Original Article

Survival with optimal medical management in a cohort of severe necrotizing bacterial lung infections

Jean-Christophe Larose[1]^, Han Ting Wang[1], George Rakovich[2]

[1]Division of Critical Care, Department of Medicine, Centre Hospitalier de l'Université de Montréal, Montréal, QC, Canada; [2]Division of Thoracic Surgery, Department of Surgery, Hôpital Maisonneuve-Rosemont, Montréal, QC, Canada

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Correspondence to: Jean-Christophe Larose, MD, FRCPC. Division of Critical Care, Department of Medicine, Centre Hospitalier de l'Université de Montréal, 1000 rue Saint-Denis, Montréal, QC H2X 0C1, Canada. Email: jc.larose@umontreal.ca.

Background: Necrotizing pneumonia and lung gangrene represent a continuum of severe lung infection. Traditionally, severe cases have been referred for surgical debridement. However, this has been linked to high mortality. Some groups have published encouraging results using a conservative medical approach. Unfortunately, lack of a standardized definition of necrotizing pneumonia has precluded meaningful comparison between medical and surgical approach in severe cases. Our objective was to describe the outcome of a cohort of severe necrotizing pneumonia treated with optimal medical management.

Methods: We conducted an observational retrospective study by reviewing charts and radiology records of patients hospitalized between 2006–2019 in a tertiary center. We included all patients with severe necrotizing infection, defined as a necrotizing cavity involving at least 50% of a lobe, or smaller multilobar cavities. We made no distinction between necrotizing pneumonia and gangrene as there are no standardized criteria.

Results: A total of 50 consecutive patients were included. On imaging, 42% had multilobar cavities and mean diameter of the largest cavity in each case was 5.9 cm. 50% required mechanical ventilation (median duration 12 days) and 44% needed vasopressors. Four patients (8%) had decortication surgery, while none underwent lung resection. Four patients (8%) died. The extent of infiltrates and number of cavities were not associated with mortality but the extent of infiltrates was associated with risk of intubation (P=0.004).

Conclusions: We presented one of the largest series of medically-treated severe necrotizing lung infections in the pre-coronavirus disease-2019 (COVID-19) era. The overwhelming majority of patients recovered with optimal medical management alone. Our results strongly support avoiding pulmonary resection in patients with severe necrotizing bacterial lung infections.

Keywords: Necrotizing lung infection; necrotizing pneumonia; lung gangrene; pneumonia; decortication

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Introduction

Necrotizing pneumonia and lung gangrene represent a continuum of severe lung infection (1-4) historically associated with prolonged hospitalization and mortality rates reaching over 45% (1,5-14). Although these terms have been used for decades, available definitions are vague and highly variable (7,10,15-19). Historically, the absence of documented tissue perfusion (affecting at least 50% of

^ ORCID: 0000-0002-2220-2063.

lobar blood supply) has been used to define lung gangrene (1,13-15,20,21). Nonetheless, it is difficult to argue how "necrosis" differs conceptually from "gangrene". As a result, these terms have been used interchangeably and often with significant overlap (18,19) to describe what are, in essence, severe lung infections with extensive parenchymal destruction. This lack of clear definitions has been a major obstacle for adequate evaluation and reporting of patients, treatment indications, and clinical outcomes. To avoid further confusion, we used the term "severe necrotizing lung infection" throughout the following text to designate the entities previously referred to as "necrotizing pneumonia" and "lung gangrene" as defined in the methods section.

The best approach in treating these complex infections has been the subject of debate. As antibiotics were thought to be ineffective in penetrating necrotic and devascularized tissue (7,15,22), aggressive surgical resection has been advocated by some, including local debridement, lobectomy or pneumonectomy (11,17,22-25), while associated effusions were treated with percutaneous drainage or decortication (2,4,21,23). On the other hand, published "medical" series rarely provide the specifics of medical management (toilet bronchoscopy or percutaneous drainage) (13,21) making comparisons between medical and surgical series impossible.

For severe necrotizing lung infections, various surgical indications have been proposed over the years. Some were related to complications of the infection itself (hemoptysis, empyema and bronchopleural fistula) (5,9,10,21,23). In some cases, the simple development of non-perfused tissue on computed tomography (CT)-scan was stated as an indication for lung resection surgery (4,7,8,21). Certain authors have even qualified the resection of gangrenous tissue as "mandatory" and "life-saving" (4,7,18,21,22,25). This surgical approach progressively emerged as the preferred treatment for several authors (21-23,25). In surgical series, consisting mainly of lobectomies and pneumonectomies, the mortality rates varied mostly between 8.5% and 40% (4,7-11,13,16,21,22,24,25). The anesthesia-related risks, possible spread of infection and post-operative clinical deterioration (11) in already precarious patients can explain these high mortality rates. This is why the very necessity and ideal timing of surgical interventions are still being debated (4,26).

The failure of medical treatment has also been suggested as a relative indication for surgery (3,5,10,13,21,23,27). In fact, it is still unclear what intensity of treatment defines failure of medical therapy. This knowledge gap can lead to different interpretations about the appropriate intensity of treatment that should be offered before considering lung parenchyma resection surgery. Data on the outcome of medically managed patients are scarce. Few large cohorts of medically-treated necrotizing lung infections exist, with most of them dating prior to 2000 (5,6,17,28). One cohort study published in 2013 revealed a mortality rate of 3% (12). Nevertheless, these cases could hardly be compared to severe necrotizing lung infections, as they consisted in 68 cases of pulmonary abscesses and focal necrotizing pneumonias. Another consideration is that many of these medically-managed patients had less severe clinical pictures [mean pneumonia severity index (PSI) score was low and they had relatively short length of stay] and this further prevented comparison with surgically-managed patient series (12).

At our tertiary care hospital, we believe that surgical interventions aimed at resecting necrotic lung tissue carry great risks. Over time, we have adopted an aggressive medical strategy to avoid major lung resection in critically ill patients. Our approach consisted of prolonged treatment with wide-spectrum antibiotics, ventilator support, aggressive bronchoscopy use, rapid percutaneous or surgical drainage of pleural collections and angioembolization for hemoptysis. In order to better identify our study population, we first set a clear definition for severe cavitating lung infections. Then, we performed a retrospective cohort study, of severe necrotizing bacterial lung infections treated

Highlight box

Key findings

- In severe necrotizing lung infections, aggressive medical management without lung resection surgery is effective.
- The extent of pulmonary infiltrates, not cavitation, determines clinical severity.

What is known and what is new?

- Anatomic pulmonary resection for necrotizing pneumonia is associated with major morbidity and mortality.
- Assessment of treatment efficacy has been difficult because of a lack of uniform definitions and case heterogeneity.
- A novel, conceptually sound definition of severe necrotizing pneumonia is proposed.
- Given the high success rate of "optimal medical therapy" alone, major lung resection should be avoided in these patients.

What is the implication, and what should change now?

- Major lung resection should be avoided in severe necrotizing lung infections.

at our center. The objective was to determine their outcome with aggressive medical management and parenchymal resection surgery only as a last resort. We hypothesized that most medically-treated patients would have a favourable outcome. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1590/rc).

Methods

Study design and setting

We performed a retrospective cohort study through chart review. We identified consecutive cases of necrotizing bacterial lung infections with cavities, that were hospitalized between January 2006 and January 2019 in one tertiary academic center (Hôpital Maisonneuve-Rosemont, Montreal, Quebec, Canada). In our hospital, these cases are usually managed by a multidisciplinary team (respirologist, infectious disease specialist, thoracic surgeon, intensivist, interventional radiologist). Their priority is to optimize treatment of the pulmonary infection (antibiotics, percutaneous drains and chest tube insertion) and perform lung resection and debridement only as a last resort. In 2006, our institution adopted a policy of avoiding major parenchymal resections in necrotizing lung infections because of the potential for major surgical morbidity in the absence of a compelling rationale or any formal guidelines. The presence of empyema, hemoptysis and hypoxemic respiratory failure were possible indications for a surgical consultation. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by institutional ethics board of Hôpital Maisonneuve-Rosemont (No. CIUSSS-EMTL-401) and individual consent for this retrospective analysis was waived.

Participants

We included all patients hospitalized for severe necrotizing lung infection potentially amenable to lung resection surgery in the pre-coronavirus disease-2019 (COVID-19) period. These were defined as one necrotizing cavity involving 50% or more of a lobe, or at least 2 smaller multi-lobar cavities on cross-sectional imaging. The cavity extent proposed (50% or more) was based on a previously stated definition of pulmonary gangrene found in the literature (1,13-15,20,21). Considering the lack of consensus on the radiologic definition of necrotizing pneumonia and pulmonary gangrene, these criteria were intended to improve the identification of patients with severe necrotizing infections, hence proposing "clinically relevant" criteria. In fact, this subset of patients were the ones for whom a surgical intervention would have been considered. In addition, previous authors have recommended resection surgery in patients with contrast-enhanced CT revealing a lack of perfusion affecting 50% or more of a lobe (4,7,8,21). Because patients with cavities involving more than half of a lobe on CT would inevitably have a lack of perfusion reaching at least 50%, the definition proposed was also a method to select patients that would have been considered for surgery by some of these clinicians.

Cases were systematically identified through radiology imaging records and hospital archives. Both databases were searched with the following key words: "cavity" (cavitary, cavitation), "necrotizing" (necrotic, necrosis), "necrotizing pneumonia" and "pulmonary gangrene". We also searched through archive medical records for patients hospitalized for cavitary lung infections. All CT exam reports containing any of these corresponding keywords were reviewed. To limit selection biases, 2 physicians blinded to patients' outcomes independently reviewed all CT imaging for inclusion criteria (JCL and GR). In the event of a discrepancy between the two assessments, images were reviewed by a third physician (HTW) to decide on patient's selection.

We excluded cases of non-bacterial infection (mainly mycobacterial and fungal), active lung or pleural neoplasm (i.e., active disease on recent imaging or chemotherapy/radiotherapy received in the last year) and exams performed in the outpatient setting (patients not hospitalised).

Variables

We collected baseline characteristics to calculate Charlson comorbidity index (CCI) scores, intensive care unit (ICU) admission data, use of invasive mechanical ventilation and vasopressors through paper and electronic charts review. We also reviewed complications related to the necrotizing infection, medical management and interventions (bronchoscopy, percutaneous chest drains, surgical chest tubes, etc.). We collected all culture results done and pneumonic radiologic characteristics. We defined as community-acquired pneumonia an infection that became clinically symptomatic before hospital admission or in the first 48 hours of stay.

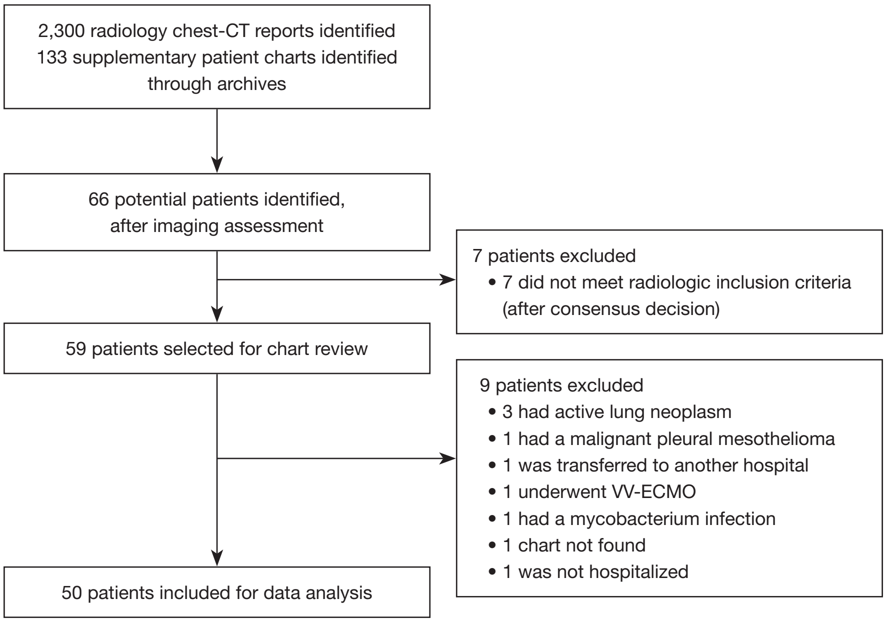

Figure 1 Study flow chart. CT, computed tomography; VV-ECMO, veno-venous extra corporeal membrane oxygenation.

Primary and secondary outcomes

Our primary outcome was the requirement of debridement and lung resection surgery or in-hospital mortality. Our secondary outcomes were hospital length of stay and ICU length of stay.

Quantitative variables and statistical analysis

Statistical analysis was performed using the IBM SPSS Statistics 25 (IBM Corporation, Armonk, NY, USA). Descriptive data were presented as mean or median with their central distribution depending on normality of data distribution. Normality were tested using Shapiro-Wilk test. Categorical variables were presented as proportions. Clinical differences between patients treated with medical management and surgical management were compared using Chi-Squared test or Fisher's exact test for categorical variables and independent *t*-test or Wilcoxon rank sum test. Due to the small number of deaths, we did not perform any regression analysis.

Results

A total of 2,300 chest-CT reports were identified through radiology imaging records and hospital archives. *Figure 1* shows the number of patients screened and excluded. After reviewing CT images, 66 potential patients were identified as they fulfilled the predefined criteria for severe necrotizing lung infection. Fifty were finally selected for chart review. *Table 1* shows patients' characteristics. No patient had any missing data. The mean age was 55.1 years (range, 25–97) with 31 male patients (62%). The mean CCI was 2.9±2.1 (range, 0–8), 31 patients (62%) were active smokers and 15 patients (30%) had a diagnosis of chronic pulmonary obstructive disease (COPD). Shortly after presentation, 22 patients (44%) required vasopressors and 25 patients (50%) needed endotracheal intubation.

As shown in *Table 2*, 29 patients (58%) had a large cavity in a single lobe, while the remaining patients (42%) had a multi-lobar cavity involvement. Cavities involved the right upper lobe (RUL) in 24 patients (48%), the right lower lobe (RLL) in 24 patients (48%) and the left lower lobe (LLL) in 17 patients (34%). The RLL and the RUL were the most affected lobes in the mono-lobar cases (9 and 8 patients respectively). Pulmonary infiltrates were present in multiple lobes in 44 patients (88%), with 30 patients (60%) who had bilateral involvement. Four patients (8%) developed clinically significant hemoptysis, 14 patients (28%) complex parapneumonic effusions and 7 patients (14%) pneumothoraces. As seen in *Table 3*, a bacterial agent was identified in 39 patients (78%). Twenty patients (40%) had a monobacterial infection and 19 patients (38%) a

Table 1 Characteristics of the patients

Characteristics	N=50
Age (years)	55.1±15.8
Male sex	31 (62.0)
Smoker	31 (62.0)
Alcohol use	12 (24.0)
Intravenous drug use	5 (10.0)
CCI score	2.9±2.1
Patients with CCI scores	
0	6 (12.0)
1	8 (16.0)
2	11 (22.0)
3	9 (18.0)
≥4	16 (32.0)
Diabetes	11 (22.0)
CKD	12 (24.0)
COPD	15 (30.0)
Active cancer, except pulmonary	7 (14.0)
Pulmonary cancer in remission	3 (6.0)
Community-acquired pneumonia	44 (88.0)
Duration of symptoms prior to admission (days)	3 [0–7]
Need for vasopressors	22 (44.0)
Need for mechanical ventilation	25 (50.0)

Continuous variables are described as means ± SD or median [25–75th percentile] and categorical variables as n (%). CCI, Charlson comorbidity index; CKD, chronic kidney disease; COPD, chronic pulmonary obstructive disease; SD, standard deviation.

Table 2 Clinical and radiologic data

Variables	N=50
Pneumonia-associated complications	
Hemoptysis	4 (8.0)
Complex parapneumonic effusion	14 (28.0)
Pneumothorax	7 (14.0)
Bronchopleural fistula	1 (2.0)
Distribution of lung infiltrates	
Unilateral	20 (40.0)
Bilateral	30 (60.0)
Internal diameter of largest cavity (cm)	5.9±2.4
Lobes affected by cavities	
Mono-lobar	29 (58.0)
Multi-lobar	21 (42.0)
RUL	24 (48.0)
RML	16 (32.0)
RLL	24 (48.0)
LUL	13 (26.0)
LLL	17 (34.0)

Continuous variables are described as means ± SD and categorical variables as n (%). RUL, right upper lobe; RML, right middle lobe; RLL, right lower lobe; LUL, left upper lobe; LLL, left lower lobe; SD, standard deviation.

polybacterial infection. *Staphylococcus aureus* was the most common gram-positive agent, affecting 19 patients (38%).

As for interventions and outcomes, *Table 4* shows that the median duration of antibiotic therapy was 25 days [with 14–40 as the 95% confidence interval (CI)]. Flexible bronchoscopy was performed in 23 patients (46%), for diagnostic and therapeutic purposes [mainly for bronchoalveolar lavage (BAL) samples and toilet]. Chest tubes were inserted in 29 patients (58%) for drainage of complex effusions or pneumothoraces. Pleural decortication surgery was performed in only 4 patients (8%). None of our patients underwent lung resection surgery. The median duration of hospital stay was 26 days (95% CI: 15–51). Among those intubated, the median duration of mechanical ventilation was 12 days (95% CI: 5–24). Eight patients (16%) later required tracheostomy. Overall, 4 patients (8%) died during their hospital stay. The dramatic capacity for the lung to heal is illustrated in a typical case (*Figure 2*). It is the case of a 56-year-old female who was mechanically ventilated for more than one month (*Figure 2A*) and clinically improved. A repeat chest CT was obtained four weeks later, which revealed a drastic improvement and a resolving cavity (*Figure 2B*).

None of the characteristics related to patients or disease severity was associated with an increased risk of mortality. As a result, multiple factors were analyzed in relation to intubation risk (*Table 5*). Importantly, none of the characteristics related to cavity extent (lower *vs.* upper lobe distribution, size of largest cavity, total number of cavities) correlated with intubation rate. On the other hand, the

Table 3 Microbiological data

Variables	N=50
Monomicrobial	20 (40.0)
Polymicrobial	19 (38.0)
Non-identified	11 (22.0)
Associated pathogens	
MSSA	14 (28.0)
MRSA	5 (10.0)
Streptococcus pneumoniae	9 (18.0)
Streptococcus anginosus	4 (8.0)
Pseudomonas sp.	8 (16.0)
Klebsiella sp.	3 (6.0)
Other gram-negative rods	11 (22.0)
Anaerobes	1 (2.0)
Influenza A/B	5 (10.0)

Categorical variables are described as n (%). MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*.

Table 4 Interventions and outcomes

Variables	N=50
Duration of antibiotics (days)	25 [14–40]
Patients with bronchoscopies performed	23 (46.0)
Percutaneous chest tube	16 (32.0)
Surgical chest tubes	13 (26.0)
Decortication surgery	4 (8.0)
Lung resection surgery	0 (0.0)
Duration of hospital stay (days)	26 [15–51]
Duration of ICU stay (days)	14 [8–25]
Duration of mechanical ventilation (days)	12 [5–24]
Need for tracheostomy	8 (16.0)
Mortality	4 (8.0)

Continuous variables are described as median [25–75th percentile] and categorical variables as n (%). ICU, intensive care unit.

extent of parenchymal infiltrates seemed to better correlate with intubation risk. Patients that had infiltrates involving 3 or more lobes had a significant increased risk of intubation [odds ratio (OR) =6.77; 95% CI: 1.6–28.5]. Also, patients with bilaterally distributed infiltrates had an increased risk of intubation when compared to patients with unilateral infiltrates (OR =6.00; 95% CI: 1.7–21.2).

Due to the low mortality rate in our cohort, it was not possible to perform regression analysis on factors associated with mortality. For this reason, we summarize below the characteristics of the four deceased patients (#4, 6, 26 and 52). The first two patients had experienced significant clinical improvement in relation to the acute respiratory episode. They later died from complications not directly related to their necrotizing lung infection. Patient #4 was 81 years old and had a RLL cavity with unilateral infiltrate. He died during hospital stay from unknown causes on the ward. He was found in cardio-respiratory arrest during the nursing night round and his previous vital signs were normal. Patient #6 was 71 years old and had an important RUL cavity with right lung infiltrates and empyema. He developed hypoxemic respiratory failure and required non-invasive ventilation (NIV). He improved with medical management but had a massive aspiration pneumonia on the ward. His family decided not to re-intubate and he was placed in palliative care. Patient #26 was 59 years old and known for significant intellectual handicap. She had a LLL cavity with bilateral infiltrates. She was improving and was extubated on day 8 of mechanical ventilation. Due to physical weakness, she was unable to cough secretions and developed hypoxemia 24 hours after extubation. Her family decided not to re-intubate and she was transitioned to palliative care. Patient #52 was 59 years old and known for a prior autologous transplant in the context of multiple myeloma. He developed a methicillin-resistant *Staphylococcus aureus* (MRSA) pneumonia after *Influenza A* infection. He had significant vasopressor needs and required mechanical ventilation for a total of 23 days. He further developed systemic Herpes simplex virus 1 (HSV-1) reactivation with suspected lung involvement. He was in multi-organ failure with ongoing sepsis and was

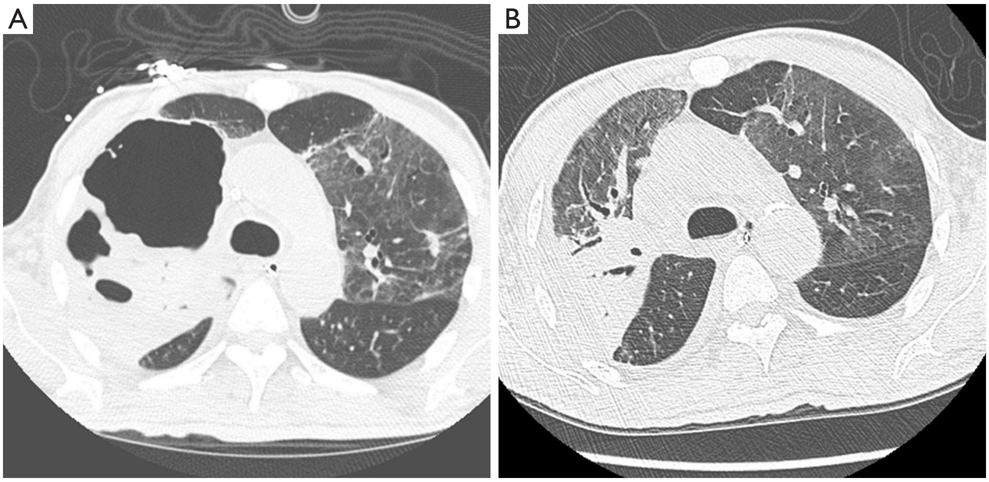

Figure 2 Impressive radiologic improvement over the course of critical care stay, in a 56-year-old female with prolonged mechanical ventilation. (A) Initial CT images revealing significant RUL pulmonary gangrene (max diameter 13.5 cm). (B) CT images obtained 4 weeks later showing marked radiologic evolution and a resolving cavity. The patient was ventilated and required tracheostomy. No surgery was performed. CT, computed tomography; RUL, right upper lobe.

Table 5 Risk for endotracheal intubation

Infection characteristics	Total, N	Intubated, n (%)	P value	OR	95% CI
Distribution of infiltrates					
Unilateral distribution	20	5 (25.0)	0.004	6.00	1.7–21.2
Bilateral distribution	30	20 (66.7)			
Present in 1 or 2 lobes	15	3 (20.0)	0.005	6.77	1.6–28.5
Present in ≥3 lobes	35	22 (62.9)			
Distribution of cavities					
Unilateral	36	15 (41.7)	0.059	–	–
Bilateral	14	10 (71.4)			
Monolobar	29	12 (41.4)	0.152	–	–
Multilobar	21	13 (61.9)			

OR, odds ratio; CI, confidence interval.

transitioned to palliative care.

Discussion

Our retrospective study reviewed the outcome of 50 consecutive cases of severe necrotizing lung infection in a tertiary center, that were admitted in the pre-COVID-19 era. Aggressive medical management and targeted interventions without lung resection surgery resulted in a low mortality rate and the resolution of pneumonia and complications in the overwhelming majority of patients. This was the case despite significant physiologic impairment on admission (half of the patients needed mechanical ventilation/vasopressors) and a high burden of disease (mean CCI of almost 3).

Our care strategy was intended to address overall patient physiology/sepsis, parenchymal infection, pleural complications (complex effusion/empyema, pneumothorax) and parenchymal complications (collections, hemoptysis). Treatment consisted of aggressive medical therapy, which included standard respiratory and circulatory support strategies, early involvement of microbiology and respirology consultants, appropriate antibiotic therapy, bronchoscopy, as well as targeted interventions for complications arising during the patient's course (i.e., percutaneous drainage of pleural/parenchymal collections and bronchoscopic or interventional radiology-driven management of hemoptysis). As previously explained, surgery was strictly reserved for complications not responsive to medical therapy, specifically complex pleural effusions, which were treated by surgical decortication. Parenchymal (namely anatomic) resections were strictly avoided. In this series, the only case of local debridement was in a patient requiring thoracotomy and decortication for a pyo-pneumothorax resulting from a parenchymal cavity that ruptured into the pleural space.

Furthermore, the mortality rate seen in our study is comparable or lower than many of the previously-published cohorts (4-11,13,16,17,21,22,24,28). In fact, it is lower than studies that included medically-treated patients (3–20%) (5,6,12,28) or surgically-debrided patients [8.5–20% (8,10,11,21,25)]. Of course, the comparison with some of these older cohorts is difficult, namely because the management strategies might have differed over time [for example: possibility of receiving less antibiotics, less protective-ventilation strategy and different intensive care unit (ICU) techniques]. Despite having a lower mortality rate than other cohorts of medically-treated patients, our group of patients had similar rates of comorbidities and a greater burden of disease. This is shown by a significantly shorter hospital length of stay [mean: 10–25.7 (6,12) *vs.* 37.3 days in ours] and low PSI scores (12) reported in some papers. Although we did not calculate a PSI score, many patients presented signs of severity: need for vasopressor, mechanical ventilation and presence of empyema. In addition, none of these studies revealed information about patients' ICU stay or need for mechanical ventilation (5,6,12,28). When compared with studies using surgical debridement as mainstay treatment (8,9,11), our medical patients had similar rates of hemoptysis, respiratory failure and septic shock.

Since our in-hospital mortality rate was low, it was not possible to assess risk factors for mortality. However, we found that the risk of intubation was associated with the extent of parenchymal infiltrates (bilateral disease involving 3 or more lobes) rather than the extent of cavitation. This is an interesting finding, because it suggests that parenchymal disease might be a key element linked to clinical deterioration and undermine any rationale in favour of resecting cavitating tissue. Therefore, it is doubtful that any single intervention, especially lung resection, would significantly affect the clinical timeline. Of note, this is in contrast to the recent findings that massive necrosis could be linked to unfavorable outcomes in a Chinese pediatric population (29). Undoubtedly, it is difficult to compare this population to ours because of age, ethnicity and management differences (many severe cases were treated by surgery).

Again, the most important challenge in assessing mortality rates and comparing results across studies is the absence of a clear and consistent definition of disease patterns that fall within the spectrum of severe cavitating pulmonary infections. The rationale behind making a distinction between necrotizing pneumonia and lung gangrene was that according to conventional surgical principles gangrenous tissue should be debrided. In the lung, debridement may include lobectomy or pneumonectomy. However, we argue that there is no clear scientific basis that supports the application of this principle to the lung. In fact, typical cases in our series recovered with minimal radiologic sequelae, highlighting the healing potential of the lung, even in the setting of extensive initial destruction. Interestingly, the absence of long term respiratory impacts, measured by lung function tests, has also been reported in a pediatric population of necrotizing lung infections (none was addressed by surgery) (30). In addition, the risks for anatomic lung resection in this setting are high. The establishment of single lung ventilation, lateral decubitus positioning and surgical handling of the lung risk exacerbating parenchymal inflammation and contaminating spared portions of the lung. The technical challenges of such surgery can be formidable and the risk of intraoperative technical mishaps (major vascular or visceral injury) and severe postoperative complications (bronchopleural fistula) cannot be overstated. Perhaps a more compelling rationale for parenchymal resection would be the removal of infected fluid to prevent continued microbial soiling of the airway and parenchyma, but such an approach is not supported by our results.

To our knowledge, this is the first study that systematically reports the interventions done on medical patients treated for severe necrotizing lung infections. We also reported the proportion of patients that underwent pleural decortication surgery. The distinction between this procedure and parenchymal lung resection surgery is important, the latter causing more morbidity and potentially leading to further complications. A major strength of this study is our selection of patients through a standardized and systematic method to minimize the risk of selection bias for medical or surgical patients. We used a simple radiologic definition of necrotizing lung infection, that could be used in further studies. Many patients that we encounter with severe clinical pictures do fulfill these criteria. Thus, we believe that this study can help guide physicians facing this surgical dilemma. One potential limitation of our study, in addition to the retrospective method of chart review and data collection, was that we only assessed for in-hospital mortality but not for out-of-hospital deaths.

Conclusions

We presented one of the largest series of necrotizing lung infections treated medically. We have proposed what we consider to be a clear and conceptually sound definition of severe cavitating pulmonary infection. As shown in our contemporary cohort of severe lung infections, failure of medical treatment is quite infrequent. There is definitely a place for aggressive medical care in the treatment of moderate to severe cavitary pulmonary infections. In fact, our low mortality rate with "optimal medical therapy" alone supports the idea that surgical indications proposed over the years (4,5,7,9,10,21,23) are only relative ones. An interesting finding was that the extent of cavitation had no impact on the risk of intubation. With this observation in mind, we strongly believe that the extent of cavitation/necrosis on CT cannot be used as a valid argument to justify lung resection surgery [as previous authors claimed (7,8,21)]. There seems to be no rationale and no role for extensive lung resection in severe necrotizing infections. In fact, medical therapy alone should probably be the standard of care. Because no randomized study has been done on the subject, the potential benefit or timing of lung resection surgery will remain a matter of debate.

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This study's preliminary results were presented in abstract form at the 2019 International Conference of the American Thoracic Society, Dallas on May 20th 2019.
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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1590/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1590/dss

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-1590/coif). The authors have no conflicts of interest to declare.

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 institutional ethics board of Hôpital Maisonneuve-Rosemont (No. CIUSSS-EMTL-401) and individual consent for this retrospective analysis was waived.

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