Outcomes of Tube Thoracostomies in COVID-19 Patients: A Retrospective Cohort Study in the University of the Philippines - Philippine General Hospital COVID-19 Referral Center

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ABSTRACT

Objective. To describe the treatment outcomes of patients who underwent tube thoracostomy for pleural complications in patients with COVID-19 and determine the association between patient profile and treatment outcomes.

Methods. A single-institution retrospective review of patients who underwent tube thoracostomy for complications of COVID-19 infection in the University of the Philippines - Philippine General Hospital (UP-PGH) from March 30, 2020, to March 31, 2021, was performed. These patients' demographic and clinical profiles were evaluated using median, frequencies, and percentages. The association between patient profile, and mortality and reintervention rates was assessed using univariable Cox proportional hazards regression analysis.

Results. Thirty-four (34) of 3,397 patients (1.00%) admitted for COVID-19 pneumonia underwent tube thoracostomy. Of these, 34, 47.06% were male, 52.94% were female, the median age was 51.5 years old, 85.29% had comorbid conditions, and 29.41% had a previous or ongoing tuberculous infection. The most common indication for tube thoracostomy was pleural effusion (61.76%), followed by pneumothorax (29.41%), and pneumo-hydrothorax (8.82%). The mortality rate was 38.24%, and the reintervention rate was 14.71%. Intubated patients had 14.84 times higher mortality hazards than those on room air. For every unit increase in procalcitonin levels, the mortality hazards were increased by 1.06 times.

Conclusion. An increasing level of oxygen support on admission and a level of procalcitonin were directly related to mortality risk in COVID-19 patients who underwent tube thoracostomy for pleural complications. There is insufficient evidence to conclude that patient-related, COVID-19 pneumonia-related, and procedure-related factors included in this study were significantly associated with reintervention risk.

Keywords: tube thoracostomy, COVID-19 pneumonia, pleural complications

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INTRODUCTION

In December 2019, the first case of Severe Acute Respiratory Syndrome secondary to Coronavirus-2 (SARS-CoV-2), an adenovirus primarily affecting pulmonary parenchyma, was reported in Wuhan, China.[1] Just months after the first detected case, in March 2020, the World Health Organization (WHO) declared COVID-19 a global pandemic affecting 219 countries worldwide. By the end of that month, on March 30, 2020, the UP-PGH began its operations as the country's first COVID-19 referral center. Since then, it has catered to 7,188 COVID-19 admissions.[2]

Pleural complications confound patients with COVID-19 due to several factors: comorbid conditions predisposing to the development of pleural effusion such as chronic kidney disease (CKD) and congestive heart failure; concurrent infective processes such as tuberculous empyema; acute events such as development of Acute Respiratory Distress Syndrome (ARDS) requiring high-pressure mechanical ventilation causing barotrauma pneumothorax from endotracheal intubation and central venous catheter placement, and even spontaneous rupture of pulmonary blebs.[3,4] The prevalence of pleural effusion in COVID-19 pneumonia patients is estimated at 9.55%. Pleural effusion is associated with increased odds of death compared to COVID-19 patients without pleural effusion (OR 4.53, 95% CI).[5] ARDS requiring mechanical ventilation with high peak end-expiratory pressures can contribute to the incidence of pneumothorax and pneumomediastinum through the Macklin effect.[4] Pneumothorax complicates 7.4% of COVID-19 patients, with mortality rates estimated at 60%, with increasing incidence in critically ill and ventilator-requiring patients.[6]

Whether COVID-19 incites a pleural reaction predisposing to pleural effusion, empyema, or pneumothorax has not been elucidated. Reported cases in the literature suggest an exudative pleural process or even a pathology in the peripheral lung pneumocytes.[3,7] Case reports of open-lung biopsy in COVID-19 patients revealed findings consistent with the early phase of proliferative diffuse alveolar damage and thrombosis of alveolar capillaries.[1,8] Bacterial and viral cultures (SARS-CoV-2) performed on tissue and fluid collected were negative, but SARS-CoV-2 RT-PCR positive results have also been reported.[8] Most pleural complications necessitate surgical intervention, commonly through a tube thoracostomy.

The mortality rate from pleural complications in patients with COVID-19 pneumonia approaches 70%.[4] However, the causal relationship and proportionality to disease severity remain unclear. It has been said that pleural effusion indicates a severe inflammatory reaction, as evidenced by a concomitant increase in inflammatory markers. It could predict progression to acute disease and poor prognosis.[9,10]

Multiple publications have described the implications of pleural complications in patients with COVID-19, such as pleural effusion, pneumothorax, and pneumomediastinum. However, none has described that of tube thoracostomy, which may be an independent risk factor for mortality in these subsets of patients. This study sought to establish information on COVID-19 patients with pleural complications needing tube thoracostomy treated at the UP-PGH, a tertiary COVID-referral center. Specifically, we aimed to 1). describe the demographic and clinical profile of patients who underwent tube thoracostomy for pleural complications in COVID-19-afflicted patients, 2). the immediate outcomes of their treatment, and 3). determine the association between these two factors. Moreover, no similar local studies or data are available in the Philippines, where the prevalence of tuberculous disease is high. Western studies may not represent the heterogeneity of pleural diseases complicating COVID-19 patients.

With the information gained from this research, we can identify predictors of poor prognosis and modifiable risk factors by determining the demographic and clinical profile of COVID-19 patients who underwent tube thoracostomy and correlating these with their surgical outcomes. This information can help refine medical and surgical interventions and improve patient outcomes. This study can aid surgeons in managing patients with COVID-19 pneumonia and pleural disease, and medical professionals in prognosticating and stratifying disease severity if an association can be established. Repeated surgical interventions, prolonged hospital stays, and morbidities and mortalities can be avoided. Ultimately, we aim to reduce the disease burden and cost of treatment for COVID-19.

METHODS

This retrospective cohort study involved a review of patient medical records. The study included all adult patients (age >18 years) admitted at the UP-PGH with COVID-19 diagnosed via RT-PCR swab testing who underwent tube thoracostomy between March 30, 2020, and March 31, 2021. Patients who received postoperative tube thoracostomy in open chest surgeries, e.g., after cardiac surgery, lung resection, or esophagectomy for caustic ingestion, were excluded.

Patients were identified using the Integrated Surgical Information System (ISIS) database of the Department of Surgery and the Philippine General Hospital's Computerized Registry of Admissions and Discharges (RADISH).

Demographic and clinical data were collected, such as age, sex, comorbidities (e.g., COPD, bronchial asthma, hypertension, diabetes mellitus, CKD, congestive heart failure, chronic liver disease), previous or present pulmonary or extrapulmonary tuberculosis, previous chest surgeries, symptoms on admission, the severity of COVID illness on admission, COVID-19 vaccination status, duration (days) of symptoms before tube thoracostomy, duration (days) of ventilator management before tube thoracostomy, diagnosis/indication for tube thoracostomy, type of drain (e.g., pigtail catheter, JP drain, chest tube), chest radiograph and ultrasound findings, blood and sputum culture, inflammatory markers, pleural fluid studies (e.g., Light's criteria, pleural fluid culture, and TB studies, cytology and histopathology).

Data were also collected on the clinical course and surgical outcomes such as complete or partial lung re-expansion after tube thoracostomy, need for reintervention (e.g., tube revision, tube re-insertion, VATS, thoracotomy, fibrinolysis), duration (days) of ICU admission, duration (days) of ventilator management after tube thoracostomy, duration (days) with tube thoracostomy, all-cause mortality rate, duration (days) after tube thoracostomy to discharge,

duration (days) after tube thoracostomy to mortality including all-cause mortality rate. The degree of lung expansion was determined by complete resolution or interval decrease in pneumothorax or pleural effusion with documented apposition of the visceral and parietal pleura by chest radiography or CT scan. Indications for reintervention included partial lung expansion, unchanged or interval increase in pneumothorax or pleural effusion, worsening clinical symptoms, or inadvertent tube removal. The need for re-intervention was discussed thoroughly and approved by a board- certified thoracic surgeon. Patients' data were made anonymous by assigning a code.

The University of the Philippines Manila Research Ethics Board approved the study protocol.

Descriptive statistics summarized the demographic, clinical profile, and outcomes. Numerical variables were described as median and interquartile range; categorical variables were expressed as count and percentage. The association of the different factors of interest with in-hospital mortality was determined by univariable Cox proportional hazards regression. Mortality was the failure event, discharge was the success event, and time-to-mortality or discharge was the time-to-event. The association of the different factors of interest with reintervention was determined by univariable logistic regression. All analyses were performed using Stata 17.0 and were evaluated at α=0.05.

RESULTS

From March 30, 2020, to March 31, 2021, 3,397 patients with COVID-19 pneumonia were admitted to the UP-PGH. Thirty-four of these patients underwent tube thoracostomy. Table 1 shows the demographic profile of these patients.

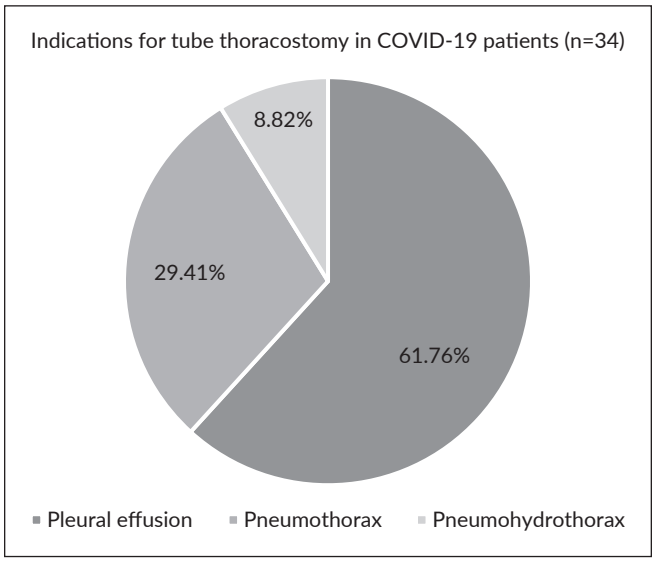

Figure 1. Pie chart of indications for tube thoracostomy in patients with COVID-19 pneumonia (n=34).

The median age was 51.5 years (IQR = 21), with sixteen (47.05%) males and eighteen (52.94%) females.

The most common comorbidity was an active or previous malignancy (18/34, 52.04%), with breast cancer being the most common primary malignancy (7/18, 38.89 %). Three patients each (9.09%) had COPD, bronchial asthma (9.09%), and chronic kidney disease (9.09%). Thirteen (38.24%) had hypertension, and five (14.71%) had diabetes mellitus. One patient each had congestive heart failure (2.94%), prior coronary artery disease (2.94%), and with history of chronic steroid use (2.94%). Of all these patients, only five did not have any comorbid conditions.

Pulmonary tuberculosis, whether clinically diagnosed or bacteriologically confirmed, may confound the incidence of pleural disease in patients with COVID-19 pneumonia. Almost one-third (10/34, 29.41%) of patients in this study had previous pulmonary tuberculosis, with only three out of the ten having completed previous treatment. Of all subjects, only three out of twenty-five (12.00%) (Table 1) had microbiologic evidence of Mycobacterium tuberculosis on pleural fluid samples. Nine (27.3%) patients from this study had also undergone a previous thoracic surgery, the most common being a previous ipsilateral thoracentesis.

Among all these patients, only three (8.8%) were found to have no apparent symptoms upon admission. The most common complaint was still shortness of breath (85.29%). In comparison, others experienced cough (52.94%), easy fatigability (26.47%), fever (17.65%), in decreasing order of frequency, and even less commonly myalgia (8.82%), nausea and vomiting (8.82%), diarrhea (5.88%) and anosmia (5.88%). Based on the WHO Severity Classification for COVID-19 pneumonia, there were five (14.71%), fifteen (44.12%), nine (26.47%), and five (14.71%) patients who had mild, moderate, severe, and critical disease, respectively. Since the study's time frame was towards the early phases of the pandemic, none of the patients had received any form of COVID vaccination.

From the study population, the most common indication for tube thoracostomy was pleural effusion (61.76%), followed by pneumothorax (29.41%) and the combination of both entities, pneumo-hydrothorax (8.82%) (Figure 1). Hemothorax, empyema thoracis, and chylothorax were not noted in these subsets of patients.

Upon admission into the hospital, the patients' median Mean Arterial Pressure (MAP) was at 93.5 mmHg (IQR = 18.33). The median heart rate is noted to be within the upper border of normal 100.5 bpm (IQR = 29.75). None of the patients were bradycardic on admission; 47.06% had a normal heart rate, while 52.94% had tachycardia over 100 bpm. Of the common inflammatory markers taken upon the time of the procedure, median white blood cell count (WBC) was noted at 11.35 (IQR = 4.95), procalcitonin was 0.405 (IQR = 0.6525), and CRP 55.5 (IQR = 122.765).

Blood cultures were also positive in five (15.62%) out of 32 cases. Sputum or endotracheal secretions were also positive in five (22.73%) of 22 cases. Interestingly, none of

the pleural fluid studies from patients with pleural effusion rendered positive aerobic culture results. As previously mentioned, three out of twenty-five (12%) cases had a positive Mycobacterium Tuberculosis (MTB) study.

Table 2 shows the outcomes of patients who underwent tube thoracostomy for pleural complications in COVID-19 pneumonia. Of the thirty-four patients in this study, twelve (35.29%) required intensive care unit admission. There were thirteen mortalities (38.24%). There were five (14.70%) cases requiring reintervention, with three (8.82%) tube revisions and two (5.88%) tube reinsertions.

Of the thirty-four patients, twenty (58.82%) were discharged, thirteen (38.82%) expired, and one (2.9%) absconded. Of those discharged, ten (47.62%) were sent home with a chest tube, most of whom had a chest tube due to pleural effusion (80.00%). Seventeen patients (50.00%) achieved complete lung expansion; the rest only had partial lung re-expansion.

Table 1. Demographic and Clinical Profile of 34 Patients who Underwent Tube Thoracostomy for COVID-19 Pleural Complications

Characteristic	Frequency	Percentage
Age, years	Median = 51.5 Interquartile range = 21	
19-39	7	20.59
40-49	9	26.47
50-59	9	26.47
60-69	6	17.65
70-79	3	8.82
Sex		
Male	16	47.06
Female	18	52.94
Known comorbidities		
COPD	3	8.82
Bronchial asthma	3	8.82
Hypertension	13	38.24
Diabetes Mellitus	5	14.71
Coronary artery disease	1	2.94
Cerebrovascular disease	0	0.00
Chronic Kidney Disease	3	8.82
Congestive Heart Failure	1	2.94
HIV	0	0.00
Chronic steroid use	1	2.94
Active or previous malignancy	18	52.94
Previous or present tuberculosis	10	29.41
Pulmonary tuberculosis	10	29.41
Extrapulmonary tuberculosis	0	0.00
Treatment completed [n=10]	3	30.00
Previous chest surgeries		
Tube thoracostomy, ipsilateral	1	2.94
Tube thoracostomy, contralateral	1	2.94
Other thoracic surgery	7	20.59
Symptoms on admission		
No apparent symptoms	3	8.8
Cough	18	52.94
Fever	6	17.65
Chills	0	0.00
Shortness of breath	29	85.29
Fatigue	9	26.47
Myalgia	3	8.82
Headache	0	0.00
Anosmia	2	5.88
Sore throat	0	0.00
Congestion or rhinorrhea	1	2.94
Nausea or vomiting	3	8.82
Diarrhea	2	5.88

Characteristic	Frequency	Percentage
COVID Severity		
Mild	5	14.71
Moderate	15	44.12
Severe	9	26.47
Critical	5	14.71
COVID Vaccination status		
Unvaccinated	34	100.00
Vaccinated	0	0.00
Indication for tube thoracostomy		
Pleural effusion	21	61.76
Pneumothorax	10	29.41
Hemothorax	0	0.00
Pneumo-hydrothorax	3	8.82
Empyema thoracis	0	0.00
Chylothorax	0	0.00
Hemodynamic parameters		
Mean arterial pressure, mmHg	Median = 93.5 Interquartile range = 18.33	
<65	0	0.00
≥65	34	100.00
Heart rate, bpm	Median = 100.5 Interquartile range = 29.75	
<60	0	0.00
60-99	16	47.06
≥100	18	52.94
WBC	Median = 11.35 Interquartile range = 4.95	
<4.5	0	0.00
4.5-11.0	16	47.06
>11.0	18	52.94
Procalcitonin, ng/ml [n=31]	Median = 0.405 Interquartile range = 0.6525	
<0.25	13	41.93
≥0.25	18	58.06
CRP, mg/L	Median = 55.5 Interquartile range = 122.765	
<6.00	3	8.82
≥6.00	31	91.18
Microbiologic studies		
Blood culture positive [n=32]	5	15.62
Sputum/ETA culture positive [n=22]	5	22.73
Pleural fluid culture positive [n=25]	0	0.00
Pleural fluid M.tb. Positive [n=25]	3	12.00

Table 2. The Outcomes of Patients who Underwent Tube Thoracostomy for Pleural Complications in COVID-19 (n=34)

Outcome	Frequency	Percentage
Lung re-expansion		
Complete	17	50.00
Partial	17	50.00
ICU admission	12	35.29
Mortality	13	38.24
Went home with CTT among survivors	10	47.62
Reintervention		
Tube revision	3	8.82
Tube reinsertion	2	5.88
VATS	0	0.00
Fibrinolysis	0	0.00

Table 3. The Length of Stay (days) of Patients who Underwent Tube Thoracostomy for Pleural Complications in COVID-19

Length of stay, *days*	Median	IQR
ICU stay	8	8
Total hospital stay	18	23
Among survivors	26	21
Among mortality	13	16
Number of days from CTT insertion		
To discharge among survivors	14	11.5
To mortality	6	11

Among survivors, the median length of hospital stay was 26 days (IQR 21), two times longer than the length of stay for mortalities (13 days, IQR 16). The median number of days from tube insertion to discharge among survivors is 14 days (IQR 11.5), significantly longer than the tube duration in mortalities which is only six days (IQR 11) (Table 3).

Table 4 describes the factors associated with in-hospital mortality and reintervention among patients who underwent tube thoracostomy for pleural complications in COVID-19. The hazard ratio for mortality and the odds ratio for reintervention is computed for the patient-related, COVID-19-related, and procedure-related factors. All patient-related factors were not statistically significant.

Among COVID-19-related factors, presence of symptoms on admission, hemodynamic instability, and COVID-19 severity classifications rendered statistically insignificant associations. Regarding oxygen requirement, intubated patients had a14.84 times increase in mortality hazard compared to those on room air only (HR 1.95%, p-value 0.004, 95% CI 2.36-93.42). Though there was also an increased mortality hazard in those on nasal cannula (HR 1.95%, p-value 0.466, CI 0.32-11.75) and face mask (HR 2.69%, p-value 0.282, 95% CI 0.44-16.40), these were not statistically significant. It is important to note that these means of oxygen supplementation were taken upon admission and not at the time of the procedure. Hence, none of the patients were on high-flow nasal cannula since this was an institutional limitation.

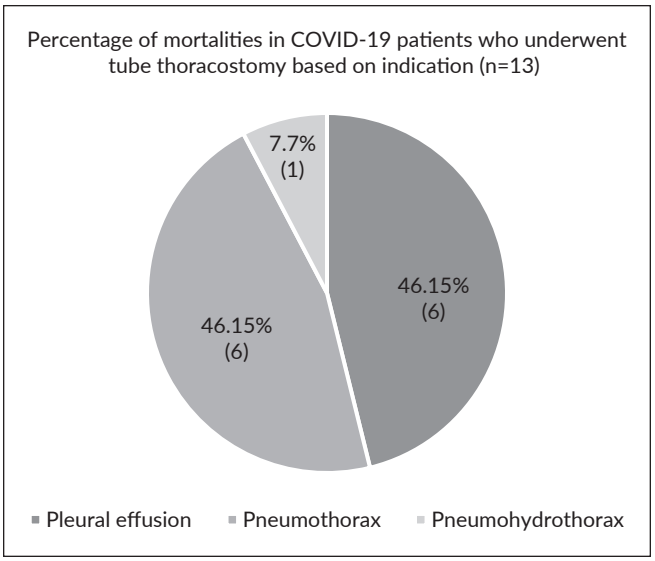

Figure 2. Pie chart of proportion of mortalities in COVID-19 patients who underwent tube thoracostomy based on indication (n=13).

Among procedural factors relating to mortality, it was notable that the initial indication for intervention had no statistically significant association with mortality. Figure 2 illustrates the proportion of mortalities incurred based on indication for the procedure, with six out of the thirteen (46%) mortalities from those with pleural effusion, six (46%) from pneumothorax, and one (8%) from pneumo-hydrothorax. Meanwhile, among those with pneumothorax (n=10), six died (60%) compared to those with pleural effusion (n=21), where six died (28.6%), and those with pneumo-hydrothorax (n=3), where only one (33%) died.

The laterality of the procedure (unilateral vs. bilateral tube thoracostomy) did not render any increased risk for mortality or reintervention. Comparing a Jackson-Pratt drain vs. a chest tube, for every numerical increase in the French size of the drain, hazards of mortality increased by 1.05 times (p-value 0.435, 95% CI 0.93-1.20), and hazards of reintervention increased by 1.09% times (p-value 0.478, 95% CI 0.86-1.37), however both hazards risk were statistically insignificant.

Among the peri-operative laboratory parameters of subjects, for every unit increase in procalcitonin levels, the mortality hazards were increased by 1.06 times (p-value 0.011, 95% CI 1.01-1.11). Increased WBC and CRP did not have a similar statistically significant effect on mortality and reintervention.

Figure 3 illustrates the distribution of reinterventions performed based on the initial indication for tube thoracostomy. Four (80.00%) of the second interventions were for patients with pleural effusion as the initial indication and one (20.00%) with pneumothorax as the indication.

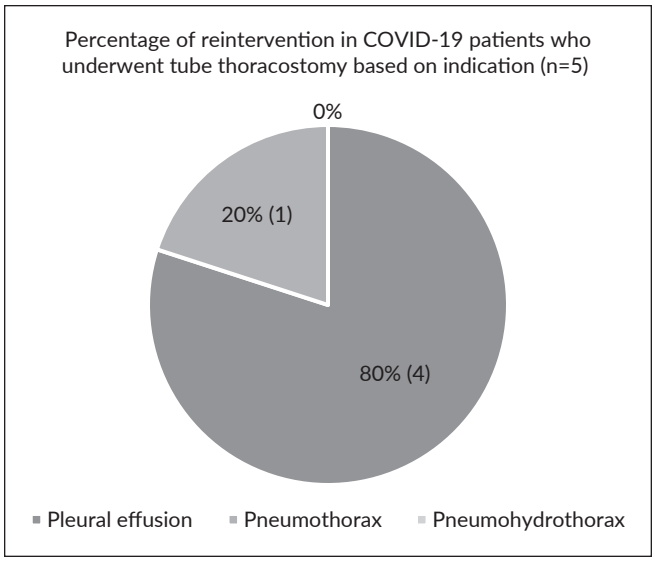

Figure 3. Pie chart of proportion of reinterventions in COVID-19 patients who underwent tube thoracostomy based on indication (n=5).

Out of the thirty-four subjects, only five patients (14.7%) had to undergo tube revision (3, 8.82%) and re-insertion (2, 5.88%). Those who had to undergo reintervention were predominantly from the pleural effusion subset (80%), and only one patient (20%) had to undergo reintervention for pneumothorax. Data associating the type of drain used, and the drain size, needed to be more consistent. Three (60%) used JP drains, one (20%) had a French 28-chest tube, and another (20%) had a French 32-chest tube. Most patients with a JP drain inserted did not require a second intervention for drainage (76.92%). However, only four out of the thirteen (30.77%) of those who utilized a JP drain achieved complete radiologic lung expansion.

DISCUSSION

The limited data provided in this study supports previous publications theorizing that COVID-19 patients receiving a tube thoracostomy for the pleural disease have a poor prognosis. The largest and most recent of these studies was a multicenter retrospective observational cohort study of ICU patients admitted for COVID-19 pneumonia in the Pennsylvania Health System, which concluded that those

Table 4. Factors Associated with In-hospital Mortality and Reintervention among Patients who Underwent Tube Thoracostomy for Pleural Complications in COVID-19

Factors	Mortality			Reintervention		
	HR	95% CI	*p*-value	OR	95% CI	*p*-value
Patient factor						
Age	1.01	0.97, 1.06	0.533	0.85	0.87, 1.03	0.190
Sex	1.15	0.37, 3.64	0.806	0.18	0.02, 1.78	0.142
Pulmonary tuberculosis	0.41	0.09, 1.90	0.257	*	*	*
Prior chest surgery	0.23	0.03, 1.83	0.165	2.56	0.35, 18.92	0.358
COVID-19 factor						
Presence of symptoms on admission	0.35	0.07, 1.67	0.189	0.46	0.04, 5.60	0.544
Hemodynamic instability	0.86	0.28, 2.70	0.803	4.92	0.49, 49.61	0.176
Disease severity						
Mild/Moderate	Reference			Reference		
Severe/Critical	2.26	0.71, 7.17	0.167	0.31	0.03, 3.10	0.317
O_2 support						
Room air	Reference			Reference		
Nasal cannula	1.95	0.32, 11.75	0.466	0.18	0.02, 1.92	0.154
Face mask	2.69	0.44, 16.40	0.282	*	*	*
Intubated	14.84	2.36, 93.42	0.004	*	*	*
Procedural factor						
Indication for surgery						
Pleural effusion	Reference			Reference		
Pneumothorax	2.03	0.61, 6.72	0.245	0.67	0.06, 7.35	0.741
Pneumo-hydrothorax	0.98	0.12, 8.22	0.989	3.00	0.20, 44.36	0.424
Bilateral procedure	0.93	0.12, 7.29	0.943	3.38	0.25, 46.36	0.363
Size of drain	1.05	0.93, 1.20	0.435	1.09	0.86, 1.37	0.478
Inflammatory markers						
WBC	0.13	0.97, 1.19	0.150	0.81	0.58, 1.11	0.191
Procalcitonin	1.06	1.01, 1.11	0.011	0.64	0.11, 3.62	0.612
CRP	1.00	0.99, 1.00	0.415	1.00	0.99, 1.01	0.859

requiring tube thoracostomy within the course of their COVID-19 infection heralded an unfavorable prognosis in terms of increased mortality, prolonged duration of mechanical ventilation, prolonged ICU LOS, and hospital LOS. Furthermore, they identified that delayed development of pleural disease requiring tube thoracostomy was associated with decreased survival.[11]

The prevalence of tube thoracostomy in COVID-19 critically-ill patients is estimated at 4.0%.[11] This is significantly higher than the prevalence of tube thoracostomy in all COVID-19-positive patients in the Philippine General Hospital, which is 1.05%. A total of 34 patients satisfied the inclusion criteria for this retrospective study, among whom 13 (38.24%) expired. This finding is comparable to results from Geraci et al., with 44.9% in-hospital mortality in the tube thoracostomy group compared to 27.1% mortality in those who did not receive tube thoracostomy.[12]

None of the patient characteristics analyzed in this study had a statistically significant association with mortality. A systematic review of 207 articles across 12 countries, including 75,607 patients, identified radiographic findings of pleural effusion as a poor prognostic factor in those with COVID-19 pneumonia, with an odds ratio for severe ARDS at 3.31%. However, tube thoracostomy as a procedure for treating pleural effusion was not investigated as a possible prognostic factor in this study. Patient-related factors identified as predictors of severe disease included age per 10 years increase, male sex, active smoking status, presence of comorbidity, cerebrovascular disease, COPD, CKD, coronary heart disease or heart failure, arrhythmia, hypertension, diabetes, dementia, obesity, and dyslipidemia.[13] Similar comorbid conditions were noted in this study; however, none of these factors showed a statistically significant difference in survival rate or reintervention rate. A larger study population is hence, recommended.

Multiple studies cite increasing age as a prognostic factor for mortality in COVID-19.[14,15] Goldstein et al. noted that all-cause mortality across age groups increases by 10% every year above the age of 30.[14] Bonanad et al. noted <1.1% mortality in patients aged less than 50 years old, with the most significant increase in mortality risk at age 60-69 (odds ratio 3.13, 95% confidence interval 2.61-3.76).[15] The age distribution of COVID-19 patients who required tube thoracostomy was not normally distributed. The highest age frequencies were noted at ages 40-49 and 50-59 (Table 1). Age correlation to the incidence of pleural complications requiring tube thoracostomy cannot be determined.

Indications for tube thoracostomy may be divided into pneumothorax, pleural effusion, pneumo-hydrothorax, empyema thoracis, and hemothorax. In the published literature, pneumothorax is the leading indication for tube thoracostomy in COVID-19-afflicted patients, with an incidence as high as 7.6%.[11] However, pneumothorax in COVID-19 pneumonia is not in itself an independent poor prognostic factor as suggested by retrospective studies by Martinelli et al. and Wang et al.[16,17] The rationalization for such a high incidence rate of pneumothorax in COVID-19 infection is backed up by autopsies of deceased COVID-19 patients revealing diffuse alveolar damage with perivascular T-cell infiltration, diffuse pulmonary vessel microangiopathy and thrombosis depicting noncompliant lungs, combined with the need for positive pressure ventilation.[6,12] The incidence of pneumothorax in adult COVID-19-positive patients admitted to the Philippine General Hospital is 3.09% only. This study's leading indication for tube thoracostomy was pleural effusion (61.76%) instead of pneumothorax (29.41%). The incidence of pleural effusion in COVID-19 patients is 0.65% (21/3839) for this study, significantly less than a review of 47 observational studies estimating the pleural effusion incidence rate at 7.03%.[7] Pleural effusions were typically identified 5-7 days after hospital admission and 11 days after the onset of COVID-19 symptoms.[7] It must be noted that among subjects who underwent tube thoracostomy for pleural effusion, fifteen out of the 21 patients (71.4%) have a previous or current malignancy. Furthermore, six (28.6%) of those with effusion had previous or current pulmonary tuberculosis. This finding may be an important confounding variable, especially in a country where tuberculosis is still endemic. Pleural fluid studies were predominantly exudative, consistent with findings in COVID-19 pneumonia.[7]

Analyzing primary and secondary outcomes in terms of indication for tube thoracostomy, we note that the mortality was higher in patients who underwent tube thoracostomy for pneumothorax than those who had pneumo-hydrothorax and pleural effusion, 60%, 33%, and 29% respectively. This situation can be correlated to the high incidence of mechanical ventilation in the subset of patients referred for pneumothorax. The need for invasive means of positive pressure ventilation may be an independent poor prognostic factor, for which higher plateau and driving pressures have also been investigated.[12]

In this study, patients with elevated procalcitonin levels had a higher risk for mortality, reflecting the severe COVID-19 infection. *Procalcitonin* is a biomarker produced by the body that is elevated in times of systemic inflammation. Feng et al. reported that elevated procalcitonin levels in COVID-19 patients are strongly associated with mortality and ICU acceptance.[18]

Reintervention for surgically treated pleural complications in COVID-19 pneumonia was low regardless of patient factors, COVID-19 factors, and procedural factors (Table 3). Despite the hypothesis that smaller bore tubes were more prone to occlusion[12] and hence required repeated interventions, for every numerical increase in French size, there was only a 1.09 hazard risk for intervention but was noted to be statistically insignificant (p-value 0.478). Therefore, outright recommendations regarding the type of drain to avoid repeated interventions and reduce the cost of treatment cannot simply be deduced from the results of this study.

Limitations and Recommendations of the Study

This study has several limitations. First, this is a retrospective study highly subject to information bias. Some known prognostic factors, such as BMI and psychological status, could not be included in this analysis as these were poorly documented, especially during the earlier parts of the pandemic. Second, this study involves a small sample size of 34 patients, severely limiting our ability to identify prognostic factors and accurately claim the generalizability of findings. Finally, we cannot provide long-term clinical outcomes such as overall survival and quality of life after discharge. Future prospective studies, including larger sample size, are ideal. However, given the developments in immunization and the subsequent decline in COVID-19 incidence and severity, this may no longer be achievable and even necessary. Instead, a multi-institutional research can be initiated.

CONCLUSION

There is no sufficient evidence to conclude that the patient-related, COVID-19 pneumonia-related, and procedure-related factors included in this study are significantly associated with mortality, except for the level of oxygen support on admission and the level of procalcitonin. Intubated patients have 14.84 times higher mortality hazards than those on room air. For every unit increase in procalcitonin levels, the mortality hazards are increased by 1.06 times. There is insufficient evidence to conclude that any factors of interest are significantly associated with the need for tube revision, tube re-insertion, fibrinolysis, or video-assisted thoracoscopic surgery.

Statement of Authorship

All authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

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