REVIEW

Video assisted thoracic surgery in the management of spontaneous pneumothorax: the current status

C S H Ng, T W Lee, S Wan, A P C Yim

Postgrad Med J 2006;**82**:179–185. doi: 10.1136/pgmj.2005.038398

Over the past decade, video assisted thoracic surgery (VATS) has changed the way spontaneous pneumothorax (SP) is managed. Benefits of VATS include less postoperative pain, shorter hospital stay, and attenuated postoperative inflammatory response are evident compared with open thoracic procedures. Furthermore, the increasing acceptance by patients and referring physicians is testament to its success. Recent studies and the authors decade of experience in management of SP by VATS show that it is quick, safe, and effective, with recurrence rates generally comparable to open procedures, with some exceptions. However, selecting the correct procedure and patient, as well as knowing the limitations of the surgeons and techniques are paramount for success. Even to this day, there are considerable variations in the treatment of SP and large scale controlled studies are needed to better define timing of surgery and the role of the different procedures in the treatment and prevention of SP.

SURGICAL MANAGEMENT: IS THERE A CONSENSUS?

Currently, there is no good consensus on the treatment for first time or recurrent primary spontaneous pneumothorax (PSP).^{3,4} Conservative management (observation, needle aspiration, chest tube) of SP has been shown to result in significant recurrence of 16% to 52% (average 30%), with most recurrences occurring within six months to two years.⁵ Furthermore, the rate of recurrence increases dramatically with more episodes of SP, and stopping air leak becomes harder to achieve by conservative medical management.⁵

With the lowered morbidity of VATS, the old surgical algorithms developed based on the morbidity from major access trauma of thoracotomy should be re-evaluated. The accepted surgical indications for pneumothorax include:

- persistent air leak^{3,6}
- recurrence^{3,6}
- radiologically demonstrated large bulla⁷
- spontaneous haemopneumothorax (fig 1A)⁸
- incomplete expansion of the lung despite chest drainage and suction
- tension pneumothorax⁹
- bilateral pneumothorax
- SP in a high risk occupation (such as pilot or scuba diver)³

Furthermore, SP associated with rare conditions such as Marfan's syndrome, pulmonary lymphangioleiomyomatosis (fig 1B), and catamenial pneumothorax¹⁰ may benefit from surgical intervention to prevent recurrence. Some authors have even recommended VATS for uncomplicated first time pneumothorax,³ which we currently do not advocate. However, there remain considerable controversies on issues such as the duration of persistent air leak and the number of recurrences before surgery is deemed appropriate.³ A recent consensus from the American College of Chest Physicians (ACCP) recommended the observation of air leaks for four days before surgical intervention.³ In contrast, the latest British Thoracic Society (BTS)

Therapeutic thoracoscopy can be traced back to 1910 when Jacobaeus performed intra-pleural pneumolysis in patients with tuberculosis.¹ However, technological advancements in videoendoscopy in the past decade have enabled the re-introduction of thoracoscopy in the form of video assisted thoracoscopic surgery (VATS) with much wider clinical applications.² The advances that have played key parts in the transformation include, the development of microcameras and rod lens technology permitting a panoramic view of the hemithorax (instead of the previous tunnel-like vision); evolution of general anaesthetic technique to allow one lung ventilation thereby permitting free manoeuvrability of the telescope and instruments within the pleural cavity; and availability of specialised endoscopic surgical instruments. Furthermore, the success and excitement of laparoscopic cholecystectomy gave impetus to the application of such technique to the chest.

VATS is now regarded by many surgeons to be the gold standard in the surgical management of a variety of thoracic conditions, such as spontaneous pneumothorax (SP), pleural diseases, and indeterminate lung nodules. The different aetiologies associated with primary and secondary SP (with underlying lung disease) can have bearing on the surgical strategies. In this review, the role of VATS in the management of SP is discussed.

See end of article for authors' affiliations

Correspondence to:
Dr C S H Ng, Division of
Cardiothoracic Surgery,
The Chinese University of
Hong Kong, Prince of
Wales Hospital, Sha Tin,
NT, Hong Kong;
calvingng@surgey.cuhk.
edu.hk

Submitted 13 June 2005
Accepted 19 July 2005

Abbreviations: CT, computed tomography; SP, spontaneous pneumothorax; PSP, primary spontaneous pneumothorax; SSP, secondary spontaneous pneumothorax; VATS, video assisted thoracic surgery; ABC, argon beam coagulation; HP, haemopneumothorax; SHP, spontaneous haemopneumothorax; THP, traumatic haemopneumothorax

guidelines recommended referral to cardiothoracic surgeon when the patient cannot be weaned off chest drain after five days.⁴ Our experience supports the use of VATS when persistent air leak is present for more than three days, and on the second admission for SP. However, in patients who are not suitable for surgery or general anaesthesia, medical management in the form of chemical pleurodesis (such as talc) should be considered.^{3 11}

The role of surgical treatment for the future prevention of SP in the ipsilateral and contralateral lung for high risk patients has also been divided. The question of whether radiological evidence of pulmonary bulla can predict pneumothorax occurrence or recurrence, and thereby select patients for “prophylactic” VATS therapy, remains unanswered. Many are sceptical of the causal relation between bulla and PSP, however, videoscopic findings have shown that a large proportion (78%–89%) of patients presenting with PSP in presumable normal lungs have endoscopically visible blebs or bullae (table 1). Previously, it was shown that the presence of bullae by CT scan and during thoracoscopy at the initial presentation of SP did not predict recurrence.⁵ Interestingly, a recent study reported that the detection of bullae by CT in the contralateral lung after unilateral PSP may be associated with a higher rate of subsequent pneumothorax in that lung¹² (fig 2). Therefore, the value of VATS as primary therapy for PSP and for preventing ipsilateral or contralateral pneumothorax occurrence, by

Figure 2 CT thorax showing bilateral apical bullae and right sided SP from a young man. The initial SP was treated with VATS stapled bullectomy and abrasion pleurodesis. However, contralateral (left) SP occurred two days after surgery.

way of bulla detection with CT scans remain issues to be resolved. Furthermore, there is no consensus on when to use thoracic CT scan for evaluating patients with recurrent pneumothoraces or persistent air leaks.³ Carefully conducted randomised clinical trials are warranted in these areas.

Figure 1 (A) Chest radiograph showing right spontaneous hemopneumothorax. (B) CT thorax of a young woman with pulmonary lymphangioliomyomatosis showing multiple bilateral pneumatoceles.

VATS FOR PNEUMOTHORAX

Surgical access for the management of pneumothorax can be performed via open techniques (usually axillary or lateral thoracotomy) or by minimal access VATS. The success of VATS in the treatment of pneumothorax has led to earlier referral by physicians and increased acceptance by patients for surgery.¹³ The experience so far shows that VATS procedures in elderly (>75 years) patients are safe with low postoperative pulmonary complications.¹⁴ In addition, VATS can also be a useful approach in selected cases in the paediatric population for a variety of endoscopic procedures.¹⁵

There is increasing evidence to associate VATS with less access trauma and quicker recovery, with many realising that trauma from access is often worse than the surgery for correction.¹⁶ Postoperative proinflammatory cytokine levels were lower,¹⁷ and T cell subgroups as well as natural killer cells were less suppressed after VATS compared with their open counterparts.¹⁸ In addition, patients undergoing VATS required significantly less postoperative parenteral narcotics and pain medications than the open techniques.^{17 19} However, the incidence of chronic sequelae (chronic pain, numbness, or disaesthesia) after thoracoscopic procedures were present in 25% to 31% of patients and the rate of chronic pain was equal for VATS and thoracotomy.^{20–22} In our experience, many of the patients who underwent VATS for SP thought that chest tube insertion upon admission (with or without sedation) was more painful than VATS.

Pulmonary function tests performed postoperatively after VATS for SP showed little deterioration when compared with normal controls. In contrast, patients who underwent thoracotomy and parietal pleurectomy for SP had a 7.5% to 16% reduction in vital capacity before returning to preoperative values after five months.²³ The difference is probably attributed to access trauma from rib spreading in thoracotomy. Furthermore, we found patients undergoing VATS to have significantly less shoulder mobility dysfunction in the early postoperative period when compared with posterolateral thoracotomy.¹⁹

Table 1 Recent data of VATS for spontaneous pneumothorax

Authors	Case description	Patient number	Blebs/bullae seen at VATS (%)	Stapled bullectomy	Endoloop/endosuture/ABC	Abrasion pleurodesis (%)	Prolonged postoperative air leak (%)	Mean hospital stay in days (range)	Mean or median follow up in months (range)	SP recurrence (%)
Yim ³³ (1997)	PSP	483	87	196	261/35/6	100 (alone in 20 cases)	3	3 (1–30)	20 (1–36)	1.7
Liu ³⁴ (1999)	PSP and SSP	757	89	312	352/52/6	(alone in 49 cases)	4 (>10 days)	4.5 (0–27)	30 (1–60)	2.1
Hatz ²⁷ (2000)	PSP and SSP	PSP: 95 SSP: 14	NA	109 (alone in 72)	0	34	2.8 (>2 days)	PSP: 4 (2–14) SSP: 8 (1–18)	53 (2–86)	4.6
Ayed ⁴⁸ (2000)	PSP	72	78	56	0	54	6.9 (>5 days)	4	42 (36–54)	5.5 (by gauze abrasion)
Loubani ⁴⁹ (2000)	PSP	49	NA	52 (+/- acromycin)	0	0	NA	6.8/4.8	38 (36–40)	20/4
Cardillo ⁴⁷ (2000)	PSP	432	78	235	104/0/0	0	1.4 (>5 days)	6	38 (2–72)	4.4
Chan ²² (2001)	PSP	82	NA	NA	NA/0/0	100	NA	NA	44 (8–85)	5.7
Gossoi ²⁸ (2004)	PSP	185	88	163	0	100	4.3	5 (2–17)	36.5	3.6
Chen ⁵⁰ (2004)	PSP	313	95	313 (or apical wedge; + minocycline)	0	100	7 (>5 days)	5.8	39 (1–120)	2.9

ABC, argon beam coagulation; NA data not available; PSP primary spontaneous pneumothorax; SSP secondary spontaneous pneumothorax.

General approach

The chest is the most suitable body cavity for the minimal access approach, because once the lung is collapsed (with selective one lung ventilation), there is plenty of room for instrument manoeuvring. The use of carbon dioxide insufflation and hence valved ports, is therefore unnecessary. In fact, there is evidence that thoracic carbon dioxide insufflation during VATS has an adverse effect on the patient's haemodynamics compared with selective one lung ventilation.²⁴

Figure 3 (A) Bulla at the apical segment of right lower lobe in a patient with PSP. (B) Endoscopic stapled bullectomy.

The patient is positioned in the lateral decubitus position with the operating table flexed at 30° to open up the intercostal spaces for thoracoscope insertion and instrumentation. The standard VATS pleurodesis procedure requires three ports placed at the 7th intercostal space mid-axillary line, 4th intercostal space anterior axillary line, and the last port just anterior to the tip of the scapula. The arrangement permits a panoramic view of the hemithorax, and the instruments are at a suitable distance from the target lesion to provide space for manipulation. Furthermore, the instrument and camera ports should be sufficiently far apart in a “triangulation” manner to prevent instrument “fencing”, and be within the same 180° arc to avoid mirror imaging. Recently, single port VATS for pneumothorax has been reported, potentially further reducing postoperative pain and chest wall paraesthesia.²⁵

There are additional strategies in VATS that can assist in minimising chest wall trauma and hence postoperative pain. For example, flexing of the operating table to open up the intercostal space, avoiding the use of trocar ports by introducing instruments directly through the wound, avoiding torquing of the thoracoscope by visualising with an angled lens, and use smaller telescopes (5 mm) when clinically permitted are strategies to reduce wound size as well as decrease the risk of intercostal nerve injury.²⁶

Endoscopic stapled bullectomy

The presence of subpleural bullae has been reported to be present in 76% to 100% of PSP patients during VATS⁶ (fig 3A). Endoscopic stapled bullectomy remains the preferred procedure for bullectomy³ (fig 3B) and should be accompanied by some form of pleural symphysis.^{27–28} Evidence suggests that even when no bleb or bulla is identified intraoperatively, stapled apical lung wedge resection should be performed to decrease recurrence.²⁹ Complications associated with the technique include air leak from the staple line, especially in emphysematous patients,³⁰ which can be greatly reduced by pericardial buttress reinforcement.³¹ Furthermore, staple cutter malfunctioning has also been reported.³²

Endoscopic suturing

Video assisted thoracoscopic suturing of apical bullae with mechanical pleurodesis has been shown to be a viable alternative to endoscopic stapled bullectomy with mechanical pleurodesis.^{13–33–34} Parenteral narcotic requirement, chest drainage duration, hospital stay, and pneumothorax recurrence were similar for both techniques.^{33–34} To minimise cost, the long conventional needle holder and standard monofilament polypropylene sutures can be used for thoracoscopic

suturing of bullae. Therefore, in view of the high cost of staple cutters, endoscopic suturing of apical bullae should be considered in selected cases of small localised bullae for PSP.^{13 33 34} However, it must be emphasised that endoscopic suturing should be performed by surgeons adequately trained in the skill.

Endoloop ligation

Endoscopic endoloop bulla ligation can be suitable for bulla in PSP and secondary SP (SSP).^{34 35} It is performed using a pre-tied commercial endoloop or by a homemade polydioxanone loop. Homemade devices are, of course, more cost effective. However, a known complication of endoloop ligation is the accidental slipping off of the loop during lung expansion or after a forceful sneeze. The problem can be minimised by the placement of a double or triple loop around each bulla, then secured with surgical clip.^{30 32}

VATS for pneumothorax during pregnancy

The third trimester, particularly near term, is the most common period for PSP to occur. Most cases result from the rupture of a subpleural apical bulla or bleb, precipitated by pulmonary and thoracic pressure changes. Pneumothorax management difficulties during pregnancy come from the reduced maternal respiratory reserve (diaphragmatic splinting), increased oxygen demand during pregnancy and labour, inadequate fetal oxygen supply, and preterm labour. A chest drain should be inserted when the patient presents with a PSP in the first, second or early in the third trimester, then VATS should be considered.³⁶ However, if the patient presents near term and has a large pneumothorax, VATS should be delayed until early in the postpartum period. Preparations should be made for an emergency caesarean section in case of acute fetal distress.

Limitations and complications

There are comparatively few contraindications to VATS. In addition to the general contraindications like recent myocardial infarction and severe coagulopathy, specific ones include pleural symphysis and patients with severe underlying lung disease or poor lung function. Prior operation³⁷ or talc pleurodesis³⁸ in the ipsilateral chest should not be regarded as a contraindication. Adhesions can usually be taken down using a combination of sharp and blunt dissection under videoscopic vision. However, patients with difficult adhesions to take down may be more suitable for thoracotomy approach (table 2)

Those who are elderly with multiple comorbidities may benefit more from a chemical pleurodesis (we prefer talc slurry) if the lung can be fully re-expanded.³ Patients with severe underlying lung disease or poor lung function may not be able to tolerate the selective one lung ventilation during general anaesthesia, which is used by many thoracic surgeons to gain room for instrument manoeuvring during VATS. Simple procedures in infants could be performed using endotracheal intubation with lowered tidal volume alone or

intermittent apnoea.¹⁵ Some thoracoscopic procedures (for example, bullectomy) can also be performed under local and epidural anaesthesia, but may only be applicable to a selected group of patients.³⁹ Therefore, treatment of SSP (with established lung disease like emphysema or pneumoconiosis) requires more clinical judgement. In addition, clinicians should bear in mind the higher mortality associated with VATS for SSP compared with PSP.⁴⁰

The recurrence rate of SP after VATS (2%–14%) can be slightly higher than the mini-thoracotomy (0%–7%) approach.⁵ The different recurrence rate between the techniques may reflect the inadequate exposure of the chest cavity in VATS, and subsequent incomplete detection and resection of apical bullae.⁵ Additionally, a change to thoracotomy from VATS is required in 2% to 10% of patients with PSP²⁸ and up to 29% of patients undergoing VATS for SSP, because of technical difficulties associated with the procedure.

Most complications after VATS for pneumothorax are not serious. Persistent air leak, wound infection or bleeding, intercostal neuralgia and surgical emphysema are the more common complaints.³² Rarely, re-expansion pulmonary oedema can occur after VATS (0.15%), which can be treated with oxygen therapy, continuous positive airway pressure, or full ventilatory support in severe cases.^{32 41}

Other therapeutic modalities

Different types of glue and their applications have been investigated to aid in stopping pulmonary air leak. In a recent murine study, the collagen-polysaccharide glue was well tolerated, and effective in sealing air leaks without increasing adhesion formation.⁴² Additionally, intrapleural infusion of diluted fibrin glue as a sclerosing sealing agent in high risk patients with intractable pneumothorax and prolonged air leaks after lung resection have also shown some promising results.⁴³ However, further clinical trials are needed to elucidate the role of glue in the management of SP.

Another recent invention is the rotating electrical brush system in VATS mechanical pleurodesis for the treatment of SP. The brush system when combined with VATS was shown to be a highly effective and safe treatment for SP. The drainage time, hospitalisation time, and recurrence rate are comparable with VATS using other forms of pleurodesis.⁴⁴

It is important to be able to detect and remove pulmonary bullae and blebs in the treatment of SP. A special thoracoscope using near infrared rays can permit detailed and effective imaging of the pleural and subpleural lesions because of its permeability to tissue, thus identifying small blebs and bullae as well as being able to better define the margin of pulmonary resection.⁴⁵

VATS FOR HAEMOPNEUMOTHORAX (HP)

In general, a cardiothoracic surgeon should be consulted for spontaneous or traumatic HP, and patients transferred to specialist centre for monitoring. In the past, exploratory thoracotomy has been the gold standard for both spontaneous

Table 2 Difficult conditions for VATS in SP

Difficulties	Potential strategies
Poor lung function (cannot tolerate one lung ventilation)	Intraoperative ventilation by intermittent apnoea, or low tidal volume
Prior thoracic surgery or talc pleurodesis (extensive adhesions)	Consider non-surgical chemical pleurodesis Meticulous VATS adhesiolysis Conversion to open thoracotomy (Consider non-surgical chemical pleurodesis)
Giant pulmonary bulla	Intraoperative puncture of bulla for space to manoeuvre
Severely emphysematous lungs	Extra gentle instrumentation Pericardial buttressing of staple line

and traumatic HP, however, VATS has recently gained acceptance as a new therapeutic modality for the management of HP in selected patients.

Spontaneous haemopneumothorax (SHP)

SHP is associated with between 1% to 12% of all SP, and the incidence is higher in men.⁸ The condition can be life threatening and should be suspected in patients with unexplained signs of hypovolaemia. SHP has also been reported to be associated with congenital cystic adenomatoid malformation, haemophilia, Ehlers-Danlos syndrome, sarcoidosis, and systemic lupus erythematosus. Chest roentgenogram is the most useful investigation, however, in 10% of SHP cases the presentation radiograph may show only pneumothorax. Initial output after chest tube drainage can be up to two litres, and blood transfusion may be necessary.⁸ The source of bleeding is either from a small non-contractile vessel in an area of torn vascular adhesion between the two layers of pleurae, or rupture of a vascular bulla or lung parenchyma at the apex of the lungs. In the era of minimally invasive surgery, we advocate VATS exploration and haemostasis for all SHP patients, except those with haemodynamic instability when thoracotomy would be more appropriate.⁸ The conservative approach of chest drainage alone for SHP is not recommended because of complications including haemodynamic instability, persistent airleak, clot retention, empyema, and need for delay decortication.⁸

Traumatic haemopneumothorax (THP)

THP can be the result of blunt or penetrating injury to the chest. Most haemodynamically stable patients with thoracic injuries can initially be managed with tube thoracotomy and close observation. For haemodynamically unstable patients with persistent chest drainage, exploratory thoracotomy is mandatory. However, for stable patients, thoracic imaging in the form of CT, with or without transthoracic echocardiogram and aortogram should be performed. Those suspected of major vascular injury should undergo open exploratory thoracotomy. Exploratory VATS is advocated in THP patients who are haemodynamically stable, with persistent drainage (>200 ml/h for three hours) and evidence of acute haemorrhage (initial chest drainage of >1000 ml), pleural space collection/infection, suspected thoracic organ injury, recurrent pneumothorax, and intrathoracic foreign body. Conversion from VATS to open thoracotomy in blunt and penetrating chest injuries is between 13% to 30%.⁴⁶

RESULTS AFTER VATS FOR SP

There has been numerous studies reporting the effectiveness of VATS in the treatment of SP, and the techniques described above have all been used with minimal morbidity (table 1). At experienced centres the recurrence rate has consistently been reported to be as low as treatment via thoracotomy.^{28 30 32-34 47} Furthermore, recently available long term data (up to 53 months) showed that pneumothorax recurrence rate remained low for patients treated by VATS for SP.^{27 48} Thorough pleural examination and experience of the surgeon may be the two most important factors in determining recurrence rate and incidence of postoperative prolonged air leak. Often, recurrences were more frequent in patients in whom no blebs or bullae were identified.⁴⁸ Missed bullae and more conservative surgical procedures in these patients are possible explanations. Some evidence suggests that apical lung excision, even in the absence of visible lesion, may reduce SP recurrence.⁴⁸

The results from patient series have consistently concluded that stapled bullectomy is a safe and reliable method, which is unlikely to be complicated by prolonged air leak and pneumothorax recurrence, particularly when used with a form of pleurodesis.^{27 28 33 34 47 49} One of the most popular is apical abrasion pleurodesis, which is preferred by ourselves, and is often performed with Marlex mesh.^{27 33 34} The alternative dry gauze abrasion pleurodesis has been shown to be less effective and is associated with higher pneumothorax recurrence in the treatment of SP.⁴⁸ Irrespective of the material used, thorough pleural abrasion remains the key for reducing pneumothorax recurrence.^{30 32} Some reports have suggested that performing apical pleurectomy can further reduce the incidence of pneumothorax recurrences when compared with abrasion pleurodesis.^{22 48} However, the more radical procedure can potentially lead to more bleeding complications and postoperative neuralgia,²² and it will probably make future thoracic surgery difficult. An alternative is the administration of talc intraoperatively, which was associated with a lower SP recurrence when compared with (subtotal) pleurectomy.⁴⁷ Acromycin pleurodesis when used with stapled bullectomy has been reported to have significantly lower SP recurrence than stapled bullectomy alone.⁴⁹ In addition, instillation of minocycline after VATS stapled bullectomy and mechanical pleurodesis may further decrease the recurrence rate.⁵⁰

The results from endoloop bullous ligation in terms of postoperative prolonged air leak, hospital stay and pneumothorax recurrence has been generally comparable with other bullectomy procedures, particularly when applied to small bullae.^{33 34} However, Cardillo *et al* reported that bulla ligation had a significantly higher pneumothorax recurrence rate compared with stapled bullectomy during a mean postoperative follow up of 38 months.⁴⁷ On the whole, we believe endoloop bullous ligation is viable, safe, and cost effective in selected cases.

Argon beam coagulation (ABC) was shown to be less effective than stapled, suturing, or endoloop ligation bullectomy in several patient series.^{33 34} Patients treated with ABC had more postoperative prolonged air leaks (>10 days), as well as pneumothorax recurrences.^{33 34} Therefore, the consensus is that ABC should not be used as the primary treatment modality for SP.

The surgical treatment of bilateral pneumothoraces can be simultaneous or in stages. Patients who underwent simultaneous bilateral VATS (bleb resection and pleurodesis) for metachronous bilateral SP had similar recovery and recurrence rate compared with patients who had staged bilateral VATS.⁵¹ In addition, a separate study found the simultaneous VATS procedure to be both effective and safe, with excellent long term results.⁵² Therefore, simultaneous bilateral VATS

Key references

- Baumann MH, Strange C, Heffner JE, *et al*. Management of spontaneous pneumothorax. An American College of Chest Physicians Delphi Consensus Statement. *Chest* 2001;**119**:590-602.
- Henry M, Arnold T, Harvey J. BTS guidelines for the management of spontaneous pneumothorax. *Thorax* 2003;**58**(suppl 2):ii39-52.
- Hatz RA, Kaps MF, Meimarakis G, *et al*. Long-term results after video-assisted thoracoscopic surgery for first-time and recurrent spontaneous pneumothorax. *Ann Thorac Surg* 2000;**70**:253-7.
- Yim APC, Liu HP. Complications and failures of video-assisted thoracic surgery: experience from two centres in Asia. *Ann Thorac Surg* 1996;**61**:538-41.
- Liu HP, Yim APC, Izzat BM, *et al*. Thoracoscopic surgery for spontaneous pneumothorax. *World J Surg* 1999;**23**:1133-6.

should be considered in selected patients requiring bilateral surgery for pneumothorax, instead of staged bilateral VATS, bilateral thoracotomy or median sternotomy.

In SSP, treatment by VATS resulted in similar post-operative prolonged air leak and recurrence when compared with thoracotomy or PSP treated by VATS (table 1).²⁷⁻³⁴ However, the length of hospital stay was longer (mean eight days) for SSP patients treated by VATS when compared with PSP (mean four days).²⁷

FUTURE PERSPECTIVE

Several clinical management issues remain unanswered. Firstly, the duration of prolonged airleak that warrants VATS remain controversial. Current recommendations range from five days by BTS to three days advocated by our institute with more than a decade of experience with VATS for SP. Furthermore, whether VATS should be offered to all patients with low general anaesthetic risk presenting with first episode of SP is unclear. Secondly, the role of CT scan in assessing the need for surgical referral, risk of recurrence, and contralateral pneumothorax, as well as identifying unsuspecting disease should be better defined. Furthermore, the evolution of surgical techniques to allow ipsilateral thoroscopic approach to treat contralateral bullous lesion may redefine the indications for CT scan in SP.⁵³ Technically, the debate will continue among the surgeons on the type of VATS procedure that will minimise pneumothorax recurrence. Most surgeons will agree that some form of bullectomy (endoscopic staple or suturing) is mandatory. However, the nature of pleurodesis (mechanical, chemical, or both) that follow is often at the discretion of the individual clinician. Proper large scale randomised trials are required to investigate these controversies in the future.

MULTIPLE CHOICE QUESTIONS; TRUE (T)/FALSE (F) (ANSWERS AT THE END OF THE REFERENCES)

- In spontaneous pneumothorax, referral to cardiothoracic surgeon is recommended:
 - Failure to completely re-expand the lung
 - Failure to position chest drain towards lung apex
 - Chest drain no longer "swings"
 - Persistent airleak for five days
 - Bilateral pneumothorax
- VATS for spontaneous pneumothorax:
 - Three surgical ports must be used to perform the operation
 - Pneumothorax recurrence is lower than surgery by thoracotomy approach
 - Is associated with less postoperative pain and analgesic requirement than thoracotomy
 - Lung blebs and bullae are rarely seen intraoperatively
 - Should never be performed in patient with prior thoracic surgery
- In patients with first episode of spontaneous pneumothorax:
 - In general, VATS should be the first line management
 - CT scan should be performed if air leak is longer than three days.
 - VATS may benefit patients in certain occupations such as pilots.
 - Talc pleurodesis should be given to all patients

- Associated with haemothorax should be referred to the cardiothoracic surgeon
- After VATS surgery for primary spontaneous pneumothorax, patients should expect:
 - Mean hospital stay of between three to six days
 - Recurrence rate of 2% to 6%
 - Decrease risk of spontaneous pneumothorax in the contralateral lung
 - Complication of prolong postoperative air leak in 10% of cases
 - Smaller skin incision scars compared with thoracotomy
 - VATS should not be performed:
 - In any elderly or paediatric age group patients
 - If patient cannot tolerate one lung ventilation
 - Without thoracic carbon dioxide insufflation
 - During near term (end of 3rd trimester) pregnancy
 - When CT thorax shows bilateral blebs and bullae

CONTRIBUTORS

All the authors have contributed significantly to the preparation of this manuscript.

Authors' affiliations

C S H Ng, T W Lee, S Wan, A P C Yim, Division of Cardiothoracic Surgery, The Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, NT, Hong Kong

Funding: none.

Conflicts of interest: none declared.

REFERENCES

- Jacobaeus HC. Ueber die Möglichkeit die Zystoskopie bei untersuchung seroser hohlungen anzuwenden. *München Med Wochenschr* 1910;**57**:2090-2.
- Braimbridge MV. Thoracoscopy: a historical perspective. In: Yim AP, Hazelrigg SR, Izzat MB, et al. *Minimal access cardiothoracic surgery*. Philadelphia: WB Saunders, 1999.
- Baumann MH, Strange C, Heffner JE, et al, eds. Management of spontaneous pneumothorax. An American College of Chest Physicians Delphi Consensus Statement. *Chest* 2001;**119**:590-602.
- Henry M, Arnold T, Harvey J. BTS guidelines for the management of spontaneous pneumothorax. *Thorax* 2003;**58**(suppl 2):ii39-52.
- Sahn SA, Heffner JE. Primary care: spontaneous pneumothorax. *N Engl J Med* 2000;**342**:868-74.
- Weisberg D, Refaely Y. Pneumothorax: experience with 1,199 patients. *Chest* 2000;**117**:1279-85.
- Ng CSH, Sihoe ADL, Wan S, et al. Giant pulmonary bulla. *Can Respir J* 2001;**8**:369-71.
- Hwong MT, Ng CSH, Lee TW, et al. Video-assisted surgery in spontaneous hemopneumothorax. *Eur J Cardiothorac Surg* 2004;**26**:893-6.
- Ng CSH, Wan S, Yim APC. Paradigm shift in surgical approaches to spontaneous pneumothorax: VATS. *Thorax* 2004;**59**:357.
- Korom S, Canyurt H, Missbach A, et al. Catamenial pneumothorax revisited: clinical approach and systematic review of the literature. *J Thorac Cardiovasc Surg* 2004;**128**:502-8.
- Tschopp JM, Bollinger CT, Boutin C. Treatment of spontaneous pneumothorax: Why not simple talc pleurodesis by medical thoracoscopy? *Respiration* 2000;**67**:108-11.
- Sihoe ADL, Yim APC, Lee TW, et al. Can CT scanning be used to select patients with unilateral primary spontaneous pneumothorax for bilateral surgery? *Chest* 2000;**118**:380-3.
- Yim APC. Video assisted thoracoscopic surgery (VATS) in Asia: its impact and implications. *Aust NZ J Med* 1997;**27**:156-9.
- Yim APC. Thoracoscopic surgery in the elderly population. *Surg Endosc* 1996;**10**:880-2.
- Yim APC, Low JM, Ng SK, et al. Video assisted thoracoscopic surgery in the paediatric population. *J Paediatr Child Health* 1995;**31**:192-6.
- Yim APC. Minimising chest wall trauma in video-assisted thoracic surgery. *J Thorac Cardiovasc Surg* 1995;**109**:1255-6.
- Yim APC, Wan S, Lee TW, et al. VATS lobectomy reduces cytokine responses compared with conventional surgery. *Ann Thorac Surg* 2000;**70**:243-7.

- 18 **Ng CSH**, Lee TW, Wan S, *et al.* Thoracotomy is associated with significantly more profound suppression in lymphocytes and natural killer cells than video-assisted thoracic surgery following major lung resections for cancer. *J Invest Surg* 2005;**18**:81–8.
- 19 **Li WWL**, Lee RLM, Lee TW, *et al.* The impact of thoracic surgical access on early shoulder function: video-assisted thoracic surgery versus posterolateral thoracotomy. *Eur J Cardiothorac Surg* 2003;**23**:390–6.
- 20 **Stammler U**, Steinacher C, Hillinger S, *et al.* Early and long-term complaints following video-assisted thoracoscopic surgery: evaluation in 173 patients. *Eur J Cardiothorac Surg* 2000;**18**:7–11.
- 21 **Hutter J**, Miller K, Moritz E. Chronic sequelae after thoracoscopic procedures for benign diseases. *Eur J Cardiothorac Surg* 2000;**17**:687–90.
- 22 **Chan P**, Clarke P, Daniel FJ, *et al.* Efficacy study of video-assisted thoracoscopic surgery pleurodesis for spontaneous pneumothorax. *Ann Thorac Surg* 2001;**71**:452–4.
- 23 **Singh VS**. The surgical treatment of spontaneous pneumothorax by parietal pleurectomy. *Scand J Thorac Cardiovasc Surg* 1982;**16**:75–80.
- 24 **Brock H**, Rieger R, Gabriel C, *et al.* Haemodynamic changes during thoracoscopic surgery the effects of one-lung ventilation compared with carbon dioxide insufflation. *Anaesthesia* 2000;**55**:10–16.
- 25 **Jutley RS**, Khalil MW, Rocco G. Uniportal vs standard three-port VATS technique for spontaneous pneumothorax: comparison of post-operative pain and residual paraesthesia. *Eur J Cardiothorac Surg* 2005;**28**:43–6.
- 26 **Yim APC**. Minimizing chest wall trauma in video-assisted thoracic surgery. *J Thorac Cardiovasc Surg* 1995;**109**:1255–6.
- 27 **Hatz RA**, Kaps MF, Meimarakis G, *et al.* Long-term results after video-assisted thoracoscopic surgery for first-time and recurrent spontaneous pneumothorax. *Ann Thorac Surg* 2000;**70**:253–7.
- 28 **Gossot D**, Galetta D, Stern JB, *et al.* Results of thoracoscopic pleural abrasion for primary spontaneous pneumothorax. *Surg Endosc* 2004;**18**:466–71.
- 29 **Czerny M**, Salat A, Fleck T, *et al.* Lung wedge resection improves outcome in stage I primary spontaneous pneumothorax. *Ann Thorac Surg* 2004;**77**:1802–5.
- 30 **Yim APC**. Negative outcomes following video-assisted thoracic surgery. *Asian Cardiovasc Thorac Ann* 1996;**4**:133–8.
- 31 **Yim APC**, Ho JKS, Ng SK, *et al.* The use of a bovine pericardial buttress in the bilateral staple resection of emphysematous bullae. *HKMJ* 1996;**2**:429–32.
- 32 **Yim APC**, Liu HP. Complications and failures of video-assisted thoracic surgery: experience from two centres in Asia. *Ann Thorac Surg* 1996;**61**:538–41.
- 33 **Yim APC**, Liu HP. Video-assisted thoracoscopic management of primary spontaneous pneumothorax. *Surgical Laparoscopy and Endoscopy* 1997;**7**:236–40.
- 34 **Liu HP**, Yim APC, Izzat BM, *et al.* Thoracoscopic surgery for spontaneous pneumothorax. *World J Surg* 1999;**23**:1133–6.
- 35 **Liu HP**, Chang CH, Lin PJ, *et al.* An alternative technique in the management of bullous emphysema thoracoscopic endoloop ligation of bulla. *Chest* 1997;**111**:489.
- 36 **Reid CJ**, Burgin GA. Video-assisted thoracoscopic surgical pleurodesis for persistent spontaneous pneumothorax in late pregnancy. *Anaesth Intensive Care* 2000;**28**:208–10.
- 37 **Yim APC**, Liu HP, Hazelrigg SR, *et al.* Thoracoscopic operations on reoperated chests. *Ann Thorac Surg* 1998;**65**:328–30.
- 38 **Doddoli C**, Barlesi F, Fraticelli A, *et al.* Video-assisted thoracoscopic management of recurrent primary spontaneous pneumothorax after prior talc pleurodesis: a feasible, safe and efficient treatment option. *Eur J Cardiothorac Surg* 2004;**26**:889–92.
- 39 **Yim APC**, Izzat MB. Therapeutic Thoracoscopy under local anesthesia. *Chest* 1997;**111**:1785.
- 40 **Waller DA**, Forty J, Morritt GN. Video-assisted thoracoscopic surgery versus thoracotomy for spontaneous pneumothorax. *Ann Thorac Surg* 1994;**58**:372–7.
- 41 **Iqbal M**, Maltz AS, Rossoff LJ, *et al.* Reexpansion pulmonary edema after VATS successfully treated with continuous positive airway pressure. *Ann Thorac Surg* 2000;**70**:669–71.
- 42 **Feito BA**, Rath AM, Longchamps E, *et al.* Experimental study on the in vivo behaviour of a new collagen glue in lung surgery. *Eur J Cardiothorac Surg* 2000;**17**:8–13.
- 43 **Kinoshita T**, Miyoshi S, Katoh M, *et al.* Intrapleural Administration of a large amount of diluted fibrin glue for intractable pneumothorax. *Chest* 2000;**117**:790–5.
- 44 **Maier A**, Anegg U, Renner H, *et al.* Four-year experience with pleural abrasion using a rotating brush during video-assisted thoracoscopy. *Surg Endosc* 2000;**14**:75–8.
- 45 **Suzuki T**, Kitami A, Suzuki S, *et al.* Infrared observation during thoracoscopic surgery for bullous disease. *J Thorac Cardiovasc Surg* 2000;**119**:182–4.
- 46 **Manlulu AV**, Lee TW, Thung KH, *et al.* Current indications and results of VATS in the evaluation and management of hemodynamically stable thoracic injuries. *Eur J Cardiothorac Surg* 2004;**25**:1048–53.
- 47 **Cardillo G**, Facciolo F, Giunti R, *et al.* Videothoracoscopic treatment of primary spontaneous pneumothorax: a 6-year experience. *Ann Thorac Surg* 2000;**69**:357–61.
- 48 **Ayed AK**, Al-Din HJ. The results of thoracoscopic surgery for primary spontaneous pneumothorax. *Chest* 2000;**118**:235–8.
- 49 **Loubani M**, Lynch V. Video assisted thoracoscopic bullectomy and acromycin pleurodesis: an effective treatment for spontaneous pneumothorax. *Resp Med* 2000;**94**:888–90.
- 50 **Chen JS**, Hsu HH, Kuo SW, *et al.* Effects of additional minocycline pleurodesis after thoracoscopic procedures for primary spontaneous pneumothorax. *Chest* 2004;**125**:50–5.
- 51 **Yim APC**. Simultaneous vs staged bilateral video-assisted thoracoscopic surgery. *Surg Endosc* 1996;**10**:1029–30.
- 52 **Lang-Lazdunski L**, de Kerangal X, Pons F, *et al.* Primary spontaneous pneumothorax: one-stage treatment by bilateral videothoracoscopy. *Ann Thorac Surg* 2000;**70**:412–17.
- 53 **Wu YC**, Chu Y, Liu YH, *et al.* Thoracoscopic ipsilateral approach to contralateral bullous lesion in patients with bilateral spontaneous pneumothorax. *Ann Thorac Surg* 2003;**76**:1665–7.

ANSWERS

1. (A) T, (B) F, (C) F, (D) T, (E) T; 2. (A) F, (B) F, (C) T, (D) F, (E) F; 3. (A) F, (B) F, (C) T, (D) F, (E) T; 4. (A) T, (B) T, (C) F, (D) F, (E) T; 5. (A) F, (B) T, (C) F, (D) T, (E) F.