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Review:

Diagnosis and treatment of primary spontaneous pneumothorax

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Abstract: Primary spontaneous pneumothorax (PSP) commonly occurs in tall, thin, adolescent men. Though the pathogenesis of PSP has been gradually uncovered, there is still a lack of consensus in the diagnostic approach and treatment strategies for this disorder. Herein, the literature is reviewed concerning mechanisms and personal clinical experience with PSP. The chest computed tomography (CT) has been more commonly used than before to help understand the pathogenesis of PSP and plan further management strategies. The development of video-assisted thoracoscopic surgery (VATS) has changed the profiles of management strategies of PSP due to its minimal invasiveness and high effectiveness for patients with these diseases.

Key words: Primary spontaneous pneumothorax (PSP), Diagnosis, Treatment
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1 Pneumothorax definition and classification

Pneumothorax is defined as air or gas accumulated in the pleural cavity. A pneumothorax can occur spontaneously or after trauma to the lung or chest wall. Pneumothorax can also be divided into tension and non-tension. A tension pneumothorax can be a medical emergency due to rising intrathoracic pressure from progressive air accumulation in the pleural space. Circulatory or respiratory failure might be developed from subsequent lung or mediastinal compression. A non-tension pneumothorax can be divided into open or close (partial) type. It is not as critical as tension pneumothorax because there is no ongoing air accumulation and hence no compression of intrathoracic organs from rising pressures (Shields *et al.*, 2005; Noppen and de Keukeleire, 2008).

Spontaneous pneumothorax can be classified as either primary or secondary. Primary spontaneous pneumothorax (PSP), which is defined as a pneumothorax without underlying lung disease, predominantly occurs in young, thin males. It is usually caused by ruptured pleural blebs or bullae (Abdala *et al.*, 2001; Chen Y.J. *et al.*, 2008). Secondary spontaneous pneumothorax (SSP) usually occurs in older people with underlying pulmonary disease, such as emphysema or asthma, acute or chronic infections, lung cancer, and congenital diseases including cystic fibrosis, catamenial pneumothorax, or lymphangioleiomyomatosis (LAM) (Luh *et al.*, 1998; 2004; Wallach, 2000).

2 Epidemiology of PSP

The age-adjusted incidence of PSP is from 7.4 to 18 per 100000 population per year in males, and from 1.2 to 6 per 100000 population per year in females (Sahn and Heffner, 2000; Noppen and de Keukeleire, 2008). It usually occurs in tall, thin males of 10 to 30 years old. Rarely does it occur in people at the age of more than 40 years. PSP might be associated with some congenital disorders such as Marfan's syndrome, or some environmental factors such as smoking (Roman *et al.*, 2003). PSP usually occurs at rest. There are some precipitating factors, such as change in atmospheric pressure or emotional change. These can partially explain the cluster appearance of

PSP observed in our prior reported series and literature (Alifano *et al.*, 2007; Luh and Tsao, 2007). In our experience, in the treatment of more than 700 patients with PSP, occurrences are more common during weather changes, and midterm or final exam seasons for students. In our patients, PSP occurred during sexual activity (woman on top position) in two young males. This may be related to Valsalva maneuver, which has been regarded as a mechanism of pneumothorax or pneumomediastinum in other reported series (Birrer and Calderon, 1984). Hearing loud music has also being reported as a risk factor of PSP, which may be due to acute changes in transpulmonary pressure by exposure to sound energy (Noppen *et al.*, 2004). Approximately 10% of patients with PSP have a positive family history. Some gene mutations, such as folliculin (FLCN, related to a rare disease, Birt-Hogg-Dube syndrome), have been found with relation to the development of PSP (Graham *et al.*, 2005). Smoking is also regarded as a precipitating factor for PSP. The relative risk of pneumothorax ranged from 7 to 100 times higher in light to heavy smokers (Bense *et al.*, 1987). A case-control study reviewing related epidemiological and clinicopathological data between smokers and non-smokers with PSP showed that more severe bronchiolitis and a higher recurrence rate of pneumothorax occur in smokers (Cheng *et al.*, 2009).

3 Pathogenesis of PSP

Most authors believe that PSP results from spontaneous rupture of a subpleural bleb or bulla (van Schil *et al.*, 2005). However, only a portion of patients with PSP could be found with blebs or bullae in imaging or at the time of surgery (Mitlehner *et al.*, 1992; Amjadi *et al.*, 2007). Other mechanisms may be considered, such as increase in pleural porosity secondary to inflammation (Ohata and Suzuki, 1980). The development of bullae, blebs, or pleural porosity might be related to many factors, such as distal airway inflammation, distal bronchial tree anomaly, disorders of connective tissue formation, local ischemia, and malnutrition (Noppen and de Keukeleire, 2008).

Spontaneous hemopneumothorax (SHP) accounts for 0.5% to 2.6% of patients with spontaneous pneumothorax. It is defined as air and blood (>400 ml) accumulation in the pleural cavity without underlying pulmonary disease or chest trauma within the previous 48 h (Wu *et al.*, 2002; Luh and Tsao, 2007). The most probable origin of bleeding is the aberrant blood vessels which come from the chest wall and grow into the pleural lesions (bullae or blebs) of the lung through the adhesion band (Hsu *et al.*, 2005). This phenomenon has been proved by pre-operative angiography for patients with SHP (Tsukioka *et al.*, 1989). These vessels are usually torn when recurrent PSP with collapsed lung tears the pleural adhesion, which has been observed in over 80% of patients in some reported series undergoing bullectomy through video-assisted thoracoscopic surgery (VATS) (Sharpe *et al.*, 1995; Luh and Tsao, 2007). The bleeders could also arise from the surface of ruptured bullae (Sasai and Shioda, 1995; Wu *et al.*, 2002).

4 Clinical presentations of PSP

PSP usually occurs at rest, and presents with acute onset of local pleuritic chest pain accompanied by shortness of breath. This pain may be mild or severe, sharp and steady ache in character, and usually resolves within 24 h even though pneumothorax still exists (Noppen and de Keukeleire, 2008). On physical examination, decreased breath sounds on auscultation, decreased chest wall movement on inspection, hyperresonance (tympanic) on percussion, and reduced tactile fremitus on palpation of the chest are most often detected in patients with large pneumothorax (free air occupies more than 15% to 20% area of hemithorax) (Shields *et al.*, 2005). Reflex tachycardia can be found in most patients in response to discomfort or circulating or respiratory compromise. Tension pneumothorax should be suspected if severe tachycardia, cold sweating, hypotension, or cyanosis has developed. Blood gas analysis in patients with large pneumothoraces may reveal increased alveolar-arterial difference in oxygen partial pressure ($PA\text{-}aO_2$) due to increased intrapulmonary shunt from the collapsed lung (Cottrell, 2003). Re-expansion pulmonary edema may occur in some PSP patients after undergoing chest tube insertion and drainage procedures. This complication, being rare, but life-threatening, arises from rapid pulmonary

re-expansion after decompression (Schmidt-Horlohe *et al.*, 2008). Young age, large and persistent (usually >24 h) pneumothorax, and rapid expansion of the lung are risk factors for this complication.

5 Diagnostic approaches to PSP

Most PSP cases are confirmed by upright posteroanterior chest radiograph, which can be used to assess the pneumothorax size with good accuracy (Noppen *et al.*, 2001). A pleural line with or without an air-fluid level can be seen in the chest radiograph, but sometimes it is difficult to detect these signs, especially in patients with small pneumothoraces, emphysema, or poor exposure of the film. Expiratory chest radiographs have no diagnostic value for patients with PSP (Bradley *et al.*, 1991).

Computed tomography (CT) of the chest can be used to detect patients with small pneumothoraces (less than 15% area of hemithorax). In addition, CT can provide more detailed information to assist in the subsequent management. Findings which can be noted include the number, size, and location of bullae/blebs (ipsi- or contra-laterally), as well the possibilities of pleural adhesion, pleural fluid accumulation, and possible underlying pulmonary diseases (Luh and Tsao, 2007). For more than 90% of patients with PSP, pathological lung changes can be detected by CT. The most common type is few (n<5) and small (<2 cm in diameter) blebs, followed by mixed blebs and bullae (>2 cm in diameter). Pure large bullae are found in less than 20% patients with PSP. On the other hand, in only one-third of patients with PSP will the bullae be seen in the chest film (Mitlehner *et al.*, 1992). Over 85% of patients with visible bullae during VATS could be detected pre-operatively by CT scan (Sihoe *et al.*, 2000). Similar results were also observed in our clinical experience (Luh *et al.*, 2004). The apical bullae/blebs shadows on the CT scan should be differentiated from the normal 'apical lines' (Guimaraes *et al.*, 2007). More than 50% of patients with PSP have contralateral blebs/bullae, and about a quarter of them will develop a contralateral pneumothorax (Mitlehner *et al.*, 1992; Sihoe *et al.*, 2000; Chou *et al.*, 2010). CT scanning can also be used to predict the risk of recurrence of patients with PSP, allowing preemptive surgical intervention in selected patients (Mitlehner *et al.*, 1992). Thus, we have used pre-contrast high resolution CT (HRCT) as a routine procedure for patients with PSP (Chen J.S. *et al.*, 2008). However, some prior studies revealed that the existence and number of bullae/blebs on CT were not associated with the risk of recurrence (Ouanes-Besbes *et al.*, 2007).

6 Non-surgical management of PSP

Therapeutic options include bed rest, oxygen supplementation, manual aspiration, chest tube drainage, and thoracoscopic and surgical interventions (Al-Qudah, 2006). A small (<15%) pneumothorax in an otherwise healthy patient can be observed and supplied with oxygen inhalation, which can facilitate the reabsorption of air in the pleural cavity up to four-fold faster (Shields *et al.*, 2005). The risk of recurrence is estimated to be 20%–50%. The effectiveness of simple aspiration for patients with PSP can be assessed by taking chest radiograph 6 h later. Larger (>15%) pneumothoraces can be treated by simple aspiration with an intravenous or thoracentesis catheter, or drainage with pigtail catheter or chest tube. Simple aspiration is more effective (in about two thirds) for patients with small or moderate pneumothoraces (Chen J.S. *et al.*, 2008).

For patients with larger pneumothoraces, recurrent attacks, or larger volumes of aspirated pleural air (>30%), more aggressive therapies such as chest tube drainage or surgery should be considered (Chambers and Scarci, 2009).

Chest tube drainage can be effective in about 85% to 90% of patients on the first episode of PSPs. However, probabilities of recurrent PSPs can be increased up to 50% after the first recurrence, and 85% after the second recurrence (Qureshi *et al.*, 2005). A recent evidence-based medicine (EBM) review found no significant difference between simple aspiration and intercostal tube drainage with regard to immediate success rate, early failure rate, duration of hospitalization, one-year success rate, and number of patients requiring pleurodesis at one year. Simple aspiration does not require hospitalization, compared with intercostal tube drainage (Wakai *et al.*, 2007; Zehtabchi and Rios, 2008).

A chest tube can be connected into the Heimlich one way valve or water-seal system. Large-bore chest

tubes are required for PSP patients who are mechanically ventilated, or require drainage of viscous pleural liquids. Smaller-bore tubes may be adequate in patients with limited production of pleural air or of free-flowing pleural liquid (Baumann, 2003). Negative pressure suction applied on the drainage system should be used cautiously to prevent the possible complication of re-expansion lung edema (Light, 1990). Chest tubes can be removed successfully at either end expiration or end inspiration, and potentially as soon as less than 200 ml/fluid output per day is achieved (Baumann, 2003). Talc pleurodesis through a chest tube or medical thoracoscopy under local anesthesia is superior to conservative treatment by chest tube drainage only in cases of PSP that fail after simple aspiration (Tschopp *et al.*, 2002). However, recurrences may still occur in over half of these patients undergoing talc pleurodesis only (Oransky, 2007). Hence, we use talc pleurodesis in combination with bullae/blebs resection through VATS for selective patients with PSP (Luh *et al.*, 2004). Unfortunately, talc has been prohibited for the sake of safety in Taiwan since 2000. However, recent clinical trials have proved the safety and minimal adverse effects of talc pleurodesis in the management of patients with pneumothorax (Hunt *et al.*, 2007; Tschopp *et al.*, 2009).

7 Surgical management of PSP

Surgical management of PSP is usually indicated in patients with recurrent ipsilateral pneumothorax, first episode with occupational risk or persistent air-leakage (more than 5 to 7 d), or prior contralateral pneumothorax (Gossot *et al.*, 2004; Shields *et al.*, 2005). A first episode of a PSP is treated by observation if the area of pneumothorax is <20% or by simple aspiration if >20%, but recurrences are frequent. For recurrent or persisting pneumothorax, a more invasive surgical approach is indicated (van Schil *et al.*, 2005). The procedure can be approached through open thoracotomy or VATS (Luh and Liu, 2006).

There are two objectives in the surgical management of pneumothorax. The first widely accepted objective is resection of blebs or the suture of apical perforations to treat the underlying defect. The second objective is to create a pleural symphysis to prevent recurrence (Morimoto *et al.*, 2002; Klopp *et al.*, 2007). There is nearly zero mortality and very low major morbidity with either VATS or open approaches. Postoperative complications are low (5%–10%), and usually minor and self-limited, including prolonged air-leakage, pleural effusion or hemorrhage, wound infection or hematoma, pulmonary atelectasis or pneumonia (Gossot *et al.*, 2004; Luh *et al.*, 2004; Sawada *et al.*, 2005; Ben-Nun *et al.*, 2006).

The traditional open approach has gradually been replaced by minimally invasive VATS in the diagnosis and treatment for patients with various intrathoracic diseases, including the treatment of PSP (Luh and Liu, 2006). The outcomes of VATS for patients with PSP are very good compared to conservative treatment and equal to those of open thoracotomy (Sedrakyan *et al.*, 2004; Sawada *et al.*, 2005). The VATS approach has the benefits of less postoperative pain, better wound cosmetics, shorter hospital stay and duration of drainage, better functional recovery, better short and long term patient satisfaction, and equivalent cost-effectiveness to the open approach (Ben-Nun *et al.*, 2006; Vohra *et al.*, 2008). A systematic review of 12 randomized trials including 670 patients revealed that VATS was associated with a shorter hospital stay, less pain or use of pain medication than the open procedure in five of the seven trials, and fewer recurrences than the pleural drainage in two trials (Sedrakyan *et al.*, 2004). At three-year follow-up, 97% of the VATS group patients considered themselves completely recovered from the operation, compared with only 79% in the thoracotomy group (P<0.05). Chronic or intermittent pain, requiring the use of analgesics more than once a month, was experienced by 90% of the thoracotomy group patients and 3% of the VATS group patients. In addition, 13% of the thoracotomy group patients required clinical pain management (Ben-Nun *et al.*, 2006; Olavarrieta and Coronel, 2009). Therefore, VATS is recommended as the first-line surgical treatment for patients with recurrent PSP or first episode of PSP (Sawada *et al.*, 2005; Olavarrieta and Coronel, 2009). However, the recommendation can only be graded as B or C as there have been only a limited number of patients in relevant randomized trials (van Schil and de Vos, 2004).

The risk of postoperative recurrence requiring re-operation for the VATS and surgical groups varies

in different reported series. Gossot *et al.* (2004) reported a low recurrence rate (3.6%) during a mean 36.5 months follow-up period after VATS and none of them required re-operation. VATS bullae/blebectomy, pleurodesis, and pleurectomy have been proven to be as effective as the open procedure (Sedrakyan *et al.*, 2004). However, re-operation following VATS is more often required than that after open thoracotomy (Tomasdottir *et al.*, 2007), with a higher rate of both late recurrent pneumothoraces and prolonged early postoperative air-leakage. A four-fold increase in the recurrence of pneumothorax following VATS pleurectomy (as compared to open pleurectomy) has been reported in a meta-analysis with 4 randomized and 25 non-randomized studies (Barker *et al.*, 2007), although a second meta-analysis of only the randomized trials did not show this difference (Vohra *et al.*, 2008).

VATS for PSP can be accomplished mostly through three ports, but two or single port(s) with the use of single incision port laparoscopic surgery (SILS) system has been reported in recent years (Jutley *et al.*, 2005; Gigirey Castro *et al.*, 2010). In our experience, the two- or one-port approach can only be applied in selective cases, and the three-port approach is still preferred because the telescope and instruments are more easily manipulated. Endotracheal general anesthesia with the use of a double or single lumen endotracheal tube is still recommended by most reported series for PSP patients undergoing VATS (Sawada *et al.*, 2005; Luh and Liu, 2006; Olavarrieta and Coronel, 2009). VATS procedures through local or epidural anesthesia for patients with PSP (the awake procedure) have been reported (Mukaida *et al.*, 1998; Pompeo *et al.*, 2007). However, we do not consider this kind of anesthesia to be safe and comfortable, and thus it has not been tried in our patients.

The bullae/blebs in patients with PSP can be managed through VATS by stapling and resection, no-knife stapling, suturing, or endo-loop ligation (Liu *et al.*, 1999; Cardillo *et al.*, 2001; Luh and Liu, 2006). Pleurodesis is usually required in addition to bullae/blebectomy for surgical management of patients with PSP. It can significantly decrease the risk of early air-leakage or late recurrence, which is especially important for patients undergoing VATS. A retrospective review concluded that blebectomy with additional chemical pleurodesis appears to have less risk of ipsilateral recurrence, but longer postoperative stay and chest tube drainage (Bialas *et al.*, 2008). Pleurodesis has been found, in another review, to be effective in preventing postoperative recurrence of pneumothorax and has no disadvantages in terms of worsening postoperative pain or pulmonary function (Horio *et al.*, 2002). Chemical pleurodesis by minocycline injection, which has been developed in our group (Luh *et al.*, 1996), has been shown to be a safe and convenient procedure that can reduce the rate of recurrence after VATS in a retrospective or prospective randomized trial by colleagues (Chen *et al.*, 2004; 2006). However, we do not routinely perform this procedure because it frequently results in intense chest pain and fever, and this additional procedure is only preserved for patients with persistent air-leakage or a higher risk of recurrence, such as multiple or huge bullae (Luh *et al.*, 2004; Luh and Tsao, 2007; Chen Y.J. *et al.*, 2008).

Since the surgical treatment for patients with PSP has become less invasive through VATS in recent years, there have been many published papers suggesting the use of this surgical intervention for patients with the first PSP. A quality adjusted life year (QALE) analysis for patients with first or recurrent PSP compared different treatment options, including VATS as the primary therapy, pleural drainage followed by VATS at first and second recurrences, pleurodesis followed by VATS at first and second recurrences, pleural drainage at first attack, pleurodesis at first recurrence, and VATS at the second recurrence. It was concluded that thoracoscopic surgery can be considered the treatment of choice for the first episode of PSP (Morimoto *et al.*, 2002). A collective survey of 183 papers concluded that VATS has superior outcomes in terms of recurrence rates of pneumothorax (0–13% according to several studies for VATS vs. 22.8%–42.0% for tube thoracostomy alone), duration of chest tube drainage (CTD) (4.56 vs. 7.60 d), and mean hospital stay (2.4–7.8 d vs. 6.0–12.0 d for CTD) after first episode of PSP, compared with conservative treatment. Additionally, even if VATS is associated with an average increased cost of 408 USD, this is mitigated by the reduced length of stay and decreased pneumothorax recurrence, both resulting in a reduction of cost of 42% compared to a conservative approach (Chambers and Scarci, 2009). There are still

some reported series that do not agree with the use of VATS after the first PSP. Retrospective cost effective analysis has revealed that tube thoracostomy should be used at first occurrence, followed by VATS bullae/blebectomy and pleurodesis in case of recurrence (Cook *et al.*, 1999; Qureshi *et al.*, 2005). However, these studies were only based on single, retrospective, and small case number analyses, and the patient satisfaction and quality of life were not considered. VATS will be expected as an option of management for patients with their first PSP. However, the management of the first PSP remains controversial because there is still little high-quality evidence to guide the decision-making (Kelly, 2009; Robinson *et al.*, 2009).

8 Value of CT in prediction of prognosis and choice of management for patients with PSP

CT is of value in the detection of pleural blebs in patients with PSP. Particular attention should be paid to the lung apices, where the majority of blebs are located. Definitive surgical treatment should be considered at the first occurrence if these morphological abnormalities were noted on CT (Choudhary *et al.*, 2005). However, some other reported studies revealed no correlation between recurrences and anatomical status assessed by CT, and thus VATS surgery cannot be recommended after a first episode of PSP (Mitlehner *et al.*, 1992; Jordan *et al.*, 1997; Martinez-Ramos *et al.*, 2007).

In addition to assessing the necessity of surgical intervention, CT scan can also be used to localize the bullae/blebs at multiple areas or unusual sites (Luh *et al.*, 2004; Luh and Liu, 2006), and detect existence of hemopneumothorax (Luh and Tsao, 2007). These above information can help in planning surgical strategies and in explaining the indication, risks, and benefits to the patients and their families.

CT scan can also be used to detect the existence of bullae/blebs on the contralateral lung, thereby predicting the risk of contralateral PSP. Sihoe *et al.* (2000) reported that one-fourth of patients with contralateral blebs developed PSP in the untreated lung. On the contrary, none of the patients without contralateral blebs developed PSP. The necessity of surgical treatment of asymptomatic contralateral blebs/bullae in patients with PSP has been proven beneficial because pneumothorax on this side will develop within one and a half years for one-fifth of them (Chou *et al.*, 2010). In addition to the CT findings, the risk of contralateral recurrence of pneumothorax can also be significantly higher in patients with a low body mass index (<18.5 kg/m^2) (Huang *et al.*, 2007).

9 Management of patients with SHP

SHP is defined as significant blood (>400 ml) and air accumulation in the pleural cavity without underlying pulmonary disease or chest trauma history in the last 48 h (Hsiao *et al.*, 2003). SHP is an uncommon complication of PSP, with a reported incidence of 0.5%–2.6% for all patients and 4.8%–12.0% for patients undergoing surgical intervention (Sasai and Shioda, 1995; Wu *et al.*, 2002). SHP is sometimes life-threatening and regarded as a surgical emergency (Luh and Tsao, 2007). The bleeding usually originates from the ruptured aberrant blood vessels on the surface of bullae/blebs, which adhered to the chest wall (Tsukioka *et al.*, 1989). Earlier reports suggest that SHP can be treated with chest tube insertion (de Perrot *et al.*, 2000), and surgical intervention is reserved for patients with massive bleeding and hemodynamic instability, persistent bleeding for more than 24 h or retained blood clots refractory to tube drainage (Hart *et al.*, 2002). Since VATS has gradually replaced open thoracotomy as the standard surgical approach for patients with PSP, its minimal invasiveness, excellent safety, and effectiveness makes it the primary treatment for SHP (Miyazawa *et al.*, 2002; Luh and Tsao, 2007). Treatments of SHP through VATS include controlling the bleeders, which are most commonly on the parietal pleural side, and stapling or looping the bullae/blebs, usually on the visceral pleural side near the bleeding area, to seal off the air-leakage (Luh and Tsao, 2007).

10 Management of patients with bilateral PSP

As many as 54%–88% of patients with unilateral PSP have contralateral bullae/blebs (Ikeda *et al.*, 1988; Bertrand *et al.*, 1996; Sihoe *et al.*, 2000).

Hence, PSP can occur bilaterally, either simultaneously or sequentially, in around 7.8%–20.0% of patients surgically treated for PSP (Baumann and Strange, 1997; Liu *et al.*, 1999; Lang-Lazdunski *et al.*, 2003).

For patients with simultaneously bilateral PSP, there is little to be debated about the use of bilateral VATS at the first occurrence, because the possibility of visible bullae/blebs rupture and the risk of recurrent pneumothorax are very high (Sihoe *et al.*, 2000). However, the necessity of bilateral procedures for patients with unilateral pneumothorax with asymptomatic contralateral bullae/blebs remains controversial, even if some prior studies have proven its benefits (Chou *et al.*, 2010). Based on our clinical experience, we do not recommend bilateral procedures for these patients even if the chest CT revealed visible bullae/blebs on the contralateral side (Chen J.S. *et al.*, 2008). However, these patients should be more closely followed up for a longer period postoperatively. A second VATS will be undertaken once any clinical symptoms develop and CT scan proves the appearance of contralateral PSP.

Some reported series performed bilateral VATS in the supine position, instead of the traditional decubitus position, for bilateral PSP (Huang *et al.*, 2007). Consideration of the supine position for VATS usually depends on the condition of patients and the location of the lesions. PSP patients are usually young in age with a normal lung function, and the bullae/blebs are usually located at the apical area, in which the posterior aspect is difficult to check thoracoscopically in the supine position. Moreover, there are usually dense adhesions with engorged vessels from the chest wall for patients with recurrent PSP (Chen Y.J. *et al.*, 2008). Thus, bilateral VATS for PSP in the supine position is not necessary.

In summary, VATS is a safe and effective procedure in the treatment of bilateral PSP. Bilateral VATS is only recommended for patients with simultaneously bilateral PSP, because the incidence of recurrence, even with visible bullae, was not so high in our experience and in the literature. Bilateral VATS in a supine position should only be used in selective cases, because of possible pleural adhesion or hidden bullae on the posterior side (Chen Y.J. *et al.*, 2008).

11 Conclusions

The development and application of new diagnostic tools, especially the high resolution CT scan, have helped to better understand the pathogenesis of PSP and influence the management. The development of the minimally invasive VATS technique has changed the profiles of traditional management strategies. However, there still exist many controversies in the selection of optimal diagnostic tools and management plans in specific cases. In the future, further evidence from more prospective randomized trials will be required to answer these questions. In addition, better minimal surgical techniques to detect and remove hidden bullae/blebs, or pleurodesis techniques with better effectiveness and less adverse effects, are still expected to improve the treatment outcomes of patients with PSP.

References

Abdala, O.A., Levy, R.R., Bibiloni, R.H., Viso, H.D., de Souza, M., Satler, V.H., 2001. Advantages of video assisted thoracic surgery in the treatment of spontaneous pneumothorax. *Medicina (B Aires)*, **61**(2):157-160.

Al-Qudah, A., 2006. Treatment options of spontaneous pneumothorax. *Indian J. Chest Dis. Allied Sci.*, **48**(3): 191-200.

Alifano, M., Forti Parri, S.N., Bonfanti, B., Arab, W.A., Passini, A., Boaron, M., Roche, N., 2007. Atmospheric pressure influences the risk of pneumothorax: beware of the storm! *Chest*, **131**(6):1877-1882. [doi:10.1378/chest.06-2206]

Amjadi, K., Alvarez, G.G., Vanderhelst, E., Velkeniers, B., Lam, M., Noppen, M., 2007. The prevalence of blebs or bullae among young healthy adults: a thoracoscopic investigation. *Chest*, **132**(4):1140-1145. [doi:10.1378/chest.07-0029]

Barker, A., Maratos, E.C., Edmonds, L., Lim, E., 2007. Recurrence rates of video-assisted thoracoscopic versus open surgery in the prevention of recurrent pneumothoraces: a systematic review of randomised and non-randomised trials. *Lancet*, **370**(9584):329-335. [doi:10.1016/S0140-6736(07)61163-5]

Baumann, M.H., 2003. What size chest tube? What drainage system is ideal? And other chest tube management questions. *Curr. Opin. Pulm. Med.*, **9**(4):276-281. [doi:10.1097/00063198-200307000-00006]

Baumann, M.H., Strange, C., 1997. Treatment of spontaneous pneumothorax: a more aggressive approach? *Chest*, **112**(3):789-804. [doi:10.1378/chest.112.3.789]

Ben-Nun, A., Soudack, M., Best, L.A., 2006. Video-assisted thoracoscopic surgery for recurrent spontaneous pneumothorax: the long-term benefit. *World J. Surg.*, **30**(3):

285-290. [doi:10.1007/s00268-005-0235-2]

Bense, L., Eklund, G., Wiman, L.G., 1987. Smoking and the increased risk of contracting spontaneous pneumothorax. *Chest*, **92**(6):1009-1012. [doi:10.1378/chest.92.6.1009]

Bertrand, P.C., Regnard, J.F., Spaggiari, L., Levi, J.F., Magdeleinat, P., Guibert, L., Levasseur, P., 1996. Immediate and long-term results after surgical treatment of primary spontaneous pneumothorax by VATS. *Ann. Thorac. Surg.*, **61**(6):1641-1645. [doi:10.1016/0003-4975(96)00190-7]

Bialas, R.C., Weiner, T.M., Phillips, J.D., 2008. Video-assisted thoracic surgery for primary spontaneous pneumothorax in children: is there an optimal technique? *J. Pediatr. Surg.*, **43**(12):2151-2155. [doi:10.1016/j.jpedsurg.2008.08.041]

Birrer, R.B., Calderon, J., 1984. Pneumothorax, pneumomediastinum, and pneumopericardium following Valsalva's maneuver during marijuana smoking. *N. Y. State J. Med.*, **84**(12):619-620.

Bradley, M., Williams, C., Walshaw, M.J., 1991. The value of routine expiratory chest films in the diagnosis of pneumothorax. *Arch. Emerg. Med.*, **8**(2):115-116. [doi:10.1136/emj.8.2.115]

Cardillo, G., Facciolo, F., Regal, M., Carbone, L., Corzani, F., Ricci, A., Martelli, M., 2001. Recurrences following videothoracoscopic treatment of primary spontaneous pneumothorax: the role of redo-videothoracoscopy. *Eur. J. Cardiothorac. Surg.*, **19**(4):396-399. [doi:10.1016/S1010-7940(01)00611-X]

Chambers, A., Scarci, M., 2009. In patients with first-episode primary spontaneous pneumothorax is video-assisted thoracoscopic surgery superior to tube thoracostomy alone in terms of time to resolution of pneumothorax and incidence of recurrence? *Interact. Cardiovasc. Thorac. Surg.*, **9**(6):1003-1008. [doi:10.1510/icvts.2009.216473]

Chen, J.S., Hsu, H.H., Kuo, S.W., Tsai, P.R., Chen, R.J., Lee, J.M., Lee, Y.C., 2004. Effects of additional minocycline pleurodesis after thoracoscopic procedures for primary spontaneous pneumothorax. *Chest*, **125**(1):50-55. [doi:10.1378/chest.125.1.50]

Chen, J.S., Hsu, H.H., Chen, R.J., Kuo, S.W., Huang, P.M., Tsai, P.R., Lee, J.M., Lee, Y.C., 2006. Additional minocycline pleurodesis after thoracoscopic surgery for primary spontaneous pneumothorax. *Am. J. Respir. Crit. Care Med.*, **173**(5):548-554. [doi:10.1164/rccm.200509-1414OC]

Chen, J.S., Hsu, H.H., Tsai, K.T., Yuan, A., Chen, W.J., Lee, Y.C., 2008. Salvage for unsuccessful aspiration of primary pneumothorax: thoracoscopic surgery or chest tube drainage? *Ann. Thorac. Surg.*, **85**(6):1908-1913. [doi:10.1016/j.athoracsur.2008.02.038]

Chen, Y.J., Luh, S.P., Hsu, K.Y., Chen, C.R., Tsao, T.C., Chen, J.Y., 2008. Video-assisted thoracoscopic surgery (VATS) for bilateral primary spontaneous pneumothorax. *J. Zhejiang Univ. Sci. B*, **9**(4):335-340. [doi:10.1631/jzus.B0720235]

Cheng, Y.L., Huang, T.W., Lin, C.K., Lee, S.C., Tzao, C., Chen, J.C., Chang, H., 2009. The impact of smoking in primary spontaneous pneumothorax. *J. Thorac. Cardiovasc. Surg.*, **138**(1):192-195. [doi:10.1016/j.jtcvs.2008.12.019]

Chou, S.H., Li, H.P., Lee, J.Y., Chang, S.J., Lee, Y.L., Chang, Y.T., Kao, E.L., Dai, Z.K., Huang, M.F., 2010. Is prophylactic treatment of contralateral blebs in patients with primary spontaneous pneumothorax indicated? *J. Thorac. Cardiovasc. Surg.*, **139**(5):1241-1245. [doi:10.1016/j.jtcvs.2009.07.047]

Choudhary, A.K., Sellars, M.E., Wallis, C., Cohen, G., McHugh, K., 2005. Primary spontaneous pneumothorax in children: the role of CT in guiding management. *Clin. Radiol.*, **60**(4):508-511. [doi:10.1016/j.crad.2004.12.002]

Cook, C.H., Melvin, W.S., Groner, J.I., Allen, E., King, D.R., 1999. A cost-effective thoracoscopic treatment strategy for pediatric spontaneous pneumothorax. *Surg. Endosc.*, **13**(12):1208-1210. [doi:10.1007/PL00009622]

Cottrell, G.P., 2003. Cardiopulmonary Anatomy and Physiology for Respiratory Care Practitioners. Davis Co., Philadelphia, FA.

de Perrot, M., Deleaval, J., Robert, J., Spiliopoulos, A., 2000. Spontaneous hemopneumothorax-results of conservative treatment. *Swiss Surg.*, **6**(2):62-64. [doi:10.1024/1023-9332.6.2.62]

Gigirey Castro, O., Berlanga González, L., Sánchez Gómez, E., 2010. Single port thorascopic surgery using the SILS® tool as a novel method in the surgical treatment of pneumothorax. *Arch. Bronconeumol.*, **46**(8):439-441 (in Spanish). [doi:10.1016/j.arbres.2009.11.013]

Gossot, D., Galetta, D., Stern, J.B., Debrosse, D., Caliandro, R., Girard, P., Grunenwald, D., 2004. Results of thoracoscopic pleural abrasion for primary spontaneous pneumothorax. *Surg. Endosc.*, **18**(3):466-471. [doi:10.1007/s00464-003-9067-z]

Graham, R.B., Nolasco, M., Peterlin, B., Garcia, C.K., 2005. Nonsense mutations in folliculin presenting as isolated familial spontaneous pneumothorax in adults. *Am. J. Respir. Crit. Care Med.*, **172**(1):39-44. [doi:10.1164/rccm.200501-143OC]

Guimaraes, C.V., Donnelly, L.F., Warner, B.W., 2007. CT findings for blebs and bullae in children with spontaneous pneumothorax and comparison with findings in normal age-matched controls. *Pediatr. Radiol.*, **37**(9):879-884. [doi:10.1007/s00247-007-0537-7]

Hart, S.R., Willis, C., Thorn, A., Barfoot, L., 2002. Spontaneous haemopneumothorax: are guidelines overdue? *Emerg. Med. J.*, **19**(3):273-274. [doi:10.1136/emj.19.3.273]

Horio, H., Nomori, H., Kobayashi, R., Naruke, T., Suemasu, K., 2002. Impact of additional pleurodesis in video-assisted thoracoscopic bullectomy for primary spontaneous pneumothorax. *Surg. Endosc.*, **16**(4):630-634. [doi:10.1007/s00464-001-8232-5]

Hsiao, C.W., Lee, S.C., Tzao, C., Chen, J.C., Cheng, Y.L., 2003. Minithoracotomy with simultaneous video-assisted thoracoscopic surgery vs. video-assisted thoracoscopic surgery for spontaneous hemopneumothorax. *Thorac. Cardiovasc. Surg.*, **51**(5):288-290. [doi:10.1055/s-2003-43077]

Hsu, N.Y., Shih, C.S., Hsu, C.P., Chen, P.R., 2005. Spontaneous hemopneumothorax revisited: clinical approach

and systemic review of the literature. *Ann. Thorac. Surg.*, **80**(5):1859-1863. [doi:10.1016/j.athoracsur.2005.04.052]

Huang, T.W., Lee, S.C., Cheng, Y.L., Tzao, C., Hsu, H.H., Chang, H., Chen, J.C., 2007. Contralateral recurrence of primary spontaneous pneumothorax. *Chest*, **132**(4):1146-1150. [doi:10.1378/chest.06-2772]

Hunt, I., Barber, B., Southon, R., Treasure, T., 2007. Is talc pleurodesis safe for young patients following primary spontaneous pneumothorax? *Interact. Cardiovasc. Thorac. Surg.*, **6**(1):117-120. [doi:10.1510/icvts.2006.147546]

Ikeda, M., Uno, A., Yamane, Y., Hagiwara, N., 1988. Median sternotomy with bilateral bullous resection for unilateral spontaneous pneumothorax, with special reference to operative indications. *J. Thorac. Cardiovasc. Surg.*, **96**(4):615-620.

Jordan, K.G., Kwong, J.S., Flint, J., Muller, N.L., 1997. Surgically treated pneumothorax. Radiologic, pathologic findings. *Chest*, **111**(2):280-285. [doi:10.1378/chest.111.2.280]

Jutley, R.S., Khalil, M.W., Rocco, G., 2005. Uniportal vs. standard three-port VATS technique for spontaneous pneumothorax: comparison of post-operative pain and residual paraesthesia. *Eur. J. Cardiothorac. Surg.*, **28**(1):43-46. [doi:10.1016/j.ejcts.2005.02.039]

Kelly, A.M., 2009. Treatment of primary spontaneous pneumothorax. *Curr. Opin. Pulm. Med.*, **15**(4):376-379. [doi:10.1097/MCP.0b013e32832ae314]

Klopp, M., Dienemann, H., Hoffmann, H., 2007. Treatment of pneumothorax. *Der Chirurg*, **78**(7):655-668. [doi:10.1007/s00104-007-1358-9]

Lang-Lazdunski, L., Chapuis, O., Bonnet, P.M., Pons, F., Jancovici, R., 2003. Videothoracoscopic bleb excision, pleural abrasion for the treatment of primary spontaneous pneumothorax: long-term results. *Ann. Thorac. Surg.*, **75**(3):960-965. [doi:10.1016/S0003-4975(02)04544-7]

Light, R.W., 1990. Pleural Diseases. Lea & Febiger, Philadelphia.

Liu, H.P., Yim, A.P., Izzat, M.B., Lin, P.J., Chang, C.H., 1999. Thoracoscopic surgery for spontaneous pneumothorax. *World J. Surg.*, **23**(11):1133-1136. [doi:10.1007/s002689900636]

Luh, S.P., Liu, H.P., 2006. Video-assisted thoracic surgery—the past, present status, the future. *J. Zhejiang Univ.-Sci. B*, **7**(2):118-128. [doi:10.1631/jzus.2006.B0118]

Luh, S.P., Tsao, T.C., 2007. Video-assisted thoracic surgery for spontaneous haemopneumothorax. *Respirology*, **12**(3):443-447. [doi:10.1111/j.1440-1843.2006.01008.x]

Luh, S.P., Lee, Y.C., Lee, J.M., Lee, C.J., 1996. Videothoracoscopic treatment of spontaneous pneumothorax. *Int. Surg.*, **81**(4):336-338.

Luh, S.P., Koon, W.J., Su, M.S., Yang, C.C., Lee, Y.C., 1998. Videothoracoscopic diagnosis, treatment of pulmonary lymphangio leiomyomatosis (PLAM) with recurrent pneumothorax. *J. Surg. Assoc. ROC*, **31**:251-255.

Luh, S.P., Tsai, T.P., Chou, M.C., Yang, P.C., Lee, C.J., 2004. Video-assisted thoracic surgery for spontaneous pneumothorax: outcome of 189 cases. *Int. Surg.*, **89**(4):185-189.

Martinez-Ramos, D., Angel-Yepes, V., Escrig-Sos, J., Miralles-Tena, J.M., Salvador-Sanchis, J.L., 2007. Usefulness of computed tomography in determining risk of recurrence after a first episode of primary spontaneous pneumothorax: therapeutic implications. *Arch. Bronconeumol.*, **43**(6):304-308. [doi:10.1016/S1579-2129(07)60075-5]

Mitlehner, W., Friedrich, M., Dissmann, W., 1992. Value of computer tomography in the detection of bullae, blebs in patients with primary spontaneous pneumothorax. *Respiration*, **59**(4):221-227. [doi:10.1159/000196062]

Miyazawa, M., Fujita, T., Misawa, R., Sakai, T., Toishi, M., Koyama, H., Hyougotani, A., Haba, Y., Kato, K., Muramatsu, A., 2002. Thoracoscopic treatment for spontaneous hemopneumothorax. *Surg. Endosc.*, **16**(7):1106. [doi:10.1007/s00464-001-4182-1]

Morimoto, T., Fukui, T., Koyama, H., Noguchi, Y., Shimbo, T., 2002. Optimal strategy for the first episode of primary spontaneous pneumothorax in young men. A decision analysis. *J. Gen. Intern. Med.*, **17**(3):193-202. [doi:10.1046/j.1525-1497.2002.10636.x]

Mukaida, T., Andou, A., Date, H., Aoe, M., Shimizu, N., 1998. Thoracoscopic operation for secondary pneumothorax under local and epidural anesthesia in high-risk patients. *Ann. Thorac. Surg.*, **65**(4):924-926. [doi:10.1016/S0003-4975(98)00108-8]

Noppen, M., de Keukeleire, T., 2008. Pneumothorax. *Respiration*, **76**(2):121-127. [doi:10.1159/000135932]

Noppen, M., Alexander, P., Driesen, P., Slabbynck, H., Verstraete, A., 2001. Quantification of the size of primary spontaneous pneumothorax: accuracy of the light index. *Respiration*, **68**(4):396-399. [doi:10.1159/000050533]

Noppen, M., Verbanck, S., Harvey, J., van Herreweghe, R., Meysman, M., Vincken, W., Paiva, M., 2004. Music: a new cause of primary spontaneous pneumothorax. *Thorax*, **59**(8):722-724. [doi:10.1136/thx.2003.007385]

Ohata, M., Suzuki, H., 1980. Pathogenesis of spontaneous pneumothorax. With special reference to the ultrastructure of emphysematous bullae. *Chest*, **77**(6):771-776. [doi:10.1378/chest.77.6.771]

Olavarrieta, J.R., Coronel, P., 2009. Expectations, patient satisfaction related to the use of thoracotomy, video-assisted thoracoscopic surgery for treating recurrence of spontaneous primary pneumothorax. *J. Bras. Pneumol.*, **35**(2):122-128. [doi:10.1590/S1806-37132009000200004]

Oransky, I., 2007. Long-term follow-up of thoracoscopic talc pleurodesis for primary spontaneous pneumothorax. *Eur. Respir. J.*, **30**(3):598. [doi:10.1183/09031936.00044107]

Ouanes-Besbes, L., Golli, M., Knani, J., Dachraoui, F., Nciri, N., El Atrous, S., Gannouni, A., Abroug, F., 2007. Prediction of recurrent spontaneous pneumothorax: CT scan findings versus management features. *Respir. Med.*, **101**(2):230-236. [doi:10.1016/j.rmed.2006.05.016]

Pompeo, E., Tacconi, F., Mineo, D., Mineo, T.C., 2007. The role of awake video-assisted thoracoscopic surgery in spontaneous pneumothorax. *J. Thorac. Cardiovasc. Surg.*, **133**(3):786-790. [doi:10.1016/j.jtcvs.2006.11.001]

Qureshi, F.G., Sandulache, V.C., Richardson, W., Ergun, O., Ford, H.R., Hackam, D.J., 2005. Primary vs. delayed surgery for spontaneous pneumothorax in children: which is better? *J. Pediatr. Surg.*, **40**(1):166-169. [doi:10.1016/j.jpedsurg.2004.09.042]

Robinson, P.D., Cooper, P., Ranganathan, S.C., 2009. Evidence-based management of paediatric primary spontaneous pneumothorax. *Paediatr. Respir. Rev.*, **10**(3):110-117. [doi:10.1016/j.prrv.2008.12.003]

Roman, M., Weinstein, A., Macaluso, S., 2003. Primary spontaneous pneumothorax. *Medsurg. Nurs.*, **12**(3):161-169.

Sahn, S.A., Heffner, J.E., 2000. Spontaneous pneumothorax. *N. Engl. J. Med.*, **342**(12):868-874. [doi:10.1056/NEJM200000233421207]

Sasai, T., Shioda, M., 1995. Treatment, etiology of spontaneous hemopneumothorax. *Kyobu Geka*, **48**(4):337-339.

Sawada, S., Watanabe, Y., Moriyama, S., 2005. Video-assisted thoracoscopic surgery for primary spontaneous pneumothorax: evaluation of indications, long-term outcome compared with conservative treatment, open thoracotomy. *Chest*, **127**(6):2226-2230. [doi:10.1378/chest.127.6.2226]

Schmidt-Horlohe, N., Rudig, L., Azvedo, C.T., Habekost, M., 2008. Fulminant unilateral pulmonary edema after insertion of a chest tube: a complication after a primary spontaneous pneumothorax. *Dtsch. Arztebl. Int.*, **105**(50):878-881. [doi:10.3238/arztebl.2008.0878]

Sedrakyan, A., van der Meulen, J., Lewsey, J., Treasure, T., 2004. Video assisted thoracic surgery for treatment of pneumothorax, lung resections: systematic review of randomised clinical trials. *BMJ*, **329**(7473):1008. [doi:10.1136/bmj.38243.440486.55]

Sharpe, D.A., Dixon, K., Moghissi, K., 1995. Spontaneous haemopneumothorax: a surgical emergency. *Eur. Respir. J.*, **8**(9):1611-1612.

Shields, T.W., Locicero, J., Ponn, R.B., Rusch, V.W., 2005. General Thoracic Surgery. Lippincott Williams & Wilkins, New York.

Sihoe, A.D., Yim, A.P., Lee, T.W., Wan, S., Yuen, E.H., Wan, I.Y., Arifi, A.A., 2000. Can CT scanning be used to select patients with unilateral primary spontaneous pneumothorax for bilateral surgery? *Chest*, **118**(2):380-383. [doi:10.1378/chest.118.2.380]

Tomasdottir, G.F., Torfason, B., Isaksson, H.J., Gudbjartsson, T., 2007. Comparison of video-assisted thoracoscopic surgery, limited axillary thoracotomy for spontaneous pneumothorax. *Laeknabladid*, **93**(5):405-412.

Tschopp, J.M., Boutin, C., Astoul, P., Janssen, J.P., Grandin, S., Bolliger, C.T., Delaunois, L., Driesen, P., Tassi, G., Perruchoud, A.P., 2002. Talcage by medical thoracoscopy for primary spontaneous pneumothorax is more cost-effective than drainage: a randomised study. *Eur. Respir. J.*, **20**(4):1003-1009. [doi:10.1183/09031936.02.00278202]

Tschopp, J.M., Schnyder, J.M., Froudarakis, M., Astoul, P., 2009. VATS or simple talc poudrage under medical thoracoscopy for recurrent spontaneous pneumothorax. *Eur. Respir. J.*, **33**(2):442-443. [doi:10.1183/09031936.00127008]

Tsukioka, K., Okimoto, T., Koizumi, H., Mizukami, K., Muramatsu, H., Fukuda, S., Unno, K., Hirata, S., Yamashita, A., 1989. Angiographic findings in a patient with spontaneous hemopneumothorax. *Kyobu Geka*, **42**(6):478-481.

van Schil, P., de Vos, B., 2004. Current treatment of primary, secondary pneumothorax. *Rev. Mal. Respir.*, **21**(2 Pt. 1):372-380.

van Schil, P.E., Hendriks, J.M., de Maeseneer, M.G., Lauwers, P.R., 2005. Current management of spontaneous pneumothorax. *Monaldi. Arch. Chest Dis.*, **63**(4):204-212.

Vohra, H.A., Adamson, L., Weeden, D.F., 2008. Does video-assisted thoracoscopic pleurectomy result in better outcomes than open pleurectomy for primary spontaneous pneumothorax? *Interact. Cardiovasc. Thorac. Surg.*, **7**(4):673-677. [doi:10.1510/icvts.2008.176081]

Wakai, A., O'Sullivan, R.G., McCabe, G., 2007. Simple aspiration versus intercostal tube drainage for primary spontaneous pneumothorax in adults. *Cochrane Database Syst. Rev.*, (1):CD004479. [doi:10.1002/14651858.CD004479.pub2]

Wallach, S.L., 2000. Spontaneous pneumothorax. *N. Engl. J. Med.*, **343**(4):300-301. [doi:10.1056/NEJM200007273430413]

Wu, Y.C., Lu, M.S., Yeh, C.H., Liu, Y.H., Hsieh, M.J., Lu, H.I., Liu, H.P., 2002. Justifying video-assisted thoracic surgery for spontaneous hemopneumothorax. *Chest*, **122**(5):1844-1847. [doi:10.1378/chest.122.5.1844]

Zehtabchi, S., Rios, C.L., 2008. Management of emergency department patients with primary spontaneous pneumothorax: needle aspiration or tube thoracostomy? *Ann. Emerg. Med.*, **51**(1):91-100. [doi:10.1016/j.annemergmed.2007.06.009]

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