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ORIGINAL ARTICLE

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Initial management of primary spontaneous pneumothorax with video-assisted thoracoscopic surgery: a 10-year experience

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Abstract

OBJECTIVES: First-line conservative treatment of primary spontaneous pneumothorax (PSP) may be challenged by recurrence rates and complications associated with different treatment options. The aim of this study was to evaluate the use of a standardized surgical treatment as 'first-line' treatment.

METHODS: In a 10-year period, 185 patients with PSP were treated with a standardized video-assisted thoracic surgery (VATS) approach including wedge resection and parietal pleurectomy. Data were evaluated retrospectively. All patients with a first event of PSP were included in the study. In addition, follow-up was done by a questionnaire.

RESULTS: Mean follow-up period was 70.8 months (±33.5 months). Sub-pleural emphysematous changes were found in every histopathological specimen. In addition, 70.8% had fibrosis of visceral pleura. Recurrence occurred in 4 patients (2.2%). Ten-year freedom from recurrence was 96.2%. Procedure-related morbidity rate was 7.6%. Approximately 85.7% of patients were satisfied with the procedure and the cosmetic result. Three patients died during follow-up (1.6%).

CONCLUSIONS: Treatment of first episode of PSP by VATS is a safe procedure, with a very low rate of recurrence and a high patient satisfaction. This management of first episode of PSP is based on the underlying pathology. We recommend the use of VATS as the treatment of first choice for patients with PSP.

Keywords: Spontaneous pneumothorax • First episode • Video-assisted thoracoscopic surgery • Pathogenesis • Patient satisfaction

INTRODUCTION

Pneumothorax is defined by the presence of air in the pleural cavity. The cause of pneumothorax can be a trauma, but it usually develops without evident underlying cause. These pneumothoraces are addressed as 'spontaneous'. Thus, 'primary' spontaneous pneumothorax (PSP) is defined as pneumothorax occurring in otherwise healthy people. In contrast, secondary spontaneous pneumothorax (SSP) arises in patients with underlying lung disease such as chronic obstructive lung disease [1].

PSP is common, with an annual incidence of 18–28/100 000 cases for men and 1.2–6/100 000 for women [1]. The goals of PSP treatment are the drainage of air in pleural space and the prevention of recurrence. Essential issues of controversy are recurrence rates and the complications correlated with different treatment options.

Different conservative options are available for initial treatment, such as needle aspiration, chest drain or Heimlich valve. In order to reduce recurrence rates, chemical pleurodesis with talc by medical thoracoscopy is commonly used [1].

Surgical intervention is the established treatment for patients with SSP or recurrences of PSP. Surgical approaches include open thoracotomy, transaxillary mini-thoracotomy or video-assisted thoracoscopic surgery (VATS). These methods can be supplemented with different pleurodeses such as pleurectomy or pleural abrasion [2–4].

As regards pathogenesis, both emphysema-like-changes (ELCs) with ruptured blebs and bullae as the cause of PSP and 'pleural porosity' may be present. In order to prevent recurrence, therapy options should be related to the pathology behind the clinical event of pneumothorax. Moreover, treatment should be adjusted according to the needs of patients. PSP is a common disease in young men [5]. These patients may differ compared with patients with comorbidities in their view about optimal treatment [6].

We studied a large number of patients with a first episode of PSP and VATS as 'first-line' treatment approach in order to evaluate success rates, histopathology of PSP and satisfaction of patients.

MATERIALS AND METHODS

Patient population

The study population included all patients admitted to our thoracic surgery centre between May 2003 and April 2012 with a first

episode of PSP. All patients underwent initial treatment at our department.

The diagnosis of PSP was based on a first episode of pneumothorax (diagnosed by chest radiography) and the absence of conditions known to be associated with secondary pneumothorax. We excluded all patients with underlying lung disease, traumatic, malignant or recurrences of pneumothorax. We also excluded all patients without clinically apparent lung disease but bullous lung disease in histopathological specimen.

Of 567 patients with pneumothorax treated during the study period, 207 had a first episode of PSP. After the exclusion of 22 patients who decided for conservative treatment, overall 185 patients were subject to surgical intervention and underwent standardized VATS (Fig. 1).

Data recording

The following variables were recorded: age, gender, recurrence, duration of hospitalization, surgeon, surgeonś qualification, duration of operation, blood loss, macroscopic bullae, duration of suction and intra- and postoperative complications. Data were completely available for all patients.

Postoperative complications were defined as those occurring from first postoperative day to discharge, including one appointment for outpatient examination 10 days after discharge.

Surgical technique

VATS was performed in lateral decubitus position under general anaesthesia and one-lung ventilation with double-lumen intubation in 3-port-technique. If the patient had undergone tube thoracostomy with 28 Fr-chest drain for initial treatment, thoracostomy wound was used for one 10 mm trocar and video-thoracoscope with a 30-degree lens (Karl Storz, Tuttlingen, Germany). If he had had no incisions yet, first incision was made in the fifth intercostal space in anterior axillary line and 10 mm trocar was placed. After initial exploration of the pleural space, two more incisions were made under thoracoscopic control in the eighth intercostal space posterioraxillary line and third intercostal space mid-axillary line. The pulmonary ligament was dissected and the lung was mobilized by adhesiolysis. Afterwards, warm saline solution was instilled into the pleural cavity and investigated for the site of air leak, like ruptured bullae, by ventilating the lung. Bullae were grasped and resected by Endo-GIA endostapling device (Endo-GIA, Covidien (former AutoSuture), Germany). In case of no identification of bullae and no air leakage sign, apical wedge resection of segment 1 was performed. Finally, saline solution was instilled, the lung was inflated and carefully inspected for air leaks. Pleurodesis was accomplished by sub-total parietal pleurectomy from the first to fifth intercostal space. A 28 Fr chest tube was inserted through posterior incision and connected to a mobile aspiration system (Weinmann ACCUVAC Rescue, Weinmann, Germany) with fixed suction of 50 mmHg. Local infiltration with 20 ml of 0.5% bupivacaine was given in each intercostal space used for incision.

The endotracheal tube was removed in operating theatre and the patients were observed at standard care unit. There was no conversion of VATS to open thoracotomy.

The specimens of apical lung and the visceral pleura were sent to pathological examination.

Postoperative care

In the period from 2003 to April 2008, chest drain with external suction was applied for at least 96 h. Since May 2008, we reduced the duration of external suction to at least 72 h. After finishing external suction, the chest tube was closed for 24 h and removed if chest radiography revealed no evidence of pneumothorax. Postoperative pain management included oral tramadol (100 mg four times daily) and diclofenac retard (75 mg twice daily). Patients received omeprazole 20 mg once daily. This medication was continued until the patients were discharged. After discharge, the general practitioner tapered this medication completely within 10 days.

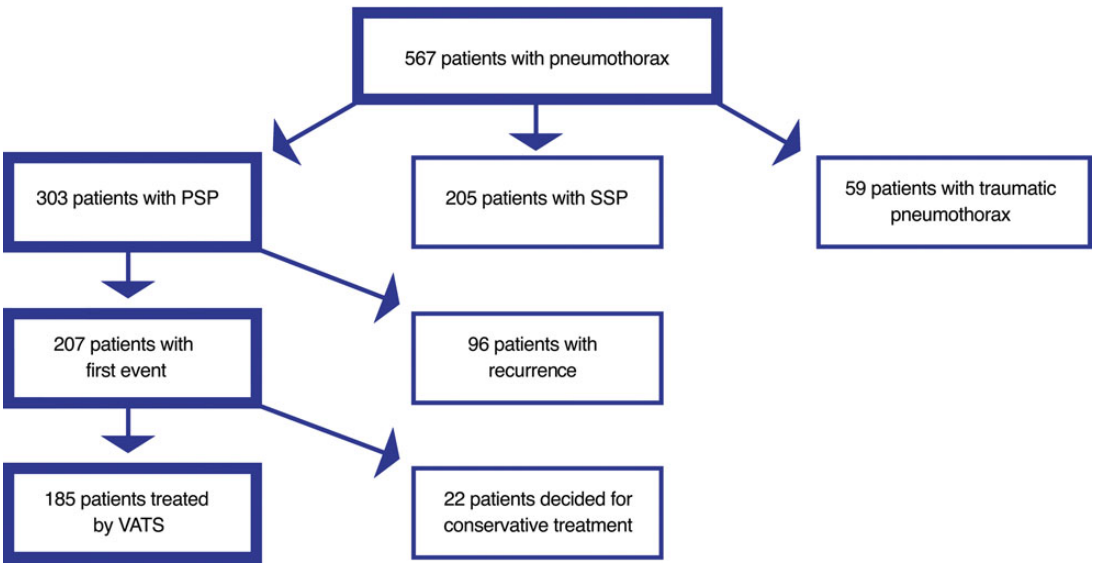

Figure 1: Aetiology of pneumothorax of patients treated in our department and patients' treatment decision. PSP: primary spontaneous pneumothorax; SSP: secondary spontaneous pneumothorax; VATS: video-assisted thoracic surgery.

Patients received low-molecular-weight heparin, 0.4 mg of nadroparine (2003–08) or enoxaparin (2008–13) daily during the entire hospitalization.

Physical therapy included mobilization at the day of the surgery. Furthermore, daily respiratory exercises under supervision of a physiotherapist and patient-controlled exercises with volumetric exerciser spirometer (Voldyne, Germany) and pressure-cycled respiratory exercises (Salvia ALPHA, SALVIA medical, Germany) were performed.

Outcomes

All procedures were timed from skin incision to skin suture.

We defined prolonged air leak as every leakage of air into pleural space for up to 5 days after VATS. Early recurrence corresponded to such event within 1 month after surgical intervention. Late recurrences included all events later than 1 month after surgical intervention.

Follow-up

We sent a questionnaire to all patients. Patients who did not answer the questionnaire were contacted via telephone.

Patients were asked whether there was any recurrence and whether a potential recurrence was treated. They were also requested to score their physical working capacity at a numerical rating scale. Zero points corresponded with no physical fitness at all and 10 points corresponded with complete physical capacity. Patients were asked about their satisfaction with cosmetic results and whether they would still prefer minimally invasive surgical technique.

In addition, patients were asked to report the duration of postoperative pain. In case of persisting pain, they were asked to score the intensity on a scale from 0 to 10 points. The numeric rating scale item defines 1–4 as mild, 5–6 as moderate and 7–10 as severe pain [7].

Statistics

Data entry was carried out using Microsoft Excel 2010. For descriptive statistical assessment, the SPSS Version 17.0 was used. Continuous variables are presented as means with SD or median with range. Recurrence-free times were calculated according to Kaplan–Meier analysis.

RESULTS

Patient characteristics

The 185 patients had a mean age of 32.6 ± 15.5 years. A total of 56 patients (30.3%) were female, and 129 (69.7%) male. Hundred (54.1%) patients were treated on the right side, 85 (45.9%) were treated on the left side. Median duration of hospitalization was 9 (8, 10) days, median (IQR) duration of postoperative stay was 7 (6, 8) days. Most important secondary diagnoses were previous contralateral pneumothorax (21 patients, 11.4%), pulmonary (10 patients, 5.4%) and infectious (9 patients, 4.9%) diseases. The age distribution of our study population is shown in Fig. 2. We compared it with the age distribution of the patients treated for first episode of SSP in our institution during the same period (n = 125).

Operation data

On average, VATS lasted 63.5 (±26.9) min. Mean loss of blood was less than 100 ml. Only one patient lost 150 ml of blood. Exact measurement, at less than 100 ml, was not possible, because of the limitations of the scale of the collecting container. Chest tubes were removed after 4 (±1.1) days. We used prolonged external suction therapy for additionally 4.3 (±1.3) days in 18 patients because of prolonged air leak.

About 55.7% of the procedures were performed by a consultant surgeon, 44.3% by residents under supervision of a senior physician. We found macroscopic bullae in 147 patients (79.5%). Further demographic and clinical data are summarized in Table 1.

Complications

There were no perioperative deaths. Three patients died during observation period, 22, 41 and 96 months after their surgical treatment of pneumothorax. At the date of surgery, they were 56, 63 and 75 years old. Causes of death included cancer or cardiopulmonary disease. The 10-year survival is calculated as 95.3%.

There were no intraoperative complications. The postoperative morbidity due to surgery was 7.6% (14 of 185 cases).

Thirteen patients (7%) needed revision during their hospitalization because of complications. Six patients, of these, had prolonged air leak, five cases experienced postoperative bleeding, and two patients empyema.

In 13 cases of prolonged air leak, the leakage stopped within 1 week, without further intervention. Re-expansion pulmonary oedema and wound infection occurred in one patient each (0.5%).

Follow-up

A total of 133 patients (71.9%) fulfilled follow-up and 52 patients were lost to follow-up. Mean follow-up period was 70.8 months (±33.5 months). Recurrence occurred in four cases (2.2%) after 12, 30, 36 and 40 months, so there were no early recurrences. Three-year recurrence-free time was 97.3% and 4-year recurrence-free time and 10-year recurrence-free time was 96.2%. The Kaplan–Meier curve for recurrence-free time is shown in Fig. 3.

One of the patients with recurrence (25%) had prolonged air leak during his hospitalization, which was treated conservatively. The other three patients showed no postoperative complications. Macroscopic bullae were found in two patients (50%) with recurrence during follow-up. One of the patients with recurrence (25%) had previous contralateral pneumothorax; the other three patients had no secondary diagnoses.

Mean physical working capacity was 7.95 points (±2.0). Pain due to surgery lasted less than 4 weeks in 71 cases (53.4%), in 40 cases (30.1%) 4 to 12 weeks, and in 22 cases (16.5%) longer than 12 weeks.

Only 6.2% of patients still declared moderate or severe pain. Eighteen patients (13.5%) still had pain during physical activity.

Twenty-eight (21.1%) patients developed paraesthesia and five patients (3.8%) suffered from paraesthesia and pain on exertion.

A total of 114 patients (85.7%) were satisfied with the cosmetic result and 130 (97.7%) responded that they would prefer a

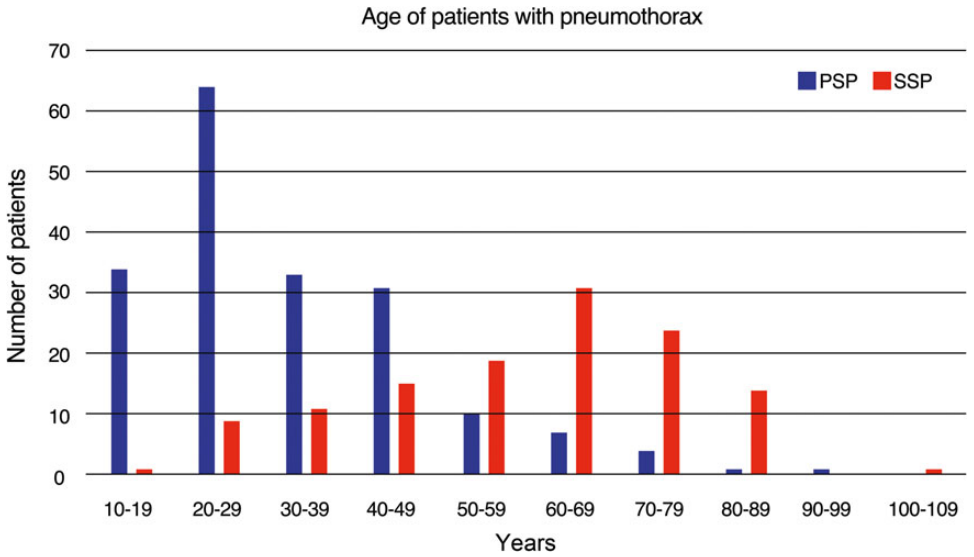

Figure 2: Comparison of age distribution of patients treated in our department for PSP and SSP. PSP: primary spontaneous pneumothorax; SSP: secondary spontaneous pneumothorax.

Table 1: Demographic, intraoperative and clinical characteristics

Demographic data	
Age (years)	
Median (range)	29 (14–90)
Mean (± SD)	32.6 (±15.2)
Gender	
Male (%)	69.7
Female (%)	30.3
Operated side	
Right (%)	54.1
Left (%)	45.9
Bullae identified (%)	79.5
Parenchymal scars identified (%)	63.2
Duration of procedure (minutes)	57 (26–153)
Hospitalization (days)	9 (6–30)
Operation to discharge (days)	7 (4–30)
Suction therapy (days)	4 (3–11)

Data are mean (± SD), median (range) or %.
SD: standard deviation.

minimally invasive surgery over an open technique. Results of follow-up are summarized in Table 2.

Pathological findings

Sub-pleural emphysematous changes were present in 100% of the lung specimen. Fibrosis of visceral pleura was additionally found in 131 cases (70.8%). Acute haemorrhage was found in 61.1% and residual haemorrhage in 35.7% and 51.4% of the resected lung apices revealed signs of chronic inflammation.

We found mesothelial hyperplasia of the parietal pleura in 173 cases (93.5%) and 89.2% of the pleural specimen showed pleural fibrosis and 78.9% showed chronic inflammatory changes. Further results of histopathological examination of the specimen of lung parenchyma and parietal pleura are given in Table 3.

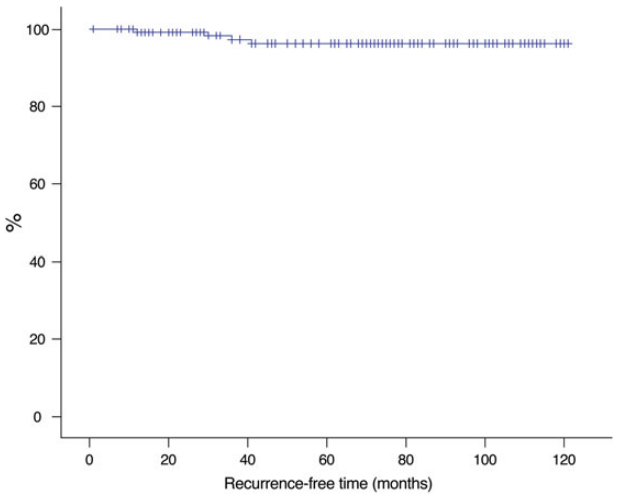

Figure 3: Kaplan–Meier curve of freedom from PSP recurrence.

DISCUSSION

The main findings of our study were as follows: (i) sub-pleural emphysematous changes were found in every histopathological specimen ; in addition, 70.8% showed fibrosis of visceral pleura; (ii) recurrence rate was (2.2%), and procedure-related morbidity rate 7.6%; (iii) 85.7% of patients were satisfied with the procedure and the cosmetic result.

The pathogenesis of PSP is still subject to debate. ELCs, such as blebs and bullae, are observed in 48–100% of cases [8], and ruptured bullae could cause PSP [2]. However, there are also patients without blebs and bullae. Several studies show that these patients have parenchymal lung lesions [3, 4]. These abnormalities include emphysema, pleural fibrosis and mesothelial thickening. We found the whole spectrum of lesions in our patients. Abnormalities of visceral pleura and lung parenchyma should underlie the so-called 'pleural porosity' [9–11]. Radomsky *et al.* found ruptured bullae only in 25% of their patients, but 'pleural porosity' as the reason for PSP

Table 2: Follow-up data

Follow-up	
Follow-up (month)	
Median (range)	77 (7–114)
Mean (±SD)	70.8 (33.5)
Recurrence rate (%)	2.2
Pain free (%)	72.9
Pain free or mild pain (%)	93.8
Pain, less than 4 weeks (%)	53.4
Pain, longer than 4 weeks (%)	30.1
Pain, longer than 12 weeks (%)	16.5
Satisfied with cosmetic result (%)	85.7
Prefer minimally invasive surgery (%)	97.7

Data are mean (± SD), median (range) or %.
SD: standard deviation.

Table 3: Results of histopathological examination

Specimen of parietal pleura (%)		Specimen of lung parenchyma (%)	
Mesothelial hyperplasia	93.5	Sub-pleural emphysema	100
Pleural fibrosis	89.2	Pleural fibrosis	70.8
Chronic inflammation	78.9	Acute haemorrhage	61.1
Sub-pleural fibrosis	76.2	Chronic inflammation	51.7
Oedema	16.8	Residual haemorrhage	35.7
Acute haemorrhage	3.2	Parenchymal scars	31.9
Pleural scars	1.1	Sub-pleural fibrosis	29.2
Residual haemorrhage	0.5	Mesothelial hyperplasia	13.5
		Oedema	1.6

Specimen of parietal pleura and lung parenchyma were examined.

in 75% of their cases, with air leakage through the irregular surface of intact bullae. Ohata and Suzuki [10] described 'small pores of several microns' in the surface of bullae causing air leakage. In examination by electron microscope, they detected the total absence of mesothelial cells and naked collagen fibres around these pores.

In other series, it is supposed that mesothelial cells may be replaced by an inflammatory elastofibrotic cell layer after disrupture [3, 12]. This inflammatory cell layer seems to have an increased porosity. Noppen *et al*. performed 'fluorescein-enhanced autofluorescence thoracoscopy' (FEAT) in patients with PSP in comparison with normal individuals. They found high-grade FEAT lesions in 58% of the PSP population and none in their control group. They observed that these lesions were located in addition to bullae noticed in white light thoracoscopy [11].

Our macroscopic and microscopic findings support both theories. First, we were able to identify macroscopically visible bullae during surgery in 79.5% of our patient population. In addition, we found emphysema in every microscopic lung specimen, combined with pleural fibrosis in 70.8% and chronic inflammation in 51.7%. Thus, it appears that underlying lung disease is regularly present in every case of PSP.

It remains controversial whether the presence of blebs and bullae or ELC is the driving risk factor for recurrence [5]. By resection of ruptured bullae, the current site of air leakage will be removed. Based on pathological findings of Ohata and colleagues, we assume that bullectomy is justifiable, even when no air leaking is visible.

The importance of pleurodesis is shown by Hatz *et al*. [13]. In their survey of 109 patients, they only performed pleurodesis (with parietal pleurectomy or talc powder) when no ruptured bullae were seen. They reported a recurrence rate of 4.6%; in all patients with recurrence, no pleurodesis was performed.

Currently, needle aspiration is recommended for first-line treatment of PSP by BTS [1]. If aspiration is not successful, therapy via chest tube should be the next step. Needle aspiration and chest tube show immediate success in 59.3%/68% [14, 15]. Ayed *et al*. compared treatment by needle aspiration with the treatment by chest tube. In addition, 10.8% of the intent-to-treat group with needle aspiration group (and 12.5% in the chest tube group) needed VATS anyway because of prolonged air leak. In the patient population of Noppen *et al*., 15% of the patients in the intent-to-treat with chest tube needed surgical intervention and 11% of the patients treated with simple aspiration needed tube drainage after 1 week. Recurrence rates reached 26% for needle aspiration and up to 27% for chest tube within the first year, respectively. Eberhardt [16] showed recurrence rates of 47% after chest drainage within 14.2 months. In a similar group of patients, treated via VATS, recurrence rate after 12 months was 4.2%. In the work of Tschopp *et al*. [5], the recurrence rate is stated up to 54%.

Overall, more than 10% of patients with PSP definitely need surgical intervention for the first episode of PSP and up to 54% of the initially successfully treated patients need surgical treatment because of recurrence within 4 years. Thus, it appears that more than 50% of the patients are undertreated by chest tube only.

Our data ascertain that PSP is always associated with a pulmonary pathology treatable with a limited surgical procedure and a low risk of complications. In view of these findings, it appears more logical to recommend primarily the curative approach and to explain the patients that needle aspiration and chest tube drainage are merely symptomatic treatment approaches with a high risk of recurrence.

Waller *et al*. [17] and Passlick *et al*. [2] found reduction of postoperative stay, use of analgetics, drainage duration and pulmonary dysfunction for patients treated by VATS, compared with lateral thoracotomy. Although VATS does not seem to be superior to transaxillary mini-thoracotomy in the duration of operation, recurrence and duration of chest tube, it seems to have advantages in long-term freedom from pain. For the perioperative and postoperative use of analgetics, conflicting results were published [18–20]. Kim *et al*. observed no benefit for patients treated by VATS, in the remaining series a shorter usage of analgetics was reported.

Sihoe *et al*. [21] showed paraesthesia is a common postoperative complication in long-term follow-up. One year after surgery, still 21% of their patients experienced paraesthesia. Gotoda *et al*. [22] reported that 1 year after thoracotomy, paraesthesia was reported in 28.2% and hypoesthesia in 16.5% of the cases. We found paraesthesia in 24.9% of our patients during the follow-up period (mean 70.8 months). Although there is less paraesthesia and pain after VATS, compared with open thoracotomy, the results are not satisfying. Unfortunately, different strategies to decrease pain and paraesthesia after surgery, like intercostal nerve blockade or early aggressive postoperative pain control, resulted insufficient [21]. In further studies, the reduction of pain by pre-emptive local anaesthesia and reduced pain and paraesthesia by gabapentin was shown [23, 24]. Overall, VATS shows advantages in long-term

freedom from pain and lower rates of paraesthesia when compared with thoracotomy.

Intra- and postoperative complications in surgical treatment of PSP by VATS occur in 0–12% [5]. The most frequent complication in all studies—as well in ours—is prolonged air leak. Our rate of complications was 7.6%, including 10.3% prolonged air leak.

Various authors presume that young patients might prefer surgical intervention for initial treatment because the fear of recurrence is associated with a loss of quality of life [6, 25]. Unfortunately, there is no survey about this question. We informed the patients about risks and advantages of all different therapy options and let them choose the treatment on their own. In our study period, only 22 patients (10.6%) decided for conservative treatment.

Satisfaction with the procedure was excellent. The large majority of our patient population was satisfied with the cosmetic result and would choose minimally invasive surgery again. Ben-Nun *et al.* [18] reported similar results. In their study, 83% were satisfied with cosmetic result and 94% with the operative results of VATS. They compared these results with satisfaction after mini-thoracotomy: 52% of these patients were satisfied with cosmetic and 73% with operative results. Olavarreti and Coronel published even better results for the treatment via VATS compared with mini-thoracotomy. Satisfaction with cosmetic results was 99 vs 4% and satisfaction with procedure 98 vs 63% [19].

STUDY LIMITATIONS

Our study has some limitations. First, it is a retrospective survey and, therefore, principally open to selection bias. Second, we made no direct comparison with conservative treatment, and had to refer to the results of the literature. This is also true for satisfaction rates. However, the strength of our study is that we performed a standard VATS approach in all patients and systematically evaluated all patients for pathological pulmonary lesions. We do not feel that the three main findings of our study are biased by the limitations inherent to retrospective surveys.

CONCLUSIONS

VATS with apical wedge resection and parietal pleurectomy is based on the underlying pathology of PSP and a most curative approach to the treatment. It combines low complication and recurrence rates. Long-term follow-up for postoperative pain and patient satisfaction after VATS show good results and a high patient acceptance.

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Conflict of interest: none declared.

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