



High-pressure continuous suction drainage for thoracic empyema with pulmonary fistula

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Background: The treatment of thoracic empyema with pulmonary fistula (PF) is challenging and involves administration of antibiotics and efficient drainage of pus. Open window thoracostomy (OWT) is typically offered for these cases, but it has several disadvantages, notably postoperative pain that is associated with rib resection. We described six consecutive cases of thoracic empyema with PF that were successfully treated with high-pressure continuous suction drainage (HCSD) instead of conventional OWT.

Methods: Between January 2015 and December 2018, six consecutive patients (mean age of 65.0 years) with thoracic empyema and PF underwent HCSD treatment. Suction was initially set at -20 cmH₂O and was increased incrementally up to -50 cmH₂O with careful attention to any potential changes in the patients' circulatory and respiratory dynamics.

Results: All six patients were successfully treated with HCSD alone, and there were no related complications. The mean duration of air leakage was 57.2 days (range, 22–100 days). The drainage tubes were removed after a mean period of 60.2 days (range, 27–105 days). All patients were discharged from the hospital without later readmission.

Conclusions: HCSD treatment was safe, minimally invasive, and effective for patients with thoracic empyema with PF and may be considered as an alternative treatment to OWT.

Keywords: Thoracic empyema; continuous suction drainage; surgery

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Introduction

The treatment of thoracic empyema involves administration of antibiotics and efficient drainage of pus from the thorax in order to control the infection. Open window thoracostomy (OWT) should be offered for efficient drainage, especially for thoracic empyema with pulmonary fistula (PF), which continuously supplies infected pus into the thoracic cavity. Although conventional OWT offers excellent drainage, postoperative quality of life may be impaired, owing to postoperative pain associated with rib

resection, and it necessitates subsequent surgery to close the chest wall.

The method of treatment of thoracic empyema has been changing. The first reports on intrapleural vacuum-assisted closure (VAC) therapy were published in 2006 (1). Later reports (2–5) demonstrated that VAC therapy can accelerate the treatment of complex thoracic empyema after OWT. Hofmann [2012] *et al.* (6) reported a case that was successfully treated by VAC therapy without a preceding thoracostomy. However, VAC therapy requires proficient staff and careful management, such as changing of sponges



Figure 1 Drainage tubes are connected to a continuous suction unit. The set pressure and actual intrathoracic pressure are displayed. The actual intrathoracic pressure will gradually increase as the thoracic cavity is obliterated by granulation tissue.

every two to three days. VAC therapy method cannot be offered in every institution. A simpler and commoner method should be considered.

We described a consecutive case series of thoracic empyema with PF that was successfully treated with high-pressure continuous suction drainage (HCSD) alone. To our knowledge, this was the first article to outline multiple cases of thoracic empyema with PF that were treated without either OWT or VAC devices.

Methods

We retrospectively investigated six consecutive cases of thoracic empyema with PF between January 1, 2015 and December 31, 2018. The diagnosis of thoracic empyema was made by laboratory, radiologic, and microbiologic examinations. PF was confirmed by thin-slice computed tomography (CT). We aimed to discharge patients without any unfilled pleural cavities. The study was conducted in accordance with the Declaration of Helsinki (as revised

in 2013). This study was approved by the Akashi Medical Center institutional review board (2020-30), and written informed consent was obtained from each patient.

Surgical procedure

Preparatory surgery was generally performed to decrease the number of bacteria and fungi and to properly place drainage tubes. Video-assisted thoracic surgery was adopted for preparatory debridement and decortication. The thoracic cavity was irrigated with saline solution, followed by placement of one or two 20–24-Fr. thoracic drainage tubes, depending on the intrathoracic conditions.

HCSD procedure

Drainage tubes were connected to a continuous suction unit (MERA Sucuum; MERA, Tokyo, Japan) (Figure 1). Suction was initially set at -20 cmH₂O and was increased incrementally up to -50 cmH₂O, which was the maximum set pressure of the suction units. Utmost care was taken to identify any possible changes in the patients' circulatory and respiratory dynamics when the set pressure was changed. Intrathoracic pressure and the presence of air leakage were evaluated based on the number displayed on the unit. The drainage tube was removed when the pleural cavity was completely obliterated with granulation tissue and no air leakage was detected. When the drainage was deemed insufficient and the intrathoracic infection was out of control, conversion to OWT was considered without hesitation. The patients with PF treated for lung cancer were to be followed up for five years as our conventional manner. The patients without lung cancer were followed for roughly one year after discharge to see if there were any changes inside thoracic cavity.

Corresponding nursing care

The drain insertion site should be observed regularly. As the duration of drain placement is relatively long, there is some possibility that the drain tube can fall off easily due to enlargement of the drain inserting stoma.

Effect measurement

Pleural fluid cultures were taken roughly on a weekly basis, with appropriate antibiotics added accordingly. Blood

Table 1 Patient demographics

Patient	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Age (year)	61	61	69	64	66	69
Sex	Male	Male	Male	Male	Male	Male
Diagnosis	Pneumonia	Pneumonia	NSCLC	NSCLC	NTM	Meso.
Cause	Pneumonia	Pneumonia	intra-OP	intra-OP	intra-OP	intra-OP
PYI	20	43	37	80	0	47
Diabetes	+	–	+	+	–	–
Laterality	Left	Left	Left	Right	Left	Right
Debridement	Done	Done	Undone	Done	Done	Done
PFC	Staph.	Ent.	Pseudo.	Ent.	Pseudo.	Candida

+, presence; –, absence. Ent., *Enterobacter* species; intra-OP, intra-operative injury; Meso., pleural mesothelioma, NSCLC, non-small cell lung carcinoma; NTM, non-tuberculous mycobacterial infection; PFC, pleural fluid culture; Pseudo., *Pseudomonas* species; PYI, pack-year index; Staph., *Staphylococcus* species.

samples and X-rays were taken regularly to see if the management was effective. CT scans were used for detailed evaluation of the thoracic cavity.

Antibiotic administration

Appropriate antibiotics that were targeted to the isolated bacteria or fungi were administered and continued for 2–4 weeks, even after drainage tube removal, depending on the condition of the patients.

Results

Course and outcome of continuous suction drainage

The patient demographics are summarized in *Table 1*. All patients were men, with a mean age of 65.0 years (range, 61–69 years). The causes of thoracic empyema with PF were intraoperative parenchymal injury in four patients and pneumonia in two patients. Four patients required surgical intervention for the primary disease (cases 3–6), and three patients were taking medications for diabetes mellitus. All patients, except case 3 (patient's refusal), underwent preparatory surgical debridement before the HCSD treatment. Various bacteria and fungi were isolated from the pleural fluid culture and were as follows: *Pseudomonas* species, *Staphylococcus* species, *Enterobacter* species, *Candida tropicalis*, and *Corynebacterium* species.

The outcomes of HCSD treatment are shown in *Table 2*.

All six patients were successfully treated by HCSD alone. The patients tolerated a suction of –50 cmH₂O without any associated complications, including arrhythmia or mediastinal shift. None required conversion to conventional OWT. The mean period of HCSD treatment was 60.2 days (range, 27–105 days), and the mean duration of air leakage was 57.2 days (range, 22–100 days). To accelerate the treatment, endobronchial Watanabe spigot (EWS) was placed in three patients. In three cases (cases 3, 4, and 6) that initially had some bacterial colonies, the bacteria completely disappeared by the time of tube removal. In all cases, the dimension of the pleural cavity was decreased and filled with granulation tissue (*Figure 2A,B*). None of our patients developed associated complications and recurrence of empyema within a median follow-up period of 643.0 days (range, 216–1,245 days).

Discussion

Thoracic empyema with PF is refractory and challenging to treat. In cases that require long-term administration of antibiotics and adequate drainage, OWT can facilitate excellent drainage of collected pus (7). However, despite widespread acceptance, OWT has disadvantages (4), including postoperative pain associated with rib resection, unaesthetic appearance of a cavity on the chest, and the necessity for a subsequent operation for chest wall closure. Hato [2014] *et al.* (8) reported that OWT closure was achieved in only 34.3% of patients. Furthermore, Palmen

Table 2 Outcome

Patient	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Age (y. o.)	61	61	69	64	66	69
Sex	Male	Male	Male	Male	Male	Male
Disease	Pneumonia	Pneumonia	NSCLC	NSCLC	NTM	Meso.
Cause	Pneumonia	Pneumonia	Intra-OP	Intra-OP	Intra-OP	Intra-OP
EWS	Undone	Undone	Done	Done	Undone	Done
AL stops (POD)	55	43	50	22	73	100
Drain tube removal (POD)	56	45	52	27	76	105
PFC	Staph.	No growth	No Growth	Ent.	Pseudo.	No growth
Complications	None (respectively)	None (respectively)	None (respectively)	None (respectively)	None (respectively)	None (respectively)
Conversion to OWT	None (respectively)	None (respectively)	None (respectively)	None (respectively)	None (respectively)	None (respectively)
Follow-up (day)	1,245	1,008	588	445	356	216

AL, air leakage; Ent., Enterobacter species; EWS, endobronchial Watanabe spigot; intra-OP, intra-operative injury; Meso., pleural mesothelioma; NSCLC, non-small cell lung carcinoma; NTM, non-tuberculous mycobacterial infection; OWT, open-window thoracostomy; PFC, pleural fluid culture; POD, postoperative day; Pseudo., Pseudomonas species; Staph., Staphylococcus species.

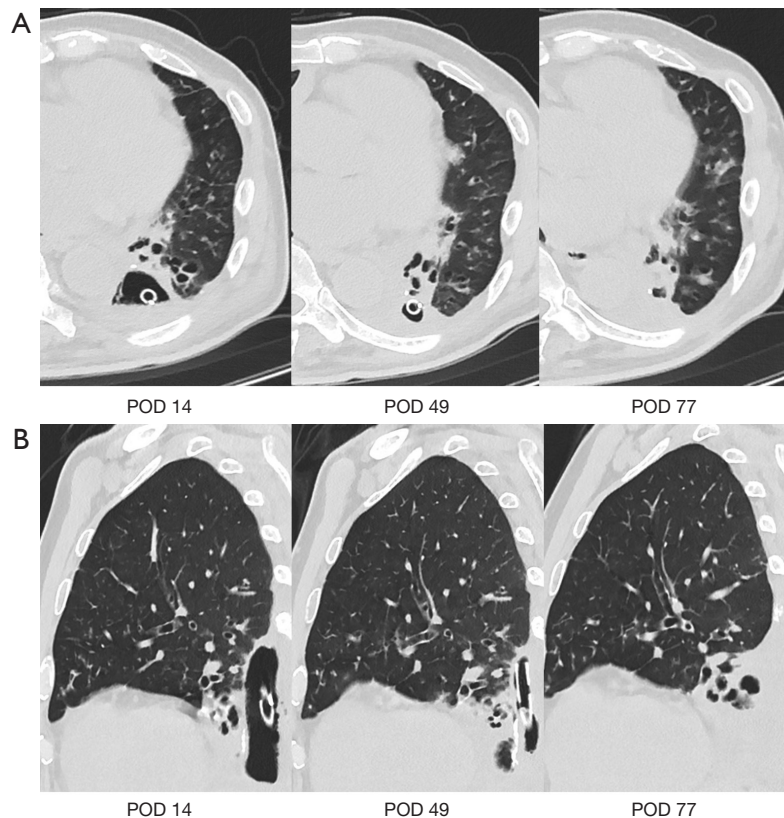


Figure 2 Postoperative pleural cavity is monitored by regular chest CT scans (A: axial plane and B: sagittal plane). The dimension of the pleural cavity is decreased and is filled with granulation tissue. POD, postoperative day.

[2009] *et al.* (3) reported that half of their patients died of OWT-related complications, such as bleeding and recurrent infections, during follow-up. The common causes of death after OWT are sepsis and multiorgan failure (3,8-10).

Several recent reports (1-5) have demonstrated the efficacy of VAC therapy for patients treated with conventional OWT. Although this method shortens the treatment period, OWT is needed in advance. Some reports (6,11,12) presented cases that were successfully treated by VAC therapy without a preceding OWT. Nevertheless, VAC therapy requires experienced staff and careful management, such as changing of sponges every two to three days. In this present report, we described consecutive cases of thoracic empyema with PF that were successfully treated with continuous suction drainage alone.

HCSD

There are some potential benefits in HCSD. Firstly, only the readily available devices are used, which do not require skilled specialists for operation. Secondly, continuous drainage can provide a relatively clean environment by keeping the number of bacteria and fungi low. In our institution, suction pressure is typically set at $-15 \text{ cmH}_2\text{O}$ for patients with thoracic empyema. In the present study, suction pressure was eventually increased up to $-50 \text{ cmH}_2\text{O}$, which may have allowed more efficient drainage of intrathoracic pus. We hypothesized that negative pressure would enhance expansion of the residual lung and advance the proliferation of granulation tissue, similar to the effects of VAC treatment. During VAC therapy, a maximum pressure of -125 mmHg is applied to the chest cavity; by far, there had been no reports on ipsilateral mediastinal shift or any other associated complications with this technique (1-6,11,12). In this present study, no cases needed discontinuation of the HCSD or conversion to OWT because of associated complications. Although we considered the application of more negative pressure, $-50 \text{ cmH}_2\text{O}$ was the maximum set pressure of the suction unit that we used. Further studies should try other units that have even higher suction pressure.

Thirdly, OWT can be avoided which causes several complications as mentioned above.

Lastly, HCSD method is conservative and minimally invasive, and we believe patients with other underlying diseases who may not be suitable for surgical intervention can tolerate this method. At least, all the patients in our study completed this therapy.

Timing of drainage tube removal

The drainage tube was removed when the pleural cavity was completely filled with granulation tissue and no air leakage was detected. The presence of remaining infection on the latest culture result was not a factor for the decision on drainage tube removal, because we assumed that the tube can be safely removed when there was no more space for bacteria or fungi to proliferate. If drain tube is removed too early, recurrence of thoracic empyema will be likely as there still remains some space for air leaks from lung to come out.

In our study, drainage tubes were removed on postoperative day 60.2 on the average (range, postoperative day 27–105). In three patients, EWS was placed to accelerate treatment and was effective in decreasing air leakage. Therefore, EWS should be considered for patients with major air leakage.

Duration of therapy

The duration of OWT is relatively long. Palmen [2009] (3) reported that the OWT was created 58 ± 119 days after the diagnosis of the empyema and that the length of hospital stay after the OWT was 60 ± 41 days with additional VAC treatment. Patients later underwent surgery for closure. In another report (2), OWT was created 52 days (range, 21–126 days) after the primary intervention, with a mean hospital stay of 22.7 days after OWT and VAC installation. Closure of the OWT was planned after a mean period of three months. In both reports, OWT was delayed after the diagnosis of empyema. In our study, the mean period of HCSD treatment was 60.2 days (range, 27–105 days), and there was no need for subsequent surgery to close the chest wall. EWS may shorten the duration of HCSD.

Study limitations

This study had some limitations, such as the retrospective observational design and the small number of patients. Future large-scale prospective study will be required to conclude if HCSD is effective for thoracic empyema with PF.

Conclusions

HCSD treatment was safe, minimally invasive, and effective for patients with thoracic empyema with PF and may be considered as an alternative treatment to OWT.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the ethic board of Akashi Medical Center (2020-30) and informed consent was taken from all individual participants.

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