

Video-assisted thoracic surgery in spontaneous pneumothorax

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The proven safety and efficacy of minimal access video-assisted thoracic surgery has changed the way that spontaneous pneumothorax is managed. This review presents some of the experiences of the decade, discusses the controversies and reviews the current video-assisted thoracic surgical management of spontaneous pneumothorax.

Key Words: *Spontaneous pneumothorax; Thoracoscopy; Video-assisted thoracic surgery*

Pneumothorax spontané et chirurgie thoracique assistée par vidéo

RÉSUMÉ : L'innocuité et l'efficacité avérées de la chirurgie thoracique assistée par vidéo, comportant une effraction minimale a changé le traitement du pneumothorax spontané. Le présent article fait état de certaines expériences menées au cours de la dernière décennie, des controverses actuelles et du traitement chirurgical assisté par vidéo des pneumothorax spontanés, mis en œuvre aujourd'hui.

The history of therapeutic thoracoscopy can be traced back to the year 1910, when intrapleural pneumolysis for tuberculosis was performed by Jacobaeus (1). However, it is not until the last decade that technological advancements in videoendoscopy have enabled the re-introduction of thoracoscopy, with its increasing clinical application, in the form of video-assisted thoracoscopic surgery (VATS) (2). These advances are as follows: the improved rod lens coupled with the development of microcameras that allow for a panoramic view of the hemithorax (instead of the previous tunnel-like vision); improved anesthetic technique with one lung ventilation,

permitting free manoeuvrability of the telescope and instruments; and availability of recently developed endoscopic surgical instruments such as the linear staple cutter, which has widened the spectrum of therapeutic procedures. Furthermore, the success and excitement of laparoscopic cholecystectomy gave impetus to the application of a similar technique to the chest.

Although controversy still exists, VATS is now regarded by many surgeons to be the approach of choice in the management of a variety of thoracic conditions such as spontaneous pneumothorax (SP), pleural diseases and indeterminate lung nodules.

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Figure 1) Bullae at the apex of right upper lobe in a patient with primary spontaneous pneumothorax

SURGICAL MANAGEMENT: IS THERE A CONSENSUS?

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

With the lowered morbidity of VATS, the old surgical algorithms, based on the morbidity of thoracotomy, should

be re-evaluated. The accepted surgical indications for pneumothorax include persistent air leak (3,5), recurrence (3,5), radiologically demonstrated huge bullae, spontaneous hemopneumothorax, incomplete expansion of the lung, tension pneumothorax, bilateral involvement and SP in a high risk occupation such as a pilot or scuba diver (3). Some authors have even recommended VATS for uncomplicated first-time pneumothorax (3), which we currently do not advocate. However, there remain many 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 statement from the American College of Chest Physicians recommended observation of air leaks for four days before surgical intervention (3). Our experience supports the use of VATS when a 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 anesthesia, medical management in the form of talc pleurodesis should be considered (3,6).

The role of surgical treatment for the future prevention of SP in the ipsi- and contralateral lung for high risk patients has also been divided. The question of whether radiological evidence of pulmonary bullae can predict pneumothorax occurrence or recurrence, and thereby select patients for 'prophylactic' VATS therapy, remains unanswered. Many people are sceptical of the causal relationship between bullae and PSP, but videoscopic findings have shown that a large proportion (78% to 89%) of patients presenting with PSP in presumably normal lungs have endoscopically visible blebs or bullae (Figure 1, Table 1). Detecting the presence of bullae by computed tomography (CT) scan and thoracoscopy at the initial presentation of

TABLE 1
Video-assisted thoracoscopic surgery (VATS) for spontaneous pneumothorax: recent data

Author (reference), year	Case description	Patient (n)	Blebs/bullae seen at VATS (%)	Stapled bullectomy	Endoloop/Endosuturing/ABC	Abrasion pleurodesis (%)	Prolonged postoperative air leak (%)	Mean hospital stay in days (range)	Mean or median follow-up in months (range)	SP recurrence (%)
Yim and Liu (24), 1997	PSP	483	87	196	261/35/6	100 (alone in 20 cases)	3	3 (1-30)	20 (1-36)	1.7
Liu et al (25), 1999	PSP and SSP	757	89	312	352/52/6	NA (alone in 49 cases)	4 (>10 days)	4.5 (0-27)	30 (1-60)	2.1
Hatz et al (20), 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 and Al-Din (37), 2000	PSP	72	78	56	0	54	6.9 (>5 days)	4	42 (36-54)	5.5 (from gauze abrasion)
Loubani and Lynch (38), 2000	PSP	49	NA	52 (with or without acromycin)	0	0	NA	6.8/4.8 (bullectomy/ bullectomy with acromycin)	38 (36-40)	20/4 (bullectomy/ bullectomy with acromycin)
Cardillo et al (36), 2000	PSP	432	78	235	104/0/0	0	1.4 (>5 days)	6	38 (2-72)	4.4
Chan et al (16), 2001	PSP	82	NA	NA	NA/0/0	100	NA	NA	44 (8-85)	5.7

ABC Argon beam coagulation; NA Data not available; PSP Primary spontaneous pneumothorax; SP Spontaneous pneumothorax; SSP Secondary spontaneous pneumothorax

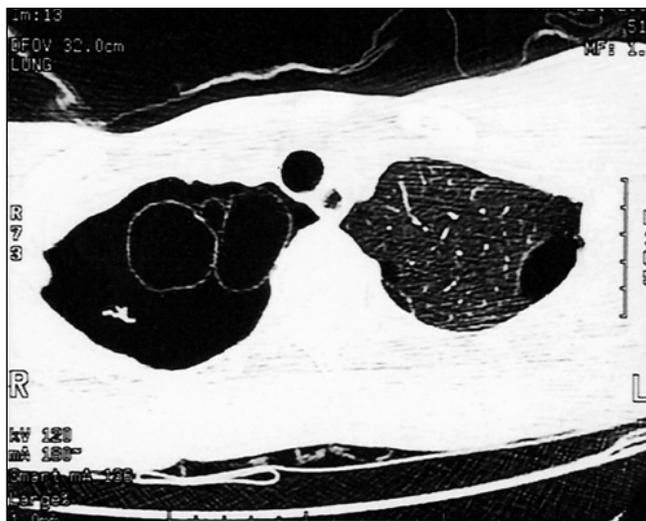


Figure 2) Computed tomography scan of the thorax of a 17-year-old man showing bilateral apical bullae and right-sided spontaneous pneumothorax. The initial spontaneous pneumothorax was treated with video-assisted thoracoscopic surgery, stapled bullectomy and abrasion pleurodesis. However, contralateral spontaneous pneumothorax occurred two days later

SP was shown not to predict recurrence (4). Interestingly, a recent study reported that the detection of bullae by CT scanning in the contralateral lung after unilateral PSP is associated with a higher rate of subsequent pneumothorax in that lung (7) (Figure 2). Thus, the value of VATS as primary therapy for PSP and in preventing ipsi- or contralateral pneumothorax occurrence by way of bulla detection with CT scans remains controversial. Additionally, there appears to be no consensus on the use of thoracic CT for evaluating patients with recurrent pneumothoraces or persistent air leaks (3). Results from carefully conducted randomized clinical trials are needed in these areas.

VATS FOR PNEUMOTHORAX

Surgical access for the management of pneumothorax can be obtained by 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 of surgery by patients (8). The experience so far shows that VATS procedures in elderly patients (older than 75 years of age) are safe, with few postoperative pulmonary complications (9). In addition, VATS can also be a useful approach in selected cases of the pediatric population for a variety of endoscopic procedures (10).

There is increasing evidence to associate VATS with less access trauma and quicker recovery, with many doctors realizing that the trauma from access is often worse than the surgery (11). Postoperative proinflammatory cytokine levels are lower, and T (CD4) cells, as well as natural killer cells, are less suppressed after VATS compared with their open counterparts (12,13). Also, patients undergoing VATS require significantly less postoperative parenteral



Figure 3) Endoscopic stapled bullectomy

narcotics than patients undergoing procedures using the open techniques (12). However, chronic sequelae (chronic pain, numbness or disesthesia) occur after 25% to 31% of thoracoscopic procedures; the rate of chronic pain is equal in VATS and thoracotomy (14-16). In our experience, many of the patients who underwent VATS for SP thought that the chest tube insertion (with or without sedation) was more painful than VATS.

Pulmonary function tests performed postoperatively after VATS for SP showed little deterioration 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 (17). The difference is likely to be attributed to access trauma from rib-spreading in thoracotomy.

General approach

The chest is the most suitable body cavity for minimal access surgery, 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 hemodynamics compared with selective one-lung ventilation (18).

The patient should be routinely positioned in the lateral decubitus position. The operating table is flexed to 30° to open up the intercostal spaces for thoracoscope insertion and instrumentation. For exploratory thoracoscopy, we prefer to place the telescope low in the chest (seventh intercostal space, mid-axillary line) so that one can obtain a panoramic view of the hemithorax. Most procedures require two instrument ports, which should be inserted under direct thoracoscopic vision. The trocar sites should be 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.

There are additional strategies in VATS that can assist in minimizing chest wall trauma and hence postoperative pain. These strategies include: rib-spreading may be unnecessary, because flexing of the operating table at the level of the minithoracotomy may adequately open up the intercostal space; avoiding the use of trocar ports by introducing instruments directly through the wound; avoiding torquing of the thoracoscope by using an angled lens; using smaller telescopes (5 mm) when clinically allowed; and delivering specimens through the anterior port, because the anterior intercostal spaces are wider (19).

Endoscopic stapled bullectomy

The presence of subpleural bullae has been reported in 76% to 100% of PSP patients during VATS (5). Endoscopic stapled bullectomy remains the preferred procedure for bullectomy (Figure 3) (3) and should be accompanied by some form of pleurodesis (20). Complications associated with the technique include air leak from the staple line, especially in emphysematous patients (21), which can be greatly reduced by pericardial buttress reinforcement (22). Furthermore, malfunctioning of staple-cutters has also been reported (23).

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 (8,24,25). Parenteral narcotic requirements, chest drainage duration, hospital stay and pneumothorax recurrence are similar for both techniques (24,25). To minimize cost, the long conventional needle holder and standard monofilament polypropylene sutures were found to be as effective as specialized endoscopic suturing equipment for thoracoscopic suturing of bullae. Thus, in view of the high cost of staple-cutters, endoscopic suturing of apical bullae should be considered in selected cases of small, localized bullae for PSP (8,24,25). However, it must be emphasized that endoscopic suturing should be performed by surgeons adequately trained in this skill.

Endoloop ligation

Endoscopic endoloop bulla ligation may be suitable for bullae in PSP and secondary SP (25,26). It is performed using a pretied commercial endoloop or a homemade polydioxanone loop. Homemade devices are, of course, more cost effective. However, a known complication of endoloop ligation is the accidental slipping of the loop during lung expansion or after a forceful sneeze. The problem can be minimized by the placement of a double or triple loop around each bulla (21,23).

VATS for pneumothorax during pregnancy

The third trimester, particularly near term, is the most common time for PSP to occur during pregnancy. Most cases result from the rupture of a subpleural apical bulla or

bleb, precipitated by pulmonary and thoracic pressure changes. Difficulties in pneumothorax management during pregnancy are related to 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 or second trimester, or early in the third trimester; then, VATS should be considered (27). 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 caesarian section in case of acute fetal distress.

Limitations and complications

There are relatively few contraindications to VATS. In addition to general contraindications such as recent myocardial infarction and severe coagulopathy, specific contraindications include pleural obliteration and severe underlying lung disease or poor lung function. Prior operation in the ipsilateral chest should not be regarded as a contraindication (28). Adhesions can usually be divided using a combination of sharp and blunt dissection under video-scopic vision. However, patients with difficult adhesions may be more suitable for thoracotomy.

Patients who are elderly with multiple comorbidities may benefit 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 selective one-lung ventilation during general anesthesia, which is used by many thoracic surgeons to gain room for instrument manoeuvring. Simple procedures in infants may be performed using endotracheal intubation with lowered tidal volume alone or intermittent apnea (10). Some thoracoscopic procedures such as bullectomy may also be performed under local and epidural anesthesia but may only be applicable to a selected group of patients (29). Thus, treatment of secondary SP (with established lung pathology) requires more clinical judgement. In addition, clinicians should bear in mind the higher mortality rate associated with VATS for secondary SP compared with PSP (30).

The recurrence rate of SP after VATS (2% to 14%) may be slightly higher than the minithoracotomy (0% to 7%) approach (4); this difference between the techniques may reflect the inadequate exposure of the chest cavity in VATS, and subsequent incomplete detection and resection of apical bullae (4). Additionally, a change to thoracotomy from VATS is required in 2% to 10% of patients with PSP and up to 29% of patients with secondary SP 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 (23). Rarely, re-expansion pulmonary edema can occur post-VATS (0.15%), which can be treated with oxygen, continuous positive airway pressure or full ventilatory support in severe cases (23,31).

Other therapeutic modalities

Different types of glue have been investigated to aid in stopping pulmonary air leaks. In a recent murine study, the collagen-polysaccharide glue was well tolerated and effective in sealing air leaks without increasing adhesion formation (32). 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 also has shown some promising results (33). 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 mechanical pleurodesis for VATS 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, hospitalization time and recurrence rate are comparable with other forms of pleurodesis in VATS (34).

It is very 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 allow 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 define better the margins of pulmonary resection (35).

CURRENT RESULTS

There have 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 after VATS has consistently been reported to be as low as with treatment via thoracotomy (21,23-25,36). Furthermore, recently available long term (up to 53 months) data showed that pneumothorax recurrence rates remained low for patients treated by VATS for SP (20,37). Thorough pleural examination and the experience of the surgeon may be the two most important factors in determining recurrence rate and prolonged air leaks. Often, recurrences are more frequent in patients in whom no blebs or bullae are identified (37). Missed bullae and more conservative surgical procedures in these patients are likely explanations. Some evidence suggests that apical lung excision, even in the absence of a visible lesion, may reduce SP recurrence (37).

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 (20,24,25,36,38). One of the most popular is apical abrasion pleurodesis, which is preferred by the authors, and is often performed with Marlex mesh (CR Bard, USA) (20,24,25). The alternative of dry gauze abrasion pleurodesis is less effective and is associated with higher pneumothorax recurrence (37). Irrespective of the material used, thorough pleural abrasion remains key to reducing pneumothorax recurrence (21,23). However, some reports have suggested that apical pleurec-

tomy may be marginally better in preventing pneumothorax recurrences than abrasion pleurodesis (16,37), although the risk of bleeding and postoperative neuralgia is higher (16), and it is likely to make future thoracic surgery difficult. In addition, talc pleurodesis was associated with a lower SP recurrence when compared with (subtotal) pleurectomy (36). Acromycin pleurodesis, when used with stapled bullectomy, has been reported to have significantly lower SP recurrence than stapled bullectomy alone (38).

The results from endoloop bullous ligation in terms of postoperative prolonged air leak, hospital stay and pneumothorax recurrence has generally been comparable with other bullectomy procedures, particularly when applied to small bullae (24,25). However, Cardillo et al (36) reported that bulla ligation had a significantly higher pneumothorax recurrence rate compared with stapled bullectomy during a mean postoperative follow-up of 38 months. On the whole, we believe that 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 (24,25). Patients treated with ABC had more postoperative prolonged air leaks (longer than 10 days), as well as pneumothorax recurrences (24,25). Thus, the consensus is that ABC should not be used as the primary treatment modality for SP.

The surgical treatment of bilateral pneumothoraces can be completed simultaneously or in stages. Patients who underwent simultaneous bilateral VATS (bleb resection and pleurodesis) for bilateral SP had similar recovery and recurrence rates compared with patients who had staged bilateral VATS (39). In addition, a separate study found the simultaneous VATS procedure to be both effective and safe, with excellent long term results (40). Therefore, simultaneous bilateral VATS should be considered in selected patients requiring bilateral surgery for pneumothorax, instead of staged bilateral VATS, bilateral thoracotomy or median sternotomy.

Secondary pneumothorax treated by VATS resulted in similar rates of postoperative prolonged air leaks and recurrence compared with thoracotomy or PSP treated by VATS (Table 1) (20,25). However, the length of hospital stay was longer for secondary SP patients treated by VATS (mean eight days) compared with PSP patients treated by VATS (mean four days) (20).

SUMMARY

Technological advancements over the past decade and the introduction of VATS have changed the management strategy for SP. The advantages offered by VATS, ranging from lesser postoperative pain to shorter hospital stays, cannot be disputed, and evidence of lesser inflammatory response after VATS compared with open procedures is emerging. Perhaps most importantly, VATS is increasingly being accepted and preferred by patients and referring physicians. Minimal access surgery need not be expensive, and we have discussed a number of cost-containing strategies. We have reviewed

the most recent published data and our own patient series, highlighting the various VATS techniques in the treatment of pneumothorax and their efficacy. The results from the past decade indicate that VATS is a quick, safe and effective treatment for SP, with recurrence rates that are comparable with open procedures. Hence, VATS should be the gold standard in the treatment of SP. However, selecting the cor-

rect procedures and patients, as well as knowing the limitations of the surgeons and the techniques, are paramount for success. Even to this day, there are considerable variations in the treatment of pneumothorax; large scale controlled studies are needed to define better the timing of surgery and the role of the different procedures in the treatment and prevention of SP.

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