

Short and Long-Term Outcomes of Surgical Intervention for Empyema in The Post-Fibrinolytic Era

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Abstract

Background: Open window thoracostomy is indicated for patients with bronchopleural fistulae or trapped lung in the setting of empyema refractory to non-surgical interventions. We investigated the role of open window thoracostomy in the era of minimally invasive surgeries, endobronchial valves and fibrinolytic therapy.

Methods: A retrospective chart review of all patients who underwent open window thoracostomy at a single institution from 2010-2020 was performed. Indications for the procedure as well as operative details and morbidity and mortality were evaluated to determine patient outcomes for open window thoracostomy.

Results: Eighteen patients were identified for the study. The most common indication for open window thoracostomy was post-resectional bronchopleural fistula (n=8). Patient comorbidities were quantified with the Charleston Comorbidity index (n=11 score ≥ 5 , 10-year survival $\leq 21\%$). Three (16.7%) patients died <30 days post-operatively and 12 (66%) patients were deceased by the study's end (overall survival 24.0 ± 32.2 months). Mean number of ribs resected were 2.6 ± 1.2 (range 1-6). Patients were managed with negative pressure wound therapy (n=9) or Kerlix packing (n=9). Eleven patients (61.6%) underwent delayed closure (mean time from index surgery to closure 4.8 ± 6.7 months).

Conclusions: Our study illustrates the significant comorbidities of patients undergoing open window thoracostomy, the poor outcomes therein, and pitfalls associated with this procedure. We show that negative pressure wound therapy can be utilized as potential way to obliterate the pleural space and manage an open chest in the absence of an airleak; however open window thoracostomy procedures continue to be extremely morbid.

Background

Since the inception of pleural fibrinolytic therapy in 2011 for management of empyema and complicated parapneumonic effusions, the incidence of decortication has substantially declined¹⁻⁴. Surgical management is considered for empyema when non-surgical therapy – i.e. antibiotics, tube thoracostomy, fibrinolytics – fails as well as in cases presenting as organized empyema with lung entrapment^{5,6}. Surgical interventions include video assisted thoracoscopic surgery (VATS) decortication and open thoracotomy with decortication. For unstable patients, Clagett type open-window thoracostomy (OWT) with rib resection and modified Eloesser flap (MEF) with rib resection both with or without negative pressure wound therapy (NPWT) are options, as both operations allow for continuous access to the pleural space for pus evacuation and debridement⁶⁻¹⁰.

An OWT is a procedure which may include elements of the Clagett window, EF, or MEF, but fundamentally involves removal of one or more rib segments and circumferentially marsupializing the parietal pleura to the skin (Fig. 1A,B). In 1935, Eloesser described the original procedure for open chest drainage, with

creation of a U-shaped cutaneous flap sutured apically under a resected rib segment (Fig. 1C)¹¹. In 1963, Clagett and Geraci described a new drainage procedure which entailed the removal of one rib segment and suturing the superficial fascia down to the periosteum of the resected rib⁷. The MEF was introduced in 1971 by Symbas et al. with the idea of providing superior empyema decontamination by a dependent drainage system not present in the traditional EF. The MEF is an inverted U-shaped cutaneous flap sutured inferiorly to the diaphragm below a segment of resected rib (Fig. 1D)¹². In contrast to the traditional Clagett window and OWT, where the ultimate goal is chest closure after successful empyema treatment, EF and MEFs are historically closed primarily through epithelialization and obliteration of the empyema cavity over time with resolution of the empyema itself¹¹⁻¹³.

Thus, current practices of open chest drainage for patients with empyema are best described as an OWT including Clagett windows, MEFs, and EFs. The aim of our study was to review our own practice and compare short and long-term outcomes of OWT for management of empyema, in the era of minimally-invasive surgery, endobronchial valves, and fibrinolytic therapy.

Methods

We identified all patients who underwent OWT at our institution between 2010 and 2020 by querying International Classification of Disease (ICD) 9 code 510 (empyema), and ICD 10 J86.0 (pyothorax with fistula). These ICD codes were then cross-matched to relevant current procedural terminology (CPT) codes including: 32035 (thoracostomy with rib resection), 23036 (thoracostomy with flap drainage), 32220 (release of lung), 32225 (partial release of lung), 32810 (closure chest after drainage), 32905 and 32906 (both revise and repair chest wall). These procedure codes were also cross-referenced to ICD 9 and ICD 10 procedure codes in order to capture additional patients.

A retrospective review of all patients undergoing any of the three OWT procedures was performed under an institution-approved IRB protocol. Statistical analysis included modeling survival data using a standard Kaplan Meier curve. Additionally, 10-year survival estimates at the time of the index operation was calculated for each patient using the Charleston Comorbidity Index score; points were given for age at time of surgery (age 50–59, 60–69, 70–79 and ≥ 80 given + 1, 2, 3, and 4 points respectively), history of myocardial infarction, congestive heart failure, peripheral vascular disease, cerebral vascular accident or transient ischemic attack, dementia, chronic obstructive pulmonary disease, connective tissue disease, peptic ulcer disease (all + 1 point), liver disease (+ 1 mild = chronic hepatitis or cirrhosis without portal hypertension; +2 moderate to severe = cirrhosis and portal hypertension without or with variceal bleeding history), diabetes mellitus (none/diet-controlled + 0, uncomplicated + 1, end-organ damage + 2), hemiplegia (+ 2), moderate to severe chronic kidney disease (Cr > 3 mg/dL or status post kidney transplant + 2), solid tumor (localized + 2, metastatic + 6), leukemia (+ 2), lymphoma (+ 2), AIDS (+ 6).

Results

We identified 18 patients who had undergone an OWT. Their demographics are outlined in Table 1. Patients ranged in age from 31 to 79. Nine patients (50%) had a history significant for smoking. All but 3 patients had significant pre-existing comorbidities as graded by the Charleston Comorbidity Index (CCI), an estimate of 10-year survival based on individual comorbidities at the time of the index operation. Two of the 3 patients without pre-existing comorbidities as measured by the CCI had a post-traumatic cause of empyema (one occurring in an otherwise healthy 47-year-old male after a gun-shot wound to the chest and the other in a 31-year-old male with cerebral palsy after a gastrostomy-tube was inadvertently tunneled into the pleural space). Of the patients without comorbidities tabulated by CCI, 2 of 3 did not require readmission after their index operation other than for scheduled delayed closure, and they are both still living. The third patient died secondary to complications of his underlying cerebral palsy. The most common comorbidities among our patient population were metastatic cancer (n = 7) and hypertension/coronary artery disease, which is not factored into CCI (n = 7). Another common comorbidity was COPD or reactive airway disease (n = 4).

Table 1
Demographic characteristics of OWT cohort

Cohort Demographics, N = 18	
Patient age at procedure (years), M ± SD	59.44 ± 14.67
Patient age range	31–79
Gender, <i>n</i> (%)	
Male	11 (61.1)
Female	7 (38.9)
Ethnicity/Race, <i>n</i> (%)	
Non-Hispanic, Caucasian	9 (50.0)
Black, African American	4 (22.2)
Asian	1 (5.6)
Hispanic	1 (5.6)
Other, Unknown	3 (16.6)
Smoking History, <i>n</i> (%)	
Yes	9 (50.0)
No	9 (50.0)
Comorbidities, <i>n</i>	
Cancer, metastatic	7
Cancer, local	2
COPD or Reactive Airway disease	4
HTN/CAD	7
Organ transplant	1
HIV/AIDs	1
CVA/stroke	2
Cerebral Palsy	1
None	2
Charleston Comorbidity Index Score	Predicted 10 year survival

Cohort Demographics, N = 18	
0 (n = 3)	98%
1 (n = 1)	96%
3 (n = 2)	77%
5 (n = 3)	21%
6 (n = 4)	2%
8 (n = 1)	0%
9 (n = 3)	0%
12 (n = 1)	0%
Indication for OWT, <i>n (%)</i>	
Post-resectional BPF	8 (44.4)
Post-pneumonectomy	5
Post-lobectomy	3
Parapneumonic Empyema	5 (27.8)
Esophageal Related	1 (5.6)
Subdiaphragmatic Abscess	1 (5.6)
Post-traumatic BPF	2 (11.1)

Operative details of the procedures are listed in Table 2. The most common indication for OWT was a post-resectional BPF (44% with n = 3 post-lobectomy and n = 5 post-pneumonectomy). Mean number of ribs resected were 2.6 with a range notable for 1–6 ribs. NPWT was utilized 50% of the time, with Kerlix packing used in patients who did not undergo NPWT. NPWT was primarily used for patients who only had trapped lung, and had no underlying airleak as that would not allow the negative-pressure device to hold suction. There was no trend for NPWT vs Kerlix over time, and 6 of 9 NPWT therapy patients were successfully closed by the end of the study. One patient was lost to follow up and two were deceased prior to closure. Eleven of 18 patients (61.1%) underwent delayed closure, with the most common means of closure being a latissimus dorsi pedicled flap (6 of 11 closed patients). Six patients were not closed as they died in the interim and in one patient, closure status is unknown as they were lost to follow up. In 1 patient who was closed 109 days after the index operation, BPF with empyema recurred within 2 months of closure and was managed with repeat thoracotomy and MEF creation. During the closure there were no signs of ongoing infection; though there was some fibrinous material debrided.

Table 2
Short and long-term outcomes of OWT cohort

Cohort Outcomes, N = 18	
Ribs resected (number), M ± SD; range	2.6 ± 1.2; 1–6
NPWT utilized, <i>n</i> (%)	9 (50.0)
Kerlix packing, <i>n</i> (%)	9 (50.0)
Delayed Closure, <i>n</i> (%)	
Yes	11 (61.1)
Latissimus dorsi pedicled flap	6 [†]
Pectoralis major pedicled flap	1
Free flap	2
Reapproximation of surrounding tissue	2
No, due to death	6 (33.3)
Unknown, lost to follow up	1 (5.6)
Time from index surgery to closure, M ± SD (months); range	4.8 ± 6.7; 3 days – 22.2 months
Patient Deceased, <i>n</i> (%)	
Yes, total	12 (66.6)
Yes, within 30 days post-operatively	3
- N = 2 Respiratory failure, sepsis	
- N = 1 Acute MI	
Yes, within 90 days post-operatively	1
- Tracheoinnominate fistula, hemorrhage, sepsis	
Yes, > 90 days post-op	9
No	6 (33.3)
Major post-operative complication (within 90 days), <i>n</i> (%)	
Recurrent infection after closure	1 (5.6)
DVT	1 (5.6)
Pulmonary Embolism	1 (5.6)

[†]1 patient re-opened for recurrent infection and repeat OWT/Eloesser flaps

Cohort Outcomes, N = 18	
Stroke	1 (5.6)
MI	1 (5.6)
OR take-back	2 (11.1)
- POD1: Hemorrhage	
- POD 7: Subcutaneous emphysema	
Readmission	
Yes, total	7 (38.9)
Yes, within 30 days	3
- N = 1 scheduled closure	
- N = 1 fall, altered mental status	
- N = 1 dyspnea	
Yes, within 90 days	4
- N = 2 scheduled closure	
- N = 1 aspiration pneumonia	
- N = 1 bleeding from OWT	
No	6 (33.3)
Not applicable, death on primary admission	5 (27.8)
Overall Survival (months), M ± SD	24.0 ± 32.2
†1 patient re-opened for recurrent infection and repeat OWT/Eloesser flaps	

At the end of the review period, 12 patients (66.6%) were deceased, with 3 (16.7%) patients dying within 30 days postoperatively with the following etiologies: respiratory failure/sepsis, respiratory failure/BPF, and acute myocardial infarction (MI). One patient died within 90 days due to tracheoinnominate fistula. A significant long-term complication was recurrent infection after closure (1 or 5.6% of patients). Additionally, 2 patients required OR takeback within 30 days, one for hemorrhage and the other for subcutaneous emphysema resulting in respiratory failure requiring intubation and chest tube placement in the contralateral pleural space to the OWT site. Total readmissions within 90 days included 7 patients (38.9%); though 5 patients (27.8%) had died on admission for index surgery. The mean overall survival was 24 months. Our Kaplan Meier curve shows the probability of survival after OWT to 1 month is 88% and 30% at 30 months (Fig. 2).

Discussion

No literature has been published in the last 10 years looking at outcomes of OWT. Our study illustrates the often-significant comorbidities of patients undergoing OWT in the modern era as well as the associated poor outcomes for patients and pitfalls that continue to be associated with this morbid procedure. There were two previous major studies published on this subject prior to the era of widespread use of fibrinolytic therapy. The first is a study by Thourani et al. in 2003 which examined 78 patients from 1975–2001 who received strictly MEFs for empyema thoracis¹⁴. The second is a study by Reyes et al. in 2010 which looked at 78 patients who underwent OWT from 1998–2008¹⁵. However, our cohort is distinct from both of theirs for multiple reasons. Compared to Reyes' study which found a 6% 30-day mortality and Thourani's study which found a 5% 30-day mortality, our study demonstrates a 12% 30-day mortality predicted by a Kaplan-Meier curve or 16.7% based on raw data (n = 3 of 18 deceased at 30 days, Fig. 2). Our increased mortality and smaller cohort are in part explained by the advent of fibrinolytics and endobronchial valves, and improved conservative interventions for empyema management. Given these advances, fewer patients go to the operating room for OWT as their index case, and often those who do undergo OWT have either failed or were not candidates for less-invasive surgical interventions.

The First and Second Multicenter Intrapleural Sepsis Trial (MIST I, MIST II) in 2005 and 2011 respectively (after the publication of the aforementioned studies) revolutionized care for the patient with empyema through the intrapleural use of fibrinolytics. First streptokinase was trialed, which compared to placebo did not improve mortality (MIST I), followed by combined tPA and DNAase (MIST II), which was shown to reduce the frequency of surgical referral and the duration of the hospital stay^{1,16}. Additionally, in current practice decortication with same day closure (either VATS or via open thoracotomy) are considered the procedures of choice before OWT as they are known to have superior outcomes^{17,18}. Furthermore in both Reyes' and Thourani's study the primary indication for OWT was for parapneumonic empyema, whereas in our study it was postoperative BPF¹⁴. This is likely explained by current practice of management of patients with parapneumonic empyema with the aforementioned conservative modalities. The wide-use of endobronchial valves has also changed the management of persistent airleaks, albeit only in sterile fields¹⁹.

Furthermore, our study supports the recent work of Nayak et al. 2020, which analyzed the epidemiology and trends in management of thoracic empyema from 1996-2015²⁰. Like our study, Nayak et al. used the Charleston Comorbidity Index to analyze morbidity and mortality risk in their population. They observed an increased incidence over time of thoracic empyema in patients aged 50–70 and postulated that this trend both reflects a change in the etiology of empyema from risk factors affecting a younger or more at risk population (IV drug use, Tuberculosis) as well as the greater presence of risk factors such as COPD and diabetes – both independent risk factors for empyema development – in the aging population²¹. Our study likewise had older patients (an average age of 59.44) with significant comorbidities as measured according to the CCI, supporting the changing epidemiological trends reported in Nayak et al²⁰.

There are several limitations to our study. First, the cohort of OWT patients (n = 18) in this study is limited by its small size. However, it still provides a valuable illustration of the various etiologies for which OWT is still indicated, most notably for trapped lung that cannot be expanded via VATS or open decortication or post-resectional dead space which is a nidus for infection in the setting of BPF. Additionally, our study further illustrates – similarly to past studies^{9,10,22} – that NPWT can be utilized as potential way to obliterate the pleural space and manage an open chest in absence of an airleak, as this method ultimately led to successful closure in six of nine patients with NPWT.

In our study, most patients who underwent OWT were debilitated at baseline and poor surgical candidates irrespective of their underlying severe pleural space infection as evidenced by their high Charleston Comorbidity Score's (n = 13 with a score ≥ 5 indicating 21% 10 year survival or less) (Table 1). A particularly undesirable, yet possible outcome of empyema management with OWT is premature window closure leading to recurrent infection, as seen in one patient in our cohort (Table 2). This patient was significantly immunocompromised at the time of closure given his underlying stage IV non-small cell lung cancer, which likely increased his risk of recurrent infection. Cases such as this illustrates the need to be wary of the possibility of recurrent or ongoing sub-clinical infection in patients who seem otherwise well and ready for closure. This is particularly poignant for immunocompromised patients who may not mount a clinical, symptomatic response (fever, leukocytosis) to ongoing infection. While there is no consensus as to when to close OWT patients, particular care should be taken in the immunocompromised patient to give enough time to truly decontaminate the space and ensure that colonization of the pleural space has decreased to $< 10^5$ colonies/hpf.

Conclusions

Patients that undergo OWT are a sick population at baseline, and the poor outcomes associated with OWT in current practice are unsurprising as patients receiving this operation are either too sick for other interventions or are out of other treatment options. A pitfall to avoid in management of OWT patients is early closure of the window to avoid the dire effects of reinfection. Further studies are needed to compare fibrinolytics versus all surgical interventions for empyema, albeit the results can be expected to be better for the former cohort of patients.

Abbreviations

Video assisted thoracoscopic surgery (VATS), Open window thoracostomy (OWT), Eloesser flap (EF), Modified Eloesser flap (MEF), negative pressure wound therapy (NPWT), Charleston Comorbidity Index (CCI), Bronchopleural fistula (BPF)

Declarations

Ethics approval and consent to participate: Not applicable; IRB approved study

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: CJC and PGK acquired, analyzed, and interpreted the patient data on patients undergoing the regional block. CJC, MM, JFL, HRH, MEH, SM, and PGK interpreted the data, substantially revised the manuscript, and were major contributors in writing the manuscript. All authors read and approved the final manuscript.

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Figures

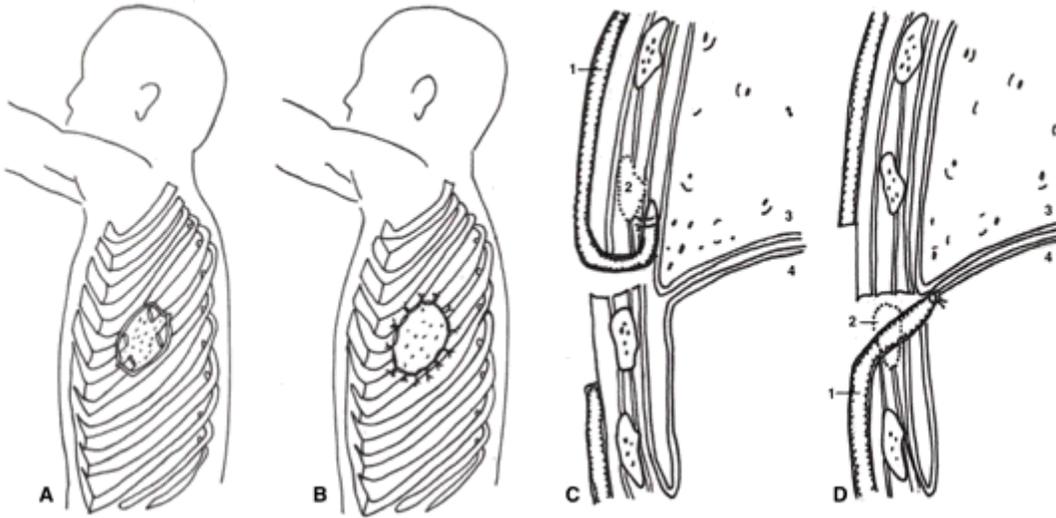


Figure 1

A – OWT part I with rib segments removed showing underlying lung parenchyma; B – OWT part II showing skin sutured circumferentially to parietal pleura (marsupialization) C – Eloesser flap (adapted from original sketch by Dr. Eloesser)¹¹, D – Modified Eloesser flap with numbers 1, 2, 3, 4 corresponding to cutaneous flap, removed rib segment, lung parenchyma, and diaphragm respectively

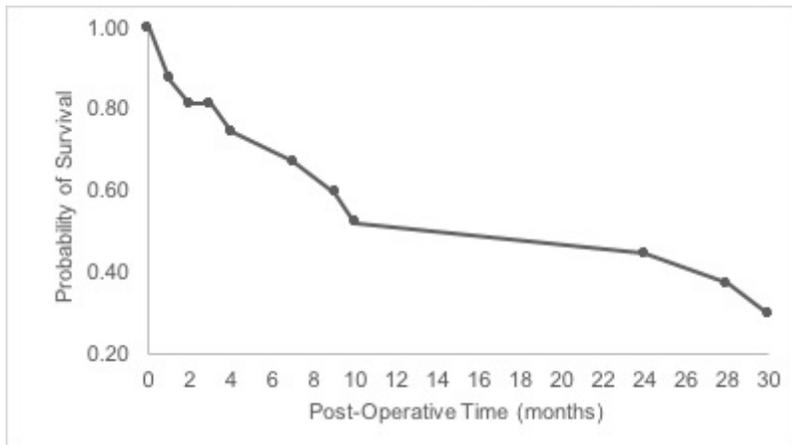


Figure 2

Kaplan Meier curve modeling survival probability for OWT cohort