




Cite this article as: Messina G, Noro A, Natale G, Bove M, Fasano M, Vicidomini G *et al.* Management of residual spaces after lung resections and air leaks: Ultrasound and pneumoperitoneum. *Interact CardioVasc Thorac Surg* 2022; doi:10.1093/icvts/ivac035.

Management of residual spaces after lung resections and air leaks: Ultrasound and pneumoperitoneum

Gaetana Messina ^{ax}, Antonio Noro^a, Giovanni Natale^a, Mary Bove^a, Morena Fasano^b, Giovanni Vicidomini^a, Mario Santini ^a and Alfonso Fiorelli ^a

^a Thoracic Surgery Unit, Università degli Studi della Campania “Luigi Vanvitelli”, Napoli, Campania, Italy

^b Medical Oncology, Department of Precision Medicine, University of Campania “Luigi Vanvitelli”, 80138 Naples, Italy

* Corresponding author: Thoracic Surgery Unit, Università degli Studi della Campania “Luigi Vanvitelli”, Napoli, Campania, Italy. Tel: +393474765175; e-mail: adamesina@virgilio.it (G. Messina).

Received 2 August 2021; received in revised form 25 January 2022; accepted 10 February 2022

Abstract

Prolonged chest tube drainage is one of the most common postoperative complications of pulmonary resections; it is related to complications such as residual pleural spaces or continuous alveolar air leaks. We retrospectively evaluated the efficacy of artificial intraoperative pneumoperitoneum in the treatment of such complications after lung resections. The presence of a residual space associated with prolonged air leaks can be difficult to treat, exposes the patient to a high risk of infection, prolongs hospitalization, and in some cases mandates reoperation. Between October 2016 and March 2020, four patients underwent pneumoperitoneum. The obliteration of the pleural cavity and the absence of air leaks were observed in 3 patients; only 1 patient was discharged with a Heimlich valve. Artificial intraoperative pneumoperitoneum is a safe and simple procedure. It decreases the duration of chest drainage and of the hospital stay; however, further studies are needed to corroborate our data. The learning curve for this technique may be relatively short.

Keywords: pneumoperitoneum • ultrasound • air-leaks • residual pleural space

INTRODUCTION

Prolonged chest tube drainage is one of the most common postoperative complications of pulmonary resections [1]; it is related to complications such as residual pleural space or continuous alveolar air leak.

During the last 20 years, the incidence of pleural space problems has been reduced thanks to improved surgical techniques and devices such as mechanical staplers.

The majority of apical spaces are self-limiting and should be not treated if they do not impact patient clinical outcomes [2].

The incidence of any kind of air leak after a lung resection is reported to be around 50%. The majority of these leaks do not require any specific intervention and cease within a few hours or days. The recent literature defines a prolonged air leak as an air leak lasting beyond postoperative day 5 [3]. Nevertheless, it is not easy to quantify the amount of air bubbling through a water seal of a closed chest tube drainage system, as reported historically by the experiences of Gotthard Bülau.

Moreover, modern digital chest drainage systems with air leak meters allow quantification of air loss over time and a way to visualize the trend [4].

In our experience, prolonged air leaks and space problems after lung resections are rare but can result in severe sequelae after a thoracic operation. We retrospectively evaluated the efficacy of pneumoperitoneum in the treatment of such complications after lung resections.

MATERIAL AND METHODS

This study is reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cohort studies. Between October 2016 and March 2020, four patients referred to the Department of Thoracic Surgery of the University Vanvitelli for lung lobectomy [5] for lung cancer [6] and who postoperatively exhibited residual pleural space or continuous alveolar air leak, were evaluated retrospectively. All patients gave signed informed consent for the procedure, which was approved by the ethics committee of the University of Campania “Luigi Vanvitelli” (ethical approval number: 833.18); they were aware that their clinical data could be used anonymously for scientific purpose only.

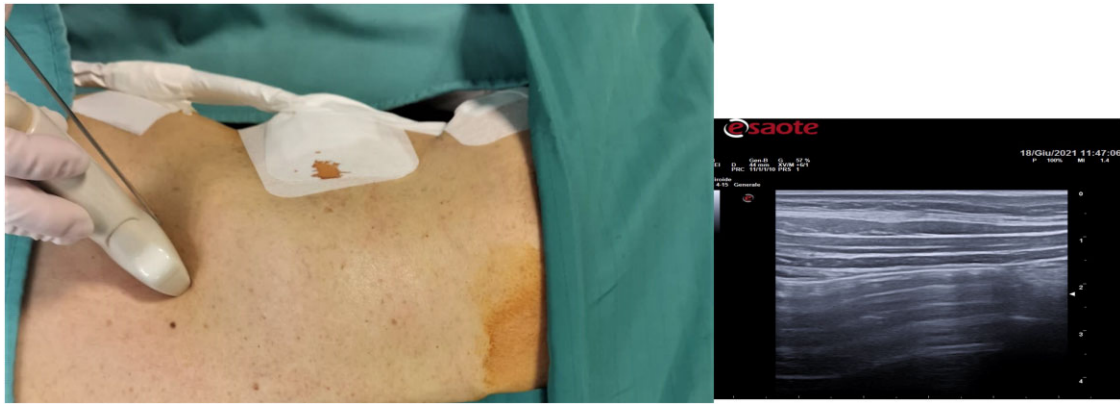


Figure 1: Pneumoperitoneum performed under ultrasound guidance; the Veress needle is introduced into the centre of the probe.

Pneumoperitoneum procedure

The pneumoperitoneum procedure was performed in the operating room; the patient was sedated, was breathing spontaneously and was monitored with an echocardiogram, a non-invasive blood pressure device and a pulse oximeter for O₂ saturation. The pneumoperitoneum was induced using a Veress needle, which was introduced under ultrasound guidance using a high frequency linear probe at the left hypochondrium; an average of 1200 ml of air was injected (range 1600– 2000 ml).

Thanks to the use of ultrasound with a high-frequency linear probe (7–13 MHz), before positioning the Veress needle, it is possible to evaluate the slipping of the intestinal loops during the respiratory acts, a plausible sign of the absence of adhesions known as “sliding viscera”, an ultrasound sign reported elsewhere (Fig. 1).

The Veress needle can be also checked using a 10-ml syringe filled with a sterile saline solution and applied directly to the Veress needle with the valve open. In this case, if the needle is in the right position, the pressure difference between the 2 compartments favours the rapid fall of the solution into the peritoneum during breathing. An average of 1200 ml of air was injected (range 1600–2000 ml). An indirect sign of the correct positioning of the needle is the disappearance of hepatic dullness in response to percussion after insufflation.

This intraperitoneal free air is visualized on ultrasound scans as “acoustic reverberations”: bilateral diaphragm dysfunction diagnosed by ultrasonography showing tension from an excessive pneumoperitoneum [7]. Reverberation artefacts, like those observed in our case, are generated by large differences in acoustic impedance, which in turn determine the reflectivity of sound waves at tissue interfaces.

Outcome measures

Immediately after the procedure, the patients had a chest X-Ray; on postoperative day 2, a computed tomography scan of the chest was performed.

RESULTS

Between October 2016 and March 2020, four patients (3 women and 1 man), average age 60 years (range 50–71), underwent a pneumoperitoneum. Of the 4 patients, 1 had a left lower

lobectomy, 2 had a right lower lobectomy and 1 had a right bilobectomy. All patients had tumour-free bronchial resection margins, resection of the triangular ligament and correct positioning of the endopleuric drainage tube. All patients underwent flexible bronchoscopy to ensure the absence of a bronchopleural fistula. All patients had continuous air leakage monitored on a Thopaz digital chest drain system, medium value 1280l/min (1200, 1370,1300,1350); they underwent pneumoperitoneum on post-operative day 9.5. No patient had complications during the pneumoperitoneum procedure; only 1 patient complained of widespread abdominal pain and tension. Obliteration of the pleural cavity and the absence of air leaks occurred gradually in 3 patients at an average time of about 72–96 h (interval of 3–4 days); the average length of hospitalization was approximately 16 days; only 1 patient was discharged with a Heimlich valve due to a persistent air leak (Fig. 2).

Pneumoperitoneum should be used in patients in whom air leakage associated with a residual pleural cavity persists; however, further studies need to corroborate our data. (Fig. 3)

DISCUSSION

After lung resection, different physiologic mechanisms including expansion and hyperinflation of the remaining ipsilateral lung, mediastinal shifting, narrowing of the intercostal spaces and elevation of the diaphragm contribute to minimizing the residual pleural space. Hence, any restrictive process involving the lung and chest wall, such as restrictive lung disease, previous thoracic operations or induction chemo- and/or radiotherapy, may increase the likelihood of postoperative residual pleural space. Generally about 50% of all patients present with at least minor air leaks after lung resections; the majority of these leaks stop spontaneously within a few hours to 3 days. As a consequence, any air leakage should be considered a surgical complication. Brunelli and colleagues reported a significantly increased rate of empyema in patients with air leaks lasting more than 7 days compared to patients with lesser air leaks (8.2% –10.4% vs 0%–1.1%) [8]. In addition to empyema, Varela *et al.* found air leaks lasting longer than 5 days associated with other kinds of pulmonary complications like atelectasis and pneumonia [9]. Conservative approaches include prolonged chest tube drainage, to try clamping chest tube and removing chest tube if possible, physiotherapy, application of various agents for pleurodesis such as tetracycline, talcum or silver nitrate through the chest tube or outpatient

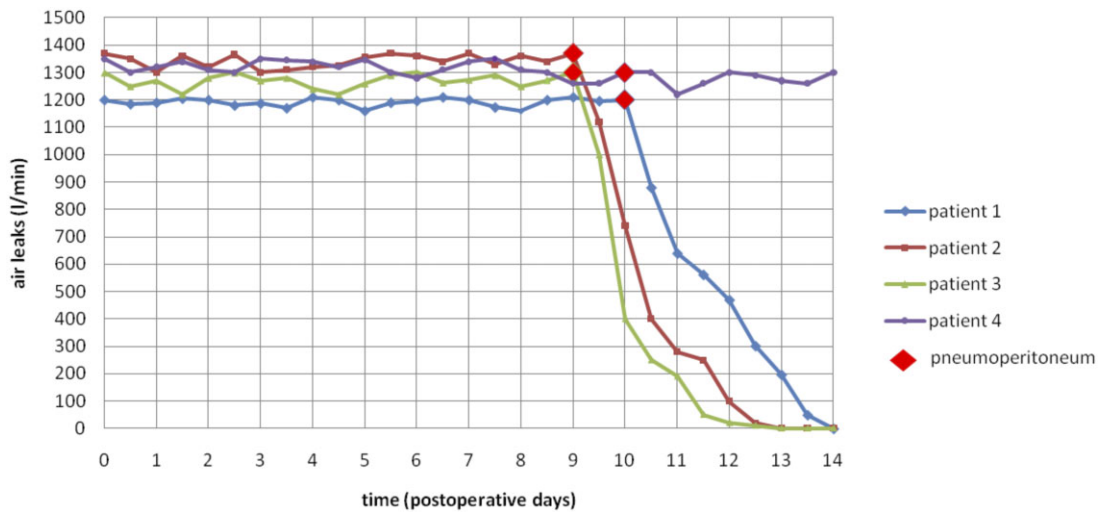


Figure 2: Chart showing the gradual obliteration of the pleural cavity and the absence of air leaks in 3 patients in an average time of about 72–96 h (interval of 3–4 days); the average length of hospitalization was approximately 16 days; only 1 patient was discharged with a Heimlich valve due to persistent air leakage.

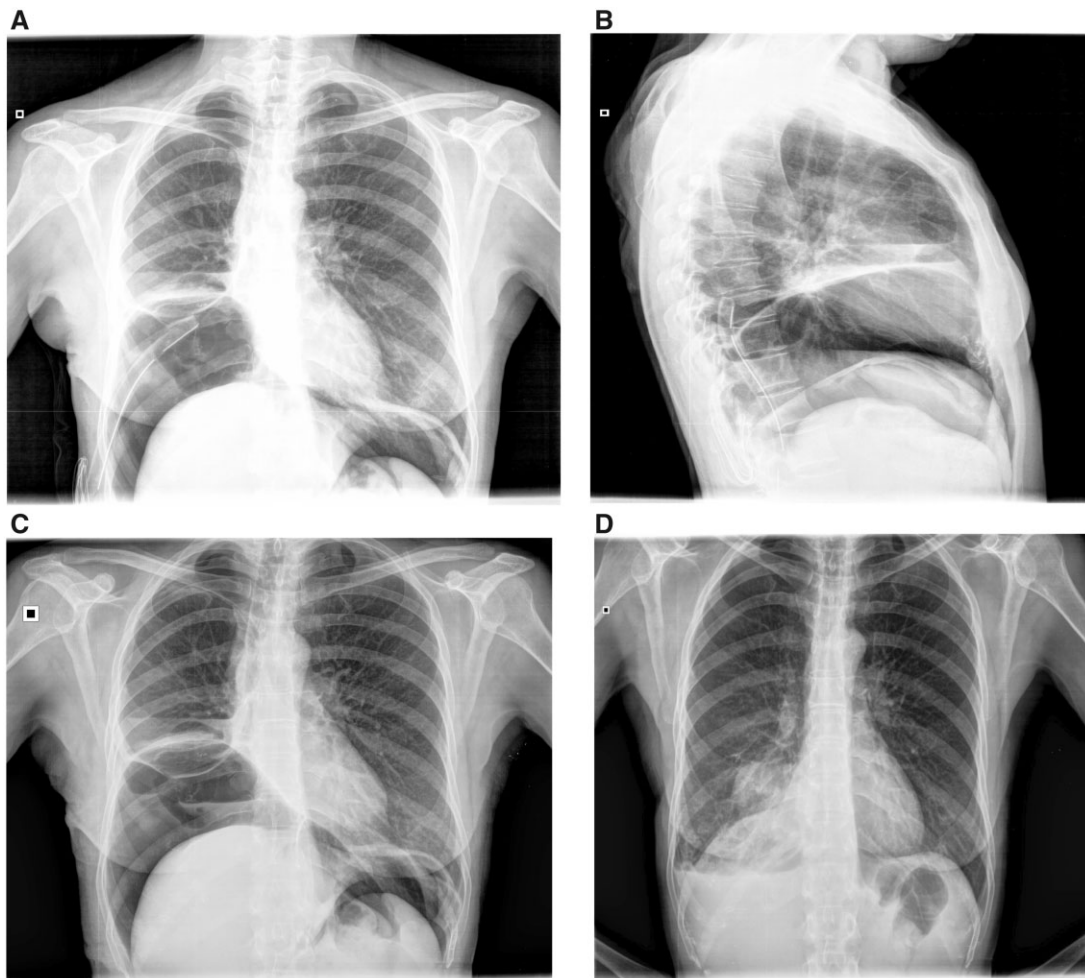


Figure 3: (A, B) Chest x-rays of anteroposterior laterolateral pneumoperitoneum with gradual reduction of air leaks. (C) Anteroposterior chest x-ray with resolution of air leaks and removal of the endopleural drainage tube. (D) Thirty-day follow-up.

management with a chest tube and a Heimlich valve [10]. The use of pneumoperitoneum to treat prolonged air leaks in patients with basal spaces after lung resection is not new [11]. Some

authors recently recommended its use after lung volume reduction surgery to manage apical spaces and prolonged air leaks. The residual space associated with prolonged air leaks can be

difficult to treat, exposes the patient to a high risk of infection, prolongs hospitalization and in some cases mandates a reoperation.

Our brief communication confirms how the use of pneumoperitoneum to treat postoperative air leak complications represents an effective treatment for basal air spaces. It is easy to perform and, most importantly, allows temporary elevation of the diaphragm with no long-term sequelae. We also noted that air leaks and pleural space problems were more difficult to treat in patients who had induction chemotherapy. This observation might be explained as being the result of the effects of chemotherapy or radiotherapy, major tissue fragility, fibrosis and a diffuse desmoplastic reaction, especially when marked shrinking of the tumour is obtained. Surgeons who deal with these patients are aware that the operation can be technically demanding and associated with higher morbidity.

Furthermore, in patients with lung cancer who need adjuvant treatment, the start of chemotherapy or radiation therapy may be delayed. In our practice, some oncologists prefer to start the treatment after chest tube removal because of the higher risk of infectious complications.

The consequences for the individual patient and the entire healthcare system are manifold: prolonged chest tube drainage causes prolonged pain; restricted ventilation leads to increased risk of pneumonia; decreased mobility because of chest tubes and the related pain results in increased risk of thromboembolism; necessity of pleurodesis, mechanical ventilation and reoperation; higher readmission rates to intensive care units; prolonged hospital stays and related higher overall costs.

CONCLUSION

The prevention of postoperative pleural space problems and prolonged air leaks is one of the major issues after pulmonary resection. Pulmonary resection also requires longer hospital stays with increased discomfort for the patient, increases the patient's risk of infection and can require reoperation when the conservative approach is unsuccessful. An intraoperative pneumoperitoneum after a lower lobectomy or a lower bilobectomy for lung cancer or inflammatory lung diseases is a safe and simple procedure, and it decreases the duration of chest drainage and hospital stays; however, further studies are needed to corroborate our

data. Our results suggest that the learning curve for this technique may be relatively short.

Funding

The authors disclose no funding for the present paper.

Conflict of interest: none declared.

REFERENCES

- [1] Liberman M, Muzikansky A, Wright CD, Wain JC, Donahue DM, Allan JS *et al.* Incidence and risk factors of persistent air leak after major pulmonary resection and use of chemical pleurodesis. *Ann Thorac Surg* 2010; 89:891–7.
- [2] Misthos P, Kokotsakis J, Konstantinou M, Skottis I, Lioulias A. Postoperative residual pleural spaces: characteristics and natural history. *Asian Cardiovasc Thorac Ann* 2007 ;15:54–8.
- [3] Sakata KK, Reisenauer JS, Kern RM, Mullon JJ. Persistent air leak – review. *Respir Med* 2018 ;137:213–8.
- [4] Meyer JA, Gotthard Bülau and Closed Water-Seal Drainage for Empyema, 1875–1891. *The Annals of Thoracic Surgery* 1989;48:597–9.
- [5] Santini M, Fiorelli A, Messina G, Mazzella A, Accardo M. The Feasibility of LigaSure to Create Intestinal Anastomosis: results of Ex Vivo Study. *Surg Innov* 2015 ;22:266–73.
- [6] Cozzolino I, Ronchi A, Messina G, Montella M, Morgillo F, Vicidomini G *et al.* Adequacy of Cytologic Samples by Ultrasound-Guided Percutaneous Transthoracic Fine-Needle Aspiration Cytology of Peripheral Pulmonary Nodules for Morphologic Diagnosis and Molecular Evaluations: comparison With Computed Tomography-Guided Percutaneous Transthoracic Fine-Needle Aspiration Cytology. *Arch Pathol Lab Med* 2020 ;144:361–9.
- [7] Fiorelli A, Messina G, Capaccio D, Santini M. Recurrent spontaneous pneumomediastinum: a rare but possible event!. *J Thorac Dis* 2012 ;4: 431–3.
- [8] Brunelli A, Xieme F, Al Refai M, Salati M, Marasco R, Sabbatini A. Air leaks after lobectomy increase the risk of empyema but not of cardiopulmonary complications: a casematched analysis. *Chest* 2006;130: 1150–6.
- [9] Varela G, Jiménez MF, Novoa N, Aranda JL. Estimating hospital costs attributable to prolonged air leak in pulmonary lobectomy. *Eur J Cardiothorac Surg* 2005;27:329–33.
- [10] Rice TW, Okereke IC, Blackstone EH. Persistent air-leak following pulmonary resection. *Chest Surg Clin N Am* 2002;12:529–39.
- [11] De Giacomo T, Rendina EA, Venuta F, Francioni F, Moretti M, Pugliese F *et al.* Pneumoperitoneum for the management of pleural air space problems associated with major pulmonary resections. *Ann Thorac Surg* 2001 ;72:1716–9.