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Original Article

Size of Pneumothorax can be a New Indication for Surgical Treatment in Primary Spontaneous Pneumothorax: A Prospective Study

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Purpose: Surgical treatment of primary spontaneous pneumothorax (PSP) is usually performed in cases of prolonged air leak (PAL) or recurrence. We investigated the effect of the size of pneumothorax in surgically treated PSP cases.
Methods: Between 2007 and 2008, 181 patients hospitalized with the diagnosis of PSP were prospectively recorded. The size of pneumothorax was calculated in percentages by the method defined by Kircher and Swartzel. Patients were divided into two groups, according to pneumothorax size: Group A (large pneumothorax, ≥50%), and Group B (small or moderate pneumothorax, <50%).
Results: The mean size of pneumothorax was 80.5 ± 10.4% in Group A (n = 54, 29%) and 39.5 ± 6.5% in Group B (n = 127, 71%). History of smoking and smoking index were significantly higher in Group A patients (p = 0.02, p <0.001, respectively). Fifty-five patients (29.3%) required surgery because of PAL or ipsilateral recurrence. The rate of patients requiring surgical operation was significantly higher in Group A (51.9%) than in Group B (n = 25; p <0.001). Rates of PAL and recurrence were higher in Group A than in Group B (p = 0.007, p = 0.004, respectively).
Conclusion: The size of pneumothorax is larger in those with a smoking history and a higher smoking index. Surgical therapy can be considered in cases with a pneumothorax size ≥50% after the first episode immediately.

Keywords: pneumothorax, surgical therapy, minimally invasive surgery (includes port access, minithoracotomy)

Introduction

Pneumothorax is defined as the presence of air between the parietal and visceral pleural cavity and the collapse of the affected lung. Its incidence is 18–28/100000 per year among healthy young men and 1.2–6/100000 per year among women at the same age group.[1] It is classified as primary spontaneous pneumothorax (PSP) and secondary spontaneous pneumothorax (SSP). Whereas the patient has no underlying lung disease in PSP, there is an underlying lung disease, such as emphysema, interstitial lung disease, tuberculosis, eosinophilic granuloma and rarely lung carcinoma in patients with SSP.[2] The optimal treatment of pneumothorax aims to fully expand the lung by evacuating the air from the pleural space. Furthermore, taking the recurrence rate of PSP (20% to 50%) into consideration, another treatment goal is the prevention of recurrences.[3] Surgical therapy in PSP is usually performed because of prolonged air leak (PAL) or recurrences.

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There are also publications suggesting that thoracoscopic surgery should be the first choice of treatment in all patients with a first episode.[4)]

Considering that the size of pneumothorax is directly proportional to the amount of air in the pleural space, the size of the pneumothorax may range from a small size which can be detected only by thoracic computed tomography (CT) scans to a total lung collapse. As the defect is larger in total lung collapse, ipsilateral recurrence or PAL is likely to occur more frequently in such cases.[1)] Therefore, the size of the pneumothorax can be suggested as another indication for surgical therapy. The aim of the present study is to investigate whether or not the size of pneumothorax was important as an indication for surgical therapy or contributed to the ipsilateral recurrences or PAL.

Material and Methods

Patient population

The records of 181 patients hospitalized in our clinic with the diagnosis of PSP between March 2007 and November 2008, and underwent closed thoracic drainage were prospectively recorded. All patients who presented with a PSP during this period in our hospital were included. Those with SSP or acquired pneumothorax were not included in the study. The size of the pneumothorax was calculated in percentages by the method defined by Kircher and Swartzel.[5)] The atelectatic lung area detected on the posteroanterior chest X-ray (B) was subtracted from the area of the hemithorax (A), and the result was divided by the area of the hemithorax (A) (**Figs. 1 and 2**). The patients were divided into two groups; pneumothorax size ≥50% was considered as Group A (large or extensive) (**Fig. 1**), and <50% was considered as Group B (small or moderate) (**Fig. 2**). Based on the previous studies,[1,6,7)] we defined patients with pneumothorax size more than 50% as large or extensive (Group A) and small or moderate when smaller than 50% (Group B).

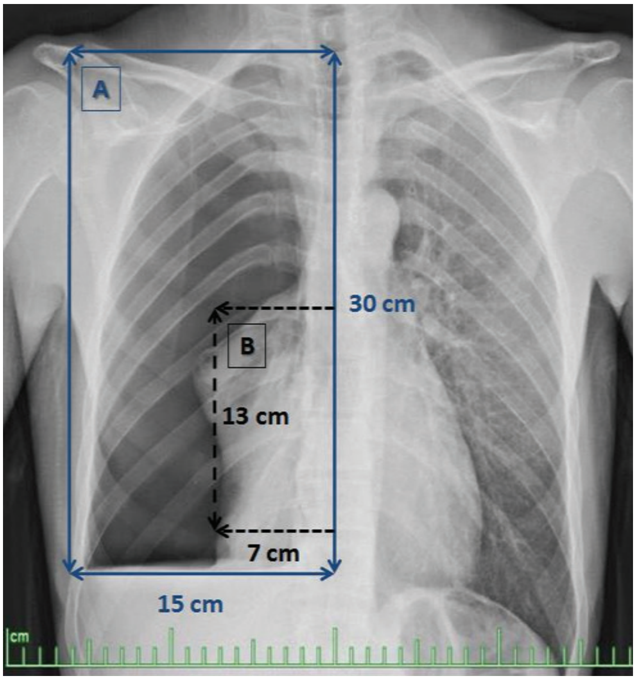

Fig. 1 Calculation of the size of pneumothorax using the method defined by Kircher and Swartzel [5] for Group A. A: Total hemithorax area ($30 \times 15 = 450$), B: Atelectatic lung area ($13 \times 7 = 91$) $(A - B)/A \times 100 = (450 - 91)/450 \times 100 = 79\%$ = Size of pneumothorax.

The initial treatment

All patients underwent tube thoracostomy, using 24F or 28F chest tubes, through the 5th intercostal space under local anesthesia and closed underwater seal drainage was performed. Following the application of the drain, control chest X-rays were obtained. Negative suction was applied in cases with massive air leaks or expansion defects on the control X-rays. The drains of patients with discontinued air leak and complete expansion were removed immediately. Their follow-up was done in the outpatient clinic.

Operation technique

Air leak persisting for more than five days was accepted as PAL. The patients with PAL or ipsilateral recurrence during the follow-up period underwent axillary thoracotomy (AT) or video-assisted thoracoscopic surgery (VATS). For AT, an incision 5–6 cm in size was made from the border of the hairy area towards the anterior-inferior in the axillary region and mini-thoracotomy was performed through the 3rd intercostal space.[4)] In VATS, the operation was performed through three ports, one of them being the tube thoracostomy site. In both procedures, apical segment of the upper lobe and superior segment of the lower lobe were examined in order to control for the presence of a bulla and/or a bleb. The lung was expanded with 30 cm water pressure under saline and checked for air leak. Using linear or endolinear staplers, we performed a wedge resection to the area of air leak or bulla/bleb. After the air leak had been controlled, total pleural abrasion was performed with a dry gauze sponge. A 24F or 28F chest tube was placed.

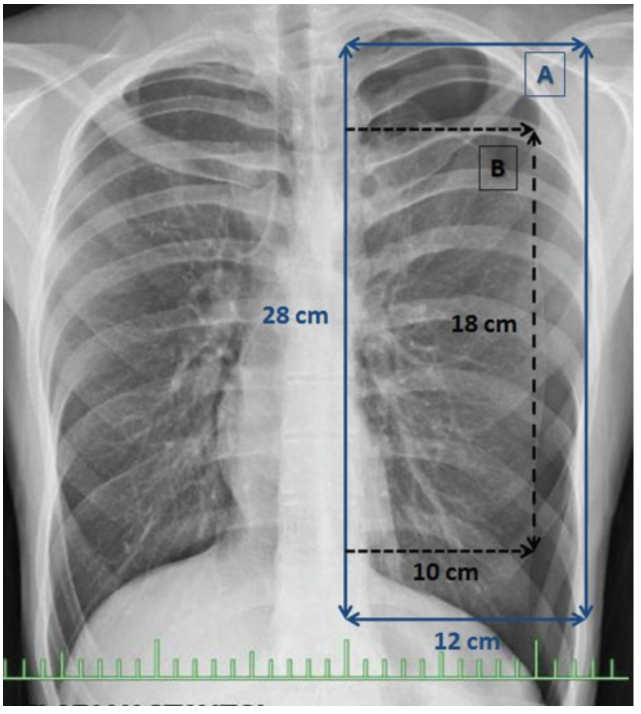

Fig. 2 Calculation of the size of pneumothorax using the method defined by Kircher and Swartzel [5] for Group B. A: Total hemithorax area (28 × 12 = 336), B: Atelectatic lung area (18 × 10 = 180) (A – B)/A × 100 = (336 – 180)/336 × 100 = 46% = Size of pneumothorax.

Postoperative chest X-rays were taken, and negative suction was applied.

Follow-up and data collection

All cases were followed in the outpatient clinic even if they had undergone surgery. The characteristics of the patients, such as age, gender, side, smoking status, the number of cigarettes smoked (packs/year) and the size of pneumothorax of the pneumothorax were recorded. Additionally, operative data, such as the need for operation because of PAL or ipsilateral recurrence, the type of operation (VATS/AT) and the mean postoperative hospital stay were also recorded. Data were analyzed by Statistical Package for the Social Sciences (SPSS) for Windows (version 15.0; SPSS Inc., Chicago, Illinois, USA). The student t-test and Chi square test were used to compare the two groups (Fisher's exact test was used if the expected cell count in one or more cells was less than 5). A p value <0.05 was considered statistically significant. Informed written consent from each patient was obtained. The interdisciplinary board of heads of departments in the institution evaluated and approved the study protocol. Because the protocol had an impact only on data collection and did not change routine clinical proceedings, a decision was made not to apply for the votum of an external review board.

Results

The mean size of pneumothorax was 80.5 ± 10.4% in Group A (n = 54, 29%), 39.5 ± 6.5% in Group B (n = 127, 71%), and 60 ± 8.4% (range, 30%–92%) for all patients. The mean age of patients in Group A (96% male) was 28.2 ± 7.7 years, whereas the mean age of patients in Group B (92% male) was 26.5 ± 6.7 years. The percentage of smokers and the smoking index were higher in patients with Group A, compared to patients with Group B. The differences between the two groups were significant (p = 0.03 and p <0.001, respectively) (**Table 1**). There was no significant difference between the groups in terms of the localization of pneumothorax (p = 0.136).

The patients were followed for a mean of 30.6 ± 5.88 months (range, 21–41 months). There was no significant difference between the follow-up periods of the two groups (p = 0.317). Fifty three cases (29.3%) required surgery because of PAL or ipsilateral recurrence. The rate of patients who required surgical operation was significantly higher in Group A (51.9%; n = 28) than in Group B (19.7%; n = 25; p <0.001). The rate of PAL was 25.9% in Group A and 10.2% in Group B (p = 0.007). Ipsilateral recurrence rate was found 25.9% in Group A and 9.4 % in Group B (p = 0.004) (**Table 2 and Fig. 3**).

VATS have been performed in approximately half of our patients (n = 31; 58.4%), whereas AT was performed on 22 patients (41.6%). There was no significant difference between the two < groups, in terms of the type of operation (p = 0.734) (**Table 3 and Fig. 3**). Postoperative complications occurred in five cases (9.4%); wound infection in two cases, PAL in two cases and expansion defect in one case. The mean postoperative hospital stay was similar in the two groups; 3.08 ± 1.15 days in Group A, and 3.1 ± 1.06 days in Group B (p = 0.936). The number of recurrences of pneumothorax for AT and VATS were similar between groups (n = 1 and n = 1 respectively, p = 0.781).

Discussion

Pneumothorax is defined as a collection of air in the pleural space, due to damage of blebs or bullae in the lung by any reason and the collapse of the affected lung. It is classified as PSP and SSP according to the etiology.[1]

Table 1 Clinical characteristics of the Group A and B

	Group A (n = 54)	Group B (n = 127)	P
Age (years), mean ± SD	28.2 ± 7.7	26.5 ± 6.7	0.145
Gender, n			
Male	52	117	0.305
Female	2	10	
Smoking, n			
Yes	46	88	**0.03***
No	8	39	
Cigarette (mean packs/year)	12.5	7.14	**<0.001***
Localization of the pneumothorax, n			
Right	41	82	0.136
Left	13	45	
Size of pneumothorax, mean ± SD	80.5 ± 10.4%	39.5 ± 6.5%	*na*
Follow-up period (months), mean ± SD	31.3 ± 5.97	30.3 ± 5.85	0.317

Group A: pneumothorax size ≥50%, Group B: pneumothorax size <50%. SD: standard deviation * p<0.05; *na*: not applicable

Table 2 Clinical progress and the need for surgery in the groups

	Group A (n = 54)	Group B(n = 127)	Total (n = 181)	p value
Need for surgery, n (%)	28 (51.9%)	25 (19.7%)	53 (29.3%)	<0.001*
PAL, n (%)	14 (25.9%)	13 (10.2%)	27 (14.9%)	0.007*
Recurrence, n (%)	14 (25.9%)	12 (9.4%)	26 (14.4%)	0.004*

Group A: pneumothorax size ≥50%, Group B: pneumothorax size <50%. PAL: prolonged air leak; SD: standard deviation * p <0.05

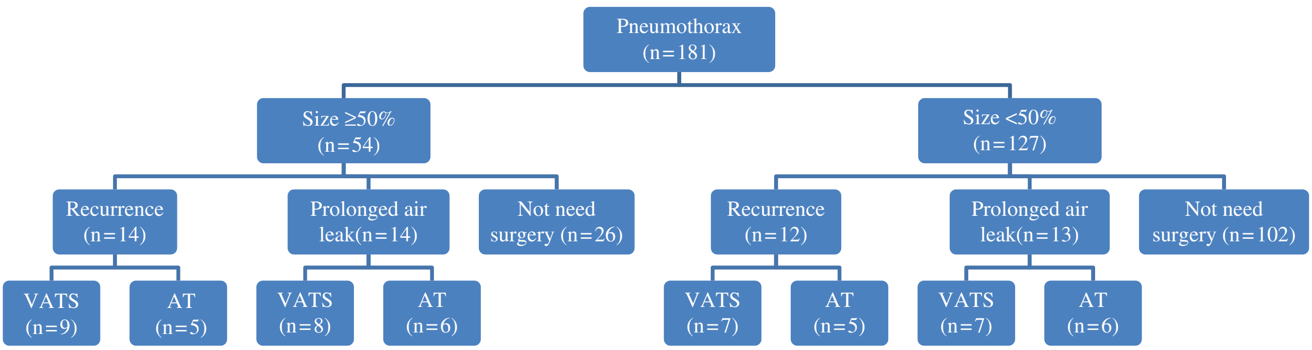

Fig. 3 Clinical progress and the need for surgery in the groups. VATS: video-assisted thoracoscopic surgery; AT: axillary thoracotomy.

Table 3 Data for surgery procedure, surgical outcomes and comparison of the hospital stay[a]

	Group A (n = 28)	Group B (n = 25)	Total (n = 53)	p value
VATS	17 (60.7%)	14 (56.0%)	31 (58.4%)	0.734
AT	11 (39.3%)	11 (44.0%)	22 (41.6%)	0.734
Postoperative complications	3 (10.7%)	2 (8.0%)	5 (9.4%)	0.742
Mean postoperative hospital stay (days), mean ± SD	3.08 ± 1.15	3.1 ± 1.06	3.09 ± 1.09	0.936
Recurren after surgery, n (%)	1 (3.5%)	1 (4.0%)	2 (3.7%)	0.781

[a]Calculated for Group A in 28 patients and for Group B in 25 patients. Group A: pneumothorax size ≥50%, Group B: pneumothorax size <50%. VATS: video-assisted thoracoscopic surgery; AT: axillary thoracotomy; SD: standard deviation * p <0.05

The patients with PSP were included in the present study. Size classification of PSP based on available treatment guideline definitions shows poor agreement.[8] The present study differ from the previously published series by calculating the pneumothorax size with Kircher and Swartzel's method,[5] which resulted better and more standardized classification of PSP.

It is still unclear under which conditions and why the blebs and/or bullae that have frequently been pointed out in the pathophysiology, are ruptured, and why some blebs or bullae are not ruptured. It is believed that bronchial abnormalities and distal airway inflammation or obstruction produces an emphysema-like picture leading to the rupture of the visceral pleura and air passage into the pleural space.[3] Smoking also affects the pathophysiology of spontaneous pneumothorax. It is directly proportional to the number of cigarettes smoked (packs/year), leading to a 22-fold increase in risk in males and 9-fold increase in risk in females.[9] The majority (74.1%) of the cases in the present study being smokers raised the thought that impairment of the distal airways by inflammation had an effect on the development of pneumothorax. It was determined that smoking and the number of cigarettes (packs/year) were associated with the size of pneumothorax ($p < 0.001$). Cigarette smoking is associated with the pathophysiologic consequences of extensive respiratory bronchiolitis, which had a significant impact on the recurrence rates of PSP.[10] This may be attributed to the fact that the ratio of corrupted distal and small airways increases with the increase in the number of cigarettes smoked leading to the enlargement of the defect that causes pneumothorax, and consequently the size of pneumothorax is proportionally increased.

Various treatment approaches from non-invasive methods to invasive methods, such as monitoring with nasal oxygen, simple aspiration and closed thorax drainage, are used in PSP.[3] There are also publications suggesting thoracoscopic surgery in the first episodes of all patients with PSP.[4] All patients admitted to our clinic underwent closed thoracic drainage, as the size of pneumothorax was over 20% in all of the cases. The mean size of pneumothorax was 40% in the Group B, and 81% in the Group A.

PAL and recurrence are the most common indications for surgical therapy in PSP. Surgical therapy is also recommended in patients with pneumonectomy, in pilots or divers in the first pneumothorax attack and in patients with bilateral synchronous pneumothorax.[3,4,11] Surgical methods include wedge resection and pleurectomy/pleural abrasion with VATS or AT and simple thoracoscopic talcage. However, the time for surgery, how many days should be considered as the limit for PAL, and after how many ipsilateral recurrences operation is required are still controversial. Considering that the prevalence of recurrence is 20% to 50% in PSP and increases up to 60% to 80% after the second episode, it is obvious that prevention of recurrences is another indication for treatment.[3,12] This may suggest that simple tube drainage is an unsatisfactory treatment for even a first episode of PSP, particularly in the presence of a large pneumothorax, lifestyle or medical factors that would make recurrence especially dangerous.[13] Chee, et al.[14] observed PAL in 25% of the cases with PSP. In our study, closed thoracic drainage was applied in all cases, and PAL was considered as air leak persisted longer than five days and cases with PAL or ipsilateral recurrence were operated. The prevalence of PAL (14.9%) and ipsilateral recurrence (14.4%) in our study was similar to those reported in the literature.[11,14] As the recurrence rates have been reported to be 54% within four years after the first attack, it can be thought that the recurrence rate in our study might be increased after long follow-up period.[15]

Bulla/bleb resection and wide pleural abrasion was applied to our patients via AT or VATS. Nowadays, AT in PSP, which is a benign disease, is considered effective to prevent ipsilateral recurrence, but it is a highly invasive procedure.[12,15] And VATS management of PSP offers good short-term results with excellent long-term freedom from re-operation and low recurrence.[13] We as well recommend VATS as the first choice in patients with PSP who require surgical intervention. VATS has been performed in approximately half of our patients (58.4%), although we have five operation rooms and only one operating room that includes a video system in our hospital.

Intriguingly, the patients had neither lung nor systemic disease and were healthy until the development of pneumothorax. The risk factors for pneumothorax and the cases that require surgery in the first episode is not clear. Emphysema-like changes were also found in 81% of patients with healed PSP who had never smoked, in contrast to none of the controls who had never smoked.[16] Although emphysema-like changes were seen in 81% of patients with PSP, no association with PAL or recurrence could be demonstrated.[17] In a publication of the British Thoracic Society in 2003 and 2010, smoking, height and age over 60 years have been reported as an independent risk factors for the recurrences in PSP.[1,18]

Potential ipsilateral recurrences or PAL might be thought to be more frequent in patients with total lung collapse since the defect has been reported to be larger in such patients.[1,18] In the study performed by Ryu, et al.[15] as well, the prevalence of ipsilateral recurrence and PAL was found higher in total lung collapse as compared to with partial collapse (70%, 39%, and 29%, 10%, respectively). These studies raise the thought that the size of pneumothorax as well may be an indication for surgery. The prevalence of ipsilateral recurrences and PAL were significantly higher in the group with a pneumothorax size ≥50% (Group A). This result naturally lead to a higher need for surgery in the Group A. Probably, as the defect that caused pneumothorax was larger in the Group A, it led to a larger collapse and a more active air leak. In this way, the higher prevalence of PAL in the group with a pneumothorax size ≥50% may be associated with the delayed closure of the defect.

Limitations of the present study are; 1) the smoking habits in the follow-up period, of patients after the first attack (but it should be kept in mind that patients are likely to give misinformation concerning smoking habits during their follow-up visits), 2) heights and weights of the patients (body mass index) were not recorded.

In conclusion, pneumothorax size is greater in patients with a smoking history and higher smoking index. As the recurrences, PAL and the need for surgery are more common in patients with a pneumothorax ≥50%, surgical option should be kept in mind after at their first episode of pneumothorax immediately.

Disclosure Statement

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