International Journal of Cardiovascular and Thoracic Surgery
2020; 6(2): 17-22
http://www.sciencepublishinggroup.com/j/ijcts
doi: 10.11648/j.ijcts.20200602.11
ISSN: 2575-4866 (Print); ISSN: 2575-4882 (Online)

Pleuroplastic Inlay with Autologous Blood Versus Gel-foam Slurry as Innovative Remedies for Trapped Lung

Ahmed Mohammed Abumossalam, Asem Abdelhamid Hewidy

Chest Medicine Department, Faculty of Medicine, Mansoura University Hospitals, Mansoura University, Mansoura, Egypt

Email address:
abumossalam79@yahoo.com (A. M. Abumossalam), ahewidy@yahoo.com (A. A. Hewidy)

To cite this article:
Ahmed Mohammed Abumossalam, Asem Abdelhamid Hewidy. Pleuroplastic Inlay with Autologous Blood Versus Gel-foam Slurry as Innovative Remedies for Trapped Lung. *International Journal of Cardiovascular and Thoracic Surgery*. Vol. 6, No. 2, 2020, pp. 17-22. doi: 10.11648/j.ijcts.20200602.11

Received: April 4, 2020; **Accepted**: April 22, 2020; **Published**: June 9, 2020

Abstract: Background: Residual pleural air following chronic empyema and intrapleural interventions implies a disgusting issue for restoration of pleural contour. Aim of work: This work was to assess the efficacy and safety of intrapleural instillation of patient autologous blood versus gel-foam slurry for obliteration and reduction of volume of residual pleural space following chronic empyema and pleural interventions as well as limitation of long term complications and as a substitute for surgical decortication. Patients and methods: This study was conducted on 28 patients with trapped lung due to chronic empyema after intercostal tube placement and were divided according to the instilled material into three groups: group A, included 9 patients who were instilled with autologous blood, group B; included 9 patients who were instilled with gel-foam slurry, group C, included 10 patients who were treated with oral Alphintern tablets three times daily for two month. Results: pulmonary functional evaluation showed that 50% reduction of total lung capacity (TLC) defect by > 75% in group A and > 65% in group B. Besides 50% reduction of computed chest tomography CT radiological volumetry was detected by > 65% in group A and by > 55% in group B while opacification of residual pleural space was found in more than 75% in group A and 85% of group B. Group C showed coalescence of pleural layers in 20% of cases. Conclusion: Intrapleural instillation of autologous blood and gel-foam slurry for obliteration of residual pleural space was associated with a reduction of (CT) chest volumetry and pulmonary function improvement.

Keywords: Trapped Lung, Gelfoam, Thoracoscopy, Autologous Blood

1. Introduction

It was well known that trapped lung, could be referred as the lung that cannot maximally inflate because of a longstanding inflammation that yielded a collagenous or a fibrous rind on the visceral pleural layer [1]. Initially, most of the causes of trapped lung originated as a type of lung entrapment. Whereas in most circumstances lung entrapment healed once the inflammatory process ended, in other conditions, the resolution was lacking resulting in a trapped lung. Thus, trapped lung and lung entrapment symbolized two varieties of the same disease process [2].

It was presented as the reverberation of an earlier pleural space inflammation that gave rise to a fibrous visceral pleural peel that impeded the lung expansion after extraction of the pleural fluid [3]. Treatment at this occasion was not usually obligatory and spontaneous improvement might be delayed or even missed, if proper treatment at the right time was not conducted [4]. Negative intrapleural pressure consequently would be disregarded, blocking the complete apposition of both pleural layers, leading to trapped lung. The diagnosis of unexpandable lung due to restriction of the visceral pleura centered on clinical suspicion in cases with either hydropneumothorax or after inefficient thoracentesis of pleural effusion due to the presence of chest pain besides it required chronicity and solidity over time [5]. Heidecker et al. had demonstrated that unexpandable lung was the most recurring cause of pneumothorax (pneumothorax ex vacuo) and after frequent thoracocentesis [6]. The diagnosis was usually delayed, either because lack of probability or due to difficulty to know how much time had leaked out since the initial lesion.[7]. Many diseases had accompanied by trapped lung as coronary artery graft bypass surgery, empyema, hemothorax, tuberculosis, uremic pleuritis and rheumatoid

arthritis [8]. The symptoms were usually minor or even nonexistent, and chest imaging did not signify contralateral mediastinal shift [9]. Resolution of this dilemma was governed by approximation of two pleural layers that represented a major obstacle due to pleural thickness, rigidity and the less negative pleural pressure. Instillation of a substance that can obliterate this space and lessen pleural layers detachment make the process easier. So we aimed to assess the efficacy and safety of intrapleural instillation of patient autologous blood versus gel-foam slurry for obliteration and reduction of volume of residual pleural space following chronic empyema and pleural interventions as well as limitation of long term complications and as a substitute for surgical decortication.

2. Methods

Study type: true experimental randomized controlled study (post-test only control design) that was conducted on 28 patients (23 male and 5 females) who were recruited from the out-patient clinic of Mansoura University hospital from October 2017 to April 2018 with trapped lung. Departmental and faculty institutional review board agreement and ethical approval were obtained.

Inclusion criteria: Patients with trapped lung with residual pleural space up to 300 ml^3 by CT chest volumetry with documented contraindication for surgery or refusing a major surgical intervention. Trapped lung caused by following lesions:

a) Parapneumonic effusion/ chronic empyema (due nonspecific infections) after 3 months of intercostal tube placement.
b) Mismanaged pneumothorax / hydropneumothorax/ Pyopneumothorax/ haemothorax
c) Post-thoracoscopic intervention.

Exclusion criteria: trapped lung caused by

1. Malignant effusion
2. Tuberculous effusion
3. Chylous effusion
4. Pleural effusion with central bronchial lesion
5. Atelectasis.

They were divided according to instilled material into three groups:

Group A: included 9 patients with trapped lung instilled with patient autologous blood.

Group B: included 9 patients with trapped lung instilled with gel-foam slurry.

Group C: included 10 patients with trapped lung treated with oral Alphintern tablets (Chymotrypsin 300 Units; 14 micro Katals, Trypsin 300 Units; 5 micro Katals) three times daily for two months.

2.1. Procedure

a) All cases were selected randomly according to the date of admission. Patients were admitted for 2 days, routine laboratory investigations were done.
b) Patients were referred firstly to CT chest for localization of the site of residual pleural air present due to trapped lung and skin area overlying the pleural space was marked by permanent marker pen by 4 letters A, B, C, D for four boundaries and the sites for primary and secondary pores were marked also.
c) The volume of trapped area in the lung was measured firstly before the procedure and then secondary after 2 months of follow up by CT chest computed volumetric estimation for calculating the amount needed to fill this place and primary volume of this space.
d) Patients were then transferred to the biopsy room in Chest medicine department where mini-thoracoscopy was done under local anesthesia.
e) The first port was done with a simple puncture with a scalpel by 1 cm in length then a trocar of mini-thoracoscopy (rigid 4 mm diameter, 30° Hopkins, Karl Storz, Germany) was introduced.
f) In the other port central venous catheter (CVC) was inserted and was held with silo tape without suturing then connected to 50 ml syringe. All pleural pockets were opened by thoracoscopy and aspiration of residual fluid followed by pleural toilet with normal saline wash 0.9%.
g) Pleural dryness was conducted by connecting the mini-thoracoscopy side channel with an oxygen source for drying up the pleural surfaces.
h) The volume of instilled material (autologous blood- gel-foam slurry) was estimated previously by CT chest volumetry.
i) In group A fresh blood was obtained from the patient immediately on the table by 50 ml syringe (one by one according to volumetry) then instilled via mini-thoracoscopy trocar into pleural space slowly while the nurse performed negative suction gently by the other CVC until the CVC syringe bring blood. The CVC then removed rapidly with the application of gauze pressure for 2-5 minutes. The first port of the mini-thoracoscopy then closed with the mattress suture.
j) In group B, gelfoam slurry was prepared by opening 3 ampoules for spaces less than 100 ml^3 and 6-8 ampoules for spaces from 100-300 ml^3 (each ampoule contain gelfoam sponge with the following features (Curaspon; 80×50×10 mm EMOH Cura Medical B. V.) **[10]** then they were divided into small pieces under aseptic technique then were enclosed into multiple 50 cm syringe barrel by opening its lower end then closing the plunger on the gelfoam then aspirate 50 ml saline 0.9% with agitation method between two syringe with T shaped connector, slurry was instilled with the same manner as in group A.
k) After instillation, confirmation of air removal was done by ultrasound imaging with 2D micro-convex (2.5-3.5 MHz) Mindray DP 2200 to visualize the degree of obliteration. Blood and gel-foam slurry appeared as anechoic to hypoechoic area between pleural boundaries.
l) In group C Alphintern tablets were taken orally three

times per/ day for two months.

Procedure outcome evaluation:

a) Clinical evaluation was excluded from our study schedule as most cases showed mild or even nonexistent symptoms due to disease chronicity.

b) Pulmonary functional test (PFT): depended mainly on the degree of improvement considering the total lung capacity TLC before the procedure and after 2 months with the help of Smart PFT (Smart PFT Laboratory, Medical Equipment in Europe GmbH, Hammelburg, Germany) according to the standardized protocol. The patient was considered to be improved and the procedure was successful if TLC (total lung capacity) defect reduced by more than 50%; as measured before and after the procedure

$$\text{Defect in TLC} = \frac{\text{Predicated TLC} - \text{Actual TLC}}{\text{Predicted TLC}} \times 100$$

c) Radiological evaluation: The patients were evaluated by CT chest after 2 months

1. By estimation of residual pleural space volumetry and calculating the

Reduction index=[Residual pleural space volume before procedure − Residual pleural space volume after the procedure by 2 months/ Residual pleural space volume before procedure × 100]→ If the index value was more than 50% considered successful procedure.

2. Opacification of residual pleural space:- the procedure was considered successful if the post procedure CT chest was totally opacified.

Figure 1. *Demonstration of instruments used in instillation procedure of gelfoam slurry into residual pleural space, two syringe 50 cm with two sponge of gelfoam.*

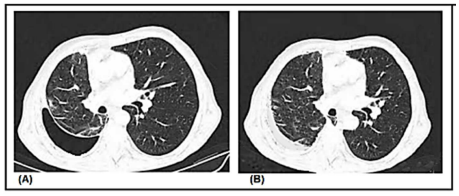

Figure 2. *CT chest of a patient with right sided posterior trapped lung with autologous blood instillation showing total radiological obliteration and significant reduction of space volumetry (A) before, (B) 70 days after instillation.*

2.2. Statistical Analysis

Data were analyzed using SPSS (Statistical Package for Social Sciences) version 21. Qualitative data were presented as number and percentage. Quantitative data were presented for normality by Kolmogorov–Smirnov test. Normally distributed data were presented as mean and standard deviation. Comparison between groups was done using Kruskal-Wallis H test guide to compare between three group (number and percentage). P value <0.05 was considered significant.

3. Results

Table 1. *Demographic data among the studied population.*

	Group A Instilled autologous blood No=9	Group B Instilled gelfoam slurry No=9	Group C Alphintern tablet oral intake No=10	P Value
Sex				
Male	8 (88.9%)	7 (77.8%)	7 (70%)	0.125
Female	1 (11.1%)	2 (22.2%)	3 (30%)	0.236
Age [mean-/+ SD]	52± 14.23	42±13.05	38± 11.75	0.032*
Type of lesion causing Trapped lung				
-Chronic empyema	5 (55.5%)	4 (44.4%)	8 (80%)	0.185
-Post-thoracoscopic intervention.	2 (22.2%)	1 (11.1%)	1 (10%)	0.171
-Mismanaged haemothorax	1 (11.1%)	2 (22.2%)	1 (10%)	0.952
-Pyopneumothorax	1 (11.1%)	2 (22.2%)	0	0.813

Table 1 showed a male predominance in studied cases in all groups, (88.8%, 77.8%, 70%) respectively. The mean age was higher in group A than the other two groups. Chronic empyema prevailed in the three groups as the primary and main etiology of trapped lung in our work (55.5%, 44.4%, 80%) respectively. No statistically significant differences were observed between studied groups regarding sex and etiological factors apart from age (p=0.032).

Table 2. *Functional and Radiological characteristics and outcome in the studied groups.*

	Group A Instilled autologous blood No=9	Group B Instilled gelfoam slurry No=9	Group C Alphintern tablet oral intake No=10	P Value
Pulmonary functional evaluation				
* Reduction TLC defect				
> 50%	7 (77.7%)	6 (66.6%)	2 (20%)	0.036*
<50%	2 (22.2%)	3 (33.3%)	8 (80%)	

	Group A Instilled autologous blood No=9	Group B Instilled gelfoam slurry No=9	Group C Alphintern tablet oral intake No=10	P Value
-CT radiological reduction of residual pleural space volumetry [reduction index]:				
> 50%	6 (66.6%)	5 (55.5%)	-Radiological absence of residual pleural space=2 cases (20%)	0.926
< 50%	3 (33.3%)	4 (44.4%)	-Persistence of residual pleural place with same volume=8 (80%)	
CT radiological obliteration of residual pleural space volumetry:				
Totally opaque	7 (77.7%)	8 (88.8%)		
Partially opaque	2 (22.2%)	1 (11.1)	No substance instilled in this group	0.024*
Outcome:-				
* Successful procedure	6 (66.6%)	5 (55.5%)	2 (20%)	0.847
* Failed procedure	3 (33.3%)	4 (44.4%)	8 (80%)	0.639

Table 2 showed that pulmonary functional evaluation expressed in 50% reduction of TLC defect was detected in more than 75% of cases in group A and more than 65% of cases in group B. Furthermore, 50% reduction of CT radiological volumetry for procedure consequence was found in more than 65% of cases in group A and more than 55% of cases in group B. Opacification of residual pleural space was detected in more than 75% of cases in group A and 85% of cases in group B. However in group C no instillation of pleural space was manipulated but improvement in TLC and coalescence of pleural layers were identified in nearly 20% of cases. Statistically significant differences were observed in TLC defect reduction in addition to residual pleural space opacification. Procedure outcome concluded that the success rate of the procedure was 66.6% in group A and 55.5% in group B on the other side Alphintern therapy succeeded in 20% of cases without statistical significance.

Table 3. *Complications of procedure in the studied groups.*

	Group A Instilled autologous blood No=9	Group B Instilled gelfoam slurry No=9	Group C Alphintern tablet oral intake No=10	P Value
Fever	1 (11.1%)	1 (11.1%)	0	0.817
Anaphylaxis	0	0	0	
Empyema	1 (11.1%)	0	0	
Pneumonitis	0	0	0	
Total	2 (22.2%)	1 (11.1%)	0	

Table 3 displayed that the least hazards of the manipulated procedure were encountered in our study presented in 22% in autologous blood group and 11% in gelfoam instilled group. One case showed fever in each group and one case complicated by empyema in group a but without statistically significant difference.

4. Discussion

So long as visceral and parietal pleural layers built up the outer caring shield of the lung and the most delicate structures yielding elastic, compliant and supporting covers. Once attaining chronicity due to inflammatory pathology these delicate layers became converted into thoracic jail behind its walls the lung complained form restriction and sacrificed for freedom.

In our study as table 1 showed that empyema was the most frequent complication of all thoracic procedures and the most common hazard of pneumonia. The nature of bacterial load in this type of pleural affection gave a small hint about complex inflammatory feedback from the body with subsequent fibrinous tissue formation that made the pleural layers detachment more frequent and coaptation more difficult.

As declared by table 2 assessment of pulmonary functional parameters as TLC which was considered the actual monitor of the lung volume change recognized that 50% reduction of TLC defect was noticed in more than 75% of cases in group A and more than 65% of cases in group B. Also 50% reduction of CT chest radiological volumetry for procedure consequence in more than 65% in group A and more than 55% of cases in group B. These findings explained the converging power of the blood in contrast to gel foam slurry paid to high fibrin content and better organization than slurry later on. Opacification of residual pleural space was identified in more than 75% in group A and 85% of group B as the distributive nature of the gel foam slurry into spaces is much more than that of the blood due to lower density and more dispersion into cavities such as study conducted on gelfoam inoculation into lung cavities [11] and also as Knowlson study [12] carried out on focal cerebral cortical lesion. However group C no substance instillation was manipulated but the disappearance of residual pleural spaces was found in 20% of cases, those cases were of small age group as well as competent fibrinolytic system that broke down the fibrous sheets with the help of little therapeutic help by Alphintern tablets and the importance of its systemic role. The procedure success rate was 66.6% in group A and 55.5% in group B on the other side Alphintern therapy succeeded in 20% of cases. Regarding instillation of fibrinolytic therapy as streptokinase was not favored in our work due to the

unconvincing success rate, also prolonged standing cases with thickened pleural peel showed little benefits of the procedure by most literatures as well the high cost of the drug in our era.

As stated by Marco F. et al, 2012 [13] that lung entrapment associated with decreased effectiveness of pleurodesis, [14] the first therapeutic option would be the insertion of a permanent pleural drain. [15] If the appropriate therapeutic measures were not taken promptly, the final result would be trapped lung. In trapped lung, most patients were asymptomatic or perhaps had small dyspnea with exertion, and they, therefore, required no treatment. The persistence of pleural effusion should not lead to repeated thoracentesis, because the fluid would accumulate rapidly with the same quantity as before in an attempt to "normalize" the more negative pleural pressure. In cases of incapacitating dyspnea, it was very important to exclude other causes before referring the patients for pleural decortication. Some authors argued that trying to achieve lung reexpansion with thoracostomy tubes should only be tried in symptomatic patients with trapped lung and who were poor candidates for surgery [16].

Through our point of view, pleuroplasty as a new remedy was much more dissimilar from pleurodesis, the former involved packing of the residual pleural space with a spongy material that hardened afterward and caused obliteration and minimization of this space mimicking synthetic filler of pleural cavity. The later; pleurodesis involved the application of soluble substance with equal surface distribution aiming for cohesion and sealing of both layers together. To our review date, no studies had been found focusing on this medical simple intervention instead of surgical role of decortication.

Concerning procedure safety, there were minimal encountered complications for both autologous blood and gel foam slurry instillation. In our study, nearly 1/5 of studied cases in autologous blood group had side effects in the form of fever in one patient and empyema in another patient while in gelfoam instilled group 11% only showed fever. This fever was of low-grade pattern and caused by pyrogenic reaction and improved spontaneously after 24 hours.

Many reports recorded fever occurrence with the use of gelfoam, without demonstrable infection. However, it might form a nidus for later infection and abscess formation [17] and potentiated bacterial growth. Foreign body reactions, ‘‘encapsulation" of fluid and hematoma had also been reported following the use of absorbable gelatin sponge in closed space [18]**.** Gelfoam had been applied locally by Nori and Pugkhem that performed intraoperative brachytherapy using gelfoam radioactive plaque implants for resected stage III non-small cell lung cancer with a positive margin [19]**.** Moreover, gelfoam was used to control bleeding from oozing surfaces in lung transplantation [20] and in bronchoscopic management of bronchopleural fistulae [21].

Many difficulties were met throughout our study, firstly limited number of cases with trapped lung without other respiratory disabilities, secondly the lack of the ultrasound machine ability to identify air containing cavities that necessitated transportation to radiology department for localization and further radiological monitoring after 2 months, finally repetition of the procedure was not feasible as once closure of this pleural space happened, it totally impeded the future access for a second session, hence the place became blocked for any later interventions.

5. Conclusion

Pleural instillation of autologous blood and gelfoam slurry offers a beneficial harmless therapy for trapped lung helping the obliteration of residual pleural space with a reduction of its volume furthermore functional improvement of TLC in and can serve as a substitute to pleural decortication in surgically unfit patients.

Abbreviations

Abbreviation	Label
2 D	Two Dimensional
CT	Computed Tomography
CVC	Central venous catheter
N	Number
PFT	Pulmonary function Test
SD	Standard deviation
SPSS	Statistical package of social science
TLC	Total lung capacity

Declarations

Ethics approval and consent to participate: our study was approved by the following ethical committees:

1- Mansoura University - Faculty of Medicine, Thoracic Medicine Department, Ethical committee number 138 on November 2016.

Faculty of Medicine: Institutional review board 138-24 on December 2016.

Consent to Participate

All cases participated in our work was informed by the study and subjected to written consent according to legalization rules in invasive procedure. This consent was approved by institutional review board of Mansoura University.

Consent for Publication

All authors approved for publishing this paper in *International Journal of Cardiovascular and Thoracic Surgery* with correspondence to Dr Ahmed Abumosslam.

Availability of Data and Material

All appendices and data is available for this study.

Conflict of Interest

All the authors do not have any possible conflicts of interest.

Funding

No funding was received from any institute through this work.

Author Contribution

Dr Ahmed Abumossalam and Dr Asem Hewidy:

Were the owner of the idea and proposal down righting of the study.

Collected the data from the out-patient clinic and evaluated the cases.

Conducted the statistical analysis and the paper manuscript writings and repeated revisions.

Performed the mini-thoracoscopic procedure with following up the cases after that till discharge.

All authors read and approved the final manuscript.

Acknowledgements

No one other than sharing team.

References

[1] Doelken P. Clinical implications of unexpandable lung due to pleural disease. Am J Med Sci 2008; 335: 21.

[2] Huggins JT, Doelken P, Sahn SA. The unexpandable lung. F1000 Med Rep 2010; 2: 77.

[3] Moore PJ, Thomas PA. The trapped lung with chronic pleural space: a cause of recurring pleural effusion. Mil Med. 1967; 132: 998–1002.

[4] Doelken P, Sahn SA. Trapped lung. Semin Respir Crit Care Med. 2001; 22: 631–6.

[5] Feller-Kopman D, Walkey A, Berkowitz D, Ernst A. The relationship of pleural pressure to symptom development during therapeutic thoracentesis. Chest. 2006; 129: 1556–60.

[6] Heidecker J, Huggins JT, Sahn SA, Doelken P. Pathophysiology following ultrasound-guided thoracentesis. Chest. 2006; 130: 1173–84.

[7] Light RW, Rogers JT, Moyers JP, Lee YC, Rodriguez RM, Alford Jr WC, et al. Prevalence and clinical course of pleural effusion at 30 days after coronary artery and cardiac surgery. Am J Respir Crit Care Med. 2002; 166: 1567–71.

[8] Lee YCG, Vaz MAC, Ely KA, McDonald EC, Thompson PJ, Nesbitt JC, et al. Symptomatic persistent post-coronary artery bypass graft pleural effusions requiring operative treatment: clinical and histologic features. Chest. 2001; 119: 795–801.

[9] Huggins JT, Sahn SA, Heidecker J, Ravenel JG, Doelken P. Characteristics of trapped lung: pleural fluid analysis, manometry, and air-contrasted CT. Chest. 2007; 131: 206–13.

[10] Goodman LS, Gilman A: Surface-acting drugs, in The Pharmacologic Basis of Therapeutics, ed 6. New York, MacMillan Publishing Co. 1980, p 955.

[11] Ahmed M. Abumossalam, Asem A. Hewidy, Ahmed M. Abd El-khalek (2016): Iatrogenic pneumodesis: Gelfoam flux inoculation in focal benign cavitary lung lesion. Egyptian Journal of Chest Diseases and Tuberculosis (2016) 65, 711–716.

[12] G. T. G. Knowlson, Gelfoam granuloma in the brain, J. Neuro. Neurosurg. Psychiatry 37 (1974) 971–973.

[13] Marco F. Pereyra, Lucía Ferreiro, Luis Valdés_(2012): Unexpandable Lung. Arch Bronconeumol. 2013; 49 (2): 63–69.

[14] Lan RS, Lo SK, Chuang ML, Yang CT, Tsao TC, Lee CH, et al. Elastance of the pleural space: a predictor for the outcome of pleurodesis in patients with malignant pleural effusion. Ann Intern Med. 1997; 126: 768–74.

[15] Cases E, Seijo L, Disdier C, Lorenzo MJ, Cordovilla R, Sanchis F, et al. Use of indwelling pleural catheter in the outpatient management of recurrent malignant pleural effusion. Arch Bronconeumol. 2009; 45: 591–6.

[16] Huggins JT, Sahn SA Drug induced pleural disease. Clin. Chest Med. 2004; 25: 141–153.

[17] P. A. Lindstrom, Complications from the use of absorbable hemostatic sponges, AMA Arch. Surg. 73 (1956) 133–141.

[18] J. H. Herndon, H. C. Grillo, E. J. Riseborough, et al, Compression of the brain and spinal cord following use of GELFOAM, Arch. Surg. 104 (1972) 107.

[19] D. Nori, X. Li, T. J. Pugkhem, Intraoperative brachytherapy using gelfoam radioactive plaque implants for resected stage III non-small cell lung cancer with positive margin: a pilot study, Surg. Oncol. J. 60 (4) (1995) 257–261.

[20] Sudish C. Murthy, M. Blair Marshal, Thorac. Surg. Clin. Lung Transpl. 25 (1) (2015) 87–88.

[21] M. Lois, M. Noppen, Bronchopleural fistulas: an overview of the problem with special focus on endoscopic management, Chest 128 (2005) 3955–3965.