Review Article

Video-assisted thoracoscopic treatment of pneumothorax

Carolina Carillo, Camilla Poggi, Ylenia Pecoraro, Sara Mantovani, Daniele Diso, Massimiliano Bassi, Davide Amore, Andreina Pagini, Tiziano De Giacomo, Antonio D'Andrilli, Erino A. Rendina, Federico Venuta, Marco Anile

Department of Thoracic Surgery, University of Rome Sapienza, Rome, Italy

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Correspondence to: Federico Venuta, MD. Thoracic Surgery, University of Rome Sapienza, Rome, Italy. Email: federico.venuta@uniroma1.it

Abstract: In the last three decades, minimally invasive techniques have progressively gained acceptance, as shown by the numerous studies published in the literature. Before the 1990s, video-assisted thoracoscopic surgery (VATS) was considered feasible almost exclusively for the diagnosis of pleural diseases. The availability of better instruments and endoscopic stapling devices allowed thoracoscopy to evolve into a new "therapeutic era". Nowadays, VATS is considered the approach of choice for the treatment of pneumothorax and other lung, mediastinal and esophageal diseases, replacing traditional approaches as thoracotomy and sternotomy. The use of ports through small incisions (one to three-four) for the camera and surgical instruments allows the surgeon to explore the pleural cavity and work easily on the lung parenchyma. This approach translates into less discomfort for the patient, reduced morbidity, shorten hospital stay and faster functional recovery. The optimal treatment of pneumothorax certainly refers thoracoscopy as the approach of choice maintaining the same indications as for open surgery.

Keywords: Pneumothorax; video-assisted thoracoscopic surgery (VATS); minimally invasive surgery

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Introduction

Pneumothorax is defined as the presence of air in the pleural cavity with partial or complete collapse of the lung. Primary spontaneous pneumothorax (PSP) is often related to the presence of small blebs on the surface of the apex of the lung. It is frequently observed in male adolescents and young adults; they are usually tall and thin and they often smoke (1). Secondary spontaneous pneumothorax occurs in the context of a variety of lung diseases. The most common is chronic obstructive pulmonary disease (COPD). Traumatic pneumothorax may result from a close trauma or a penetrating wound of the chest wall; it may also be iatrogenic after insertion of a central venous catheter or thoracentesis, during CT guided lung biopsy or in patients undergoing mechanical ventilation (1). Men were more frequently affected than women.

Commonly, symptoms are minimal or even totally absent; sometimes patient reports breathlessness and pleuritic chest pain. In case of PSP, symptoms are more pronounced. In addition to the anamnesis and physical examination, chest X-ray helps in confirming the clinical suspicion and severity of pneumothorax. The high-resolution chest CT allows to study the lung parenchyma and to highlight the presence of blebs, bullae or other underlying pulmonary disorders.

Treatment is based on the severity of pneumothorax as assessed clinically and radiologically; it may be necessary to proceed initially with the insertion of drainage to allow re-expansion of the lung.

Tension pneumothorax is a life-threatening emergency and must be treated immediately. In these cases pleural sonography could be helpful.

As reported in the ERS guidelines (1), the main indications for surgery are recurrence, persistent air leak

(>3–5 days), presence of giant bullae, hemo-pneumothorax, contralateral pneumothorax, professional risk (aircraft personnel, divers). Conservative treatment (observation, needle aspiration, chest tube insertion, etc.) has been associated with a recurrence rate between 17% and 54% (1-3). Patients with high risk of relapse of PSP should be identified at the first episode and surgical treatment should be proposed.

Video-assisted thoracoscopic surgery (VATS) treatment is associated with minor surgical invasiveness and trauma, less post-operative pain and rapid functional recovery; for this reason it is currently considered the approach of choice (4,5).

Thoracoscopic approach

Pleurectomy, pleural abrasion and bullectomy/blebectomy performed in the past through thoracotomy have been translated in VATS during the last decades. During three-port VATS, three incisions are performed based on the so-called "baseball diamond" concept for better strategic visibility and ergonomics. The port at the apex of the diamond is usually for the scope and the other two for the surgical instruments but, when required, it is possible to change the position of the instruments to obtain a better exposure and improve angles and ergonomics. VATS enables to inspect the chest cavity and the entire lung. During the surgical maneuvers, it is important to avoid squeezing the nerve in the intercostal space. Occasionally, pain or paresthesia due to compression of the intercostal nerve have been observed after VATS (6,7).

At the beginning of the 90s VATS progressively supplanted thoracotomy for the treatment of the PSP; today, it is instead a matter of deciding between the conventional three-port VATS or the uniportal approach [single port thoracoscopic surgery (SITS)], that is becoming the approach of choice for pneumothorax and other diseases. The surgical instruments are inserted through a single port in the 4th–7th intercostal space on the mid-axillary, anterior or posterior axillary line, thus further reducing the surgical trauma and the risk of postoperative pain. A wound protector inserted in the incision could help to avoid damage of the intercostal neurovascular bundle. At the end of surgery, the surgical incision (1.5–3.0 cm) is also used to place the chest tube. Also the uniportal approach, like the three-port one, requires a learning curve. Since the initial work published on thoracic sympathectomy (8), uniportal VATS has been increasingly successful and popularized, being used today for many procedures, from pulmonary resections to thymectomy, and even bronchial and vascular reconstructions.

Several studies have investigated the results of PSP treatment with the two surgical approaches. In a retrospective study, Huang *et al.* reported that the SITS group had a better outcomes in terms of operative time, intraoperative blood loss, and postoperative pain, but worse outcome for chest tube drainage time, postoperative length of hospital stay, postoperative leakage and recurrence than the three-port VATS group (9). Uniportal VATS appears to have several disadvantages, such as limitation of the visual field, difficulty of use of VATS instruments, and ergonomic discomfort.

Thus, safety and feasibility of uniportal VATS seems to be controversial.

Qin *et al.* (10) performed a meta-analysis to compare uniportal and three-port VATS for PSP and to assess the potential advantages of uniportal VATS. The study included 17 studies in the final analysis; they all were retrospective case-control studies and included 988 patients. Compared to the three-port VATS groups, there was no significant difference in the uniportal VATS groups in terms of mortality, recurrence, postoperative stay, operative time, and length of postoperative drainage.

This meta-analysis indicated that the uniportal VATS groups were significantly associated with lower paresthesia, postoperative pain, and higher patient satisfaction in the short-term. No deaths were observed. Complications were observed in 13 patients (4%): six in the uniportal group and seven in the conventional 3-port group. The complications included wound infections (2 patients), prolonged air leak (9 patients) and pleural effusion (2 patients). Overall, no major complications occurred. The analysis has therefore shown that the uniportal VATS is at least as safe and effective as conventional VATS.

A more recent meta-analysis (4) reviewed several series comparing conventional and uniportal VATS for primary pneumothorax; only nine studies were included and the assessed variables included operating time, mean duration of the chest tube, hospital stay, complication rate, recurrences and post-operative pain. The present study indicates that the operative time, mean duration of chest tube, complications and recurrence rate were similar between uniportal VATS and 3 port VATS.

However, uniportal VATS was associated with less postoperative pain, lower paresthesia rate and shorter hospital stay. These findings suggest that uniportal VATS is a safe procedure in the treatment of PSP and it is associated

with faster recovery.

However, these two studies did not include randomized controlled trials or multi-center studies, with consequent strong limits on the analysis.

Operative procedures

The indication for surgery after the first episode of PSP depends on several factors: symptoms, type of work, risk of recurrence, patient wish, presence of air leaks or failure to re-expand the lung parenchyma after chest drainage (11). Surgery aims to treat pneumothorax and reduce the incidence of recurrence. The pathogenesis of PSP has been detected in the rupture of bullae or sub-pleural blebs. Resection of these areas of pulmonary parenchyma should eliminate the problem. However, it has been observed that the resection of the dystrophic areas alone, does not prevent recurrence; for this reason chemical or mechanical pleurodesis has been associated (1,3,5,11).

Surgical procedures include resection of all visible blebs or bullae and pleurodesis to induce the formation of pleural adhesions between the visceral pleura and chest wall. During VATS, when blebs or apical bullae are visible in the surgical field, blebectomy or bullaectomy is still a rational and widely accepted part of the surgical procedure. As mentioned before, wedge resection alone has been associated with a high recurrence rate, ranging from 9.5% to 24.5% (11-15). Instead, the apical bullaectomy performed concomitantly with the pleurodesis led to low complication rate, no recurrence and minor changes in lung function by 1-year follow-up after surgery (16). However, the induction of pleural adhesions can disturb normal pleural physiology (17,18). Currently, there are several methods to obtain obliteration of the pleural cavity: abrasion of the parietal pleura (mechanical pleurodesis) and instillation of a chemical irritating agents (chemical pleurodesis) in order to prevent the formation of pleural effusion and/or pneumothorax. The international guidelines currently recommend pleurodesis for recurrent pneumothorax. However, these guidelines do not specify the optimal pleurodesis approach or agent for chemical pleurodesis.

About mechanical pleurodesis, *pleurectomy* consists in the partial stripping of the parietal pleura starting from the apex up to the 5th–6th intercostal space, separating it from the endothoracic fascia and avoiding damaging the vessels, which could be a source of postoperative bleeding.

Alternatively, the pleura may be abraded over its entire surface using sterile sandpaper, dry gauze or mesh until slight bleeding occurs in the abrasion area. Mechanical *pleural abrasion* can be performed using also electrocoagulation or argon-laser beam coagulator. The effectiveness of the two modalities in preventing PSP recurrence is still debated. One randomized controlled study on 208 patients with PSP compared the efficacy and safety of mechanical abrasion and apical pleurectomy after bullectomy through VATS. The study concluded that mechanical abrasion, which required less time to perform, was safer than apical pleurectomy, but there was no difference in terms of recurrence rate between the two procedures (19,20). However, both procedures are characterized by pros and cons. Pleurectomy is associated with a higher risk of postoperative morbidity, such as bleeding or neuralgia, but leads to more tenuous pleural adhesions than pleural abrasion with a lower risk of recurrence (21-24). Pleural abrasion is characterized by less invasiveness than pleurectomy but by less tenuous pleural adhesions, which should allow easier access to the pleural cavity if the patient need to be re-operated in the future (19,25).

In clinical practice, chemical pleurodesis is usually indicated for patients who cannot undergo surgery for spontaneous pneumothorax due to their comorbidities, especially in older patients affected by COPD (19,26). Several chemical irritants (talc, tetracycline, minocycline, iodopovidone, blood) can be applied in the chest through a chest drain in patients who cannot undergo surgery; sterile talc is the most frequently used irritant.

The administration of sterile talc in the pleural cavity induces an intense inflammatory response resulting in a fibrinous pleural adhesion; side effects of the procedure could be tachycardia, fever, up to more serious complications such as infections, pneumonitis and acute respiratory distress syndrome (ARDS). The appearance of ARDS has been shown to be related to the size of the particles and the dose of talc used. Small particles could be re-absorbed into the vascular flow and induce a strong inflammatory reaction with the development of ARDS.

Tetracycline and minocycline administration through chest tube or pigtail catheter seems to reduce the recurrence rate (27,28) in non-surgical patients with less subsequent surgical intervention.

A recent systematic review (29) was conducted to highlight the effectiveness of pleurodesis in recurrence prevention for all chemical pleurodesis agents in cases of spontaneous pneumothorax in both 'medical' pleurodesis (no intervention on the lung) and as an adjunct to surgical

procedures.

The review included 50 studies, of which nine were randomized controlled trials (RCTs). Patients with postoperative surgical air leak were specifically excluded. Studies in which the control arms were drainage with a chest tube only (i.e., no other agent) suggest recurrence rates of 26.1–50.1%.

When talc is used in patients undergoing surgical (VATS) procedures, the recurrence rate appears to be low (between 0.0% and 3.2%) and it seems that the addition of talc contributes to a lower recurrence compared with VATS bullectomy and either drainage or abrasion alone.

However, there have been no direct comparisons of VATS bullectomy and pleurectomy to VATS bullectomy and talc pleurodesis. Talc administration during VATS from eight studies (n=2,324) recurrence was between 0.0% and 3.2%, but the RCT did not demonstrate a significant difference compared with bleb/bullectomy alone. Minocycline appears similarly effective post-VATS (recurrence rates 0.0–2.9%). Prolonged air leak and recurrence prevention using tetracycline via chest drain is likely to provide recurrence rates between 13.0% and 33.3% and autologous blood patch pleurodesis between 15.6% and 18.2%. Chemical pleurodesis post-surgical treatment or via thoracoscopy appears to be most effective. Evidence for definitive success rates of each agent is limited by the small number of randomized trials or other comparative studies.

Conclusions

According to the international guidelines, chest X-ray is the first choice exam in the suspicion of pneumothorax. The first episode of pneumothorax should be treated in a conservative way: observation if the pneumothorax is of minimal severity or chest tube if it is moderate/severe with symptoms.

At the first episode, surgery is indicated in case of persistent air leak, underlying pulmonary disease, or employment needs; the high-resolution chest CT in these cases is mandatory. Resection of the pulmonary parenchyma enclosing the bullae or blebs is indicated; the type of pleurodesis depends above all on the surgeon and on the technique with which he is more familiar, especially considering the low clinical evidence by randomized studies in the literature. Certainly, mechanical pleurodesis is preferable to the chemical one, especially in young people. Thoracoscopy remains the approach of choice nowadays; the choice remains between conventional or uniportal thoracoscopy and it is operator-dependent. The surgeon's learning curve, in both cases, could affect the operative time that will certainly be longer at the beginning of the experience. In case of patients with severe comorbidities and not suitable for surgery, chemical pleurodesis through chest tube may be a treatment option. Inpatients with recurrent pneumothorax after surgery, further treatment depends on the surgeon's clinical experience.

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Footnote

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References

1. Tschopp JM, Bintcliffe O, Astoul P, et al. ERS task force

statement: diagnosis and treatment of primary spontaneous pneumothorax. Eur Respir J 2015;46:321-35.
2. Paliouras D, Barbetakis N, Lazaridis G, et al. Video-assisted thoracic surgery and pneumothorax. J Thorac Dis 2015;7:S56-S61.
3. Ng CS, Lee TW, Wan S, et al. Video assisted thoracic surgery in the management of spontaneous pneumothorax: the current status. Postgrad Med J 2006;82:179-85.
4. Yang Y, Dong J, Huang Y. Single-incision versus conventional three-port video-assisted surgery in the treatment of pneumothorax: a systematic review and meta-analysis. Interact Cardiovasc Thorac Surg 2016;23:722-8.
5. Goto T, Kadota Y, Mori T, et al. Video-assisted thoracic surgery for pneumothorax: republication of a systematic review and a proposal by the Guideline Committee of the Japanese Association for Chest Surgery 2014. Gen Thorac Cardiovasc Surg 2015;63:8-13.
6. Passlick B, Born C, Sienel W, et al. Incidence of chronic pain after minimal-invasive surgery for spontaneous pneumothorax. Eur J Cardiothorac Surg 2001;19:355-8.
7. Sihoe AD, Au SS, Cheung ML, et al. Incidence of chest wall paresthesia after video-assisted thoracic surgery for primary spontaneous pneumothorax. Eur J Cardiothorac Surg 2004;25:1054-8.
8. Nesher N, Galili R, Sharony R, et al. Videothorascopic sympathectomy (VATS) for palmar hyperhidrosis: summary of a clinical trial and surgical results. Harefuah 2000;138:913-6, 1008.
9. Huang LZ, Cao QD. Contrast research between single-port video-assisted thoracoscopic surgery and traditional thoracoscope surgery for the treatment of spontaneous pneumothorax. Journal of Ningxia Medical University 2014;36:650-2.
10. Qin SL, Huang JB, Yang YL, et al. Uniportal versus three-port video-assisted thoracoscopic surgery for spontaneous pneumothorax: a meta-analysis. J Thorac Dis 2015;7:2274-87.
11. Schnell J, Beer M, Eggeling S, et al. Management of Spontaneous Pneumothorax and Postinterventional Pneumothorax: German S3-Guideline. Zentralbl Chir 2018;143:S12-S43.
12. Horio H, Nomori H, Kobayashi R, et al. Impact of additional pleurodesis in video-assisted thoracoscopic bullectomy for primary spontaneous pneumothorax. Surg Endosc 2002;16:630-4.
13. Muramatsu T, Ohmori K, Shimamura M, et al. Staple line reinforcement with fleece-coated fibrin glue (TachoComb) after thoracoscopic bullectomy for the treatment of spontaneous pneumothorax. Surg Today 2007;37:745-9.
14. Nakanishi K. An apical symphysial technique using a wide absorbable mesh placed on the apex for primary spontaneous pneumothorax. Surg Endosc 2009;23:2515-21.
15. Sakamoto K, Takei H, Nishii T, et al. Staple line coverage with absorbable mesh after thoracoscopic bullectomy for spontaneous pneumothorax. Surg Endosc 2004;18:478-81.
16. Dubois L, Malthaner RA. Video-assisted thoracoscopic bullectomy and talc poudrage for spontaneous pneumothoraces: effect on short-term lung function. J Thorac Cardiovasc Surg 2010;140:1272-5.
17. Lee S, Kim HR, Cho S, et al. Staple Line Coverage After Bullectomy for Primary Spontaneous Pneumothorax: A Randomized Trial. Ann Thorac Surg 2014;98:2005-11.
18. Lee KF, Olak J. Anatomy and physiology of the pleural space. Chest Surg Clin N Am 1994;4:391-403.
19. Hsu HH, Chen JS. The etiology and therapy of primary spontaneous pneumothoraces. Expert Rev Respir Med 2015;9:655-65.
20. Rena O, Massera F, Papalia E, et al. Surgical pleurodesis for Vanderschueren's stage III primary spontaneous pneumothorax. Eur Respir J 2008;31:837-41.
21. Ling ZG, Wu YB, Ming MY, et al. The Effect of Pleural Abrasion on the Treatment of Primary Spontaneous Pneumothorax: A Systematic Review of Randomized Controlled Trials. PLoS One2015;10:e0127857.
22. Ayed AK, Al-Din HJ. The results of thoracoscopic surgery for primary spontaneous pneumothorax. Chest 2000;118:235-8.
23. Chang YC, Chen CW, Huang SH, et al. Modified needlescopic video-assisted thoracic surgery for primary spontaneous pneumothorax: the long-term effects of apical pleurectomy versus pleural abrasion. Surg Endosc 2006;20:757-62.
24. Min X, Huang Y, Yang Y, et al. Mechanical Pleurodesis Does Not Reduce Recurrence of Spontaneous Pneumothorax: A Randomized Trial. Ann Thorac Surg 2014;98:1790-6; discussion 1796.
25. 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.
26. MacDuff A, Arnold A, Harvey J. Management of spontaneous pneumothorax: British thoracic society pleural disease guideline 2010. Thorax 2010;65:ii18-31.
27. Almind M, Lange P, Viskum K. Spontaneous pneumothorax: comparison of simple drainage, talc pleurodesis, and tetracycline pleurodesis. Thorax 1989;44:627-30.
28. Chen JS, Chan WK, Tsai KT, et al. Simple aspiration and

drainage and intrapleural minocycline pleurodesis versus simple aspiration and drainage for the initial treatment of primary spontaneous pneumothorax: an open-label, parallel-group, prospective, randomized, controlled trial. Lancet 2013;381:1277-82.

29. Hallifax RJ, Yousuf A, Jones HE, et al. Thorax Effectiveness of chemical pleurodesis in spontaneous pneumothorax recurrence prevention: a systematic review. Thorax 2017;72:1121-31.

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