Review Article

Management of spontaneous pneumothorax: a mini-review on its latest evidence

Hei-Shun Cheng, Charles Wong, Pui-Hing Chiu, Chun-Wai Tong, Pui-Ling Flora Miu

Department of Medicine, Pamela Youde Nethersole Eastern Hospital, Hong Kong, China

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Correspondence to: Hei-Shun Cheng, MBBS (HKU), MRCP (UK), FHKCP, FHKAM. Department of Medicine, Pamela Youde Nethersole Eastern Hospital, 3 Lok Man Road, Chai Wan, Hong Kong, China. Email: chenghilson@gmail.com.

Abstract: Spontaneous pneumothorax usually presents as a medical emergency and requires prompt attention and treatment. In patients with underlying lung diseases, it is often associated with prolonged hospitalization, persistent air leak and also a high rate of recurrence. It brings considerable clinical burden to patients and therefore advancement of spontaneous pneumothorax management is eagerly anticipated. In recent years, conservative approach with avoidance of invasive treatment has risen to be a main consideration for primary spontaneous pneumothorax (PSP) patients who are clinically stable with minimal symptoms. The body of evidence in secondary spontaneous pneumothorax (SSP) group is less robust compared with that in PSP group. Non-surgical treatment in SSP is becoming more common due to concerns about morbidity and mortality after surgical pleurodesis as patients are usually older with more underlying medical diseases. Until last year, there have been no updates on the international recommendation of pneumothorax management since the British Thoracic Society (BTS) guideline published in 2010. The latest 2023 BTS guideline on pleural diseases provides us a good opportunity to review the latest development and literature of the care for patients with spontaneous pneumothorax. This article will explore the goals of pneumothorax treatment including air evacuation, cessation of persistent air leak and prevention of recurrence.

Keywords: Pneumothorax; spontaneous; persistent air leak; pleurodesis; recurrence

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Introduction

Pneumothorax, a Greek word of air (pneuma) in the chest that refers to abnormal air in pleural space, was first adopted by Jean Marc Gaspard Itard, a French physician, in his thesis published in 1803 (1). Nowadays, it is still a common clinical condition that brings considerable burden to our patients, especially those with underlying lung diseases (2,3).

Pneumothorax can be spontaneous, iatrogenic or trauma-related. Spontaneous pneumothorax is traditionally classified into primary spontaneous pneumothorax (PSP) in patients with no known underlying lung diseases and secondary spontaneous pneumothorax (SSP) in those with established lung diseases (4). This classification is considered simplistic because a significant proportion of PSP patients have structural lung abnormalities such as emphysema-like pulmonary changes on computed tomography (CT) imaging (5,6) and older PSP patients respond less favorably to certain interventions [e.g., needle aspiration (NA)] (4). Therefore, the distinction between these two entities becomes less clear (7) and patients without clinically apparent lung disease can be managed as SSP if they are older than 50 years of age with significant smoking history (8).

Pneumothorax is common worldwide. One British study published in 2018 revealed that the spontaneous pneumothorax admissions rate was 14.1 per 100,000 population of 15 years or older (2) with male to female ratio of 2.7. There was a significant increase of incidence compared with 1968 (9.1 per 100,000 population). A French study showed a slightly higher annual rate of 22.7 cases per 100,000 population of 14 years or older (9).

Treatment of pneumothorax—air evacuation

Conservative treatment

Conservative approach, despite its scarce evidence in the past (10), was recommended for patients (preferably PSP) with small pneumothorax size and minimal symptoms by 2010 British Thoracic Society (BTS) guideline (4). The rationale of conservative treatment is that almost 80% of small pneumothoraces (<15% in size) have no persistent air leak with low recurrence rate (4) and rapid lung re-expansion by means of chest drain treatment may adversely affect healing of lung defect, which is the cause of air leak (11). It is also attractive to those young PSP patients who opt to be managed in outpatient setting. Recently an Australian retrospective study on 111 PSP episodes (53 treated conservatively and 58 treated invasively) demonstrated that regardless of pneumothorax size, conservative approach resulted in significantly shorter hospital stay (0.6 *vs.* 6.5 days; P<0.05), similar recurrence rate (11% *vs.* 10%) and much lower complication risk compared with invasive treatment (12). Another randomized control trial (RCT) in 2020 on PSP showed that the percentage of lung re-expansion within 8 weeks were similar between conservative and invasive group (94.4% *vs.* 98.5%) (13). In the latest guideline, this conservative approach can be considered in those asymptomatic/minimally symptomatic PSP patients who wish to avoid invasive procedures (8).

The evidence of this approach is weak in SSP patients who have lower lung reserve, higher risk of persistent air leak and respiratory failure. There have been no prospective studies published to evaluate the efficacy of conservative treatment on SSP. Only one retrospective cohort trial attempted to address it (14). Although this study demonstrated success in the 25 SSP patients treated conservatively, it was limited by small sample size, potential bias and missing information on recurrence and hospital readmission rate.

Oxygen therapy

While supplementary oxygen therapy on hypoxemic patients is commonly adopted, oxygen therapy on non-hypoxemic patients is believed to fasten pneumothorax resolution by means of reducing partial pressure of nitrogen in alveoli and pulmonary capillaries, therefore increasing the diffusion gradient for nitrogen to be removed from the pleural cavity (15). However, this sound theory is only supported by an experimental animal study (16) or small human studies (oxygen level prescribed at 16 L/min) (17,18) that demonstrated resolution rate three to four times higher than that at room air (1.25–2.2% per day) (19,20). A Korean retrospective study in 2017 showed that oxygen therapy at 2–4 L/min also resulted in a higher resolution rate in PSP patients compared with control group (room air) (4.27% *vs.* 2.06% per day) (21). With such little evidence, the level of oxygen required and its treatment duration are not standardized. The risk of oxygen toxicity such as absorption atelectasis and CO_2 narcosis in patients with chronic lung disease has not been addressed either. As compared with previous guideline, this approach was not mentioned in the latest treatment recommendation.

Ambulatory treatment

Similar to conservative approach, the goal of management (especially PSP) emphasizes reduction of hospital stay and avoidance of complication secondary to invasive procedure. Insertion of a one-way-valve device facilitates air to be removed from the pleural cavity but not vice versa. It does not need to be connected to an underwater seal bottle system, allowing adequate patient mobility and even outpatient management. The success rate with Heimlich valve (HV) alone was up to 85.8% demonstrated by a systemic review in 2013 and 77.9% of patients with HV could be managed in outpatient clinic (22). Nevertheless, it was limited by its poor quality with high risk of bias. In view of this, an open label RCT (RAMPP trial) was published in 2020 showing that compared with standard care (either NA or chest drain insertion), ambulatory care resulted in significantly shorter median hospital stay (0 *vs.* 4 days; P<0.05), similar readmission rate but more adverse events (23).

There was another open label RCT attempting to address the efficacy and safety of ambulatory approach on SSP patient (24). However, the use of pleural vent (Fr 8) demonstrated a higher failure rate (46% *vs.* 15%) and also higher number of cases with surgical emphysema compared

with standard care group.

NA and chest drain insertion

NA involves using a 16–18G cannula to remove air in the pleural cavity and thus facilitates lung re-expansion. If there is more than 2.5 L of air being aspirated, NA should be stopped and chest drain insertion is usually indicated as persistent air leak is very likely in such scenario (4). A Cochrane systematic review of six studies (435 PSP patients) found that despite lower immediate success rate compared with chest drain insertion, the hospitalization duration was shorter with lower adverse event rate and similar 1-year success rate (25). An RCT published by Thelle *et al.*, the only study to enroll sufficient number of SSP patients for subgroup analysis (79 PSP and 48 SSP patients), demonstrated that the immediate success rate was higher than those receiving chest drain insertion with shorter hospital stay (26). However, caution should be taken that the success rate in the control group (chest drain group) was much lower than that shown in previous studies (38% *vs.* 64–100% in older studies) (27-29).

Chest drain insertion remains the most common procedure to be performed for SSP patients and PSP patients with symptoms or hemodynamic compromise as it allows immediate air removal and rapid symptoms relief. The main disadvantage, however, is the entailed complication risk (e.g., pain, haemothorax, infection) and prolonged hospitalization. The use of a smaller chest drain (12–14 Fr) has thus become a popular option to reduce post-insertion pain. Several retrospective studies have demonstrated superiority of small-bore chest drain in terms of shorter chest drain duration and lower complication risk while maintaining similar success rate as compared with large-bore chest drain (>20 Fr) (30-33). Although a small drain results in less pain, a large-bore chest drain is still indicated in patients with large air leak, surgical emphysema and those who are mechanically ventilated. However, drain size larger than 28 Fr confers no additional benefits in terms of flow rate (8,34).

After insertion, the chest drain can be connected to an underwater seal drainage system, which allows semi-quantitative assessment of air leak by observation of air bubbles. In the past decade, digital chest drain system has gained popularity as it enables physicians to assess air leak much more accurately. A meta-analysis of patients with post-pulmonary resection and a RCT on PSP patients demonstrated shorter duration of chest drain placement and length of hospital stay (35,36). It also allows better rehabilitation compared with the traditional drainage system as patient can be mobilized earlier while connecting to the drain bottle, which is smaller and has an in-built suction system.

When air leak ceases and the lung re-expands, chest drain clamping trial may be considered before tube removal. Despite recommendation by some experts, the efficacy of this practice to detect residual or unresolved pneumothorax remains controversial. It is also highly variable among physicians as revealed by a survey published by American College of Chest physicians which found that 47% of doctors performed clamping trial in PSP and 59% in SSP (37). Another Hong Kong retrospective observational study demonstrated that clamping trial is a safe procedure and it could save 11.8% of chest drain re-insertion (38). More prospective large-scale studies are required to address its efficacy and safety.

In brief, patient's symptoms and presence of high risk characteristics (haemodynamic compromise; significant hypoxia; bilateral pneumothorax; underlying lung disease; >50 years of age with significant smoking history; hemopneumothorax) are the two most important factors in initial treatment decision according to 2023 BTS guideline (8). While conservative approach can be considered in PSP, chest drain insertion is often necessary for SSP patients. Initial pneumothorax size alone no longer hints clinicians whether invasive treatment is needed but informs us whether it is safe to perform chest drain insertion at bedside (or an image-guided chest drain insertion is required).

Treatment of pneumothorax—persistent air leak cessation

Persistent air leak, defined as air leak of more than 2 days (4), is a common complication in spontaneous pneumothorax (particularly in SSP patients) (39-41) that leads to prolonged hospitalization and increased morbidity (42,43).

Surgery

Surgical approach, either by means of open thoracotomy or video-assisted thoracoscopy surgery (VATS), does not only stop air leak but also prevent recurrence. Surgery should be considered if there is ongoing air leak despite 5–7 days of chest tube drainage (8). However, it should be assessed individually as other factors including co-morbidities,

patient's wish and complication risk of operation are equally important. SSP patients are usually older with multiple underlying medical diseases and therefore often considered unfit for surgery. Other medical approaches should be considered.

Autologous blood patch pleurodesis

Different methods have been developed for PAL treatment of non-surgical candidates. Autologous blood patch pleurodesis is a technique involving injection of patient's own blood (50–100 mL) into the pleural cavity via the chest tube. The blood in the pleural cavity induces inflammatory response, enhances pleurodesis and the blood clots also seal the visceral pleural defect to prevent further air leak (44). One Egyptian study demonstrated that blood patch pleurodesis resulted in shorter air leak duration, duration to drain removal and length of hospital stay (45). Optimal volume of blood has also been addressed in a Chinese study in 2012 (46). In that study, SSP patients were randomly assigned to receive autologous blood of 2, 1, 0.5 mL/kg or normal saline of 1 mL/kg and the success rates of air leak cessation were 82%, 82%, 27% and 9% respectively. The authors suggested that blood volume of 1 mL/kg was sufficient to achieve therapeutic effect. While this approach is generally safe as only patient's own blood is required, risk of fever (10–13%) and infection (9%) should be noted (8,45,47).

Endobronchial valve (EBV) implantation

EBV, a one-way valve which prevents air going into the targeted lobe but allows air evacuation, can be deployed via a flexible bronchoscope. Balloon occlusion can be performed during the procedure to identify the site of air leak. If there is no air leak after balloon inflation on the targeted lobe or segment, EBV will be implanted on that site. However, in the presence of collateral ventilation, more than one valve may be needed and the success rate is variable. Treatment of PAL using EBV is currently supported by case reports, case series and retrospective studies (44). A case series published in 2009 demonstrated 47.5% of complete air leak resolution and 45% of air leak reduction in PAL patients who received EBV implantation (48). More recently, one multicenter retrospective study showed that success rate varied among different type of pneumothorax, with 100% success rate in iatrogenic pneumothorax but only 58% in SSP (49). A local case series pointed out that higher success rate was observed in those with fewer co-morbidities and immediate air leak cessation after EBV implantation (50).

2023 BTS guideline has made a "good-practice-point" recommendation that blood patch pleurodesis or endobronchial therapy should be considered for those who suffer from PAL but are not eligible for surgery.

Prevention of pneumothorax recurrence

Recurrence of pneumothorax brings considerable burden to patients and it was estimated to be 32% and 13–39% in PSP and SSP, respectively (2,8,51). Its prevention is therefore important and it can be achieved by either surgical or chemical approach.

Surgery

Surgery is recommended by the latest 2023 BTS guideline for the following (8):

(I) First pneumothorax presentation associated with tension and first secondary pneumothorax associated with significant physiological compromise;
(II) Second ipsilateral pneumothorax;
(III) First contralateral pneumothorax;
(IV) Synchronous bilateral spontaneous pneumothorax;
(V) Persistent air leak (despite 5–7 days of chest tube drainage) or failure of lung re-expansion;
(VI) Spontaneous haemothorax;
(VII) Professions at risk (e.g., pilots, divers), even after a single episode of pneumothorax;
(VIII) Pregnancy.

VATS or open thoracotomy are two most commonly adopted procedures with their pneumothorax recurrence being 31 per 1,000 patients and 15 per 1,000 patients, respectively (8). Bulla/bleb resection can be performed if a ruptured subpleural bulla/bleb is seen. Sometimes a non-ruptured bulla is resected in order to remove the potential source of future pneumothorax. During operation, surgical pleurodesis can also be carried out. This includes mechanical pleural abrasion, partial pleurectomy and talc poudrage. Compared with open thoracotomy, VATS is associated with lower complication rate and shorter hospital stay.

Despite a more promising result with surgical approach, some patients are considered ineligible for surgery due to their multiple co-morbidities and old age, which are more common in SSP population. The recurrence rate following surgery (9.3–12.5%) in SSP patients is also higher

compared with PSP group (52,53). In addition, a previous study revealed that older SSP patients suffered from a higher morbidity (20.6%) and mortality (4.1%) rate after surgery (53). Although patients with different underlying lung diseases are collectively categorized into SSP group, surgical outcome could be variable among them. One retrospective study demonstrated that patients with interstitial lung disease had lower success rate and survival rate compared with other lung conditions after surgery for pneumothorax (54), highlighting the importance of careful selection of SSP patients and the need of better risk stratification model in this population.

Chemical pleurodesis

Chemical pleurodesis has been shown to reduce pneumothorax recurrence rate (risk ratio: 0.56) (8) and talc (powder/slurry) is most commonly used for chemical pleurodesis among all agents. RCTs and case series demonstrated that the recurrence rates after talc poudrage (via either chest drain or thoracoscopy) ranged from 5.6% to 24.1% (55-61). Regarding minocycline pleurodesis, one Hong Kong local study on SSP patients demonstrated that minocycline had similar efficacy on immediate success rate (>70%) compared with talc (62) and another Taiwan study demonstrated reduction of recurrence in PSP patients (recurrence rate at 29.2%; OR: 0.43) compared with drainage alone (63). Caution should be taken on side effects including fever, pneumonia, chest pain and even acute respiratory distress syndrome (ARDS) after chemical pleurodesis. The risk of ARDS is markedly reduced after restriction of talc powder dose and size.

Conclusions

There have been major changes in the BTS pleural disease guideline published last year on the management of pneumothorax (8). Management of air evacuation, air leak cessation and recurrence prevention become more evidence-based but ongoing research is still warranted. While conservative and ambulatory treatments are increasingly adopted in clinically stable PSP patients, their evidence of efficacy and safety in SSP group are less robust. Chest drain insertion still remains the most common treatment in SSP patients for air evacuation. There are also concerns on morbidity and mortality following surgical approach for SSP group. Better categorization of patients' phenotypes and identification of those who benefit most from intervention are essential for risk stratification. With more upcoming large-scale studies, our understanding on pneumothorax and patient's outcome could be further enhanced.

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Footnote

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