Yonago Acta Medica 2022;65(4):320–324 doi: 10.33160/yam.2022.11.006 

# Video-Assisted Thoracoscopic Surgery Using Extracorporeal Membrane Oxygenation for Intractable Pneumothorax

**Ken Miwa,* Atsuyuki Nakanishi,* Tatsuya Miyamoto,† Takashi Ohno,† Yoshiteru Kidokoro,‡ Tomohiro Haruki† and Hiroshige Nakamura†**

**Department of Respiratory Surgery, Matsue Red Cross Hospital, Matsue 690-8506, Japan and †Division of General Thoracic Surgery, Tottori University Hospital, Yonago 683-8503, Japan and ‡Division of General Thoracic Surgery, Tottori Prefectural Central Hospital, Tottori 680-0901, Japan*

## ABSTRACT

Intractable pneumothorax with poor lung function that has received multiple conservative treatments may occur. Case 1 was a 70-year-old woman with aspergilloma who was admitted for pneumothorax. Case 2 was a 68-year-old man with acute exacerbation of interstitial pneumonia who developed pneumothorax. In both cases, multiple conservative therapies were administered, but the leak continued; thus, operations using veno-venous extracorporeal membrane oxygenation (ECMO) were planned. By video-assisted thoracoscopic surgery (VATS), we obtained the optimal surgical field by lung collapse. We removed many blood clots that were used for pleurodesis, ligated the bulla in case 1, and covered the leak point with strengthening agents in case 2. For cases of intractable pneumothorax, lung collapse by ECMO is advantageous because we can check details and leak points even in blood clots or in poor condition of the lung, and we can maneuver the lung in poor condition with a clear surgical field.

**Key words** pneumothorax; extracorporeal membrane oxygenation; video-assisted thoracoscopic surgery

Intractable pneumothorax with poor lung function that has received multiple conservative treatments may occur. If we consider surgery, managing respiration by bilateral ventilation or selective ventilation using an endobronchial blocker may make it difficult to check the leak point quickly, as visualization is poor. Moreover, blood clots that have been used for pleurodesis, adhesion by pleurodesis and the condition of the lung complicated by interstitial pneumonia or emphysema may make it difficult to check details; most importantly, it may be difficult to maneuver the lung in poor condition without lung collapse. We herein describe cases of intractable pneumothorax that were treated successfully by surgery using ECMO.

Corresponding author: Ken Miwa, MD, PhD
kenmiwa20@gmail.com
Received 2022 July 20
Accepted 2022 October 17
Online published 2022 November 28
Abbreviations: COPD, chronic obstructive pulmonary disease; ECMO, extracorporeal membrane oxygenation; NTM, non-tuberculosis mycobacteria; VA, veno-arterial; VATS, video-assisted thoracoscopic surgery; VV, veno-venous

## PATIENT REPORT

Case 1 was a 70-year-old woman with chronic obstructive pulmonary disease, aspergilloma, and nontuberculosis mycobacteria (NTM). She was admitted to our hospital with dyspnea. Her blood gas analysis was pH 7.32, arterial partial pressure of carbon dioxide was 43.9 mmHg, and oxygen was 43.3 mmHg with a 15 L reservoir mask. Chest tube drainage was performed for her right pneumothorax (Fig. 1a). Chest CT after chest tube drainage showed emphysema and shadows of aspergilloma and NTM in the left lung (Fig. 2). Multiple conservative therapies (infusion of self-blood and infusion of OK432 from the chest tube) were administered twice for the pneumothorax; however, the leak did not stop, and the lung expansion was not complete (Fig. 1b). Considering the risk of single-lung ventilation due to her poor respiratory function, especially caused by COPD, aspergilloma and NTM, an operation using extracorporeal membrane oxygenation (ECMO) was planned.

As her circulation status was stable, veno-venous (V-V) ECMO was selected. Under general anesthesia, a double-lumen endotracheal tube was placed. She was heparinized (45 U/kg), and a drainer cannula (22 Fr, SENKO MEDICAL INSRUMENT Mfg. Co., Ltd. Tokyo, Japan) was inserted from the right femoral vein, and an infuser cannula (15 Fr, TERUMO, Tokyo, Japan) was inserted from the right internal jugular vein. ECMO was commenced at a blood flow of 3 L/min and an oxygen flow of 2 L/min. In the operation with one lung ventilation, we selected 3 port VATS. Many blood clots that were used for pleurodesis were removed. The surgical field was good due to lung collapse, and a major leak was seen from the bulla near the adhesion (Fig. 3a); thus, we cauterized the bulla and ligated it with monofilament yarn (Fig. 3b), and the leak stopped. She was decannulated from ECMO and extubated in the operating room after an operation time of 52 minutes.

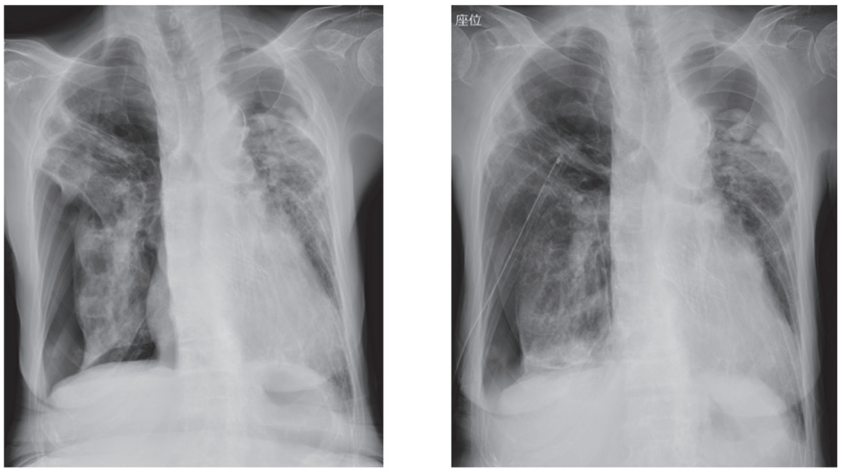



**Fig. 1.** Chest radiograph on admission revealed a right pneumothorax (**a**). The lung expansion was not complete after multiple conservative therapies (**b**).

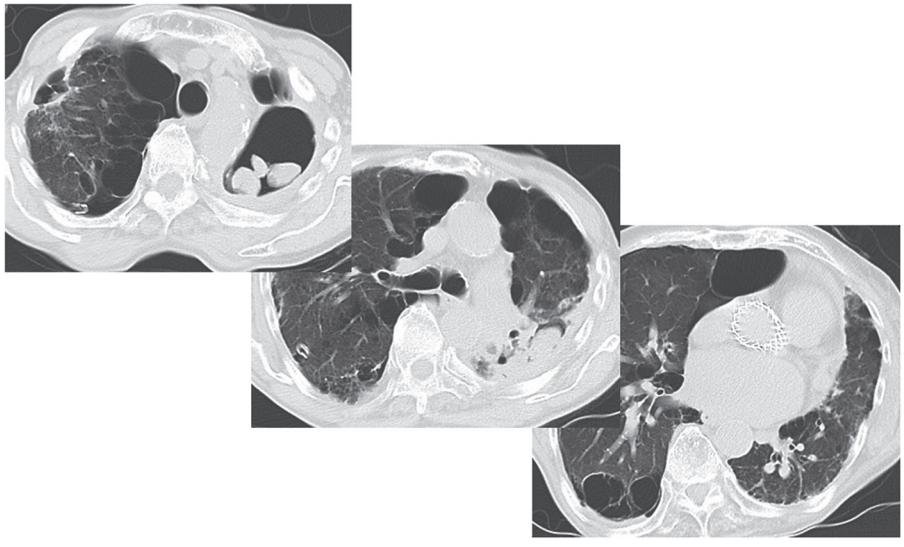


**Fig. 2.** Chest CT after chest drainage showed bullous change and shadow of aspergilloma and NTM in the left lung.

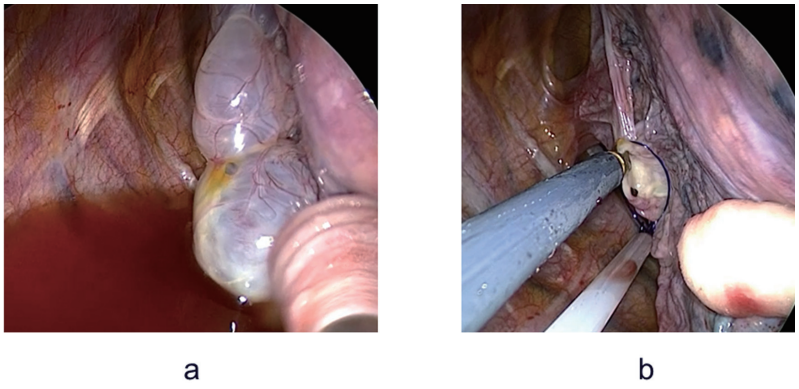



**Fig. 3.** Intraoperative findings. A major leak was seen from the bulla near the adhesion (**a**). The bulla was cauterized and ligated with monofilament yarn (**b**).

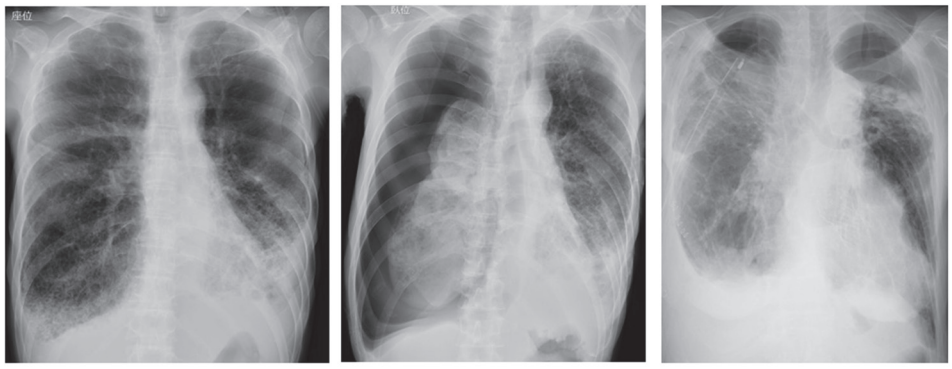



**Fig. 4.** A chest radiograph on admission revealed bilateral interstitial shadow (**a**). A chest radiograph of right pneumothorax that developed the day after admission (**b**). A chest radiograph after conservative therapies **(c)**. The right lung expanded but the leak did not stop.

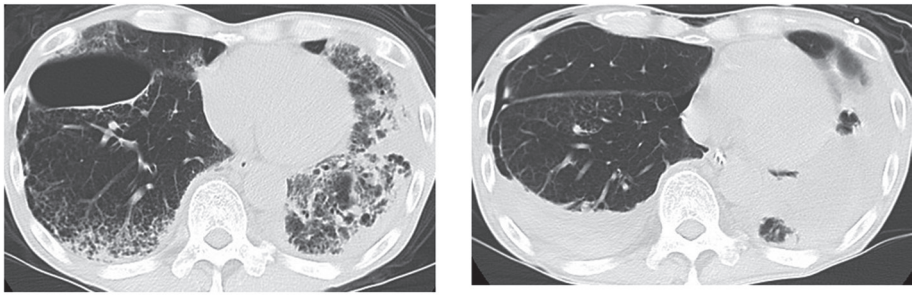
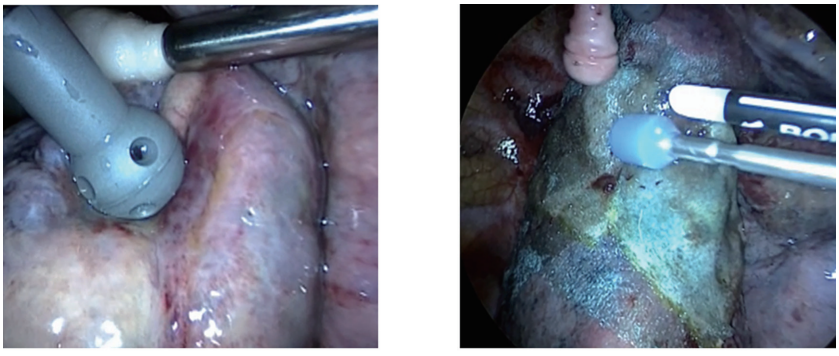



**Fig. 5.** Chest CT on admission showed shadow of interstitial pneumonia (**a**). Chest CT after conservative therapies (**b**). The shadow of interstitial pneumonia was improved, and the right lung expanded. This CT revealed blood clots that were used for pleurodesis in right thoracic cavity, the atelectasis in left lower lobe.

The blood loss was 5 grams, and the circulation time of ECMO was 105 minutes. Her postoperative recovery was uneventful. The chest drain was removed on the 3rd postoperative day, and she was discharged home on the 6th postoperative day without supplemental oxygen.

Case 2 was a 68-year-old man admitted for acute exacerbation of interstitial pneumonia (Figs. 4a and 5a). His blood gas analysis was pH 7.45, arterial partial pressure of carbon dioxide was 38.1 mmHg, and oxygen was 47.3 mmHg with a 3 L oxygen mask. Chest tube drainage was performed for right pneumothorax that developed the day after admission (Fig. 4b). He was intubated and had been managed by ventilation for four days. Steroid pulse therapy was started. Multiple conservative therapies were performed [infusion of self-blood (five times), infusion of 50% glucose from chest tube (two times)] for the pneumothorax; however, the leak did not stop despite expansion of the lung (Figs. 4c and 5b).

Considering the risk of single-lung ventilation due to his poor respiratory function, especially caused by acute exacerbation of interstitial pneumonia, an operation using ECMO was performed using the same procedure as Case 1. V-V ECMO was selected. Under general anesthesia, a double-lumen endotracheal tube was placed. He was heparinized (45 U/kg), and a drainer cannula (22 Fr, SENKO MEDICAL INSRUMENT Mfg. Co., Ltd. Tokyo, Japan) was inserted from the right femoral vein, and an infuser cannula (15 F, SENKO MEDICAL INSRUMENT Mfg. Co., Ltd. Tokyo, Japan) was inserted from the right internal jugular vein. ECMO was commenced at a blood flow of 2.5 L/min and an oxygen flow of 1.5 L/min. In the operation with one lung ventilation, we selected 3 port VATS. Many blood



a b

**Fig. 6.** Intraoperative findings. A major leak was seen from part of the right lower lobe (**a**). The pleura including the lesion was covered with strengthening agents (**b**).

clots that were used for pleurodesis were removed. The surgical field was good due to lung collapse, and a major leak was seen from part of the right lower lobe (Fig. 6a). As the lung was torn by suturing or ligation, the pleura that included the lesion was covered with strengthening agents (Fig. 6b), and the leak stopped. He was decannulated from ECMO and extubated in the operating room after an operation time of 95 minutes. Blood loss was 5 grams, and the circulation time of ECMO was 155 minutes. His postoperative recovery was uneventful. The chest drain was removed on the 4th postoperative day, and he was transferred for rehabilitation on the 57th postoperative day without supplemental oxygen.

## DISCUSSION

The present high-risk cases, which had intractable leaks despite conservative therapies, were treated successfully by surgery using ECMO. The use of ECMO for the treatment of residual lung after pneumonectomy,[1–4] bilateral pneumothorax,[5, 6] bilateral giant bullae,[7, 8] and pneumothorax with poor respiratory function[9] has been reported though it is an expensive procedure.[10] In cases of intractable pneumothorax, previous studies also performed multiple conservative therapies.[1, 9] Kameda et al.[1] administered pleurodesis (infusion of self-blood, OK432, or minocycline) six times, and Okada et al.[9] administered pleurodesis (infusion of self-blood or glucose) four times and endobronchial occlusions twice.

ECMO can achieve gas exchange despite the collapsed lung and provide a clear surgical field. Especially for cases of intractable pneumothorax, ECMO is advantageous because blood clots that were used for pleurodesis, adhesion by pleurodesis and the condition of the lung complicated by interstitial pneumonia or emphysema may make it difficult to check details; most importantly, it may be difficult to maneuver a lung in poor condition without lung collapse. We did not select VATS with local anesthesia[11] because we couldn't get enough space to maneuver a lung and check details in thoracic cavity by lung expansion. As Gillon mentioned,[3] an intermittent apneic approach, with complete cessation of ventilation for short periods, is limited by the need for gas exchange, and bronchial blockade risks excessive alveolar pressure; both approaches do not allow for an optimal field.

To treat intractable pneumothorax, bronchial embolization using an Endobronchial Watanabe Spigot,[12, 13] thoracographic fibrin glue sealing,[14, 15] and endoscopic infusion of fibrin glue,[16, 17] may also be used. But it is not easy to treat intractable pneumothorax by single treatment[13, 18, 19] and as a result, a combination of these treatments has been selected.[18–20] Thus, we decided to use ECMO for the operations as the most reliable way.

When ECMO is used for a long time, inflammatory thrombus formation or bleeding tendency[3] may occur. As we obtained good surgical fields with lung collapse, we could perform the operation quickly and could wean the patient from ECMO.

In conclusion, for cases of intractable pneumothorax with poor lung function, surgery supported by ECMO may be a reliable method.

*The authors declare no conflict of interest.*

## REFERENCES

1 Kameda Y, Morohoshi T, Koga H, Mishina Y, Ando K, Masuda M. A case of left pneumothorax after right pneumonectomy performed operation using extracorporeal membrane oxygenation (ECMO). Nihon Rinsho Geka Gakkai Zasshi (Journal of Japan Surgical Association). 2019;80:1449-53. DOI: 10.3919/jjsa.80.1449 Japanese with English abstract.

2 Lei J, Su K, Li XF, Zhou YA, Han Y, Huang LJ, et al. Ecmo-assisted carinal resection and reconstruction after left pneumonectomy. J Cardiothorac Surg. 2010;5:89-91. DOI: 10.1186/1749-8090-5-89, PMID: 20961431
3 .Gillon SA, Toufektzian L, Harrison-Phipps K, Puchakayala M, Daly K, Ioannou N. Perioperative extracorporeal membrane oxygenation to facilitate lung resection after contralateral pneumonectomy. Ann Thorac Surg. 2016;101:e71-3. DOI: 10.1016/j.athoracsur.2015.08.045, PMID: 26897234
4 .Heward E, Hayes T, Evison M, Booton R, Barnard J, Shah R. Extracorporeal membrane oxygenation assisted segmentectomy for metachronous lung cancer after pneumonectomy. Ann Thorac Surg. 2016;102:e187-9. DOI: 10.1016/j.athoracsur.2016.01.066, PMID: 27549537
5 Yanada M, Toda S. Venovenous extracorporeal membrane oxygenation support for treatment of bilateral spontaneous pneumothorax. Interact Cardiovasc Thorac Surg. 2008;7:1178-9. DOI: 10.1510/icvts.2008.183806, PMID: 18757451
6 Hashimoto M, Suzumura Y, Teramoto K. A successful case of an operation performed to close a pulmonary fistulae under PCPS support for simultaneous bilateral pneumothorax. Nihon Rinsho Geka Gakkai Zasshi (Journal of Japan Surgical Association). 2011;72:1988-92. DOI: 10.3919/jjsa.72.1988 Japanese with English abstract.
7 Araki O, Karube Y, Tamura M, Kobayashi S, Chida M, Miyoshi S. Surgery for nearly inoperable bilateral giant bullae in a patient with severe pulmonary dysfunction. The Journal of the Japanese Association for Chest Surgery. 2016;30:223-8. DOI: 10.2995/jacsurg.30.223 Japanese with English abstract.
8 Li T, Zhang W, Zhan Q, He H, Li H, Hou S. Application of extracorporeal membrane oxygenation in giant bullae resection. Ann Thorac Surg. 2015;99:e73-5. DOI: 10.1016/j.athoracsur.2014.11.036, PMID: 25742863
9 Okada M, Okada K, Kubo Y, Nakamura R, Fujiwara T, Matsuura M. Surgical treatment of intractable secondary pneumothorax under ECMO support in a patient with interstitial pneumonia. Nihon Rinsho Geka Gakkai Zasshi (Journal of Japan Surgical Association). 2019;80:1454-9. DOI: 10.3919/jjsa.80.1454 Japanese with English abstract.
10 Mishra V, Svennevig JL, Bugge JF, Andresen S, Mathisen A, Karlsen H, et al. Cost of extracorporeal membrane oxygenation: evidence from the Rikshospitalet University Hospital, Oslo, Norway. Eur J Cardiothorac Surg. 2010;37:339-42. DOI: 10.1016/j.ejcts.2009.06.059, PMID: 19699650
11 Watanabe T, Koizumi T, Koike T, Hirono T. The results of thoracoscopic surgery for intractable pneumothorax under local anesthesia. The Journal of the Japanese Associtation for Chest Surgery. 2007;21:118-22. DOI: 10.2995/jacsurg.21.118 Japanese with English abstract.
12 .Watanabe Y, Matsuo K Tamaoki A, Hiraki S, Moriyama S, Horiuchi T. Bronchial embolization using an Endobronchial Watanabe Spigot for intractable pneumothorax and bronchial fistula. J Jpn Soc Resp Endoscopy. 2001;23:510-5. DOI: 10.18907/jjsre.23.6_510 Japanese with English abstract.
13 Watanabe Y, Bessho A, Horiuchi T, Sakugawa M, Hosokawa S, Morichika D, et al. Bronchial occlusion with EWS for pulmonary diseases. J Jpn Soc Resp Endoscopy. 2013;35:552-5. DOI: 10.18907/jjsre.35.5_552 Japanese.
14 Kinoshita T, Miyoshi S, Katoh M, Yoshimasu T, Juri M, Maebeya S, et al. Intrapleural administration of a large amount of diluted fibrin glue for intractable pneumothorax. Chest. 2000;117:790-5. DOI: 10.1378/chest.117.3.790, PMID: 10713008
15 Kurihara M, Kataoka H, Ishikawa A, Endo R. Latest treatments for spontaneous pneumothorax. Gen Thorac Cardiovasc Surg. 2010;58:113-9. DOI: 10.1007/s11748-009-0539-5, PMID: 20349299
16 Muramatsu T, Ohata M, Iida M, Ohmori K, Irako M, Kitamura K, et al. Treatment of spontaneous pneumothorax by bronchofiberscopic bronchial obstruction. J Jpn Soc Resp Endoscopy. 1989;11:357-63. DOI: 10.18907/jjsre.11.4_357 Japanese with English abstract.
17 Iwasaki Y, Arimoto T, Mizobuchi K, Nakagaki Y, Hashikura H, Goto T, et al. Bronchial embolization of fibrin glue in three cases of pneumothorax. J Jpn Soc Resp Endoscopy. 1994;16:179-85. DOI: 10.18907/jjsre.16.2_179 Japanese with English abstract.
18 Hashimoto M, Ishida K, Kaku R, Ohshio Y, Ohuchi M, Kitamura S, et al. A case of intractable pneumothorax complicating malignant pleural effusion treated by endoscopic bronchial occlusion (EBO) with an Endobronchial Watanabe Spigot (EWS) and fibrin glue. J Jpn Soc Resp Endoscopy. 2013;35:81-5. DOI: 10.18907/jjsre.35.1_81 Japanese with English abstract.
19 Nomura N, Nomizo T, Emura M, Nakamura T, Kobayashi Y, Igarashi S, et al. Intractable pneumothorax completely treated with EWS filling, with thoracographic fibrin glue sealing and autologous pleurodesis. J Jpn Soc Resp Endoscopy. 2019;41:278-83. DOI: 10.18907/jjsre.41.3_278 Japanese with English abstract.
20 Ito T, Usami N, Ito K, Mizuno H, Horio M, Saito Y. Fibrin glue sealing and PGA sheet application for intractable pneumothorax with thoracoscopy under local anesthesia. J Jpn Soc Resp Endoscopy. 2016;38:201-4. DOI: 10.18907/jjsre.38.3_201 Japanese with English abstract.