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Indications of Surgery in Pneumothorax

Hany Hasan Elsayed

Abstract

Spontaneous pneumothorax (SP) is a type of collection of air in the pleural cavity that develops in the absence of trauma or iatrogenic cause. Its management has been a matter of debate for many decades. Nevertheless, clear guidelines from the American, British and European societies have been published. In this chapter, we will discuss the different society guidelines and the inter-guideline variations. We will also discuss the author's perspective for management of first-time pneumothorax which is an unsettled issue between respiratory physicians and thoracic surgeons. Finally, deviation from clinical guidelines is usually associated with deficient patient care, and in this chapter, the reflection on patient care from not following the pneumothorax guidelines will be discussed in detail.

Keywords: spontaneous pneumothorax, guidelines, first-time attack, indication for surgery, chest tube, primary pneumothorax, secondary pneumothorax

1. Introduction

Spontaneous pneumothorax (SP) is a type of collection of air in the pleural cavity that develops in the absence of trauma or iatrogenic cause [1, 2]. It is further classified as primary and secondary SP (PSP/SSP). While PSP affects patients with no clinically apparent lung disorders but small subpleural blebs/bullae, SSP involves an underlying pulmonary disease, which most often is chronic obstructive pulmonary disease (COPD) [2]. Spontaneous pneumothorax is a significant health burden, with annual incidences of 18–28 and 1.2–6 cases per 100,000 men and women, respectively [3]. The annual incidences of PSP among men and women are 7.4–18 (age-adjusted incidence) and 1.2–6 cases per 100,000 population, respectively; the annual incidences of SSP are similar, approximately 6.3 and 2 cases per 100,000 men and women, respectively [3].

Patients usually present with chest pain or breathlessness or both. Associated haemodynamic instability is an indication of a tension pneumothorax. The pathophysiology of PSP is a ruptured bleb or bullae which is usually located at the apex of the upper lobe or less frequently in the apical segment of the lower lobe. There is no known predisposing factor for its rupture and the resultant pneumothorax. SSP is caused more frequently by rupture of bullae in an underlying diseased lung, most commonly due to COPD/emphysema. It carries a significantly higher risk than PSP with mortality approaching 15% mainly due to associated patient comorbidities and low pulmonary reserve [4]. These differences between PSP and SSP are appreciated in guideline recommendations for management of spontaneous pneumothorax.

2. Percutaneous needle aspiration or chest tube drainage?

The evidence for needle aspiration NA as the initial treatment for spontaneous pneumothorax has been growing over the years. It is a simple, safe procedure and the learning curve for performing it is shorter than the classic chest tube drainage (CTD). It can also be performed in an out-patient setting, and if patients do require hospitalization, it usually requires a shorter hospital stay. Despite this, the guideline for using NA as an initial intervention is more evident in the European guidelines in comparison to the American guidelines for management of spontaneous pneumothorax.

The British Thoracic Society (BTS) guideline [5] and European Respiratory Society (ERS) task force statement [6] recommend aspiration as the first intervention, when needed, for all PSP without tension or haemodynamic instability. The BTS guideline is considered more modest for SSP: Needle aspiration can be considered for symptomatic patients with small spontaneous pneumothorax in an attempt to avoid CTD. On the other hand, the American College of Chest Physicians (ACCP) guideline [7] does not include needle aspiration for any patients with spontaneous pneumothorax. The classification of a small pneumothorax in the BTS guidelines is <2 cm on a chest X-ray.

Publication	No of patients	Includes SSP patients	Median hospital stay	Other outcomes	Recurrence rate
Harvey and Prescott, BMJ, 1994 [11]	73 (NA 35 and CTD 38)	No	3.2 vs. 5.3 (P = 0.005)	Total pain score was less with NA 2.7 vs. 6.7 (P < 0.001)	5/35 vs. 10/38 (P = 0.4)
Andrivet et al., Chest, 1995 [12]	61 (NA 33 and CTD 28)	Yes	7 vs. 7 days	CTD superior success 93% vs. 7% (P = 0.01)	29% NA vs. 14% CTD at 3 months (not significant)
Noppen et al., Am J Resp Crit Care Med, 2002 [13]	60 patients (NA 27 and CTD 33)	No	NA 54% vs. CTD 100% (P < 0.001)	1-week success rate NA 93% vs. CTD 85% (P = 0.4)	NA 26% vs. CTD 27.3% at 1 year (not significant)
Ayed et al., Eur Resp J, 2006 [14]	137 (NA 65 and CTD 72)	No	NA 1.8 days vs. CTD 4 days (P = 0.0003)	Immediate success in favour of CTD (68% vs. 62%, not significant), complications more with CTD	At 3 months NA 15% vs. CTD 8% (not significant)
Parlak et al., Resp Med, 2012 [15]	56 (NA 25 and CTD 31)	No	NA 2.4 vs. CTD 4.4 (P = 0.02)	Immediate success rate NA 60% vs. CTD 80.6% (P = 0.28)	At 1 year NA 4% vs. CTD 12.9% (P = 0.37)
Korczynski et al., Adv Exp Med Biol, 2015 [16]	49 (NA 22 and CTD 27)	No	NA 2 days vs. CTD 6 days (P < 0.05)	Immediate success rate NA 64% vs. CTD 82% (not significant)	Not measured

Table 1.

Studies comparing needle aspiration with chest tube drainage for management of spontaneous pneumothorax.

In cases of CTD, the BTS guidelines in 2003 [8] recommended insertion of the tube in the safety triangle of the chest to minimize the risks of possible injuries caused by the tube. The guidelines encourage physicians and surgeons to use the triangle in simple non-complicated pneumothoraces.

In a Cochrane review by Wakai et al. [9], they found no significant difference between simple needle aspiration and intercostal tube drainage for initial management of PSP regarding early failure rate, immediate success rate, duration of hospitalization, 1-year success rate and number of patients requiring pleurodesis at 1 year. Simple needle aspiration was associated with a reduction in the percentage of patients hospitalized when comparing it with intercostal tube insertion. Again, another recent meta-analysis by Kim and his colleagues [10] comparing seven studies for initial management of primary spontaneous pneumothorax showed that the recurrence rate of aspiration and intercostal tube drainage did not differ significantly, and again NA was associated with a shorter hospital patient stay. NA was however associated with inferior results regarding early resolution of pneumothorax in comparison to CTD. **Table 1** summarizes the studies performed showing the efficacy of NA in both PSP and SSP.

3. Indications of intervention according to the guidelines

The European Respiratory Society task force [6] for management of primary spontaneous pneumothorax has suggested five indications for definitive management: second-attack pneumothorax, persistent air leak 3–5 days, haemopneumothorax, bilateral pneumothorax and special occupations (divers and pilots).

The BTS guidelines [5, 8] agree with the same indications. The 2003 guidelines [8] had specified persistent air leak for 5 days in PSP and 3 days in SSP, but the 2010 [5] guidelines mention 5–7 days as an arbitrary number for persistent air leak for both PSP and SSP. The reason for giving a longer time period in PSP to wait for in the 2003 guidelines is that there is a better chance of healing of a ruptured bullae/bleb with the underlying normal lungs with PSP, while in SSP, the diseased lungs have a lower chance of sealing the leaking lesion if they have not done so in the first 3 days. The guidelines also add pregnancy as an indication for intervention.

The ACCP guidelines [7] mention 4 days of conservative treatment in patients with persistent air leak after drain insertion for spontaneous pneumothorax before surgical intervention. Again, the same indications mentioned by other guidelines are considered in the Delphi consensus statement.

The main indication in all guidelines for definitive intervention in cases of PSP and SSP is recurrence. The reason behind this is that the chances of a pneumothorax not recurring after the first attack are usually more than the chances recurring, and hence patients after the first attack are given a chance of no intervention provided their first pneumothorax has healed. Chances of recurrence after a second attack (ipsilateral or contralateral) are in the range of 60–80%, and hence patients are not usually offered the conservative option. Opponents of this opinion would argue that the chances of recurrence after the first attack are still too high to be acceptable for any logical patient. Estimates of the incidence of recurrent PSP range from 25 to more than 50%, with most recurrences seen within the first year [17]. As an example, a study of 153 patients with PSP found a recurrence rate of 54% [18].

Female gender, tall stature in men, low body weight and failure to stop smoking have been associated with an increased risk of recurrence [18, 19]. Unfortunately, most patients have a very unpleasant experience with their first attack of pneumothorax. The sensation of chest pain with breathlessness sounds like ‘I felt I am going to die’ as patients may express. The other unpleasant experience is insertion of a

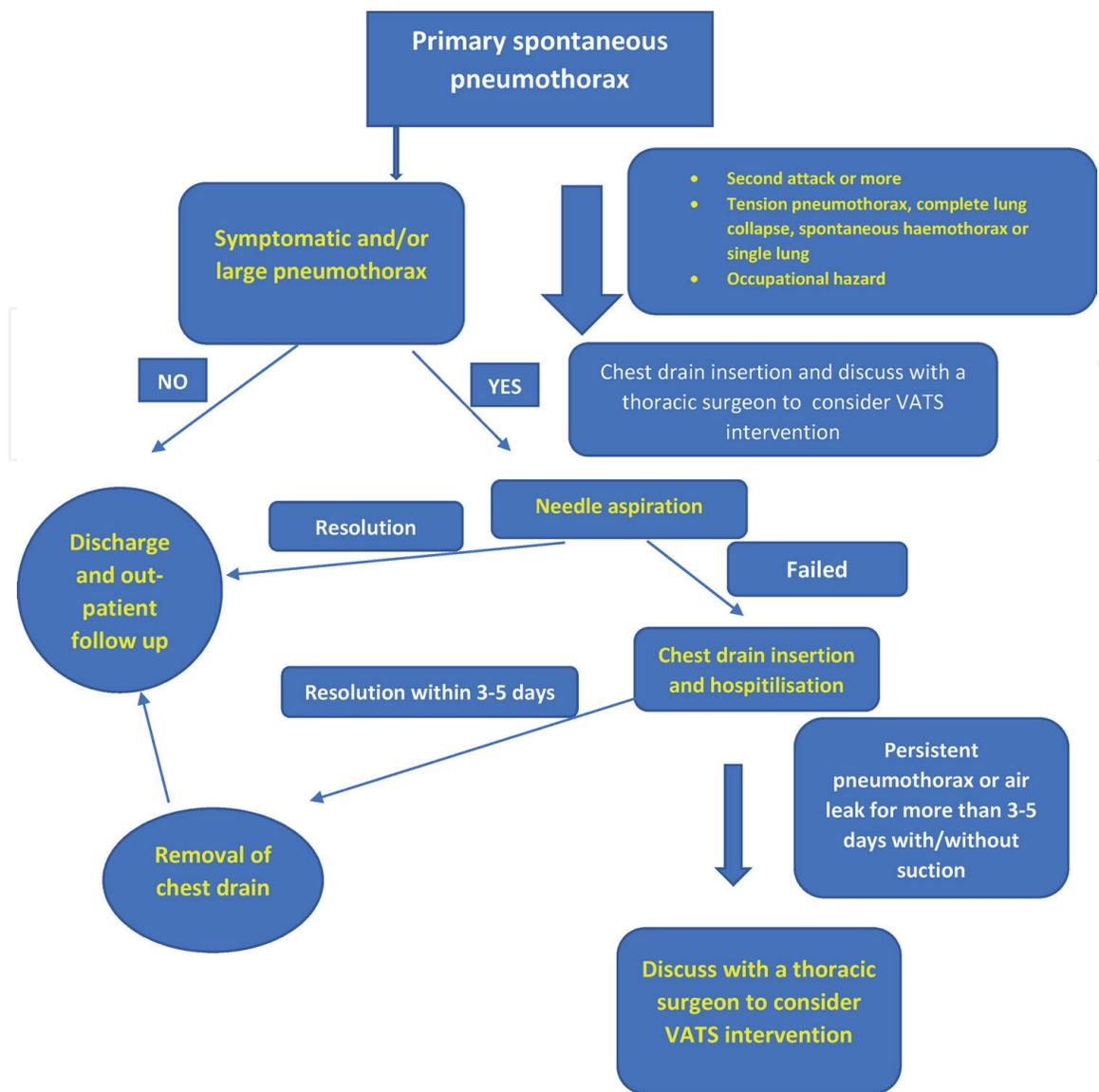


Figure 1.
Simple flowchart summary for management of primary spontaneous pneumothorax.

chest drain for drainage which is very frequently painful even with using generous local anaesthesia. These experiences usually form a painful memory scar for the patients and their parents which they would not like to experience again if the intervention to treat it carries a very low risk.

Figure 1 shows a flowchart summary recommended by the author for the different published guidelines for indications of intervention in primary spontaneous pneumothorax.

4. Guidelines for management of first-attack pneumothorax

In recent years there has been a trend towards a more conservative approach to management of primary spontaneous pneumothorax, based on the principle that intrapleural air does not necessarily require a therapeutic intervention and that management depends on the clinical symptoms and not on the size of the pneumothorax [20]. This conservative approach may be appropriate as tension pneumothorax from a PSP is extremely rare [21]. In selected patients with minimal or no symptoms and good access to medical care in case of deterioration, observation alone may be appropriate.

Within the current British Thoracic Society guidelines (from 2010), there is a significant emphasis on a conservative approach to treatment [5] with management predominantly based on clinical symptoms. In contrast, the American College of Chest Physicians Delphi consensus statement (from 2001) recommended a more aggressive approach, with intercostal drain placement recommended in any pneumothorax larger than 20% of the hemithorax, irrespective of the symptoms [7].

Patients with an attack of tension pneumothorax (quite rare in PSP) and more commonly patients with a first attack associated with complete lung collapse should be counselled about the benefits of definitive intervention with VATS due to the life-threatening condition of a tension pneumothorax or the higher than usual risk of recurrence associated with a complete collapsed lung. This is probably due to an associated larger bulla with a completely collapsed lung, and hence the chances of re-rupture seem higher than a simple smaller size pneumothorax attack which is usually associated with a bleb or small bulla.

It is in the previous context that current clinical practice guidelines for management of spontaneous pneumothorax tend to avoid use of surgery for patients with only a single episode of PSP. The trauma—considering not only physical but also perhaps psychological—of receiving such major surgery for a simple benign disease in a young patient was considered quite excessive if the recurrence rate of attacks is not high. The 2003 British Thoracic Surgery Guidelines for the management of spontaneous pneumothorax specifically referred to an open thoracotomy as the ‘gold standard’ for surgical management [8].

With this in mind, it would be unsurprising that clinicians are reluctant to offer such aggressive surgery. This is reflected in those guidelines listing the indications for surgery to only be first contralateral pneumothorax, second ipsilateral pneumothorax, synchronous bilateral spontaneous pneumothorax, single attack of tension pneumothorax, a persistent air leak after chest drain insertion, and spontaneous significant haemothorax [5–8]. First episode PSP is deliberately excluded. In a similar context back in 2001, the American College of Chest Physicians consensus statement on the management of spontaneous pneumothorax explicitly states that ‘procedures to prevent the recurrence of a primary spontaneous pneumothorax should be reserved for the second pneumothorax occurrence’ [7].

It is therefore evident that views on surgical indications are influenced by the perceived harm from surgery, the aggression of intervention and the simplicity of the disease. Over the past decade or more since the above guidelines, the trauma from thoracotomy remains existing. What we think has changed, though, is the current view of whether an open thoracotomy remains the surgical approach of choice across the world.

The combination of lowered morbidity with equivalent efficacy at preventing recurrence means that open thoracotomy should no longer be regarded as the first-line approach for the surgical management of PSP [22, 23]. Today, VATS has become the approach of choice by surgeons throughout the world, and it is rare to find traumatic open thoracotomy being offered to young patients with PSP especially that many are young patients and could be manual workers where thoracotomy would be an obstacle to perform their job satisfactorily. Compared to the 2003 version, the latest British Thoracic Surgery Guidelines for the management of spontaneous pneumothorax published in 2010 pointedly no longer uses the words ‘gold standard’ in relation to open thoracotomy [5, 8]. Instead, it is very noticeable that when the latest guidelines advised surgical pleurodesis for specific circumstances (such as pregnancy), VATS is the only approach named, and open thoracotomy is nowhere to be seen.

In summary, the management of a first-attack pneumothorax according to the current guidelines is debatable and incoherent. Advice will range from conservative

Ref.	No. of patients	Chest drain duration	Length of stay	Follow-up	Recurrence	Cost	Other
Schramel et al., ERJ [24]	149 first episode PSP VATS: 70 Chest drain: 79	(Both first and recurrent episode included)	(Both first and recurrent episode included)	Chest drain: 96 ± 18 months VATS: 29 ± 10 months	1 year: VATS (3%) < CD (19%) 2 years: VATS (4%) < CD (22%)	VATS < chest drain cost of treating recurrence: VATS similar to chest drain	
Torresini et al., EJCTS [25]	70 chest drain: 35 VATS: 35	VATS: 3.9 days Chest drain: 9 days	VATS: 6 days Chest drain: 12 days	12 months	VATS: 2.8% Chest drain: 22.8%	VATS: \$1925 Chest drain: \$2750 (cost of recurrence also included)	Secondary pneumothorax included chest drain arm: 2 VATS arm: 4
Chou et al., ICTVS [26]	VATS: 51	2 days (54%)	3 days (54%)	38 months	0	—	
Margolis et al., ATS [27]	VATS: 156	—	2.4 ± 0.5 days	2–96 months (median: 62 months)	0	—	Talc poudrage for all patients intra-op
Sawada et al., Chest [28]	281 Chest drain: 181 Thoracotomy: 13 VATS: 87	—	Chest drain: 14.5 days Thoracotomy: 22.2 days VATS: 8.3 days (<i>P</i> < 0.001)	13–163 months (mean: 78.3 months) Not specified for first episode cases	Chest drain: 54.7% Thoracotomy: 7.7% VATS: 10.3% (<i>P</i> < 0.001) (thoracotomy vs. VATS: <i>P</i> = 0.61)	—	Length of stay analysis included both first and recurrent episodes
Chen et al., ATS [29]	52 chest drain: 22 VATS: 30	—	VATS: 4.8 Chest drain: 6.1 (<i>P</i> = 0.034)	3–38 months (mean 16 months)	VATS: 3.3% Chest drain: 22.7% (<i>P</i> = 0.038)	Total cost of 1 hospital stay VATS: \$1273 Chest drain: \$865	All patients had failed initial needle aspiration

Table 2.
Studies using video-assisted thoracoscopy for management of first-attack spontaneous pneumothorax.

management of 'doing nothing' up to a VATS intervention on the next available list. Needle aspiration and chest tube drainage are commonly used modalities, but CTD will remain the most common and classic intervention for an attack of pneumothorax worldwide. It is the author's preference to send patients for a VATS intervention on the next available list without inserting a chest tube (provided there is no respiratory compromise) to allow a shorter hospital stay, allow patients to return to work or school as early as possible and most importantly avoid the high risk of recurrence. **Table 2** shows studies starting more than two decades ago considering VATS for first-attack pneumothorax.

A conservative approach with follow-up or needle aspiration seems as a reasonable first-line option in a first-attack small-sized pneumothorax. In patients with a large pneumothorax who are not keen for surgery or with hospital logistics that would hinder the availability of VATS intervention on the next morning list due to lack of facilities or personnel, a chest drain insertion is the most reasonable option. Further intervention will then be guided by the time of resolution of the pneumothorax, availability of a VATS intervention service and patient wishes after understanding the risks of recurrence after the first attack.

5. Guideline recommendations for lifestyle changes post pneumothorax

Recommendations for passengers travelling by air after an attack of pneumothorax was largely based on anecdotal case reports [30, 31]. A pneumothorax, especially an undrained one, is however an absolute contraindication to all commercial air travels [32]. Travelling with a chest drain inserted for pneumothorax had no published guidelines or recommendations. It is theoretically safe, but most airlines would not be willing to accept such a risk and would need documented medical input and insurance approval to allow patients to travel.

According to the BTS guidelines, commercial airlines advise individuals to avoid air travel for 6 weeks after an episode of primary spontaneous pneumothorax and stress that patients should not fly until resolution has been confirmed [8].

Although there is no evidence that recurrence is caused by flying, the consequences of a pneumothorax occurring during a flight could be serious because of the lack of medical care. Restrictions on flying may be more justified in patients for whom pneumothorax is associated with higher risk, such as smokers and patients with underlying lung disease (secondary spontaneous pneumothorax). In patients with secondary pneumothorax who have not been treated surgically, air travel should be avoided for 1 year after an episode (grade C recommendation). Patients with a history of pneumothorax who have not been treated surgically should also be advised against practising high-risk sports, such as diving (grade C recommendation) [8].

The performance of a VATS procedure can offer patients more safety to fly or practise diving sports. This makes patients with occupations as pilots and scuba divers candidates for a VATS intervention even with a first-attack pneumothorax. Definitive treatment significantly reduces the risk of recurrence and makes air travel safer from an airline point of view [30]; however, an individual clinical decision is usually made by the treating clinician, considering both airline policy and details of relevant insurance.

There are no specific guidelines regarding lifestyle modification to prevent patients from having another attack of pneumothorax apart from advising all patients to stop smoking. Despite the apparent relationship between smoking and pneumothorax, 80–86% of young patients continue to smoke after their first episode of PSP [33]. Smoking cessation remains the only reversible risk factor known

to reduce the chance of recurrence although we should not neglect the deleterious role of marijuana and cannabis smoking as a risk of PSP. From the author's point of view, cannabis has a more destructive effect on the lung parenchyma exposing patients to a higher risk of first-attack and recurrent pneumothorax. This has also been noted elsewhere [34]. Smoking cessation advice is therefore given to all our patients who smoke after the first episode of spontaneous pneumothorax.

6. Hazards of non-compliance with pneumothorax guidelines

Despite the availability of published guidelines, there has been a recording in the English literature of non-compliance or deviation from the guidelines, which has occasionally resulted in inconsistency or patient harm in management of spontaneous pneumothorax. We have previously published our experience in a large UK tertiary centre [35] where the median time to referral from chest physicians to thoracic surgeons after the 2003 BTS guideline publication was 10 days for a persistent pneumothorax which is longer than any time suggested by all guidelines. This has resulted in a higher incidence of developing empyema and the more frequent need of a thoracotomy rather than VATS treatment for patients with delayed referral. Delayed referral is one of the most common areas of deviation from published pneumothorax guidelines.

When assessing a pneumothorax, the size will determine the initial step of management, ranging from conservative treatment, needle aspiration up to chest tube drainage in larger pneumothoraces. There is discrepancy in size calculations of pneumothorax between different guidelines, and this has resulted in inconsistency in management. Kelly and Clooney have noticed this with management of 234 patients managed in Australia [36], and patients with a large pneumothorax were treated conservatively. Yoon et al. have studied size calculation of PSP in 87 patients in a tertiary UK centre and found significant discrepancy between the size calculation suggested in the BTS guidelines (resulting in only 70% compliance) and the ACCP guidelines (resulting in only 32% compliance) with consequent inconsistent management [37]. Sole blame on physicians and surgeons applying the guidelines can be unfair as there is obvious inconsistency in size calculation between different pneumothorax guidelines [38], and estimation of the size using only a chest X-ray can yield variable results [39].

The BTS guidelines [8] suggest explicitly inserting a chest drain for simple spontaneous pneumothorax in the 'safe triangle of chest'. We have previously published that knowledge of the guidelines regarding this site of insertion is deficient in surgeons and physicians involved in insertion of chest drains [40]. This resulted in more than 50% of drains inserted being outside the 'safe triangle' exposing patients to an unnecessary risk of higher morbidity associated with this common everyday procedure.

7. Summary

To conclude, the current guidelines available for treatment of spontaneous pneumothorax would state that in cases of spontaneous pneumothorax, patients will be assessed for clinical status and size of pneumothorax. In a very small PSP pneumothorax with no clinical complaint, it would be reasonable to discharge the patient and follow up. All patients with SSP require hospital admission. In a sizable pneumothorax with symptoms, the BTS and ERS guidelines would recommend needle aspiration with chest drain insertion if failed. The ACCP guidelines would

recommend a chest drain straightaway. If the pneumothorax persists for 3–7 days according to different guidelines, definitive treatment is required. The BTS, ACCP and ERS guidelines choose first-attack tension pneumothorax, bilateral pneumothoraces and special occupations (pilots and divers) as indications for definitive intervention after one attack of spontaneous pneumothorax, while the BTS guidelines add pregnancy and previous pneumonectomy as indications.

All guidelines agree that second-attack ipsilateral and first-attack contralateral recurrent pneumothorax are indications for intervention. The management of first-attack pneumothorax is debatable in all guidelines and will range from conservative management up to performing a VATS for definitive treatment. This will depend on the clinical situation, availability of resources/personnel and patient wishing to avoid the relatively high chance of recurrence. With the advancement in VATS techniques and significant reduction in risk of recurrence with a VATS intervention, it could be reasonable to perform the procedure on the next available list. A VATS procedure should be the standard surgical procedure for pneumothorax patients, and an open thoracotomy is no longer considered the 'gold standard' in all guidelines. All patients with an attack of spontaneous pneumothorax need lifestyle modifications regarding their smoking status, sport activity and travelling through air flights.

Physicians and thoracic surgeons should be aware of the current available guidelines for management of spontaneous pneumothorax. Deviation from the guidelines, particularly regarding the time to refer patients for definitive treatment, is associated with higher patient morbidity (particularly developing an empyema), increased hospital stay and higher medical costs.

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References

- [1] Noppen M, De Keukeleire T. Pneumothorax. *Respiration*. 2008;**76**(2):121-127
- [2] Gupta D, Hansell A, Nichols T, Duong T, Ayres JG, Strachan D. Epidemiology of pneumothorax in England. *Thorax*. 2000;**55**(8):666-671
- [3] Noppen M. Spontaneous pneumothorax: Epidemiology, pathophysiology and cause. *European Respiratory Review*. 2010;**19**(117):217-219
- [4] Won Choi II. Pneumothorax. *Tuberculosis Respiratory Disease*. 2014;**76**(3):99-104
- [5] MacDuff A, Arnold A, Harvey J. Management of spontaneous pneumothorax: British Thoracic Society Pleural Disease Guideline 2010. *Thorax*. 2010;**65**(Suppl 2):ii18-ii31
- [6] Tschopp JM, Bintcliffe O, Astoul P, Canalis E, Driesen P, Janssen J, et al. ERS task force statement: Diagnosis and treatment of primary spontaneous pneumothorax. *The European Respiratory Journal*. 2015;**46**(2):321-335
- [7] Baumann MH, Strange C, Heffner JE, Light R, Kirby TJ, Klein J, et al. Management of spontaneous pneumothorax: An American College of Chest Physicians Delphi consensus statement. *Chest*. 2001;**119**:590-602
- [8] Henry M, Arnold T, Harvey J. BTS guidelines for the management of spontaneous pneumothorax. *Thorax*. 2003;**58**(Suppl 2):ii39-ii52
- [9] Wakai A, O'Sullivan RG, McCabe G. Simple aspiration versus intercostal tube drainage for primary spontaneous pneumothorax in adults. *Cochrane Database of Systematic Reviews*. 2007;**1**:CD004479
- [10] Kim MJ, Park I, Park JM, et al. Systematic review and meta-analysis of initial management of pneumothorax in adults: Intercostal tube drainage versus other invasive methods. *PLoS ONE*. 2017;**12**:e0178802
- [11] Harvey J, Prescott RJ. Simple aspiration versus intercostal tube drainage for spontaneous pneumothorax in patients with normal lungs. British Thoracic Society Research Committee. *BMJ*. 1994;**309**:1338-1339
- [12] Andrivet P, Djedaini K, Teboul JL, et al. Spontaneous pneumothorax. Comparison of thoracic drainage vs immediate or delayed needle aspiration. *Chest*. 1995;**108**:335-339
- [13] Noppen M, Alexander P, Driesen P, et al. Manual aspiration versus chest tube drainage in first episodes of primary spontaneous pneumothorax: A multicenter, prospective, randomized pilot study. *American Journal of Respiratory and Critical Care Medicine*. 2002;**165**:1240-1244
- [14] Ayed AK, Chandrasekaran C, Sukumar M. Aspiration versus tube drainage in primary spontaneous pneumothorax: A randomised study. *The European Respiratory Journal*. 2006;**27**:477-482
- [15] Parlak M, Uil SM, van den Berg JW. A prospective, randomised trial of pneumothorax therapy: Manual aspiration versus conventional chest tube drainage. *Respiratory Medicine*. 2012;**106**:1600-1605
- [16] Korczyński P, Górska K, Nasiłowski J, et al. Comparison of small bore catheter aspiration and chest tube drainage in the management of spontaneous pneumothorax. *Advances in Experimental Medicine and Biology*. 2015;**866**:15-23

- [17] Light RW. *Pleural Diseases*. 6th ed. Philadelphia: Lippincott, Williams and Wilkins; 2013
- [18] Sadikot RT, Greene T, Meadows K, Arnold AG. Recurrence of primary spontaneous pneumothorax. *Thorax*. 1997;**52**:805
- [19] Guo Y, Xie C, Rodriguez RM, Light RW. Factors related to recurrence of spontaneous pneumothorax. *Respirology*. 2005;**10**:378
- [20] Hsu HH, Chen JS. The etiology and therapy of primary spontaneous pneumothoraces. *Expert Review of Respiratory Medicine*. 2015;**9**(5):655-665
- [21] Roberts DJ, Leigh-Smith S, Faris PD, Blackmore C, Ball CG, Robertson HL, et al. Clinical presentation of patients with tension pneumothorax: A systematic review. *Annals of Surgery*. 2015;**261**(6):1068-1078
- [22] Dagnegård HH, Rosén A, Sartipy U, Bergman P. Recurrence rate after thoracoscopic surgery for primary spontaneous pneumothorax. *Scandinavian Cardiovascular Journal*. 2017;**51**(4):228-232
- [23] Joshi V, Kirmani B, Zacharias J. Thoracotomy versus VATS: Is there an optimal approach to treating pneumothorax? *Annals of the Royal College of Surgeons of England*. 2013;**95**(1):61-64
- [24] Schramel FM, Sutedja TG, Braber JC, van Mourik JC, Postmus PE. Cost-effectiveness of video-assisted thoracoscopic surgery versus conservative treatment for first time or recurrent spontaneous pneumothorax. *The European Respiratory Journal*. 1996;**9**:1821-1825
- [25] Torresini G, Vaccarili M, Divisi D, Crisci R. Is video-assisted thoracic surgery justified at first spontaneous pneumothorax? *European Journal of Cardio-Thoracic Surgery*. 2001;**20**:42-45
- [26] Chou SH, Cheng YJ, Kao EL. Is video-assisted thoracic surgery indicated in the first episode primary spontaneous pneumothorax? *Interactive Cardiovascular and Thoracic Surgery*. 2003;**2**:552-554
- [27] Margolis M, Gharagozloo F, Tempesta B, Trachiotis GD, Katz NM, Alexander EP. Video-assisted thoracic surgical treatment of initial spontaneous pneumothorax in young patients. *The Annals of Thoracic Surgery*. 2003;**76**:1661-1663
- [28] Sawada S, Watanabe Y, Moriyama S. Video-assisted thoracoscopic surgery for primary spontaneous pneumothorax: Evaluation of indications and long-term outcome compared with conservative treatment and open thoracotomy. *Chest*. 2005;**127**:2226-2230
- [29] Chen JS, Hsu HH, Tsai KT, Yuan A, Chen WJ, Lee YC. Salvage for unsuccessful aspiration of primary pneumothorax: Thoracoscopic surgery or chest tube drainage? *The Annals of Thoracic Surgery*. 2008;**85**:1908-1913
- [30] Ahmedzai S, Balfour-Lynn IM, Bewick T, et al. Managing passengers with stable respiratory disease planning air travel: British thoracic society recommendations. *Thorax*. 2011;**66**(Suppl. 1):i1-i30
- [31] Hu X, Cowl CT, Baqir M, et al. Air travel and pneumothorax. *Chest*. 2014;**145**:688-694
- [32] Duchateau FX, Legrand JM, Verner L, et al. Commercial aircraft repatriation of patients with pneumothorax. *Air Medical Journal*. 2013;**32**:200-202
- [33] Smit HJM, Chatrou M, Postmus PE. The impact of spontaneous pneumothorax, and its treatment, on the smoking behaviour of young

adult smokers. *Respiratory Medicine*. 1998;**92**:1132-1136

[34] Hedevang Olesen W, Katballe N, Sindby JE, Titlestad IL, Andersen PE, Ekholm O, et al. Cannabis increased the risk of primary spontaneous pneumothorax in tobacco smokers: A case-control study. *European Journal of Cardio-Thoracic Surgery*. 2017;**52**(4):679-685

[35] Elsayed H, Kent W, McShane J, Page R, Shackcloth M. Treatment of pneumothoraces at a tertiary Centre: Are we following the current guidelines? *Interactive Cardiovascular and Thoracic Surgery*. 2011;**12**(3):430-433

[36] Kelly AM, Clooney M. Deviation from published guidelines in the management of primary spontaneous pneumothorax in Australia. *Internal Medicine Journal*. 2008;**38**(1):64-67

[37] Yoon J, Sivakumar P, O’Kane K, Ahmed L. A need to reconsider guidelines on management of primary spontaneous pneumothorax? *International Journal of Emergency Medicine*. 2017;**10**:9

[38] Kelly AM, Drudy D. Comparison of size classification of primary spontaneous pneumothorax by three international guidelines: A case for international consensus? *Respiratory Medicine*. 2008;**102**(12):1830-1832

[39] Salazar AJ, Aguirre DA, Ocampo J, Camacho JC, Díaz XA. Evaluation of three pneumothorax size quantification methods on digitized chest X-ray films using medical-grade grayscale and consumer-grade color displays. *Journal of Digital Imaging*. 2014;**27**(2):280-286

[40] Elsayed H, Roberts R, Emadi M, Whittle I, Shackcloth M. Chest drain insertion is not a harmless procedure: Are we doing it safely? *Interactive Cardiovascular and Thoracic Surgery*. 2010;**11**(6):745-748