although the difference was not statistically significant, the absorption period of 4-0 PDSII® is estimated to be 180 to 210 days, which is consistent with the median timing of recurrence. It was suggesting that the suture absorption process may have an effect on recurrence in the S– group.

In this study, bullectomy by hand suturing without a stapler combined with thoracoscopy showed a trend toward lower RRs, particularly in patients aged <20 years. Recently, several reports showed the benefit of single-incision VATS for PSP with a 2.5–3.0-cm skin incision (26-28). The single incision is cosmetically more beneficial than our procedure, but we also believe a 3.0-cm axillary skin incision at the third intercostal space provides cosmetic outcomes comparable to multiport VATS because it is concealed when the arm is lowered. If the camera is inserted through a small 3-cm axillary wound, a camera port near the fifth intercostal space may not be necessary in cases where preoperative drainage is not performed. Considering the efficient observation of the thoracic cavity on the diaphragm side and smooth suture operation, we currently use the 1p–1w procedure.

Regarding postoperative complications, expect for one case requiring reoperation due to postoperative bleeding, other complications did not increase, and safety is not a major concern.

We believe this procedure is beneficial, which aims to reduce postoperative RR of PSP, and this procedure could be a treatment options for PSP. This procedure is more labor intensive than performing the resection under a specular cVATS with a stapler and requires more knowledge and experience from respiratory surgeons. However, secondary advantages of this procedure include training young surgeons in pulmonary suturing techniques and being more economical because a stapler is not used.

This study has some limitations. This study was retrospective in design, implying the possibility of selection bias. In addition, the RR was not significantly different statistically, and we cannot rule out the possibility of an incidental result. We intend to further study with larger number of cases and demonstrate the benefits of this procedure.

## Conclusions

In our study, although the RR was not significantly different statistically, nonstapling bullectomy by manual suturing for young male patients with PSP showed a tendency for less RR to be lesser than stapling bullectomy. This procedure may be beneficial in reducing postoperative recurrence and may be one of the choices for surgery for young male patients with PSP.

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## Footnote

*Reporting Checklist:* The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-693/rc

*Data Sharing Statement:* Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-693/dss

*Peer Review File:* Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-693/prf

*Conflicts of Interest:* All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-693/coif). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the institutional ethics board of the Showa University Research Administration Center Ethics Committee (approval No. 2023-174-A) and individual consent for this retrospective analysis was waived.



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