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Project Title: An increase in decortications in Manitoba: A case series

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Summary (250 words max single spaced):

Background: A decortication is a thoracic surgical procedure that is associated with considerable morbidity, mortality, and resource use. There has been an increase in decortications in Manitoba with 5 performed in 2007 rising to 45 in 2014.
Methods: The charts of all adult patients that underwent a decortication in Manitoba from 2007-2014 (inclusive) were reviewed. The patients were divided into infectious and non-infectious groups based on initial etiology for comparison.
Results: One hundred and ninety-two patients underwent a decortication. The most frequent disease processes resulting in the need for a decortication were pneumonia (60%), trauma (13%), malignancy (8%), and procedural complications (5%). The number of decortications due to complications of pneumonia rose at the greatest rate over this time period. Decortications performed due to the remaining etiologies did not rise substantially. An infectious etiology resulting in the need for a decortication was associated with a higher rate of postoperative complications that resulted in an ICU admission or death, a higher rate of postoperative mechanical ventilation, and a longer duration of hospitalization.
Conclusions: A 9-fold increase in decortications in Manitoba over an 8-year period is concerning. Potential causes include an increase in pneumonia incidence, increased organism virulence, and changes in practice patterns. Earlier presentation to a health care provider and initiation of antibiotics are likely important areas of investigation and improvement in the management of patients with parapneumonic effusions in Manitoba. More studies are needed to further understand this trend.

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An increase in decortications in Manitoba: A case series

Introduction

A decortication is a thoracic surgical procedure that involves the removal of abnormal fibrous tissue from the pleural surfaces using a combination of blunt and sharp dissection and the evacuation of fluid, pus, or debris from the pleural space to facilitate lung expansion and pleural apposition. Fowler and Delorme first described a decortication in the late 19th century (1,2). Yet, this procedure evolved over the next several decades in part due to the need to treat the complications of pneumonia, tuberculosis, and penetrating chest trauma during World War II (2-4).

There are numerous disease processes that lead to the need for a decortication. Benign causes include parapneumonic effusions, hemothoraces, pleural infections, and inflammatory pleural disorders. A pleural effusion of any etiology, however, can result in the deposition of fibrous tissue on the pleural surfaces (2,5). Malignant causes include mesothelioma, metastatic infiltration of the visceral pleura, and other causes of malignant effusions (1).

A decortication is a major procedure with considerable morbidity and a mortality rate as high as 16% at 30 days, depending on factors such as baseline comorbidities, preoperative management, and etiology (1,2,6). A decortication can be performed as a minimally invasive procedure by video assisted thoracoscopic surgery (VATS) or by open thoracotomy. The decision to perform VATS versus open decortication is an area of active research (6-13). The reported rates of conversion to an open procedure range from 4-55% (11,14,15).

A decortication is required when patients are symptomatic due to unexpandable lung from remote inflammation of the pleural space or if an active pleural process such as a pleural infection fails to respond to more conservative treatment. The indications for a decortication due to a malignancy depend on such factors as expected duration of survival, and etiology. In general, the evidence supporting the timing and use of decortications is primarily based on small non-randomized studies, institutional practice, and individual experience, particularly in the case of pleural infections (1,14,16-24).

Objective

At the Winnipeg Health Sciences Centre, which is the provincial referral centre for thoracic surgery in Manitoba, there has been a progressive increase in the number of decortications with 5 performed in 2007 rising to 45 in 2014 (Figure 1). The primary objective of this study was to describe this patient population in terms of demographic data, comorbidities, etiology leading to a decortication, course in hospital, morbidity, and mortality. These findings will serve to be hypothesis generating and will contribute to future investigations into the cause of the large increase in the number of decortications in Manitoba. A secondary objective was to compare patients that underwent a decortication due to an infectious versus a non-infectious cause in terms of perioperative risk, course in hospital, morbidity, and mortality.

Methods

Approval was obtained from the University of Manitoba Research Ethics Board. Three reviewers conducted a retrospective chart review of all adult decortications performed at the Winnipeg Health Sciences Centre from the beginning of 2007 to the end of 2014. Ten percent of the charts were selected randomly and reviewed a second time independently to ensure data

accuracy and reproducibility. Thoracic surgery was centralized to the Health Sciences Centre and an electronic surgical database was developed in 2007 facilitating data collection. Collected data included: patient demographics, comorbidities, preceding disease processes, antibiotic use, microbiological results, perioperative management, and course in hospital. Postoperative complications were assessed according to the Ottawa Thoracic Morbidity & Mortality (TM&M) Classification System until discharge from hospital (Appendix A) (32,33). Presence of a condition in the preoperative period precluded inclusion as a postoperative complication with the exception of a condition that worsened or deviated from the normal postoperative course. Complications were defined in the study protocol by consensus and adapted from the Ottawa TM&M Classification System based on importance and relevance to a decortication and included myocardial ischemia or infarction, congestive heart failure, atrial arrhythmia, cardiac arrest, cerebrovascular complication, venous thrombosis, pulmonary embolism, acute respiratory distress syndrome, post-procedure ventilator support >48 hours, prolonged air leak, bronchopleural fistula, prolonged pleural drainage, hemothorax, empyema, confusion/delirium, seizure, gastrointestinal bleeding, acute kidney injury, sepsis, and death during hospitalization (32,33).

The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) Surgical Risk Calculator was used to determine the expected individual risk of a serious complication or death (34,35). The NSQIP Surgical Risk Calculator is an increasingly popular tool that estimates the risk of several outcomes until postoperative day 30 including death and a composite outcome referred to as a serious complication. The estimate is based on the input of 21 preoperative variables including the procedure (i.e. a decortication) (34,35).

The patients were divided into two broad groups based on the initial etiology that resulted in the need for a decortication, namely, an infectious group and a non-infectious group. The infectious group consisted primarily of patients that presented with a parapneumonic effusion but also included a small number of patients with pleural effusions secondary to another acquired or intrinsic infectious cause such as tuberculosis or an abdominal abscess. The non-infectious group consisted of patients that presented with non-infectious causes of a pleural space disorder including trauma, malignancies, and procedural complications. The preceding disease processes and group assignments of twenty-seven patients were reviewed a second time independently by two senior clinicians and researchers as they had multifactorial or unclear disease processes resulting in the need for a decortication. The Principle Investigator resolved ties in 8 cases.

Statistical Analysis

Statistical analysis was performed in consultation with the University of Manitoba Biostatistics Group and the Anesthesia Research Office.

The chi-square test or the Fisher exact test was used for comparison of frequencies. The unpaired t-test was used for comparison of means. The Mann-Whitney U test was used to compare differences between groups when the dependent variable was not normally distributed. A p-value of less than 0.05 was considered statistically significant.

Inter-rater reliability

Percent agreement and kappa were calculated for comorbidities, the etiology leading to a decortication, presence of 1 or more postoperative complications (any TM&M grade), presence of 1 or more postoperative complications resulting in an invasive procedure, ICU admission or

death (>TM&M grade 2), a new postoperative ICU admission, in-hospital mortality, a positive preoperative blood culture, and a positive pleural sample. Percent agreement was calculated for the duration of surgery and the length of hospitalization. The median difference between reviewers was calculated for the NSQIP predicted risk of a serious complication and the NSQIP predicted risk of death at 30 days (Appendices B, C, and D).

Results

All Patients

Preoperative Data

One hundred and ninety-two patients underwent a decortication at the Winnipeg Health Sciences Centre from 2007 to 2014, inclusive. One patient from the database was excluded, as the records could not be found. Three patients underwent 2 decortications during the same hospital admission and 3 patients had two decortications during separate hospital admissions. One patient had the first decortication at a U.S. hospital. The second decortication was regarded as a postoperative complication or a separate procedure depending on if it occurred during the same hospital admission or a separate admission, respectively.

Seventy-six percent of patients were male and the median age was 54 (interquartile range [IQR] 43.25-66). Sixty-nine percent of patients had a smoking history and 27% had a history of unhealthy alcohol use*.

The median NSQIP predicted risk of a serious postoperative complication or death at 30 days was 20% and 3%, respectively. Preoperatively, 11% of patients were intubated and ventilated, 35% were receiving supplemental oxygen, and 54% were breathing room air only.

The most frequent disease processes resulting in the need for a decortication were pneumonia (60%), trauma (13%), malignancy (8%), and procedural complications (5%) (Figure 2).

Decortications due to complications of pneumonia rose at the greatest rate (Figure 3). Among these patients, the median duration from symptom onset, first antibiotic, and thoracic consultation to decortication was 17 days (IQR 12-27), 8 days (IQR 4-16), and 2 days (IQR 1-4), respectively (Table 1).

Surgical Data

The surgical approach was a thoracotomy in 79%, VATS resulting in conversion to a thoracotomy in 12%, and VATS alone in 9% of cases. The median duration of decortication was 101 minutes (IQR 69-134). Patients were intubated with a double lumen tube in 68% of cases. An arterial line and central line were inserted intraoperatively in 92% and 13% of cases, respectively.

Postoperative Data

Twenty-two percent of patients had a postoperative complication resulting in the need for an invasive procedure, intensive care unit (ICU) admission, or death (>TM&M grade 2). The median duration of hospitalization was 15 days (IQR 9.75-23.25) with an in-hospital mortality rate of 4%.

*Defined as a documented history of unhealthy alcohol use or toxic alcohol ingestion; more than 14 standard drinks per week on average or more than 4 standard drinks per occasion for men under age 65; more than 7 standard drinks per week on average or more than 3 standard drinks per occasion for women or adults 65 years or older; or diagnosis of alcohol use disorder.

Twenty-seven percent of patients required a postoperative ICU admission and the median duration of intensive care was 5 days (IQR 3-18). Forty-four percent of patients that required a postoperative ICU admission were in an ICU in the immediate preoperative period.

Thirty-two percent of patients received a packed red blood cell transfusion intraoperatively or postoperatively and 13% were transfused with 3 or more units. Furthermore, 22% of patients required postoperative vasopressors.

Pain control included patient controlled anesthesia in 68%, an intraoperative intercostal block in 33%, paravertebral catheter in 18%, and an epidural catheter in 23% of cases. Forty-eight percent of patients received 2 or more pain control modalities.

The Infectious Group vs. the Non-infectious Group

There were 126 patients in the infectious group and 66 patients in the non-infectious group. The median age was similar between groups (54.5 [IQR 46-66] vs. 51 [IQR 36.5-66], p = 0.14). Additionally, baseline comorbidities were similar between groups (Table 2). The infectious group had a higher median predicted risk of a serious complication and death at 30 days compared to the non-infectious group (21% [IQR 16-28] vs. 16% [IQR 13.75-20.25], p<0.01, and 3% [IQR 1-8] vs. 2% [IQR 1-4], p<0.01).

The operative duration was similar between groups (99 min. [IQR 69-133] vs. 103 min. [IQR 69-156.5], p = 0.23). The decortication was right-sided in 66% of cases in the infectious group and 61% of cases in the non-infectious group (p = 0.47). Fifty-one percent of patients in the infectious group had at least 1 postoperative complication vs. 53% in the non-infectious group (p = 0.77). The rates of a postoperative myocardial infarction, atrial arrhythmia, acute kidney injury, vasopressor use greater than 12 hours, and in-hospital mortality were similar between groups (Table 3). However, the infectious group had a higher rate of postoperative complications that resulted in an ICU admission or death (>TM&M grade 3) (21% vs. 9%, p = 0.03), a higher rate of postoperative mechanical ventilation >48 hours (18% vs. 6%, p = 0.03), and a longer median duration of hospitalization (15 days [IQR 11-24.75] vs. 12.5 days [IQR 7-21.25], p = 0.04).

The majority of patients in the infectious group (91%) received at least 1 dose of an antibiotic prior to pleural sampling. The pleural sample and preoperative blood culture were positive in 59% and 10% of patients, respectively. Moreover, more than one organism was isolated from the pleural space in 18% of patients. *Streptococci*, *S. aureus*, gram negatives, and anaerobes represented 58/120, 7/120, 9/120, and 24/120 isolates from pleural samples, respectively. Furthermore, *Mycobacterium tuberculosis* was the causative organism in 3 patients (Figure 4, Table 4, Table 5).

Discussion

A nine-fold increase in decortications in Manitoba over an 8-year period is concerning as this is associated with considerable morbidity, mortality, and resource use. Furthermore the cause of this increase is not well understood and it is not known how widespread this trend is and whether or not it will continue.

Pleural infections are a significant health problem worldwide and are an important cause of the need for a decortication. The incidence of pleural infections is increasing in North America in both adults and children for reasons that are not clear (25-27). Pneumonia and parapneumonic

effusions often precede pleural infections however; the pathophysiology of this process is not completely understood. Despite the association between pneumonia and pleural infections, the organisms isolated differ considerably. Administration of antibiotics prior to sampling, low diagnostic yield, and difficulty isolating and identifying fastidious organisms likely contribute to this however; transpleural spread of bacteria may be only one of several mechanisms. Corcoran, et. al have proposed 6 potential routes of bacterial invasion of the pleural space namely, transpleural spread from adjacent consolidated lung, visceral pleural defects, hematogenous spread, penetrating tissue injury across the pleura, spread from the mediastinum, and transdiaphragmatic spread (27). The organisms isolated from community acquired pleural infections in adults are most commonly *Streptococci* and more specifically from the *Streptococcal anginosus* group which are primarily oropharyngeal flora. Furthermore, the association between pleural infections and oropharyngeal bacteria such as the *Streptococcus anginosus* group and oropharyngeal anaerobes has previously been reported with aspiration thought to be an important mechanism (27-31).

Decortications due to parapneumonic effusions represented the largest category and increased at the greatest rate over this 8-year period (3 in 2007 - 29 in 2014). Moreover, decortications performed due to the remaining etiologies did not rise substantially (Figure 3). Potential causes include an increase in pneumonia incidence, increased organism virulence, and changes in practice patterns in primary care, medical transport, and thoracic surgery. A Canadian and a U.S. database study was published demonstrating an increase in pleural infection associated hospitalizations however; the magnitude of this published increase was relatively low in comparison to a nine-fold increase over 8 years. Furthermore, the Canadian data included all provinces and territories except for Manitoba and Quebec, and the studies ended in 2003 and 2008, respectively (25,26).

An infectious etiology leading to a decortication was associated with a higher rate of postoperative complications that resulted in an ICU admission or death, and a longer duration of hospitalization. Age and baseline comorbidities were similar between the infectious and non-infectious groups but the infectious group had a higher predicted risk of a postoperative complication and death based on the NSQIP Surgical Risk Calculator. This suggests that these patients were at significantly higher risk primarily due to the severity of their infection. Furthermore, the duration of decortication, which was used as a surrogate for surgical complexity, was comparable between groups.

More patients in the infectious group had new postoperative ICU admissions suggesting a greater frequency of clinical deterioration in the intraoperative and postoperative period. The main reason for ICU admission was the requirement for postoperative ventilation. This may have been due to the inflammatory response of source control as well as the physiological stress of anesthesia and decortication in an already vulnerable population.

A causative organism was identified in approximately 60% of cases in the infectious group based on pleural samples or preoperative blood cultures. *Streptococci* and anaerobic bacteria represented a large fraction (82/120) of isolates from the pleural space, which is consistent with other studies of community-acquired infections in adults (27,36). However, community and hospital acquired pleural infections were not differentiated in this study.

The isolation of bacteria consistent with oropharyngeal flora, as well as the higher numbers of right sided surgery, gastroesophageal reflux disease, and poor dentition in the infectious group support the contributory role of aspiration in this population however, this is speculative as this study was not designed to investigate this.

Earlier presentation to a health care provider and initiation of antibiotics are likely important areas of investigation and improvement in the management of patients with parapneumonic effusions in Manitoba (Table 1). However, conclusions cannot be made regarding how to reverse the trend of increasing decortications in Manitoba, as further studies are needed.

Limitations

The retrospective and observational design of this study limit the ability to make conclusions as to the cause of the increase in decortications in Manitoba. The specific factors used to decide who underwent a decortication are not known. Additionally, the number and characteristics of patients managed non-surgically are not known. It remains unclear if more patients have developed pleural space complications or if the proportion of patients managed surgically has changed over time.

All adult patients were included in this study if they underwent a decortication between 2007-2014, inclusive. This was determined retrospectively by use of the term decortication in the operative report. Due to variations in coding and nomenclature, a few cases may have been missed.

Decortications are associated with considerable postoperative morbidity and mortality. Due to the small sample size, this study could not identify the specific risk factors associated with postoperative adverse events. The NSQIP Surgical Risk Calculator was used to calculate the predicted risk of a postoperative complication or death. However, this risk calculator has not been validated in this population.

Conclusion

In summary, there has been a nine-fold increase in decortications performed in Manitoba over an 8-year period. Decortications are associated with considerable morbidity, mortality, and resource use. Parapneumonic effusions were the most frequent cause of the need for a decortication and rose at the greatest rate. Furthermore, an infectious etiology resulting in the need for a decortication was associated with a higher rate of ICU admissions or death due to postoperative complications, a higher rate of postoperative mechanical ventilation, and a longer duration of hospitalization. More studies are needed to further understand this trend.

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Figures and tables

Figure 1. Decortications by Year

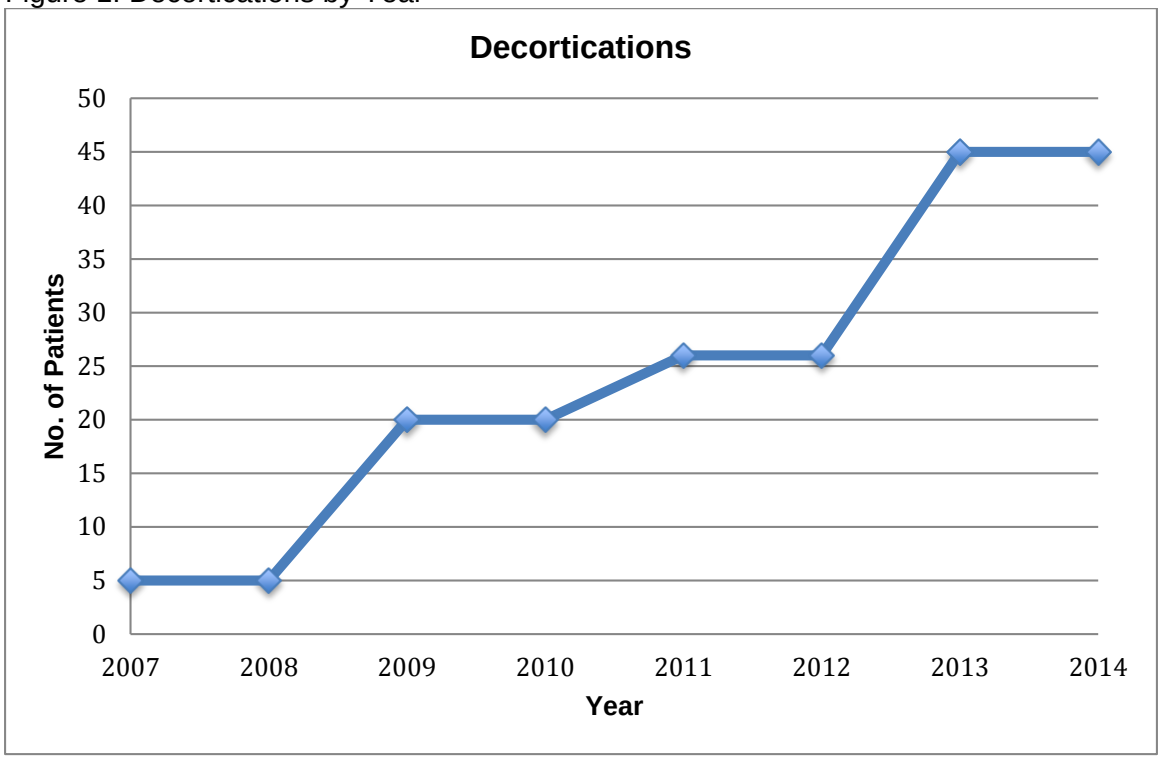

Figure 2. Etiology Leading to a Decortication

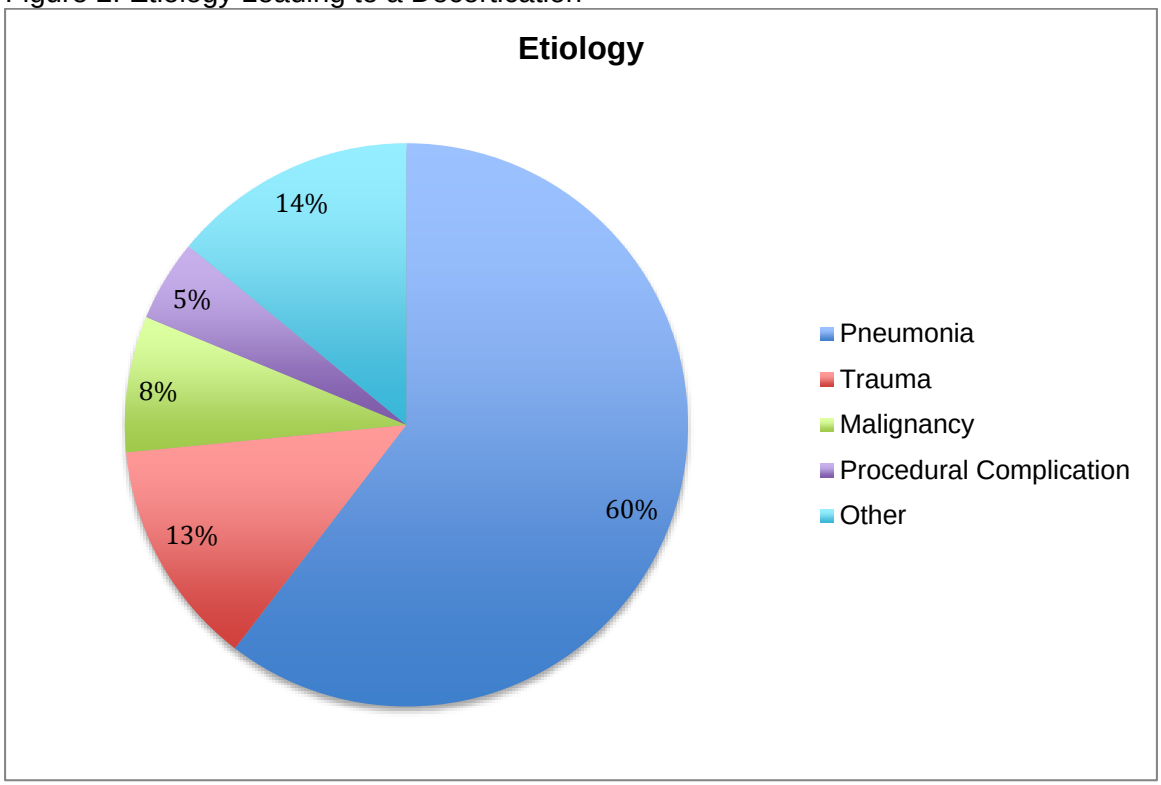

Figure 3. Etiology Leading to a Decortication by Year

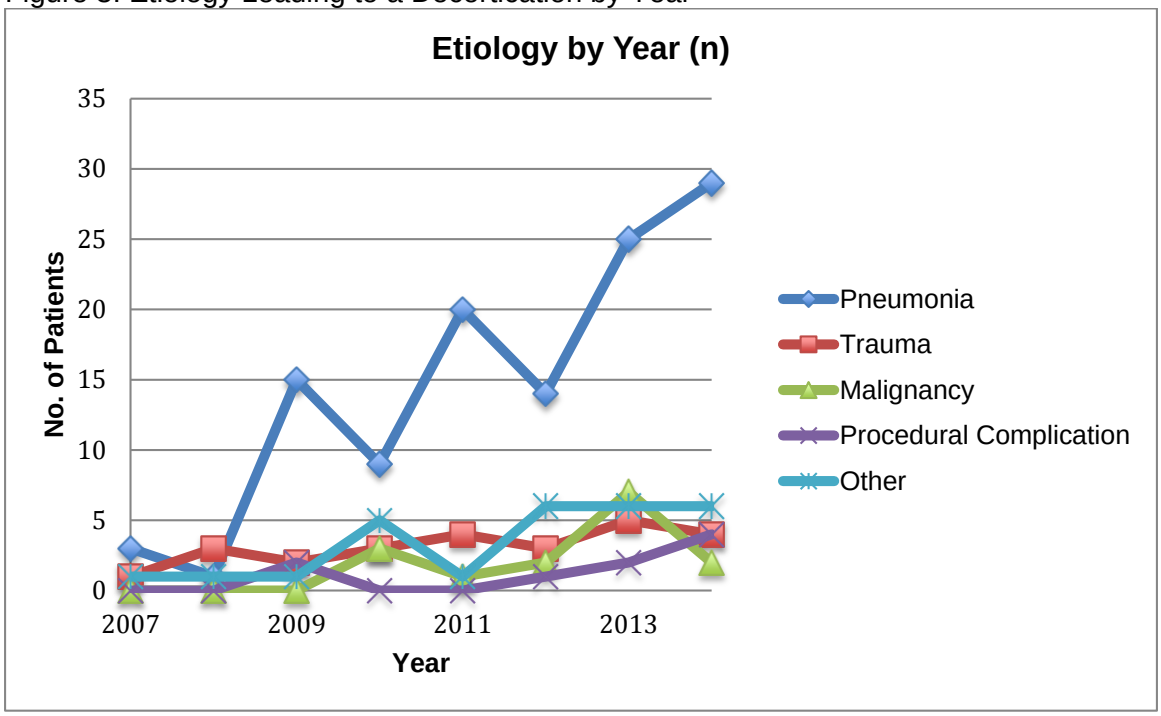

Figure 4. Organisms Isolated from Pleural Samples in the Infectious Group

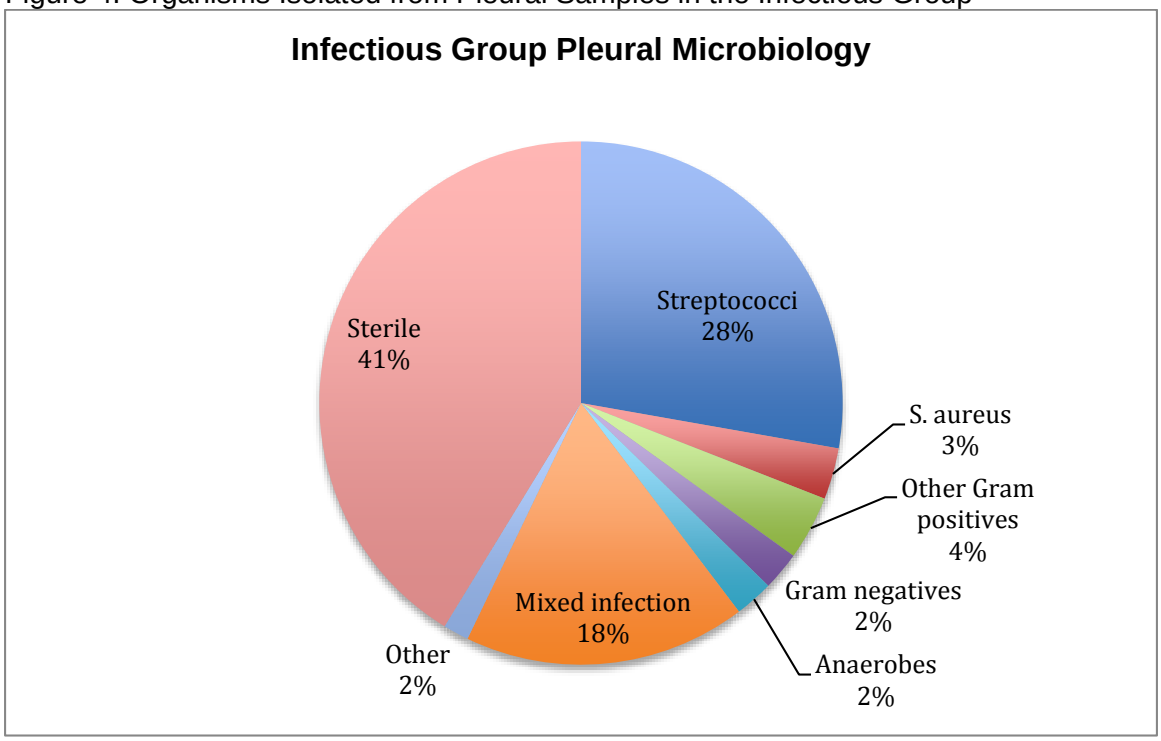

Table 1. Time Points Preceding Decortication Among Patients with Parapneumonic Effusions

Time Point	Median Duration to Decortication	IQR
Symptom onset	17 days	12-27
Presentation to a health care provider	11 days	5-20.5
First antibiotic	8 days	4-16
Hospital admission	6 days	2-10
Thoracic surgery consultation	2 days	1-4

Table 2. Baseline Comorbidities

Comorbidity	Infectious Group	Non-infectious Group	P Value
Ischemic heart disease	14/126 (11%)	7/66 (11%)	1.00
Cerebrovascular disease	3/126 (2%)	3/66 (5%)	0.42
Peripheral artery disease	2/126 (2%)	2/66 (3%)	0.61
Hypertension	48/126 (38%)	24/66 (36%)	0.88
Atrial arrhythmia	12/126 (10%)	7/66 (11%)	0.80
Chronic pulmonary disease	31/126 (25%)	17/66 (26%)	0.86
Obstructive sleep apnea	7/126 (6%)	2/66 (3%)	0.72
Gastroesophageal reflux disease	18/126 (14%)	3/66 (5%)	0.05
Liver cirrhosis	4/126 (3%)	2/66 (3%)	1.00
Chronic kidney disease	12/126 (10%)	8/66 (12%)	0.62
End-stage renal disease	5/126 (4%)	6/66 (9%)	0.19
Obesity	36/126 (29%)	14/66 (21%)	0.30
Smoking history	86/126 (68%)	46/66 (70%)	0.87
Substance use	32/126 (25%)	22/66 (33%)	0.31
Poor dentition	9/126 (7%)	1/66 (2%)	0.17
Diabetes mellitus	26/126 (21%)	14/66 (21%)	1.00

Table 3. Postoperative Complications

Complication	Infectious Group	Non-infectious Group	P Value
Myocardial infarction	0/126 (0%)	1/66 (2%)	0.34
Atrial arrhythmia	6/126 (5%)	1/66 (2%)	0.43
Acute kidney injury	13/126 (10%)	4/66 (6%)	0.43
New postoperative ICU admission	24/126 (19%)	5/66 (8%)	0.04
Postoperative vasopressors >12 hours	20/126 (16%)	7/66 (11%)	0.39
Postoperative mechanical ventilation >48 hours	23/126 (18%)	4/66 (6%)	0.03
In-hospital mortality	6/126 (5%)	1/66 (2%)	0.43

Table 4. Preoperative Blood Culture Isolates from the Infectious Group

Organism		**No. of Isolates**
Gram Positive Bacteria	*Streptococcus anginosus* group	1
	Streptococcus pneumoniae	5
	Methicillin-sensitive *S. aureus*	2
	Methicillin-resistant *S. aureus*	1
	Coagulase-negative *Staphylococci* (CoNS)	4
	Total	**13**

Table 5. Pleural Sample Isolates from the Infectious Group

Organism		**No. of Isolates**
Gram Positive Bacteria	*Streptococcus anginosus* group	41
	Streptococcus pneumoniae	2
	Streptococcus pyogenes	2
	Streptococcus mitis	2
	Other *Streptococcus* spp.	11
	Methicillin-sensitive *S. aureus*	2
	Methicillin-resistant *S. aureus*	5
	S. epidermidis	2
	S. capitis	2
	Other CoNS	1
	Diphtheroids	4
	Enterococcus spp.	1
	Bacillus spp.	1
	Micrococcus spp.	3
Gram Negative Bacteria	*E. coli*	1
	Acinetobacter radioresistens	1
	E. hermanni	1
	Legionella pneumophila	1
	Other Gram negatives	5
Anaerobic Bacteria	*Eikenella corrodens*	1
	Fusobacterium spp.	2
	B. fragilis	1
	Peptostreptococcus	3
	Veillonella spp.	2
	Parvimonas micra	6
	Prevotella spp.	2
	Clostridium clostridioforme	1
	P. acnes	1
	Other anaerobes	5
Other	*Mycobacterium tuberculosis*	3
	C. albicans	1
	Other fungi	2
	Other	2
	Total	**120**

Appendices

Appendix A. Ottawa Thoracic Morbidity & Mortality (TM&M) Grading System

Grade	Description
1	Any complication without need for pharmacologic treatment or other intervention.
2	Any complication that requires pharmacologic treatment or minor intervention only.
3	(a) Any complication that requires surgical, radiological, endoscopic intervention, or multi-therapy. The intervention does not require general anesthesia. (b) Any complication that requires surgical, radiological, endoscopic intervention, or multi-therapy. The intervention requires general anesthesia.
4	(a) Any complication requiring ICU management and life support. Single organ dysfunction. (b) Any complication requiring ICU management and life support. Multi-organ dysfunction.
5	Any complication leading to the death of the patient.

Appendix B. Percent Agreement and Kappa for Categorical Data

Categorical Data	Percent Agreement	Kappa
Ischemic heart disease	100%	N/A
Cerebrovascular disease	100%	N/A
Peripheral artery disease	100%	N/A
Hypertension	90%	0.79
Atrial arrhythmia	100%	N/A
Chronic pulmonary disease	100%	N/A
Obstructive sleep apnea	100%	N/A
Gastroesophageal reflux disease	100%	N/A
Liver cirrhosis	95%	0.64
Chronic kidney disease	95%	0.00
End-stage renal disease	100%	N/A
Obesity	100%	N/A
Smoking history	90%	0.78
Substance use	90%	0.80
Poor dentition	85%	0.00
Diabetes mellitus	100%	N/A
Etiology leading to a decortication	90%	0.81
Presence of 1 or more postoperative complications (any TM&M grade)	90%	0.80
Presence of 1 or more postoperative complications resulting in an invasive procedure, ICU admission or death (>TM&M grade 2)	85%	0.63
New postoperative ICU admission	100%	N/A
In-hospital mortality	100%	N/A
Positive preoperative blood culture	100%	N/A
Positive pleural sample	95%	0.89

Appendix C. Percent Agreement for Ratio Data

Ratio Data	Percent Agreement
Duration of decortication (mins)	90%
Length of hospitalization (days)	100%

Appendix D. Difference Between Reviewers for the NSQIP Surgical Risk Calculator Results

NSQIP Results	**Median Difference Between Reviewers**	**IQR**
NSQIP predicted risk of a serious complication (%)	4.5%	1.75-10.25
NSQIP predicted risk of death (%)	1%	0-2