Ann Thorac Cardiovasc Surg 2022; 28: 154–158
Online January 29, 2020
doi: 10.5761/atcs.cr.19-00235

Case Report

The Association of Vacuum-Assisted Closure Therapy with Dynamic Volume Change of a Muscle Flap Transposed in an Empyema Cavity for Chronic Empyema: A Case Report

Kensuke Kojima, MD, PhD, Tetsuki Sakamoto, MD, Teiko Sakurai, MD, Yuriko Yagi, MD, Tomoki Utsumi, MD, PhD, and Hyungeun Yoon, MD, PhD

A 62-year-old woman with a history of lung resection for lung cancer was admitted to our hospital due to cough, which became progressively more severe. She was diagnosed with chronic empyema with bronchopleural fistula (BPF) of the right upper bronchial stump. Although a pedicled muscle flap was transposed to the empyema cavity, the fistula remained. We used a vacuum-assisted closure system after open-window thoracotomy and observed the cavity reduction with expansion of the transposed muscle flap. We quantitatively evaluated the dynamics of the cavity change using a three-dimensional image analysis system. A reduction of the volume of the muscle flap by prolonged empyema and expansion of the muscle flap was observed immediately after vacuum-assisted management. However, expansion of the right residual lung was not recognized. Pedicled muscle flap transposition followed by vacuum-assisted management after open-window thoracotomy may be effective for treating chronic empyema caused by BPF.

Keywords: bronchopleural fistula, chronic empyema, pedicled muscle flap transposition, vacuum-assisted closure, dynamics of empyema cavity change

Introduction

Bronchopleural fistula (BPF) is defined as abnormal communication between a bronchus and the pleural space[1] and represents one of the most severe complications after lung resection surgery.[2] Because treatment of chronic empyema due to BPF is known to be difficult, the management of the disorder continues to represent a significant challenge for thoracic surgeons. Recently, the usefulness of a vacuum-assisted closure (VAC) system (KCI International, San Antonio, TX, USA) in the treatment of empyema has been reported.[3] However, few studies have described the detailed process of the change in the empyema cavity after VAC therapy. We report a case of chronic empyema with BPF after lung cancer resection that was treated by VAC therapy after pedicled muscle flap transposition. We show—based on the quantitative evaluation of the cavity change before and after VAC therapy—that muscle flap expansion was the factor that contributed most to the reduction of the empyema cavity.

Case Report

The patient was a 62-year-old woman with a history of metachronous triple lung cancer. She had undergone right middle lobectomy for pulmonary carcinoma

Department of General Thoracic Surgery, National Hospital Organization Kinki-Chuo Chest Medical Center, Sakai, Osaka, Japan

Received: August 26, 2019; Accepted: November 23, 2019
Corresponding author: Kensuke Kojima, MD, PhD. Department of General Thoracic Surgery, National Hospital Organization Kinki-Chuo Chest Medical Center, 1180 Nagasone-cho, Kita-ku, Sakai, Osaka 591-8555, Japan
Email: k7kensuke@icloud.com

(adenocarcinoma; pathological-T2aN0M0, stage IB). However, a right lower lobe lesion was detected as secondary lung cancer (adenocarcinoma; pathological-T1aN0M0, stage IA1) at the boundary between S6 and S10 on the 60 months after the first lobectomy. She had received right extended S6 segmentectomy. In addition, she had received a right upper lobectomy at 32 months after the second lung resection, due to a third lung cancer (adenocarcinoma; pathological-T2aN0M0, stage IB) in S3. She was admitted to our hospital due to the progression of severe cough with fever at 30 months after the last lung resection. Although fever was relieved by the administration of antibiotics, cough continued. Computed tomography (CT) of the chest revealed a dead space containing pleural effusion in the right thorax (**Figs. 1A** and **B**). We could confirm a fistula of approximately 2 mm in diameter between the right upper bronchial stump and the pleural cavity (**Fig. 1A**). Based on her clinical symptoms and these imaging findings, we diagnosed the patient with chronic empyema with right upper bronchial stump fistula after lobectomy. We decided to cover the fistula and fill the pleural cavity using a pedicled muscle flap. Prior to surgery, we observed the right upper bronchial stump with a bronchoscope; however, no fistula was confirmed. The patient was placed in the supine position. At first, a pedicled pectoralis major muscle flap and intercostal muscle flap were prepared. In the preparation of the pedicled intercostal muscle flap, the second rib was resected. Purulent pleural effusion was observed in the thoracic cavity and a diagnosis of empyema was confirmed. The cavity was cleaned to remove debris and necrotic tissue by drainage and debridement. Thoracoscopic observation revealed no fistula at the anterior mediastinum, where the right upper bronchial stump was considered to be located. The interior of the empyema cavity was filled with saline and a leak test was carried out with positive pressure ventilation of –30 cmH_2O. However, no air bubbles escaped from the mediastinum. The tip of the pedicled muscle flap was sutured and fixed to the anterior mediastinum and the rest was transposed in the empyema cavity. A drainage tube was inserted into the cavity and the wound was closed. Chest CT showed a reduction of the cavity, but the communication between the right bronchial stump and the dead space remained (**Fig. 1C**). Although she was discharged with a drainage tube, the discharge of purulent fluid from the tube continued. We performed open window thoracostomy and VAC therapy at 1 year and 10 months postoperatively. An incision was made along the previous surgical wound in the most dependent portion of the empyema cavity, and open window thoracostomy was performed. A VAC sponge (Black GranuForm Standard Dressing, KCI Medical) was trimmed and inserted into the empyema cavity. Film was directly attached to the surface of the inserted GranuForm. A hole was cut in the adhesive site and foam pads with suction tubing were placed. A portable pump was connected to the tubing. The dressing and tubing were changed every 48 hours. VAC therapy was performed for 4 weeks, which was the insurance application period. The suction pressure was set to −25 mmHg for the first week, to −50 mmHg for the second week, and −75 mmHg for the last 2 weeks. The second VAC therapy was performed 8 weeks after insurance reapplication from the completion of the first VAC treatment. The second VAC therapy was also conducted at negative pressure of −75 mmHg for 4 weeks, and the sponges were changed every 48 hours. The chest CT after the first VAC treatment indicated the reduction of the empyema cavity with extension of the transposed muscle flap in comparison to immediately after the transposition of the flap (**Fig. 1D**). This tendency was more pronounced after the second VAC treatment (**Fig. 1E**). We observed the cavity by bronchoscope from the open wound. When the patient coughed, we confirmed the site at which sputum emerged in the anterior mediastinum and concluded that this site was a small fistula of the right bronchial stump. We measured the volume of the transposed muscle flap immediately after transposition, as well as before and after VAC therapy using a three-dimensional (3D) image analysis system (SYNAPSE VINCENT; FUJIFILM Corporation, Tokyo). The areas of the muscle flap were manually measured from each chest CT scan, and the volumes were obtained by integrating the areas (**Figs. 1F–1G**). The volume of the residual right lower lobe was automatically measured by VINCENT. Although a reduction of the muscle flap volume with prolonged empyema and the expansion of the muscle flap immediately after VAC therapy were observed, the expansion of the right residual lung was not recognized (**Table 1**, **Fig. 2**). The open wound has not been closed completely. However, infection control was possible by gauze exchange, which the patient was able to perform herself. The patient was discharged without any complications after VAC therapy. No recurrence of infection was observed.

Discussion and Conclusion

In this case, we performed pedicled muscle flap transposition followed by VAC therapy to treat chronic

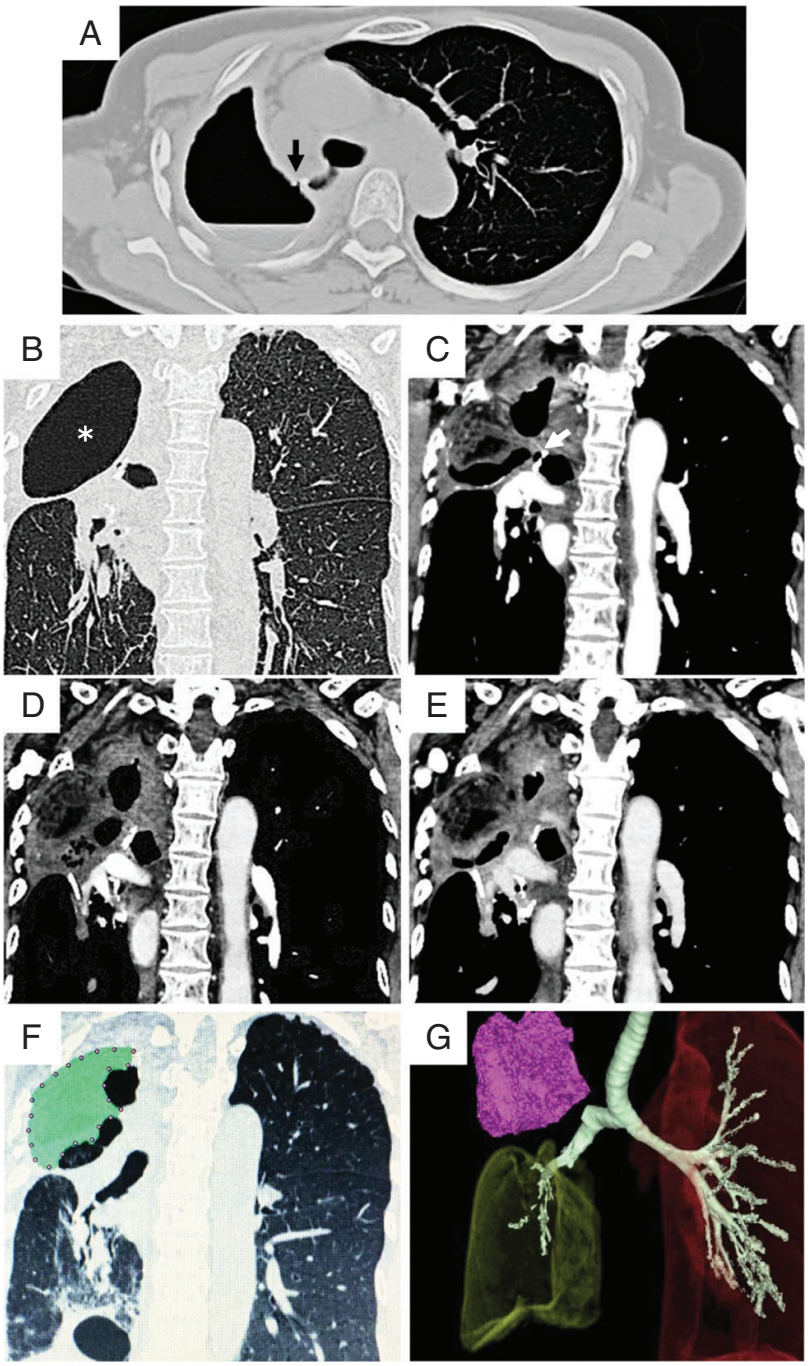

Fig. 1 (**A**) Chest CT (axial section). A fistula of approximately 2 mm in diameter was observed between the right upper bronchial stump and the pleural cavity (black-arrow). (**B**) Chest CT (coronal section). A dead space (asterisk) was confirmed. (**C**) Chest CT after muscle flap transposition showed a reduction of the cavity, but the communication between the right bronchial stump and the dead space remained (white arrow). (**D**) Chest CT after the first VAC treatment indicated the reduction of the empyema cavity with extension of the transposed muscle flap. (**E**) The tendency of cavity reduction was more pronounced after the second VAC treatment. (**F** and **G**) The areas of the muscle flap were manually measured from each captured CT images and the volumes were obtained by integrating the areas of the muscle flaps. CT: computed tomography; VAC: vacuum-assisted closure

Table 1 Change of transposed muscle flap volume and residual right lower lobe volume occupancy from baseline

Event	Muscle flap transposition	Observation	First VAC therapy	Second VAC therapy	Observation	
Clinical time course (month)	0	21	23	25	27	30
Muscle flap volume (mL)	98.7	73.8	100.7	127.5	110.4	94.9
Change rate of muscle flap volume (%)		−25.2	2.0	29.2	11.8	−3.8
RLL volume occupancy (%)	27.7	22.3	21.1	20.7	21.1	19.4
Change rate of RLL volume occupancy (%)		−19.5	−23.8	−25.2	−23.8	−29.9

We set the muscle flap volume and residual right lower lobe volume occupancy at muscle flap transposition as the baseline. We calculated the change rate of these variables at each event. RLL: residual right lower lobe; VAC: vacuum-assisted closure

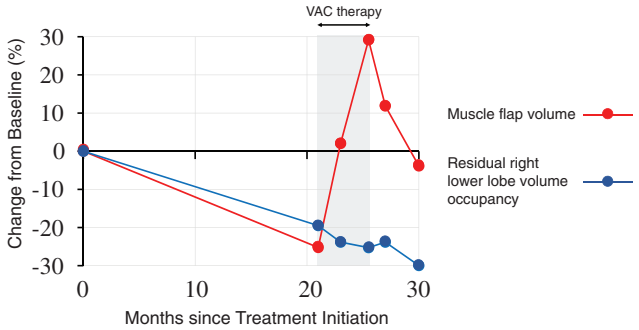

Fig. 2 A graph showing the process of the change in the muscle flap volume and the residual right lower lobe volume occupancy from baseline before and after the performance of VAC therapy. VAC: vacuum-assisted closure

empyema caused by BPF after lung resection. We quantitatively evaluated the change in the volume of the transposed muscle flap and residual right lower lobe before and after VAC therapy using a 3D image analysis system. The results showed that the volume of the muscle flap was extended in a step-wise manner after VAC therapy but that the volume tended to decrease after the end of the therapy. On the other hand, the volume of the residual right lower lobe was not extended after VAC therapy.

A previous report demonstrated the effectiveness of VAC therapy in the treatment of empyema complicated by BPF.[4] Another report noted that the negative pressure therapy (−125 mmHg) was suitable for the reduction of the infected pleural space.[5] A report investigating the impact of on the fistula diameter described that a BPF with a 1-mm fistula was closed after VAC therapy but that an 8-mm fistula could not be closed.[6] Another report noted that lung expansion was the factor that contributed most of the reduction of the empyema cavity.[7]

Our case showed that muscle flap transposition followed by VAC therapy at a low negative pressure (−25 mmHg to −75 mmHg) could reduce the empyema cavity. We also showed that the expansion of the transposed muscle flap by VAC therapy contributed to the reduction of the empyema cavity but that residual right lung expansion was not observed.

Our report suggests that muscle flap transposition followed by VAC therapy may be effective for the reduction of the remaining space involved in chronic empyema complicated by BPF. Two factors are known to be important for the reduction of the empyema cavity by VAC therapy[8]: re-expansion of the residual pulmonary parenchyma; and the acceleration of tissue granulation. In our case, re-expansion of the remaining lung was not found due to thickened visceral pleural peel with chest wall adhesion. Thus, initiation of VAC therapy immediately after the onset of empyema is considered important for reduction of the empyema cavity with the expectation of lung expansion. The factor that contributed most to reduction of the empyema cavity in our case was the accelerated granulation of the transposed muscle flap. The negative pressure environment in VAC therapy induces mechanical stress at the transposed muscle flap resulting in tissue deformation. It is known that tissue deformation is important for stimulating tissue remodeling mediated at the cellular level.[9] *In vitro* experiments showed that mechanical stress increased human fibroblast migration and growth.[10] Tissue remodeling associated with the migration and growth of fibroblasts due to mechanical stress may have resulted in granulation around the transposed muscle flap, leading to the expansion of the muscle flap. Because the fistula was not completely closed, the shrinkage of transposed muscle flap was observed after the end of VAC therapy. Since reductions in the mediators of inflammation have been demonstrated in experimental models and humans treated with VAC therapy,[11,12] the re-accumulation of inflammatory

substances after the completion of VAC therapy may be induced by lysis of the transposed tissue. Therefore, long-term VAC therapy may be important for empyema cavity reduction dependent on transposed muscle flap expansion leading to close BPF. However, since the coverage period of VAC therapy is limited to 4 weeks, continuous use for a long term is difficult at present. Further extension of the use period of the VAC system is desired.

We showed the effectiveness of pedicled muscle flap transposition followed by VAC therapy for chronic empyema caused by BPF. To the best of our knowledge, this is the first report to quantitatively evaluate the volume change of a transposed muscle flap in patient receiving VAC therapy. Further cases should be accumulated to clarify the effect of this treatment.

Disclosure Statement

The authors declare no conflicts of interest in association with the present study.

References

1) Alpert JB, Godoy MC, Degroot PM, et al. Imaging the post-thoracotomy patient: anatomic changes and postoperative complications. Radiol Clin North Am 2014; **52**: 85–103.
2) Uçvet A, Gursoy S, Sirzai S, et al. Bronchial closure methods and risks for bronchopleural fistula in pulmonary resections: how a surgeon may choose the optimum method? Interact Cardiovasc Thorac Surg 2011; **12**:558–62.
3) Varker KA, Ng T. Management of empyema cavity with the vacuum-assisted closure device. Ann Thorac Surg 2006; **81**: 723–5.
4) Otsuka T, Nakamura Y, Takeda A, et al. Clinical impact of EWS with/without NPWT on management of patients with fenestrated empyema-An early experience. J Japanese Assoc Chest Surg 2018; **32**: 668–73. (in Japanese)
5) Aru GM, Jew NB, Tribble CG, et al. Intrathoracic vacuum-assisted management of persistent and infected pleural spaces. Ann Thorac Surg 2010; **90**: 266–70.
6) Sziklavari Z, Grosser C, Neu R, et al. Complex pleural empyema can be safely treated with vacuum-assisted closure. J Cardiothorac Surg 2011; **6**: 130.
7) Yamaoka M, Kikuchi S, Yanagihara T, et al. EWS and vacuum-assisted closure (VAC) therapy for the early closure of open-window thoracostomy in the treatment of pleural empyema with a fistula. J Japanese Assoc Chest Surg 2018; **32**: 46–51. (in Japanese)
8) Palmen M, van Breugel HN, Geskes GG, et al. Open window thoracostomy treatment of empyema is accelerated by vacuum-assisted closure. Ann Thorac Surg 2009; **88**: 1131–6.
9) Urschel JD, Scott PG, Williams HT. The effect of mechanical stress on soft and hard tissue repair; a review. Br J Plast Surg 1988; **41**: 182–6.
10) Nishimura K, Blume P, Ohgi S, et al. Effect of different frequencies of tensile strain on human dermal fibroblast proliferation and survival. Wound Repair Regen 2007; **15**: 646–56.
11) Norbury K, Kieswetter K. Vacuum-assisted closure therapy attenuates the inflammatory response in a porcine acute wound healing model. Wounds 2007; **19**: 97–106.
12) Greene AK, Puder M, Roy R, et al. Microdeformational wound therapy: effects on angiogenesis and matrix metalloproteinases in chronic wounds of 3 debilitated patients. Ann Plast Surg 2006; **56**: 418–22.