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Current management of spontaneous pneumothorax

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ABSTRACT: ***Current management of spontaneous pneumothorax. P.E. Van Schil, J.M. Hendriks, M.G. De Maeseneer, P.R. Lauwers.***

Spontaneous pneumothorax is divided into primary, when there is no underlying lung disease, and secondary, mainly caused by chronic obstructive pulmonary disease. A variety of different non-invasive and invasive treatment options exist. Due to the lack of large randomised controlled trials no level A evidence is present. A first episode of a primary spontaneous pneumothorax is treated by observation if it is <20% or by simple aspiration if it is >20%, but recurrences are frequent. For recurrent or persisting pneumothorax a more invasive approach is indicated whereby video-assisted thoracic surgery provides a treatment of lung (resection of blebs or bullae) and pleura (pleurectomy or abrasion). In patients with a secondary spontaneous pneumothorax related to chronic obstructive pulmonary disease, there is an associated increased mortality and a more aggressive approach is warranted consisting of initial thoracic drainage followed by recurrence prevention by thoracoscopy or thoracotomy in patients with a low or moderate operative risk. Talc instillation by the thoracic drain is preferred for patients with a high operative risk.
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Keywords: Pneumothorax, treatment, COPD, thoracic surgery, talc, thoracic drain.

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Introduction

There are many treatment options for spontaneous pneumothorax (SP) which is subdivided into primary and secondary subtypes (fig. 1). In this review specific management of SP is discussed and specific guidelines provided. Due to the lack of well-designed large prospective randomised trials only general recommendations can be given. As well as the British Thoracic Society, the American College of Chest Physicians published consensus reports on pneumothorax in which the British society favours a more conservative approach which was confirmed in a recent update [1-3]. Within the Belgian Society of Pneumology a working group on pneumothorax was created which recently finished a report on the management of SP based on recent manuscripts on pneumothorax [4-6]. These reports form the core of this review and wherever possible, a level of evidence is indicated subdivided from A to D (table 1).

Definition

A pneumothorax is defined as air entering the pleural space resulting in a loss of negative pressure and a variable degree of lung collapse. The general classification is listed in table 2. In this review we will focus on SP subdivided into primary and secondary subtypes. A primary SP implies no clinically apparent lung disease although in most cases apical blebs or emphysema - similar changes are found on the lung surface, most often at the apex of the upper lobe [7]. Depending on the thoracoscopic findings a specific classification can be made (table 3) as proposed by Vanderschueren R [8]. There is an ongoing discussion whether the blebs are the real cause of pneumothorax or

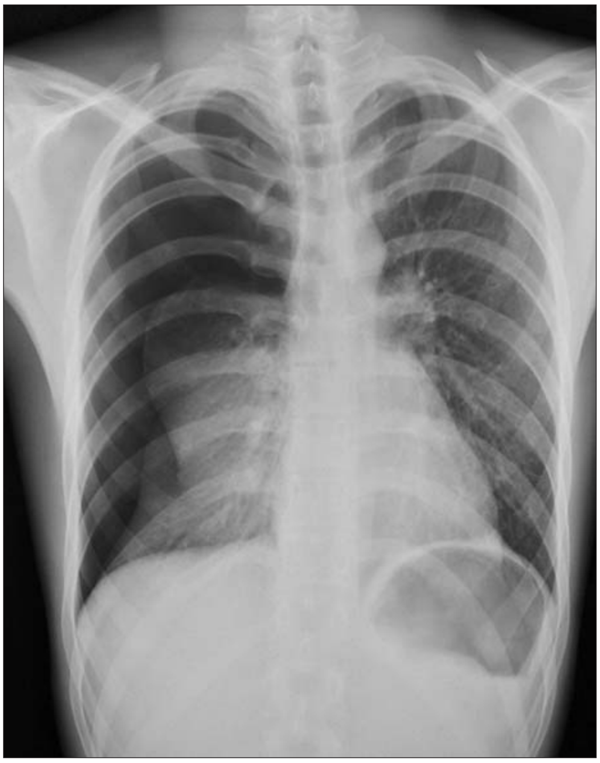

Fig. 1. - Spontaneous pneumothorax on chest radiograph.

Table 1. - Levels of evidence

Level	Description
A	Randomised controlled trials with a consisted pattern and rich body of data
B	Randomised controlled trials with a limited number of patients or inconsistent results
C	Non-randomised trials, observational studies
D	Panel consensus judgment

Table 2. - Classification of pneumothorax

Spontaneous
primary
secondary to
COPD
AIDS
cystic fibrosis
idiopathic pulmonary fibrosis
Marfan syndrome
Ehlers-Danlos syndrome
endometriosis
Langerhans cell granulomatosis
lymphangioleiomyomatosis
Traumatic
blunt chest injury
penetrating trauma
Iatrogenic
subclavian vein puncture
transbronchial biopsy
transthoracic needle aspiration
barotrauma

whether there is some kind of airway obstruction leading to interstitial and mediastinal emphysema with secondary rupture into the pleural space. Primary SP occurs more frequently in men, with an estimated incidence between 7.4 and 18 cases/100 000/year [9]. Typical characteristics of primary SP not only include male gender but also young age, tall and lean physiognomy and cigarettes smoking. Most patients with secondary SP have COPD. Other causes include interstitial and infectious lung disease, and rare disorders as thoracic endometriosis (table 2).

Primary SP usually has a benign clinical course and has been considered a low-mortality “nuisance” [7]. The average rate of recurrence of a primary SP is 30% and risk factors include radiographic evidence of pulmonary fibrosis, smoking, asthenic habitus and younger age, but not the presence of blebs or bullae [10-12].

On the other hand, a secondary SP is a serious event which can be life-threatening. Its incidence in the general population equals that of a primary SP, but it is 4 times higher in patients with COPD,

Table 3. - Thoracoscopic findings in patients with SP [8]

Stage	1	No specific abnormalities, anatomically normal lungs
	2	Pleuropulmonary adhesions
	3	Blebs or bullae < 2 cm
	4	Bullae > 2 cm

the most frequent cause of secondary SP [10]. Its recurrence rate is also similar to primary SP. Patients with COPD have a 3.5 - fold increase in relative mortality with each SP occurrence [13]. In patients with bullous emphysema differentiation between a large bulla and pneumothorax can be difficult. In case of doubt a computed tomographic (CT) scan should be obtained in order to avoid inserting a thoracic drain inside a bulla (fig. 2).

Size of pneumothorax

Obtaining a precise measurement of the pneumothorax remains difficult. In a pneumothorax model with a water filled plastic bag, the classical chest radiograph was found to be a poor tool in predicting the pneumothorax size in contrast to a chest CT scan [14]. The correlation coefficient for chest X-ray was only 0.71 and for CT scan 0.99. The reason for this discrepancy is the asymmetric collapse which occurs in most patients. In clinical practice, size is assessed on a postero-anterior chest radiograph mainly by the apex to cupula distance and the Light index which is calculated as follows: size of pneumothorax in % = $(1 - D_L^3 / D_{HT}^3) \times 100$, where D_L is the diameter of the lung measured at hilar level and D_{HT} is the internal diameter of the hemithorax also measured at hilar level [15]. Generally, lung dehiscence of the whole length of the lateral chest wall is defined as a large pneumothorax, in which case the Light index can be used with a cut-off point of 20% to guide subsequent therapeutic strategy. Because of the rou-

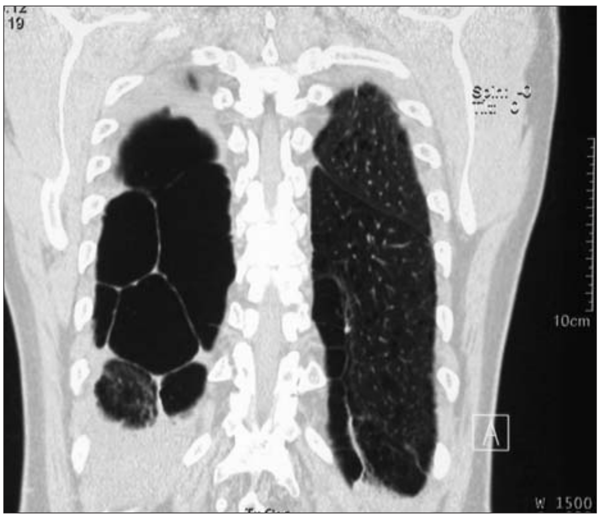

Fig. 2. - Chest computed tomography showing pronounced bullous emphysema.

tine use of digitalised chest radiographs, measurements in absolute values are no longer applicable although a pneumothorax > 2 cm on a classical chest radiograph is usually considered to be large. A partial pneumothorax, e.g. one occurring only in the apical part of the chest, is defined as small.

General treatment of pneumothorax

A variety of treatment options exist for SP. These are listed in table 4. Overall, treatment of SP has two goals: evacuation of air from the pleural space; and prevention of recurrence. We will first focus on the evacuation of air.

In 1993, guidelines where put forward by the British Thoracic Society after obtaining expert opinion from more than 150 British respiratory physicians and surgeons [1]. In these guidelines a conservative approach is favoured. Basic recommendations include the principle that intrapleural air does not necessarily imply a therapeutic intervention, and that management depends on the clinical symptoms and not on the size of the pneumothorax. The authors indicate that tension pneumothorax from a primary SP is extremely rare and that even a complete collapse can be treated by simple aspiration. In case of a limited pneumothorax with only a small rim of air around the lung, inpatient observation is recommended. When there is a moderate or complete collapse, drainage of air by aspiration is favoured, as it is also in patients with COPD. Only in cases of failure is a thoracic drain inserted.

However, this conservative approach has been much criticized [16]. In a retrospective study of 115 cases with spontaneous pneumothorax admitted at a district general hospital in the United Kingdom, only 21% of episodes were treated according to the British Thoracic Society guidelines [17]. Aspiration was effective in 58% of patients, but in 28% of cases that were initially successful, an increase in size of the pneumothorax occurred within 72 hours. The failure rate of aspiration in patients without COPD was 29%. Factors associated with failure were age above 50 years, COPD and an initial aspiration of more than 2.5 l of air. In the USA a more aggressive approach is favoured. Aspiration is performed in any pneumothorax larger than 20% of the hemithorax irrespective of the symptoms [2, 16].

Recently, the criteria of the British Thoracic Society have been clarified and modified although the basic principles have not changed: simple observation is recommended for uncomplicated cases, simple aspiration as initial treatment for larger pneumothoraces, and thoracic drainage for difficult or complicated cases [3]. A pneumothorax is considered as small when it is less than 2 cm on a chest radiograph. In cases of secondary SP limitations of simple aspiration are recognised and insertion of a thoracic drain is advocated for symptomatic patients, older than 50 years with a pneumothorax larger than 2 cm.

Table 4. - Treatment options for pneumothorax

simple observation
needle aspiration
thoracic drainage
water-seal
suction
Heimlich valve or valve device
pleurodesis - instillation of pleural irritant
talc
other agents, such as tetracyclin
VATS
thoracotomy
axillary
posterolateral
sternotomy

Aspiration or thoracic drainage?

What evidence is present to indicate whether a spontaneous pneumothorax should initially be treated by needle aspiration or a chest drain? In a 'best evidence' topic report the specific question of how a 20-year-old patient with acute shortness of breath and a left-sided pneumothorax occupying 50% of the hemithorax should be treated [18], was asked. In a Medline search from 1966 to 1999, 83 papers were reviewed. Of these, 81 were found to be irrelevant and only 2 randomised trials remained [19-20]. Recently, a third randomised trial was published [21]. In the first study reported by Harvey in 1994, 73 patients with spontaneous pneumothorax were randomised to needle aspiration (n=35) or intercostal drainage (n=38) [19]. In 80% of cases aspiration was successful, although 5 patients required two aspirations. The success rate of intercostal drainage was 100%. No difference in the total pain score was reported. The hospital stay was significantly shorter in the patients undergoing needle aspiration (3.2 days versus 5.3 days for intercostal drainage). There was no difference in the recurrence rate between the two groups. Weak points in this study are the small numbers in both groups which were ill-matched. There was a large difference in the initial size of the pneumothorax, complete collapse being present in 34% of the patients undergoing needle aspiration versus 58% in the intercostal drainage group.

In the second randomised study reported by Andrivet in 1995, 61 patients with a spontaneous pneumothorax were randomised to needle aspiration (n=33) or intercostal drainage (n=28) [20]. The success rate for needle aspiration was 67% versus 93% for intercostal drainage. This difference was statistically significant (p=0.01). There was no difference in hospital stay and recurrence rate after 3 months. The weaknesses in this study are the small numbers and the long hospital stay in the aspiration group. This was due to the fact that aspiration was not carried out for 72 hours in most patients. A second protocol was developed with immediate aspiration, but this was not a randomised study [20].

In the third study 60 patients with a first episode of primary SP were randomized between manual aspiration (n=27) and thoracic drainage (n=33) [21]. In the aspiration group the immediate success rate was 59.3% and after one week 93%. In the patients treated with a thoracic drain the immediate success rate was 63.6% and after one week 85%. These differences were not significant. There were no complications associated with the aspiration technique. Only 52% of patients undergoing manual aspiration were admitted to hospital compared to 100% of patients with a thoracic drain. The recurrence rate after one year was 26% in the aspiration group and 27.3% in the thoracic drainage group. Although the number of patients in this study is also limited, it clearly shows that for a first episode of primary SP manual aspiration is equally effective as thoracic drainage, that this procedure is well tolerated and can be performed in an ambulatory setting (level of evidence B).

Regarding overall initial treatment of SP, only grade C recommendations can be given and these are summarised in table 5. It should also be noted that failures with aspiration occur frequently, namely 25% in primary SP and 60% in secondary SP [10, 17]. The consequences of failed aspiration should also be considered. These include frustration of failure, insertion of a thoracic drain with added anxiety and pain and, inevitably, a longer hospital stay. Due to the higher failure rate of aspiration in secondary SP immediate insertion of a thoracic drain is recommended.

Recurrence prevention and indications for invasive treatment

The precise role of invasive treatment to evacuate air and prevent recurrence of SP is even more controversial and no level A evidence is available. Accepted indications are listed in table 6 (level C evidence). For a first episode of primary SP conservative treatment is warranted with simple aspiration as cost is minimal and recurrence does not occur in 75% of patients. In the case of secondary SP thoracic drainage and recurrence prevention are indicated in every case due to the higher recurrence rate and increased mortality associated with recurrent SP [13]. If an experienced thoracic surgeon is not available or in case patient refuses an operation or the operative risk is too elevated, chemical pleurodesis by instillation of a pleural irritant into the thoracic drain or by pleuroscopy under local anaesthesia is an alternative to invasive surgical treatment. In a recent review talc was found to be the most efficient drug to obtain definitive pleurodesis [22]. Moreover, talc is cheap but the optimal dosage remains to be determined. In the new recommendations of the British Thoracic Society, administration of 5g of talc is recommended although the failure rate may be as high as 9% [3]. Talc instillation carries a low risk but severe complications as pulmonary oedema, ARDS and hypotension have been reported [23,24]. Moreover, talc induces an inflammatory reaction on the pleural surfaces, which is rather painful in the majority of patients. In the case of failure of talc pleurodesis, a subsequent surgical procedure becomes more difficult due to frequent and easy bleeding from the inflamed pleural surfaces [7]. In an experimental study in the rat, rapid absorption of talc from the pleural space with a subsequent systemic distribution has been described which might explain the systemic complications [25]. For these reasons chemical pleurodesis with talc is usually reserved for patients presenting a high operative risk or who refuse an operation. For the other patients an invasive surgical procedure is preferred.

VATS treatment of SP

With the introduction of Video Assisted Thoracic Surgery (VATS) in the early 1990's the interest in early definitive treatment of SP has rekindled to avoid a large lateral thoracotomy incision and to obtain a minimally invasive treatment for pneumothorax. There is a difference between a so-called medical pleuroscopy performed by pulmonary physicians and a VATS procedure. Medical pleuroscopy is often done under local anaesthesia and is limited to an intervention on the pleural space. A chemical pleurodesis is easy to perform under direct vision. In contrast, a VATS procedure requires general anaesthesia with double lumen intubation and single lung ventilation. In this way, also an intervention on the lung itself is possible as e.g. a bullectomy with the aid of endostaplers (fig. 3). Many series have been pub-

Table 5. - Initial treatment principles for SP (level C evidence)

observation	
	no significant dyspnoea
	< 20% pneumothorax
aspiration	
	significant dyspnoea
	> 20% pneumothorax
thoracic drain	
	age > 50 years
	COPD
	recurrent or bilateral pneumothorax
	initial aspiration > 2.5 l of air
	associated pleural effusion
	ventilated patients

Table 6. - Indications for invasive treatment (level C evidence)

Recurrent or persisting pneumothorax
Bronchopleural fistula with air leak 5 to 7 days
Haemopneumothorax
Bilateral pneumothorax
First contralateral pneumothorax
Professions at risk (aircraft personnel, divers)

Fig. 3. - Endostaplers used for resection of blebs or bullae during a VATS procedure.

lished on VATS treatment for pneumothorax. The most recent ones are summarised in table 7 [26-37]. However, level A evidence is lacking; so, the results of these studies should be interpreted with caution.

Treatment of the lung

Although the exact cause of a pneumothorax remains unknown, most authors advocate to resect any blebs or bullae that are visible during VATS, although there is no level A evidence to support this. However, Naunheim *et al.* have demonstrated that the recurrence rate drops from 20 to 1.5% when a resection of bullae is performed [38]. Often endostaplers are used for this; cheaper alternatives include the use of endoloops or endoscopic sutures. Small blebs can be coagulated which is not applicable for large bullae due to frequent recurrences.

Treatment of parietal pleura

For recurrence prevention the parietal pleura should be treated to obliterate the pleural space, especially in the apical part where most blebs and bullae occur. In a comparative but non-randomised study, Horio *et al*. have shown that the recurrence rate diminished from 16 to 1.9% when a pleurodesis was added to the bullectomy [31]. Many possible techniques have been described, the most utilised being pleurectomy and mechanical pleurodesis. Pleurectomy implies the removal of the parietal pleura and can be partial or total. Other methods to obtain pleurodesis include electrocoagulation and abrasion of the pleura, injection of talc, fibrin glue or other pleural irritant, or laser pleurodesis. There are no prospective randomised studies comparing these techniques or comparing VATS to medical pleuroscopy with talc poudrage. In 1996, a retrospective study was published comparing different techniques in 1365 VATS procedures [39]. Recurrence rate was 0% after talc instillation but this technique was only applied in 15 patients, 2.7% after coagulation, 4.4% after pleurectomy, 7.9% after pleural abrasion, 10.2% without pleurodesis and 16.4% after injection of fibrin glue. Due to its retrospective nature no firm conclusions can be drawn. The studies listed in table 7 show recurrence rates of 0.8 to 9.2% after pleurectomy, of 2.1 to 9.4% after abrasion, of 1.9% after coagulation, and 1.8% after talc injection. As there is no randomisation in these studies level of evidence remains C. Although the best results are obtained after total pleurectomy, this technique makes the hemithorax inaccessible when a new intervention is required later in life. For this reason most authors advocate an apical, partial pleurectomy and a mechanical pleurodesis down to the diaphragm, technique which is also utilised in our centre.

Table 7. Recent studies on treatment of pneumothorax by VATS [26-37]

Author	Year	Ref.	Evidence	n	Type of procedure	% recurrence
Waller	1999	[26]	C	180	bull, pl	6.6
Liu	1999	[27]	C	757	bull, pl, abr, chem.	2.1
Ohno	2000	[28]	C	424	bull, abr	9.4
Cardillo	2000	[29]	C	153	bull, pl	9.2
				279	bull, talc	1.8
Chan	2001	[30]	C	82	bull, abr	5.7
Horio	2002	[31]	C	50	bull	16.0
				53	bull, coag	1.9
Onuki	2002	[32]	C	59 (SSP)	bull	1.7
Roviaro	2002	[33]	C	171	bull, pl	0.8
Sawabata	2002	[34]	C	99	bull	10.1
Casadio	2002	[35]	C	133	bull, abr	3.8
de Vos	2002	[36]	C	63 (PSP)	bull, pl, abr	4.8
				13 (SSP)	bull, pl, abr	7.7
Lang-Lazdunski	2003	[37]	C	182	bull, abr	3

SSP: secondary spontaneous pneumothorax; PSP primary spontaneous pneumothorax; bull: bullectomy; pl: pleurectomy; abr: abrasion; chem.: chemical pleurodesis; coag: coagulation.

VATS: PRIMARY SP VERSUS SECONDARY SP

Most of the studies on VATS for pneumothorax were performed for primary SP. Reports on secondary SP treated by a VATS approach are less frequent and show a recurrence rate between 0 and 8% [40-43]. Especially in these patients a SP may induce severe distress due to a limited pulmonary reserve. Advantages of VATS versus thoracotomy in patients with secondary SP probably include less postoperative pain, a shorter hospitalisation time and less pulmonary dysfunction although this has not been clearly demonstrated. In contrast, the incidence of complications after a VATS procedure for secondary SP varies between 25 and 77%, which is much higher than for primary SP where the percentage of reported complications lies between 3.2 and 25.4% [40-43]. In patients with a poor pulmonary function who can not tolerate single lung ventilation a thoracotomy is indicated.

VATS VERSUS THORACOTOMY

Three prospective studies compare a VATS procedure with a classical thoracotomy (lateral or limited axillary). Waller *et al.* published a randomized study of 60 patients treated for a pneumothorax by thoracoscopy or lateral thoracotomy [41]. In the VATS group there was less pulmonary dysfunction, less pain and a shorter hospitalisation time compared to the thoracotomy group.

Kim et al. completed a prospective trial in 66 patients comparing VATS to a limited axillary thoracotomy [44]. This was a non-randomised trial as the choice of approach was made by the patients themselves. There was no significant difference between both groups regarding the duration of intervention and chest tube drainage, need for analgesics and recurrence rate.

A third prospective and randomised study was recently reported comparing VATS to axillary thoracotomy in 90 patients [45]. Specific factors studied were postoperative blood loss, lung function, postoperative pain and use of analgesics, postoperative complications, duration of hospital stay and resumption of normal activity. There were no significant differences for every factor studied; so, VATS seems to be equally effective as a limited axillary thoracotomy (level of evidence B). However, with a minimum follow-up of two years the recurrence rate after VATS was 4.3% and after a limited thoracotomy 0% [45].

COST OF VATS VERSUS OPEN PROCEDURE

In recent literature there are only 3 manuscripts discussing the cost issue of a VATS approach and comparing it to an open intervention. In the first study which was a retrospective one, cost was analysed in 60 patients with a primary or secondary SP undergoing a VATS approach or thoracotomy [46]. In each group there were 30 patients. Multiple interventions were performed ranging from bullectomy associated with pleurectomy to simple pleural abrasion. Patients approached by a thoracotomy were operated before 1991 and those having a VATS procedure after 1991. Compared to a limited thoracotomy, the duration of intervention, thoracic drainage and hospitalisation time was shorter in the VATS group. The total cost of VATS was 22.7%

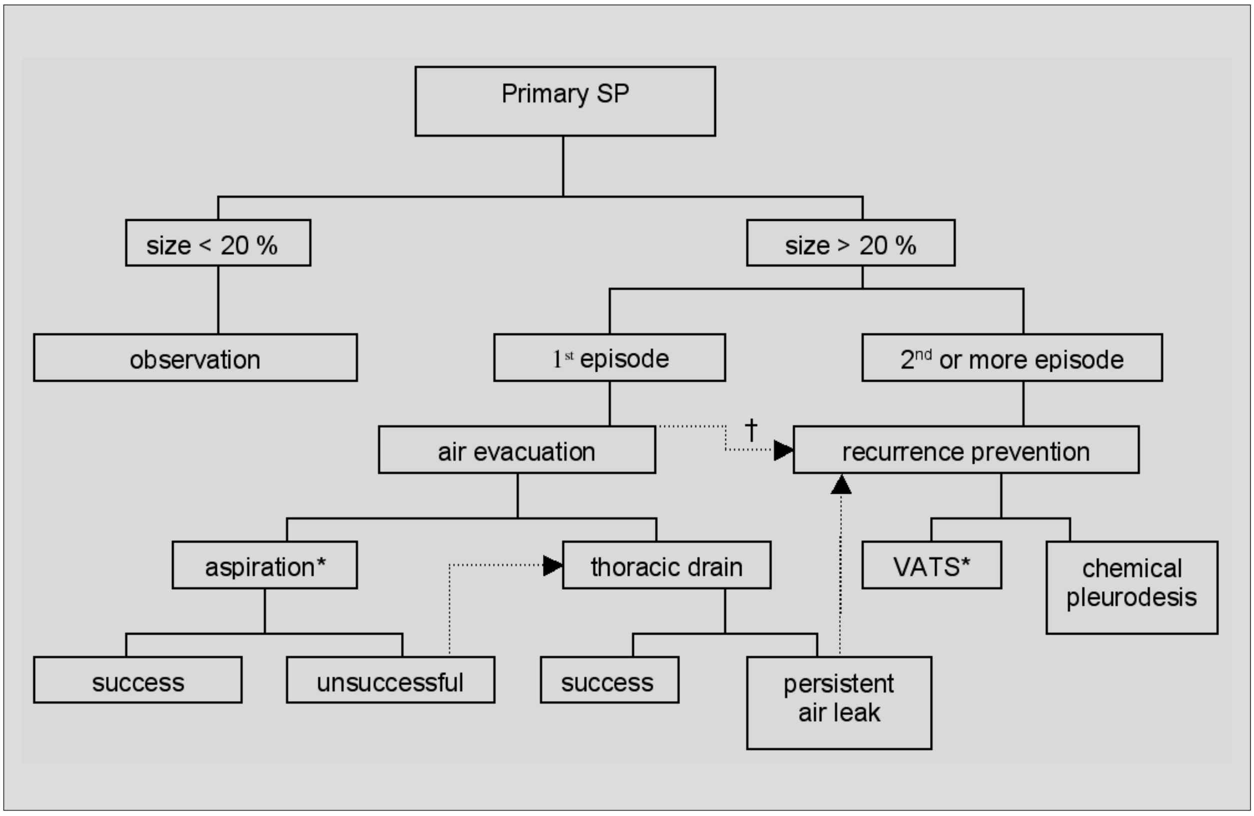

Fig. 4. - Flow chart for primary spontaneous pneumothorax (SP). * recommended, † in some cases indicated (e.g. bilateral pneumothorax, professions at risk).

less than that of an open procedure. Rather surprisingly, in the VATS group the cost of the video-equipment was not calculated [47]. Moreover, in both groups numbers were small and patient population was heterogeneous: a secondary SP was present in 40% in the thoracotomy group compared to 26.7% in the VATS group. Bullectomy and pleurectomy were more often performed in the thoracotomy group suggesting more extensive bullous disease, which could already induce a longer hospital stay in this group. One patient died in the thoracotomy group after a prolonged stay; this could influence hospital stay and cost. Recurrent pneumothorax was also more frequent in de VATS group (6.6%) than in the thoracotomy group (0%) although in the VATS group the follow-up time was shorter due to the fact that these patients were operated in a later time period.

In the aforementioned study by Kim *et al.* cost was also analysed [44]. Due to the frequent use of disposable instruments, especially endostaplers, the cost was higher in the VATS group.

In a third retrospective study cost was analysed in 50% patients operated on for spontaneous pneumothorax, 22 having a VATS procedure and 28 a limited axillary thoracotomy [48]. There was no difference in operating time, but the overall length of stay was shorter in the VATS group. However, the overall cost of VATS was not different from a limited thoracotomy. In this study socio-economic cost was also calculated and was found to be lower in the VATS group as the latter missed significantly less time from work postoperatively. The authors concluded that VATS was a cost-effective procedure which was also better tolerated than an open technique.

Due to the lack of well-designed prospective randomised studies, only level C evidence is present regarding the cost issue. However, it is clear that VATS has a higher initial cost due to the use of disposable instruments. Whether this is offset by a more rapid discharge and return to economic activity remains to be proven [49].

Conclusions

Treatment of SP remains controversial due to the lack of level A evidence. Flow charts for treatment of primary and secondary SP are provided in fig. 4 and 5. Level B evidence exists for treatment of a primary SP > 20% where simple aspiration is preferred as it can be performed in an ambulatory setting. For a secondary SP a more aggressive approach is warranted as a higher mortality can be anticipated. Regarding recurrence prevention, the optimal technique remains to be determined. VATS provides an attractive surgical method due to its superior visualisation of the thoracic cavity and possible interventions, as well on the lung parenchyma itself as on the parietal pleura, resulting in an adequate obliteration of the pleural space.

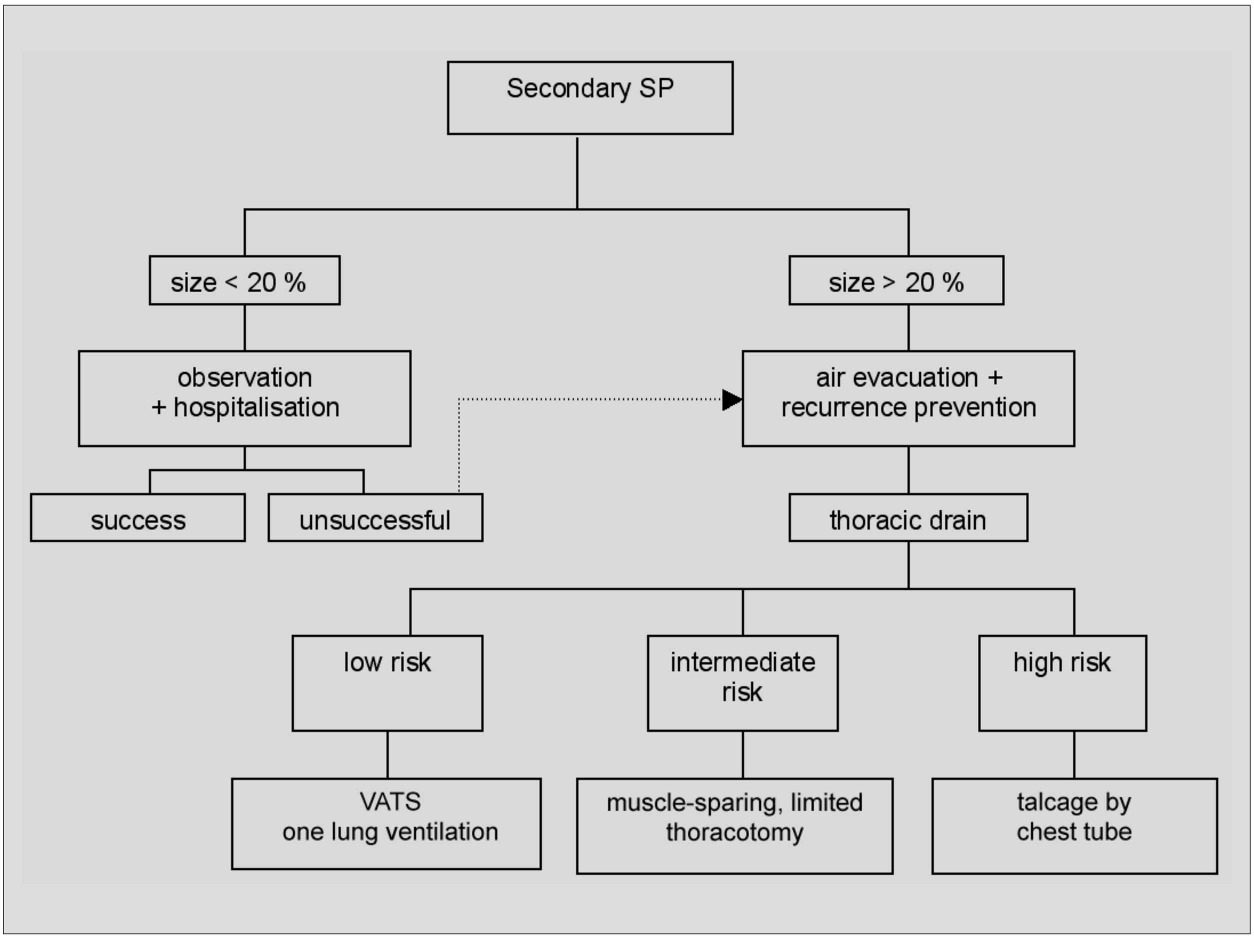

Fig. 5. - Flow chart for secondary spontaneous pneumothorax (SP).

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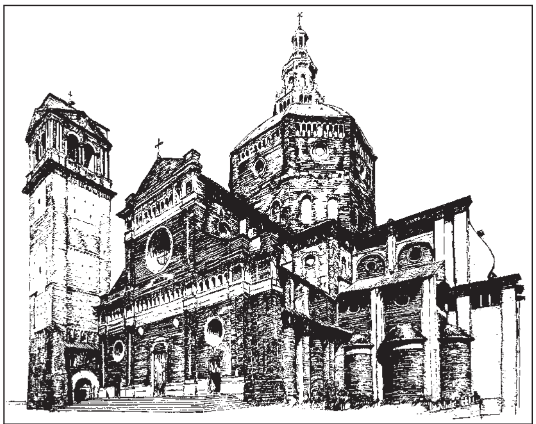

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