



THE ANNALS OF THORACIC SURGERY



Late-Onset Occult Pneumothorax After Lung Volume-Reduction Surgery

Federico Tacconi, Eugenio Pompeo and Tommaso C. Mineo

Ann Thorac Surg 2005;80:2008-2012

DOI: 10.1016/j.athoracsur.2005.06.013

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://ats.ctsnetjournals.org/cgi/content/full/80/6/2008>

The Annals of Thoracic Surgery is the official journal of The Society of Thoracic Surgeons and the Southern Thoracic Surgical Association. Copyright © 2005 by The Society of Thoracic Surgeons. Print ISSN: 0003-4975; eISSN: 1552-6259.

Late-Onset Occult Pneumothorax After Lung Volume-Reduction Surgery

Federico Tacconi, MD, Eugenio Pompeo, MD, and Tommaso C. Mineo, MD

Division of Thoracic Surgery, Policlinico Tor Vergata University, Rome, Italy

Background. Lung volume-reduction surgery has proved to be a reliable palliative surgical treatment for patients with severe emphysema. Nonetheless, late complications can arise after lung volume-reduction surgery although this matter has been poorly investigated by previous studies.

Methods. We report a series of 6 patients undergoing unilateral lung volume-reduction surgery at our institution between October 1995 and December 2004, who were readmitted several months after discharge because of the occurrence of occult pneumothorax mimicking acute respiratory failure.

Results. Occult pneumothorax occurred in 3.3% of the 182 patients treated with lung volume-reduction surgery at our institution. Patients were readmitted after a mean of 94 days (range, 20 to 700 days) from the discharge. Chest roentgenography was unable to detect the occurrence of pneumothorax, which was instead revealed by means of a computed tomographic scan in all patients.

The interval between admission and correct diagnosis averaged 22.4 hours. The number of air collections ranged between two and four. Treatment entailed solely blind chest drainage placement in 2 patients and awake video-assisted thoracoscopic surgery in the others, including placement of chest tube under direct vision in 1 patient, repair of lung tears by means of cyanoacrylate glue in 2 and bovine pericardium patch plus cyanoacrylate glue apposition in 1 patient.

Conclusions. In conclusion, we believe that occult pneumothorax should be kept in mind as one of the possible late complications of lung volume-reduction surgery and should be suspected whenever sudden worsening of dyspnea is noticed even in the presence of an uneventful chest roentgenogram. Awake video-assisted thoracoscopic surgery management can represent an effective option in these instances.

(Ann Thorac Surg 2005;80:2008–12)

© 2005 by The Society of Thoracic Surgeons

Lung volume-reduction surgery (LVRS) has proved to be a reliable palliative surgical treatment for patients with heterogeneously distributed severe emphysema. Nonetheless, several late complications can occur after LVRS including development of giant bullous emphysema [1] and the occurrence of secondary pneumothorax. This latter in particular has been poorly investigated by the previous literature. More to the point, we have found that loculated air collections can occur after LVRS even several months after discharge, leading to severe impairment of respiratory function. Prompt recognition of LVRS-related complications is crucial to avoid acute respiratory failure, which can be associated with a high mortality rate in these delicate patients. Unfortunately, detection of this complication can be a difficult first-line assessment owing to the presence of postoperative pleural adhesions resulting in complex summation artifacts on standard chest roentgenogram. Herein, we describe peculiar clinical features and surgical management of occult loculated pneumothorax occurring in a large single-center consecutive series of patients undergoing LVRS.

Accepted for publication June 7, 2005.

Address correspondence to Dr Pompeo, Cattedra di Chirurgia Toracica, Policlinico Tor Vergata, V.le Oxford 81, 0133, Rome, Italy; e-mail: pompeo.med@uniroma2.it.

Patients and Methods

We reviewed a series of 6 patients undergoing stapled LVRS at our institution between October 1995 and December 2004, and presenting several months after discharge as critical care patients because of the occurrence of secondary pneumothorax.

All patients had advanced smoking-related upper-lobe prevailing emphysema with severe airflow obstruction and marked air trapping (mean forced expiratory volume in 1 second, 33.5%; mean residual volume, 210.8% of predicted). No patient in this series had giant bullae, homogeneous emphysema, or homozygous α_1 -antitrypsin deficiency. All patients also met standard inclusion criteria for LVRS including smoking cessation of at least 6 months, poor expectoration, and absence of cor pulmonale and other concomitant diseases affecting the outcome. Additional details regarding our inclusion criteria and preoperative assessment are described elsewhere [2]. Five patients underwent unilateral videothoracoscopic LVRS, and 1 underwent staged bilateral operation. The most damaged portions of the lung were identified by visual inspection as the regions retaining inflation after ventilatory exclusion. Both computed tomographic (CT) and scintigraphic scan findings were also taken into the account. The targeted areas were resected by endoscopic staplers (Endopath 45; Ethicon Endosurgery, Pomezia, Italy). In the first 3 patients, suture lines were reinforced

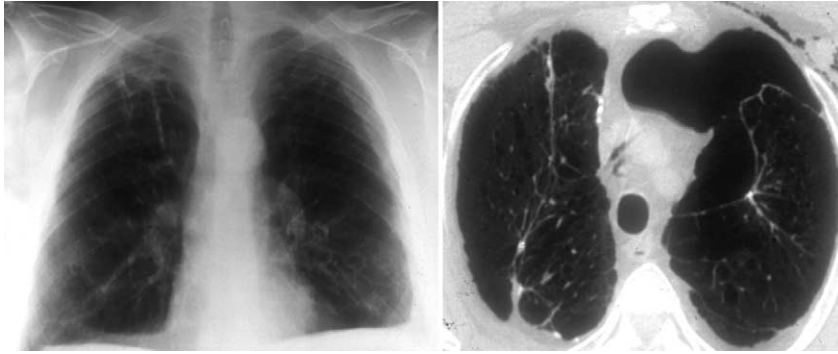


Fig 1. Figure shows roentgenogram (left) and computed tomographic (right) feature of a loculated pneumothorax occupying almost 45% of the left hemithorax. Despite the large size revealed by computed tomography, chest roentgenogram showed solely a minimal hyperlucency area on the left upper field.

with the use of bovine pericardial strips (Peristrips; Biovascular Inc, St. Paul, MN). After resection, careful assessment of pneumostasis was performed. If major leaks were identified, they were ablated by additional “no-cut” stapling (Endopath NK45B; Ethicon Endosurgery). Two chest tubes were inserted at the end of the procedure and placed under water-seal. No patient in this series required additional suction at the end of the procedure. After operation, 4 patients were discharged after complete cessation of air leaks (days 7, 10, 12, and 15). Two patients were discharged with a Heimlich valve owing to small persisting air leaks, and were controlled as outpatients thrice weekly until air leak cessation was ensured (postoperative days 18 and 21). In both groups, criteria for chest drainage removal were radiologically documented complete lung reexpansion and the absence of bubbling in the drainage chamber. After tube removal, patients underwent first follow-up within 7 days entailing solely physical examination, and complete reassessment within 15 days including respiratory function tests, 6-minute walking test, blood-gas assay, and in-expiratory chest roentgenogram. Four patients underwent postoperative respiratory rehabilitation performed either on an outpatient or on an inpatient basis, depending on individual preference.

Results

The study cohort (all men, mean age, 66.4 years) accounts for 3.3% of the 182 patients treated by LVRS at our institution. Patients were readmitted after a mean of 168 days from discharge (range, 20 to 700 days; median, 94

days). In this subgroup, mean air leak duration after LVRS was 13.8 days (range, 7 to 21 days), a number that reaches statistical difference when compared with the average duration observed in our historical cohort (5.2 days; Mann-Whitney *U* test, $p = 0.00009$).

Four patients arrived directly at the emergency department of our institution because of acute respiratory failure. The other 2 patients were referred at our institution after preliminary admission to the emergency department of a peripheral hospital. Both these subjects arrived with a misdiagnosis of exacerbated chronic obstructive pulmonary disease and deteriorating bullous emphysema, respectively.

In all patients, the acute scenario entailed a marked impairment in subjective dyspnea and severe hypoxia in the absence of fever, cough, sputum, and leukocytosis. Three patients also had cardiovascular symptoms (ie, tachycardia and hypotension). Hypercarbia was present in 2 patients.

Preliminary chest roentgenography showed signs of unilateral lung hyperinflation with flattening of the diaphragmatic dome and slight mediastinal shift (2 patients), and a slight hypertranslucent area in the involved hemithorax (3 patients). In 2 patients, chest roentgenogram was unremarkable. All patients’ CT scan was performed after a mean of 22.4 hours from admission and revealed definitive diagnosis (Figs 1, 2). Figure 3 depicts the fall in arterial oxygenation (expressed as arterial partial pressure of oxygen to fraction of inspired oxygen ratio) per patient in the interval between initial admission and definitive diagnosis.

Three patients underwent initial blind chest drainage

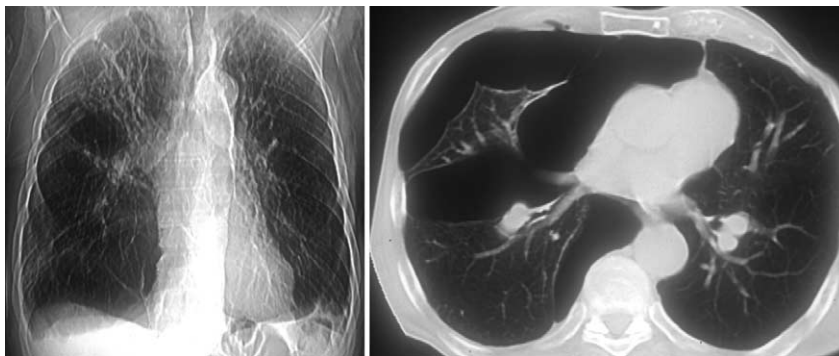


Fig 2. Tomographic feature of a very large right pneumothorax (right), which was mimicking lung hyperinflation at scout scanogram (left; slight leftward tracheal shift and compression of the upper lobe vessels).

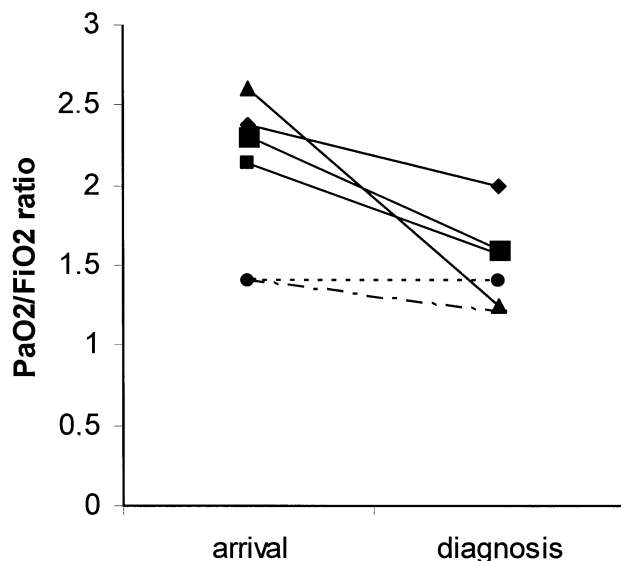


Fig 3. Decline in arterial blood oxygenation (arterial partial pressure of oxygen to fraction of inspired oxygen [$\text{PaO}_2/\text{FiO}_2$]) in the interval time between admission and diagnosis.

placement, which allowed definitive resolution of the pneumothorax in 2 patients. One patient received first blind drainage placement and was subsequently scheduled for video-assisted thoracoscopic surgery because of persisting air collection. Three patients were immediately scheduled for video-assisted thoracoscopic surgery because of the presence of multiple loculated pneumothoraces whose treatment by blind drainage was deemed dangerous. To avoid the risks of general anesthesia and mechanical ventilation, all the procedures were performed with the patient awake, under spontaneous ventilation. Analgesia entailed intercostal nerve blockade with a mix of lidocaine 2% and ropivacaine 7.5%. Mild sedation was obtained with 2 to 5 mL of intravenous midazolam. No patient required intubation or suffered functional impairment throughout the procedure. Two 15-mm trocar ports were sufficient for the operation in all patients but 1, who required an additional 7-mm port because of particular anatomic complexity. The air leak was easily discovered in 5 patients. In 1 patient the leak was not found, and operative technique entailed only video-assisted placement of a chest drainage. Sealing of a small lung tear lying in the vicinity of the suture line by means of cyanoacrylate glue instillation was carried out in 2 patients. In 1 patient, a gross bronchoalveolar leak lying on the major fissure was repaired by means of a cyanoacrylate layer covered with a bovine pericardium patch. Operative time ranged from 35 to 90 minutes. Air leak cessation was achieved after 1 to 3 days; mean hospital stay was 3.2 days. Follow-up ranged from 6 to 36 months, with no patients lost to follow-up. No patient developed a second pneumothorax during follow-up. Tables 1 and 2 report major clinical and radiologic findings of our series.

Comment

The most meaningful finding of our study is that a multiloculated pneumothorax may develop late after LVRS, and that this complication may be easily missed at standard radiographic assessment even in the presence of large air collections, thus leading to erroneous misdiagnosis of respiratory failure caused by exacerbated chronic obstructive pulmonary disease or deteriorating bullous emphysema. The causal relation of late-onset pneumothorax with previous LVRS can be exclusively hypothetical. In some cases, an alveolar, or even bronchoalveolar, leak might develop after several days as an effect of the mechanical stress induced by reexpansion of the lung surface. This mechanism supplies a better explanation of cases that present after a period of relative well-being after discharge. Alternatively, we suggest that in some patients, a minimal air leak can persist despite radiologically documented full lung reexpansion and the absence of bubbling on the water seal chamber. In these instances, pneumothorax is likely to occur early after discharge, although the presence of thick pleural adhesions might initially limit its enlargement and its radiologic detection even with a provocative clamping test. In these patients, the presence of a minuscule air collection may explain the lack of subjective improvement at first outpatient visit after surgery in some patients. In these instances, uneventful chest roentgenogram may lead the surgeon to rule out other procedure-related complications. Therefore, we now prefer to include CT scan even in the short-term follow-up of LVRS patients presenting with unsatisfactory outcome, particularly if they had prolonged postoperative air leaks. The basic mechanism of very late onset pneumothorax is more demanding to hypothesize. We acknowledge that these pneumothoraces might simply develop as a result of a progression of the native disease, without reasonable relationship with the previous surgery. Nonetheless, the regional differences in elastic recoil induced by LVRS might at least exaggerate the disruption of lung tissue and facilitate the rupture of superficial bullae, even in sites distant from the suture lines. A similar mechanism has been proposed to explain the late development of giant bullae after LVRS [1].

In our series, conventional chest roentgenography failed to pinpoint the exact diagnosis even in presence of very large sized pneumothoraces, which were instead

Table 1. Patient Data

Patient	$\text{PaO}_2/\text{FiO}_2$ Ratio	Days From Discharge	Diagnostic Delay (hours)
1	2.62	92	32
2	1.45	37	16
3	2.42	106	24
4	1.35	55	32
5	2.38	20	8
6	1.44	700	3

FiO_2 = inspiratory fraction of oxygen; PaO_2 = arterial tension of oxygen.

Table 2. Radiologic and Operative Data

Patient	Site of Air Leak	Radiographic Findings	Treatment	Hospital Stay (days)
1	Staple line	None	VATS	3
2	Staple line	Hyperlucency, mediastinal shift	VATS	4
3	Major fissure	None	DP, VATS	2
4	Lower lobe	Mediastinal shift	VATS	4
5	Unknown	Hyperlucency	DP	3
6	Unknown	Hyperlucency	DP	5

DP = drainage placement; VATS = video-assisted thoracoscopic surgery.

revealed at CT scan. The merits of CT in this setting are not surprising, and have been evidenced in both clinical and experimental studies [3–5]. In particular, Omert and coworkers [6] have stressed that CT scan results in a significant change in clinical management of trauma patients with intrathoracic complications. Nonetheless, physicians involved in primary care are sometimes reluctant to include CT in first-line assessment of patients with thoracic complications, on account of cost-saving concerns. This kind of behavior resulted in a remarkable diagnostic delay for our patients that translated in a significant decrease in arterial blood oxygenation (Fig 3), particularly in those who were first referred to peripheral hospitals. On the basis of this observation, we advise LVRS patients to be immediately referred to their specialized center rather than be seen at primary care structures not experienced with this kind of surgery nor with its particular critical care needs.

Several authors have suggested that any pneumothorax occurring in critically ill patients should be treated expeditiously by chest tube placement because of the high rate of progression to tension, especially in case of ventilatory support [7, 8]. However, although blind chest tube placement may achieve initial stabilization of the patient or even definitive resolution in certain cases, it may be demanding or even hazardous owing to the risk of lung injury in the presence of loculated pneumothorax. Moreover, chest drainage alone may not resolve the air leaks when these are sustained by a large lung tear, leading to prolonged hospital stay with increased morbidity and overall costs. We therefore now prefer video-assisted thoracoscopic surgery management with the goal of sealing pulmonary tears and reducing the risks of triggering further complications. In addition, having further experience with awake procedures for resection of pulmonary nodules [9] and LVRS [10], we are prone to adopt this option even in this setting, with the aim of reducing surgical risks in these delicate patients. Previous studies have focused on the advantages of this approach to managing air leak problems [11, 12]. Different video-assisted thoracoscopic surgery techniques can be adopted to seal the air leak, including limited resection, “no-cut” stapling, instillation of biologic glues, or a combination of these [11–13]. In particular, we have found that definitive air leak control can be rapidly achieved with the use of instilled cyanoacrylate glue, which can be also used in combination with a bovine

pericardium patch to seal large lung tears as reported by Horsley and Miller [12]. Using this technique, operative time was short even in the most demanding instances. Despite the finding that more detailed evaluation of cost-to-benefit analysis of minimally invasive surgery versus only chest drainage or interventional radiologic procedures is warranted in future studies, we believe that this approach translates into decreased morbidity, shorter hospital stay, and lower hospital costs.

In conclusion, we believe that occult pneumothorax should be considered as a possible late-onset life-threatening complication of LVRS, especially in patients with a history of prolonged postoperative air leaks. Occult pneumothorax may present even several months after the procedure as sudden, progressively deteriorating respiratory impairment in relatively well-faring patients. Nonetheless, in some patients, the presence of a minimal active air leak should already be suspected at short-term follow-up as exacerbating dyspnea is noticed despite uneventful chest roentgenogram. We therefore suggest that CT scan should be routinely included in the early postoperative management of this subgroup. Moreover, because immediate recognition and treatment of a late-onset pneumothorax is crucial to avoid the need of mechanical ventilation, we recommend that critically ill LVRS patients should be sent immediately to their referral center for prompt diagnosis and optimal management.

Supported by MURST COFIN grants No. 9906274194–06, CNR No. CU0100935 2002, and Centro di Eccellenza 2001. This study was carried out within the Research Fellowship Program Tecnologie e Terapie Avanzate in Chirurgia awarded by the Tor Vergata University.

References

- Iqbal M, Rossoff L, McKeon K, Graver M, Scharf SM. Development of a giant bulla after lung volume reduction surgery. *Chest* 1999;116:1809–11.
- Mineo TC, Pompeo E, Rogliani P, Leonardis C, Nofroni I. Results of unilateral lung volume reduction surgery in patients with distinct heterogeneity of emphysema between lungs. *J Thorac Cardiovasc Surg* 2005;129:73–9.
- Engdhal O, Toft T, Boe J. Chest radiography: a poor method for determining the size of a pneumothorax. *Chest* 1993;103:26–9.
- Phillips GD, Trotman-Dickenson B, Hodson ME, Geddes DM. Role of CT in the management of pneumothorax in

- patients with complex cystic lung disease. *Chest* 1997;112:275–8.
5. Wolfman NT, Wendell SM, Glauser SJ, Meredith JW, Chen MY. Validity of CT classification on management of occult pneumothorax: a prospective study. *AJR Am J Roentgenol* 1998;171:1317–20.
 6. Omert L, Yeane WW, Protetch J. Efficacy of thoracic computerized tomography in blunt chest trauma. *Am Surg* 2001;67:660–4.
 7. Gobien RP, Reines HD, Schabel SI. Localized tension pneumothorax: unrecognized form of barotrauma in adult respiratory distress syndrome. *Radiology* 1982;142:15–9.
 8. Streiter RM, Lynch JP. Complications in the ventilated patients. *Clin Chest Med* 1988;9:127–39.
 9. Pompeo E, Mineo D, Rogliani P, Sabato AF, Mineo TC. Feasibility and results of awake thoracoscopic resection of solitary pulmonary nodules. *Ann Thorac Surg* 2004;78:1761–8.
 10. Mineo TC, Pompeo E, Mineo D, Pampana E, Dauri M, Sabato AF. Awake non-resectional lung volume reduction surgery. *Ann Surg*. In press.
 11. Thistlethwaite PA, Luketich JD, Ferson PF, Keenan RJ, Jamieson SW. Ablation of persistent air-leaks after thoracic procedures with fibrin sealant. *Ann Thorac Surg* 1999;67:575–7.
 12. Mukaida T, Andou A, Date H, Aoe M, Shimizu N. Thoracoscopic operation for secondary pneumothorax under local anesthesia in high-risk patients. *Ann Thorac Surg* 1998;65:924–6.
 13. Horsley WS, Miller JJ. Management of the uncontrollable air-leak with cyanoacrylate glue. *Ann Thorac Surg* 1997;63:1492–3.

Online Discussion Forum

Each month, we select an article from the *The Annals of Thoracic Surgery* for discussion within the Surgeon's Forum of the CTSNet Discussion Forum Section. The articles chosen rotate among the six dilemma topics covered under the Surgeon's Forum, which include: General Thoracic Surgery, Adult Cardiac Surgery, Pediatric Cardiac Surgery, Cardiac Transplantation, Lung Transplantation, and Aortic and Vascular Surgery.

Once the article selected for discussion is published in the online version of *The Annals*, we will post a notice on the CTSNet home page (<http://www.ctsnet.org>) with a FREE LINK to the full-text article. Readers wishing to comment can post their own commentary in the discussion forum for that article, which will be informally moderated by *The Annals* Internet Editor. We encourage all surgeons to participate in this interesting exchange and to avail themselves of the other valuable features of the CTSNet Discussion Forum and Web site.

For December, the article chosen for discussion under the Adult Cardiac Dilemma Section of the Discussion forum is:

Vacuum-Assisted Wound Closure of Deep Sternal Infections in High-Risk Patients After Cardiac Surgery

Kyle Northcote Cowan, MD, PhD, Laura Teague, RN, MN, Sammy C. Sue, BS, and James L. Mahoney, MD

Tom R. Karl, MD
The Annals Internet Editor
UCSF Children's Hospital
Pediatric Cardiac Surgical Unit
505 Parnassus Ave, Room S-549
San Francisco, CA 94143-0118
Phone: (415) 476-3501
Fax: (212) 202-3622
e-mail: karlt@surgery.ucsf.edu

Late-Onset Occult Pneumothorax After Lung Volume-Reduction Surgery

Federico Tacconi, Eugenio Pompeo and Tommaso C. Mineo

Ann Thorac Surg 2005;80:2008-2012

DOI: 10.1016/j.athoracsur.2005.06.013

Updated Information & Services

including high-resolution figures, can be found at:
<http://ats.ctsnetjournals.org/cgi/content/full/80/6/2008>

References

This article cites 12 articles, 10 of which you can access for free at:
<http://ats.ctsnetjournals.org/cgi/content/full/80/6/2008#BIBL>

Subspecialty Collections

This article, along with others on similar topics, appears in the following collection(s):

Lung - other

http://ats.ctsnetjournals.org/cgi/collection/lung_other

Permissions & Licensing

Requests about reproducing this article in parts (figures, tables) or in its entirety should be submitted to:

<http://www.us.elsevierhealth.com/Licensing/permissions.jsp> or
email: healthpermissions@elsevier.com.

Reprints

For information about ordering reprints, please email:
reprints@elsevier.com



THE ANNALS OF THORACIC SURGERY

