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Lung Abscess and Pyothorax in Critically Ill COVID-19 Patients: A Single-Center Retrospective Study

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ABSTRACT: The mortality rate of patients with COVID-19 pneumonia requiring mechanical ventilation remains high. This study determined the percentage and characteristics of patients who developed lung abscesses or pyothorax and their mortality rates among adult patients with COVID-19 admitted to the ICU who required mechanical ventilation. Of the 64 patients with COVID-19 assessed, 30 (47%) developed ventilator-associated pneumonia (VAP), of whom 6 (20%) developed pyothorax or lung abscess. There were no statistically significant differences in patient characteristics, treatment after ICU admission, or outcomes between those with and without these complications, except for age. VAP complicated by Lung abscess or pyothorax was caused by a single organism, with *Staphylococcus aureus* ($n = 4$) and *Klebsiella* species ($n = 2$) being the primary causative agents. Occur infrequently in patients with COVID-19 requiring mechanical ventilation. Large-scale studies are required to elucidate their effects on clinical outcomes.

KEY WORDS: COVID-19, invasive mechanical ventilation, lung abscess, pyothorax, ventilator-associated pneumonia

To the Editor:

The COVID-19 pandemic has spread at an extremely rapid rate worldwide (1). Respiratory failure caused by COVID-19-associated pneumonia is associated with a high mortality rate and occasionally requires invasive mechanical ventilation (IMV) in the ICU (2). This high mortality rate can partially be explained as being caused by complications that occur during IMV, such as ventilator-associated pneumonia (VAP) and pneumothorax (3–5). Lung abscesses or pyothorax are complications of VAP or pneumothorax that are likely to be lethal (6). Despite the increased chance of lethality, reports on these complications are limited, and their microbiological characteristics and association with prognosis are unclear.

In this study, the epidemiology of lung abscesses and pyothorax was retrospectively examined, and their impact on the outcomes of COVID-19 patients was assessed to determine the proportion of patients who developed lung abscesses or pyothorax, their mortality rates, and the characteristics of patients with these complications.

METHODS

A retrospective review was performed at the Advanced Emergency and Critical Care Center of Hiroshima University Hospital on patients from July 2019 to February 2022. All adult (≥ 18 yr old) patients with COVID-19 admitted to

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the ICU who required IMV and subsequently developed VAP were included. VAP was defined as new or progressive infiltration observed on chest radiograph accompanied by at least two of the following factors: a body temperature of more than 38.5°C or less than 36.5°C, leukocytosis (total peripheral white blood cell count ≥ 12,000 cells/μL or ≤ 4,000 cells/μL), or the new onset of purulent tracheal secretions (7). In addition, VAP was microbiologically confirmed by the semi-quantification of microorganisms using culture from tracheal aspirate or bronchoalveolar lavage fluid (7).

Data were retrospectively collected from electronic chart reviews, including patient characteristics, medications administered after ICU admission, respiratory management, organ support, ICU mortality, length of ICU and hospital stay, and the development of complications (lung abscess or pyothorax). For lung abscess

TABLE 1.
Patient Characteristics and Outcomes

Variables	Without Lung Abscess or Pyothorax (*n* = 24)	With Lung Abscess or Pyothorax (*n* = 6)
Patient's characteristics and ICU scores		
Male sex, *n* (%)	22 (88)	5 (83)
Age, median (IQR)	58 (55–66)	68 (64–70)
Body Mass Index, median (IQR)	26.3 (24.9–29.9)	27.9 (25.3–31.1)
Sequential Organ Failure Assessment at ICU admission, median (IQR)	5 (4–6)	4 (4–5)
Acute Physiology and Chronic Health Evaluation II score, median (IQR)	17.0 (14–20)	19 (17–21)
Comorbidities, *n* (%)		
Diabetes mellitus	5 (20)	2 (33)
Chronic respiratory diseases	3 (12)	0 (0)
Chronic kidney diseases	1 (4)	1 (16)
Immunosupression[a]	3 (12)	0 (0)
Treatment administered upon ICU admission, *n* (%)		
Antibiotic therapy	1 (4)	0 (0)
Antiviral drug (remdesivir or favipiravir)	3 (12)	2 (33)
Corticosteroids	22 (88)	5 (84)
Immunosuppressant drugs (tocilizumab or baricitinib)	4 (16)	3 (50)
Organ support in ICU, *n* (%)		
Vasopressor support	9 (36)	4 (67)
Renal replacement therapy	3 (12)	3 (50)
Extracorporeal membrane oxygenation	5 (20)	2 (33)
Prone positioning	20 (83)	4 (67)
Outcomes		
ICU mortality, *n* (%)	6 (25)	3 (50)
Length of ICU stay, d, median (IQR)	15 (12–26)	22 (18–27)
Length of hospital stay, d, median (IQR)	23 (15–29)	30 (25–39)
Ventilator-free days, median (IQR)	12 (0–16)	4 (0–10)

IQR = interquartile range.

[a]Includes congenital immunodeficiency, malignancies, organ, or bone marrow transplants, and receipt of immunosuppressive agents.

or pyothorax development, the time from intubation to onset, time from diagnosis to VAP onset, foci, pathogens, and treatment modalities were also investigated.

Chest CT scans were reviewed to diagnose pyothorax or lung abscess. Lung abscess was defined as lung cavitation with an air-fluid level and thick wall, whereas pyothorax was diagnosed if there was fluid accumulation in the thoracic cavity on the CT scan and by confirming the recovery of any pathogen from the aspirated thoracic fluids in aerobic/anaerobic microbiological culture.

Continuous variables without a normal distribution are presented as medians with interquartile ranges (IQR). Categorical data were summarized as numbers or percentages. For univariate analysis, the Mann-Whitney *U* test for continuous variables and Fisher exact test for categorical variables were used for comparison. Statistical tests were two-tailed, and statistical significance was set at p less than 0.05. All statistical analyses were performed using EZR (8), a graphical user interface for R (R Foundation for Statistical Computing, Vienna, Austria).

This study was approved by the institutional review board at Hiroshima University (E2022-0157).

RESULTS

During the study period, of the 64 patients with COVID-19 who received IMV, 30 patients developed VAP, and 6 (20%) of these 30 patients with VAP were found to have lung abscesses or pyothorax. There were no statistically significant differences in patient characteristics or treatment after ICU admission between the groups with and without lung abscesses or pyothorax, except for age (**Table 1**). The use of tocilizumab and barcitinib was more common in the group with lung abscess or pyothorax than in the uncomplicated group, but the use of corticosteroids did not differ between the two groups.

The characteristics of the patients with lung abscesses and pyothorax are described in **Table 2**. There were five cases of lung abscesses (one case was complicated by pyothorax) and one case of pyothorax alone. Lung abscess or pyothorax were diagnosed within a median time of 15 (IQR, 10–18) days after tracheal intubation and a median time of 4 (2–7) days after the onset of VAP. All lung abscesses occurred in the right lung, with three patients showing occurrence in the upper lobe. The main causative organisms identified by culture were *Staphylococcus aureus* ($n = 4$) and *Klebsiella* species ($n = 2$), and all infections were found to be monomicrobial (**Table 3**). Two patients with concomitant lung abscesses or pyothorax required transcutaneous drainage. All patients received appropriate empirical and targeted antimicrobial therapy (Table 3).

TABLE 2.
The Characteristics of the Patients With Lung Abscess and Pyothorax ($n = 6$)

Complications, *n* (%)	
Lung abscess	4 (66)
Pyothorax	1 (17)
Lung abscess + pyothorax	1 (17)
Duration until occurrence of complications, median (IQR)	
Days from tracheal intubation	15 (10–18)
Days from diagnosis of ventilator-associated pneumonia	4 (2–7)
Reason for performing chest CT scan, *n* (%)	
Clinical or radiological suspicion of complications	1 (17)
Persistent respiratory failure	5 (83)
Number of lung abscesses on chest CT scan, *n* (%)	
One	4 (80)
Two or more	1 (20)
Localization of lung abscesses on chest CT scan, *n* (%)	
Right upper lobe	3 (60)
Right lower lobe	2 (40)
Lateralization of pyothorax on chest CT scan, *n* (%)	
Right	2 (100)
Left	0 (0)
Larger diameter of lung abscess on chest CT scan, mm, median (IQR)	51 (35–52)

CT = computerized tomography, IQR = interquartile range.

The ICU mortality rates tended to be higher in the group with complications than in that without (50 vs 25%), but the difference was not significant ($p = 0.33$). The lengths of ventilator-free days, ICU stay, and hospital stay were similar between the two groups.

DISCUSSION

In the present study, one-fifth of COVID-19 patients with VAP had lung abscesses or pyothorax, and the

TABLE 3.
Causative Organisms and Treatment of Patients With Lung Abscesses and Pyothorax

Patient no.	VAP Pathogens	Initial Antibiotics	Target Antibiotics	Complication	Culture of Pyothorax and Lung Abscess	Drainage
1	MSSA	Sulbactam/ampicillin	Cefazolin	Lung abscess	Not performed	–
2	*Klebsiella pneumoniae*	Sulbactam/ampicillin	Cefazolin	Lung abscess	Not performed	–
3	MSSA	Sulbactam/ampicillin	Cefazolin	Lung abscess	Not performed	–
4	MSSA	Cefazolin	Cefazolin	Lung abscess	Not performed	–
5	MRSA	Vancomycin	Vancomycin	Lung abscess +pyothorax	MRSA	+
6	*Klebsiella aerogenes*	Tazobactam/ piperacillin	Sulbactam/ ampicillin	Pyothorax	*K. aerogenes*	+

MRSA = methicillin-resistant *Staphylococcus aureus*, MSSA = methicillin-sensitive *Staphylococcus aureus*, VAP = ventilator-associated pneumonia.

mortality rate was as high as 50%. The occurrence of lung abscesses in patients with COVID-19 pneumonia complicated by VAP has previously been reported to be 12–14% (6, 9), which is comparable to the lung abscess rate of 16% in the present study. There was no statistically significant difference in mortality between the patients with and without lung abscesses or pyothorax; this may have been due to the relatively lower mortality seen in the patients with complications in this study, although it has been reported to be as high as 65% in a previous study (6). In addition, the small number of cases ($n = 6$) suggests insufficient power to properly detect a statistically significant difference in this metric.

VAP complicated by lung abscess or pyothorax was caused by a single organism, with methicillin-sensitive *S. aureus* being the most common, followed by *Klebsiella* species. In contrast, in previous studies, most patients had infections caused by multiple organisms, with *Pseudomonas aeruginosa* being the most common (6). This difference in causative organisms may be attributed to the relatively low rate of antimicrobial use at ICU admission compared with that in the previous study. Another study reported that the same organisms were persistently detected in the lung samples from two-thirds of patients with lung abscesses, suggesting that the failure of VAP treatment or recurrence may be involved (6). In this study, the same organism was detected in the pyothorax samples; however, we were unable to obtain lung abscess samples. Therefore, we were unable to assess the cause of the lung abscesses or pyothorax.

This study had a few limitations. First, this retrospective study was conducted at a single institution, limiting the number of cases studied. Similar to a previous study (6), the present study was insufficient to identify factors associated with the development of lung abscesses or pyothorax or their impact on clinically significant outcomes. Second, a lack of predefined evaluation of imaging studies or follow-up on sputum cultures potentially affected the detection rate of complications.

CONCLUSIONS

The incidence of lung abscesses and pyothorax in COVID-19 patients with concomitant VAP was 20%, with a mortality rate of 50%. Conducting multicenter epidemiological studies to investigate the risk factors for complications and the association between complications and outcomes is suggested.

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