Original Article • นิพนธ์ต้นฉบับ

Clinical Experience with Emergency Tracheal Intubation and Outcomes in Patients Infected with Coronavirus Disease 2019 at a Tertiary Neurological Center in Thailand

Pimwan Sookplung[1], Haruthai Chotisukarat[1], Thanachporn Boonsombat[1], Jatuporn Eiamcharoenwit[1], Pathomporn Suchartwatanachai[1], Pungjai Keandoungchun[2], Phuping Akavipat[1]

[1] *Department of Anesthesiology,*

[2] *Department of Internal Medicine, Neurological Institute of Thailand*

Abstract

Background: The study aimed to summarize the outcomes of a patient infected with coronavirus disease 2019 (COVID-19) following emergency tracheal intubation admitted to the tertiary neurological hospital in Thailand during a rapidly evolving COVID-19 pandemic situation with limited knowledge, a shortage of medical personnel, and inadequate medical equipment.

Methods: A single-center, cross-sectional retrospective observational study was done from 16 March 2020 to 30 September 2021. The data were recruited from COVID-19 patient's medical records who had emergency tracheal intubation, including the demographics, severity of COVID-19 disease, type of oxygen therapy, COVID-19 treatment, Laboratory findings within 48 hours before intubation, outcomes after tracheal intubation, and hospital length of stay. The descriptive statistics and nonparametric statistical test were analyzed.

Results: Nine hundred and thirty-one COVID-19 patients were admitted. Twenty-four patients (2.6%) required emergency tracheal intubation; three patients (12.5%) were intubated during emergency cardiopulmonary resuscitation (CPR). Five patients were transferred to the specialized hospital for the advanced intensive care unit. Eighteen patients suffered sudden cardiac arrest, and 50% (n=9) died within 24 hours after intubation. With significantly lower median PaO_2/FiO_2 ratio (PF ratio) and higher D-dimer levels, only one patient was successfully weaned from the ventilator and discharged from the hospital.

Conclusion: During limited crisis care for critically ill COVID-19 patients, the survival rate after tracheal intubation was poor.

Keywords: cardiac arrest, cardiopulmonary resuscitation, coronavirus disease 2019 (COVID-19), outcome, SARS-CoV-2, tracheal intubation

Correspondence to: Pimwan Sookplung, E-mail: ppimwan@hotmail.com

Received October 31, 2022, Revised April 1, 2023, Accepted April 1, 2023

Background

The World Health Organization characterized COVID-19 disease as a pandemic. The disease is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] Thailand was the first to report a case outside China on 13 January 2020. Consequently, the epidemic began to spread in Thailand. However, Thailand was relatively successful in containing the pandemic throughout most of 2020 but has been experiencing an uncontrolled resurgent outbreak since April 2021. It was identified as the highly transmissible alpha variant (B.1.1.7).[2] It was first found in the United Kingdom and is more contagious than the native strain. In May 2021, the delta variant (B.1.617.2)[3], first detected in India, attacked Thailand and spread quickly throughout the country. The officials set nationwide disease control restrictions, causing a shortage of hospital beds as government policy required admission of all confirmed cases. As of August 31, 2021, the country has reported a cumulative total of 1,603,475 confirmed cases, with 11,266 new cases and 16,727 deaths from the disease.[4]

Although most patients infected with COVID-19 are asymptomatic or have only mild symptoms[5], 14-30% of hospitalized COVID-19 patients with moderate to severe disease can develop respiratory failure and may need intensive care.[6] The intubation rate of COVID-19 patients varies in different countries. A 3.2% of infected cases in China required intubation[7], and more than 10% of COVID-19 patients in northern Italy were intubated in the ICU.[8] In comparison, 2.2% to 33.1% of infected cases in New York needed intubation.[9] In critically ill cases, the need for intubation and mechanical ventilation varies from 30 to 100%. The mortality rate ranges from 16.7% to 61.5%.[10] Emergency tracheal intubation is an essential procedure with a risk of complications.[11] The intubation problems may aggravate the patient's crisis. In addition, a rapidly evolving COVID-19 pandemic with limited knowledge, shortage of medical personnel, and inadequate medical equipment would affect outcomes after tracheal intubation in critically ill COVID-19 patients at a tertiary neurological center in Thailand.

Materials and methods

Study design and participants

The Institutional research committee of the Neurological Institute of Thailand approved this cross-sectional retrospective observational study (research project number 65004). Written informed consent was waived, as this study was a retrospective observational without patient interventions. Data were collected from hospitalized adults (more than 18 years old) with reverse transcription-polymerase chain reaction (RT-PCR) confirmed SARS-CoV-2 infection requiring emergency tracheal intubation. Patients were admitted to the Neurological Institute of Thailand between March 16, 2020 and September 30, 2021.

Institutional COVID-19 management

Neurological Institute of Thailand is the tertiary neurological center in Bangkok, Thailand. The institute specializes in neurology and neurosurgery. During COVID-19 spreading, the institute was operated according to the

Department of Medical Services (DMS) mission for treatment and care for COVID-19 patients by providing cohort wards for COVID-19 patients since March 16, 2020. Initially, the institute provided the cohort ward for only asymptomatic or mild symptoms patients with eight beds and one negative pressure isolation room. Medical staffs from all departments of the institute share daily cohort ward rounds. The internal medicine doctors set the COVID-19 institutional treatment protocol according to the updated clinical practice guidelines and work with the medical staff team as the consultant doctor for the cohort ward. Since the institute has a shortage of pulmonary and critical care doctors, the internal medicine doctors will contact a tertiary referral hospital for an advanced intensive care transfer when patients have worsened symptoms.

However, when the epidemic intensified and became widespread, the institute had to urgently set additional cohort wards for COVID-19 patients, totaling 80 beds to support COVID-19 patients with moderate to severe symptoms or critically ill if unable to transfer to the specialized hospital for intensive care services due to unavailable bed. The administration started with the medical staff team, the internal medicine doctors, wards nurses, and available medical equipment. The anesthesiologist's role for critically ill COVID-19 patients was emergency tracheal intubation, consultant for sedative drugs administration, ventilator setting adjustment, invasive arterial blood pressure monitoring, central line insertion, and cardiopulmonary resuscitation. Tracheal intubation was performed when 1) patients had moderate to severe dyspnea, a respiratory rate of more than 30 breaths per minute (BPM), SpO_2 less than 94%, or the ratio of pulse oximetry (SpO_2)/fractional inspired oxygen concentration (FiO_2) to respiratory rate (ROX index) less than five after high flow nasal cannula (HFNC) with a flow rate of 60-70 liters per minute (LPM) was applied 2) sudden cardiac arrest. In this study, the primary outcome was the survival rate of critically ill COVID-19 patients after emergency tracheal intubation. Secondary outcomes were problems and adverse events during emergency tracheal intubation.

Data Collection

Demographics and baseline characteristics include age, sex, body mass index, comorbid conditions, ROX index, quick Sequential Organ Failure Assessment (qSOFA) score, vital signs, COVID-19 treatments, HFNC administered, days of intubation after the date of infection, complications after admission, days of death after intubation, hospital length of stay and the laboratory findings, e.g., a white blood cell count (WBC), lactate dehydrogenase (LDH), a high-sensitivity c-reactive protein test (hs-CRP), D-dimer test, arterial blood gas tests were obtained from the medical records. Detail of cardiopulmonary resuscitation (CPR) was obtained from the CPR records.

The anesthesiologists recorded patient status, detail of personal protection equipment used, anesthetic drugs preparation for intubation, problems, and adverse events during tracheal intubation in the COVID-19 intubation records. Difficult laryngoscopy was defined as a Grade III-IV Cormack and Lehane view of laryngoscopy. Hypoxemia was defined as oxygen saturation (SpO_2) <94% or tachypnea with respiratory rate

>30 BPM. Hypotension was defined as blood pressure <90/60 mmHg, while hypertension was blood pressure >140/90 mmHg. Tachycardia was defined as a heart rate >120 BPM. Transmission of infection to tracheal intubation was monitored and assessed continuously by clinical symptoms and signs of COVID-19 during a 14-day after tracheal intubation procedure.

Statistical Analysis

SPSS Statistical software (version 22; IBM SPSS inc., Chicago, IL) was performed for all statistical analyses. Descriptive statistics were used to evaluate the study cohort. Data were presented as median with interquartile ranges (IQR) for continuous variables and proportions for categorical variables. Categorical variables were compared by Chi-square or Fisher's exact test. The non-parametric test with independent sample analysis, Mann-Whitney U test was used to compare continuous variables. *P*-value ≤0.05 was considered statistically significant.

Results

Study Population

Between 16 March 2020, to 30 September 2021, nine hundred and thirty-one patients were admitted to the institute with COVID-19. Twenty-five patients were intubated. One patient was excluded based on intubation due to emergency-wide craniotomy. The remaining twenty-four patients (2.6%) with emergency tracheal intubation were included in this analysis. (Figure 1)

Clinical characteristics of all intubated patients

The median age of all intubated patients was 70 (IQR, 26-92) years, mostly females (75.0%). As the institute is a referral hospital for COVID-19 patients with neurological diseases, seven patients (29.2%) had neurological diseases such as brain tumors (12.5%), acute ischemic stroke (8.3%), epilepsy (8.3%), and myasthenia gravis (4.2%). The most common comorbidities include diabetes mellitus (75.0%), asthma or chronic obstructive pulmonary disease (COPD) (75.0%), dyslipidemia (54.2%), and hypertension (45.8%). Most patients were overweight (45.8%), with a median body weight of 68 (IQR, 41-120) kg. (Table 1)

Laboratory findings and COVID-19 treatment

Median values of inflammatory markers, e.g., hsCRP, LDH, and D-dimer during admission was 42.9 (IQR, 1.48-192.4) mg/L, 512 (IQR, 113-1,591) U/L, and 2,695 (IQR, 1,389-6,881) ng/ml, respectively. (Table 2) Patients received favipiravir (91.7%), lopinavir/ritonavir (79.1%), and remdesivir (33.3%) as an anti-viral therapy for COVID-19. The monoclonal antibody regimen was used in severely affected COVID-19 patients with severe lung inflammation, one patient (4.2%) received Infliximab, and eight (33.3%) received tocilizumab. In addition, 83.3% of patients received enoxaparin.

The median baseline of oxygen saturation on admission without oxygen therapy was 92.5% (IQR, 80-98%). (Table 3) Supplemental oxygen was administered to most patients by HFNC; five patients (20.8%) were intubated within 24 hours

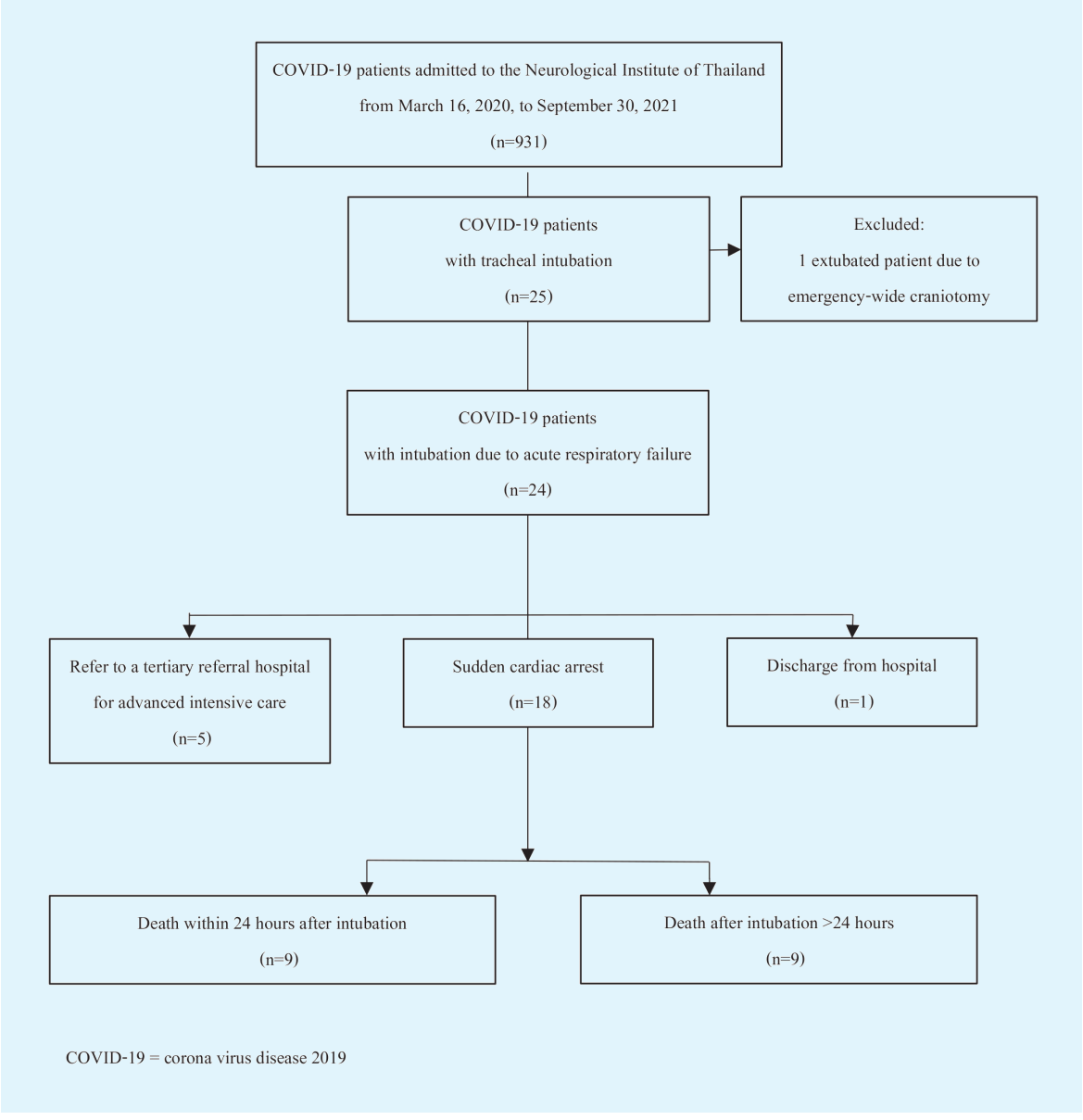


Figure 1 Flow diagram of study participants

after receiving a high-flow nasal cannula. Before intubation, eighteen patients (75.0%) were set to awake prone positions. Most of the patients (54.1%) had impaired consciousness. Eight patients (33.3%) were intubated immediately after transfer to the cohort ward or the negative pressure isolation room. Nine patients (37.5%) had SpO_2 of less than 90%. The median ROX index was 3.32 (IQR, 2.1-7.7), qSOFA was 2 (IQR, 1-3), systolic blood pressure (SBP) was 137 (IQR, 100-190) mmHg, and diastolic blood pressure (DBP) was 80 (IQR, 58-117) mmHg. Three patients (12.5%) were intubated due to sudden cardiac arrest. The median time from the day of symptoms to intubation was 9.5 (IQR, 4-15) days.

Personal protection equipment, intubation techniques and induction drugs

Personnel for tracheal intubation was a well-trained anesthetist team (including one anesthesiologist and one nurse anesthetist), with the ward nurse as a third person for an additional assistant if needed. The anesthetist team wore N95 respirators (100%), surgical masks covering the N95 respirator (95.8%), and eye protection goggles (20.8%), a protective cover all with hood (100%), foot covers (100%). The outer layer of protection comprised a water-resistant full gown (62.5%) and either a face shield (45.8%) or a powered air-purifying respirator (PAPR) (64.0%). The anesthetist team wore double pairs of gloves during intubations. Donning and doffing were checked by each anesthetist in the teams.

Before intubation, the anesthetists checked for a video laryngoscope (CMAC-D: Karl Storz GmbH, Tuttlingen, Germany), intubation drugs, peripheral intravenous access, vital signs, and rechecked with the ward nurse for available of the mechanical ventilator. The rapid sequence induction technique was done in all patients. Propofol was used in almost all patients (95.8%), often combined with midazolam (58.3%) and neuromuscular blocking agents such as esmeron (70.8%) and succinylcholine (45.8%). Although most of the patients in the study were overweight with respiratory failure symptoms, all intubation was successful on the first attempt, and no difficult intubation was found.

Problems and adverse events during tracheal intubation

The most common problem was related to personal factors, e.g., miscommunication (29.2%), ventilator setup (29.2%), and unprepared monitoring (20.0%). The monitored problems were lack of central monitoring (4.2%) and lack of capnometry (8.3%). Hypotension (25.0%) was the most common adverse event during tracheal intubation. These were potentially due to the anesthetic effect. (Table 4) Resuscitation drugs such as ephedrine (12.5%) and norepinephrine (8.3%) were required to maintain hemodynamics. Hypoxemia occurred in 20.8% of patients and was readily improved after mechanical ventilation. Hypertension was found in 12.5% of patients, while 4.2% of the patient was treated with atropine due to bradyarrhythmia. No patients in the study have pneumothorax after being supported with a mechanical ventilator.

Severity of illness and clinical outcomes of all intubated patients

Five patients were transferred to the specialized hospital for the advanced intensive care unit. The critically ill COVID-19 patient who could not transfer due to an unavailable intensive care bed was treated in the Institute at the cohort ward or the negative isolation room. Three patients (12.0%) who had been intubated during CPR died due to no return of spontaneous circulation. Subsequently, fifteen patients (62.0%) suffered sudden cardiac arrest. After 24 hours of intubation with ventilator support, 61.0% of the family usually accepted palliative care with do not resuscitate (DNAR). The median days after intubation until cardiac arrest was five days (IQR, 2-17). Eventually, all patients with cardiac arrest were dead. Nine patients dead within 24 hours after tracheal intubation. With significantly lower median PaO_2/FiO_2 ratio and higher D-Dimer levels, only one patient with emergency tracheal intubation was recovered and discharged from the institute after 26 days of admission.

Table 1 Demographics and clinical characteristics of all intubated patients

	Intubated and referred to specialized hospital (n=5)	Intubated and had cardiac arrest (n=18)	Intubated and finally discharge (n=1)	All intubated patients (n=24)
Female gender, n (%)	2 (40.0)	15 (83.3)	1 (100.0)	18 (75.0)
Age (yr), median (IQR)	62.0 (29.0-75.0)	70.0 (26.0-92.0)	71.0	70.0 (26.0-92.0)
>65, n (%)	2 (40.0)	11 (61.1)	1 (100.0)	14 (58.3)
Comorbidities, n (%)				
Diabetes mellitus	3 (16.7)	14 (77.8)	1 (5.6)	18 (75.0)
Asthma/COPD	2 (15.4)	11 (84.6)	-	18 (75.0)
Dyslipidemia	2 (12.5)	14 (87.5)	-	13 (54.2)
Hypertension	2 (18.2)	9 (81.8)	-	11 (45.8)
Coronary artery disease	2 (50.0)	2 (50.0)	-	4 (16.7)
Cardiac arrhythmia	1 (50.0)	1 (50.0)	-	2 (8.3)
Immunocompromised	1 (50.0)	1 (50.0)	-	2 (8.3)
Morbid obesity	1 (20.0)	3 (16.7)	-	4 (16.7)
Comorbidities ≥2	3 (60.0)	15 (83.3)	-	18 (75.0)
Body weight (kg), median (IQR)	72.0 (58.0-120.0)	65.6 (41.0-115.0)	72.0	68.0 (41.0-120.0)
Hospital length of stay (day), median (IQR)	14.3 (3.0-36.0)	12.5 (3.0-36.0)	26.0	26.0

Table 2 Laboratory findings of all intubated patients

Laboratory findings	Intubated and referred to specialized hospital (n=5)	Intubated and had cardiac arrest (n=18)	Intubated and finally discharge (n=1)	All intubated patients (n=24)
Hematocrit (%)	37.0 (34.4-44.0)	37.5 (25-45.9)	32.5	37.2 (25.0-45.9)
White blood cell count (10^3 uL)	13.6 (12.0-17.9)	16.7 (8.1-21.2)	6.0	15.4 (6.0 -21.2)
Platelets count (10^3 uL)	270.0 (20.0-350.0)	270.0 (20.0-470.0)	420.0	270.0 (20.0-470.0)
hs-CRP (mg/L)	89.9 (29.5-192.4)	40.6 (1.5-159.3)	6.2	42.9 (1.5-192.4)
Lactate dehydrogenase (U/L)	574.0 (314.0-860.0)	480.5 (113.0-1,590.0)	234.0	512.0 (113.0 -1,590.0)
HBA1C, %	6.7 (5.0-12.0)	5.2 (5.6-15.1)	5.4	6.2 (5.4-15.1)
D-Dimer test (ng/ml)	1,237.0 (617.0-6,450.0)	2,933.5 (389.0-6,881.0)	575.0	2,695.0 (389.0-6,881.0)
Arterial blood gas (n=20)				
pH	7.2 (7.2-7.4)	7.3 (6.9-7.5)	7.3	7.3 (6.9-7.5)
PaO_2 (mmHg)	73.5 (59.0-238.0)	126.0 (53.0-280.0)	215.0	119.0 (53.0-280.0)
$PaCO_2$ (mmHg)	66.5 (42.0-74.0)	38.0 (18.0-90.0)	46.0	44.0 (18.0-90.0)
HCO_3 (mmHg)	26.4 (24.1-32.8)	22.0 (3.0-29.6)	21.0	22.1 (3.0-32.8)

Data are presented as number (%) and median (IQR). HBA1C = glycosylated hemoglobin, type A1C, hs-CRP = a high-sensitivity C-reactive protein test

Table 3 Patients' conditions before intubation

Patients' conditions	Intubated and referred to specialized hospital (n=5)	Intubated and had cardiac arrest (n=18)	Intubated and finally discharge (n=1)	All intubated patients (n=24)
Patient status, n (%)				
Awake prone position	4 (80.0)	14 (77.8)	-	18 (75.0)
Dyspnea	4 (80.0)	8 (44.4)	1 (100.0)	13 (54.2)
Impaired conscious	3 (60.0)	10 (55.6)	-	13 (54.1)
Sudden cardiac arrest	-	3 (16.7)	-	3 (12.5)
HFNC (n=21), n (%)	4 (80.0)	17 (94.4)	-	21 (87.5)
Days of HFNC, median (IQR)	2.0 (0-5.0)	2.5 (0-13.0)	-	2.0 (0-13.0)
Intubation within 24 hours after HFNC, n (%)	1 (4.8)	4 (19.1)	-	5 (23.8)
ROX index, median (IQR)	2.8 (2.1-7.7)	3.3 (2.7-4.1)	7.2	3.3 (2.1-7.7)
qSOFA, median (IQR)	2 (1-2)	2 (1-3)	1	2 (1-3)
Oxygen saturation, n (%)				
Hypoxia on admission	4 (80.0)	9 (50.0)	-	13 (54.2)
Hypoxia before intubation	5 (100.0)	14 (77.8)	1 (100.0)	20 (83.3)
Hypoxia after intubation	1 (20.0)	8 (44.4)	-	9 (37.5)
Vital signs before intubation, n (%)				
Hypertension	1 (20.0)	7 (38.9)	0	8 (33.3)
Tachycardia	4 (80.0)	14 (77.8)	1 (100.0)	19 (79.2)
Intubation at AIIR, n (%)	2 (40.0)	1 (5.6)	0	3 (12.5)

Data are presented as number (%) and median (IQR). HFNC = high flow nasal cannula, AIIR = airborne infection isolation room, ROX index = ratio of oxygen saturation as measured by pulse oximetry/FiO_2 to respiratory rate, qSOFA = quick sequential organ failure assessment score

Table 4 Problems and adverse events during intubation

	Intubated and referred to specialized hospital (n=5)	Intubated and had cardiac arrest (n=18)	Intubated and finally discharge (n=1)	All intubated patients (n=24)
Personal factors	4 (80.0)	6 (33.3)	-	10 (41.7)
Unprepared monitoring	2 (24.0)	3 (16.7)	-	5 (20.8)
Unprepared peripheral IV line	1 (20.0)	-	-	1 (4.2)
Unprepared suction	2 (40.0)	-	-	2 (8.3)
Unprepared resuscitation drug	1 (20.0)	1 (5.6)	-	2 (8.3)
Unprepared ventilator	4 (80.0)	3 (16.7)	-	7 (29.2)
Miscommunication	3 (60.0)	4 (22.2)	-	7 (29.2)
Monitoring factors	2 (40.0)	5 (27.8)	-	7 (29.2)
Lack of central monitoring	-	1 (5.6)	-	1 (4.2)
Lack of capnometry	-	2 (11.1)	-	2 (8.3)
Adverse events during intubation			-	
Hypotension	4 (80.0)	2 (11.1)	-	6 (25.0)
Hypertension	1 (20.0)	2 (11.1)	-	3 (12.5)
Hypoxemia	2 (40.0)	3 (16.7)	-	5 (20.8)
Cardiac arrhythmia	1 (20.0)	-	-	1 (4.2)

Data are presented as number (%).

Problems and adverse events during cardiopulmonary resuscitation

Seven patients had CPR. Most CPR events (85.7%) occur 24 hours after tracheal intubation. All of the initial EKG rhythms were asystole. A mechanical chest-compression device (Lund University Cardiac Assist System [LUCAS]; Jolife, Lund, Sweden) was used in all CPR events. The median duration of CPR time was 30 (IQR, 25-58) minutes. All COVID-19 patients with CPR were dead.

Discussion

The main findings of this study were the survival rate after emergency tracheal intubation for critically ill COVID-19 patients during the COVID-19 pandemic was poor and the death within 24 hours after tracheal intubation was associated with severe hypoxemia. Severe COVID-19 illness can occur in patients of any age and gender. However, it predominantly occurs in adults who are not vaccinated or in advanced age with specific underlying medical comorbidities consistent with the result of the current study, the characteristics of patients who required emergency tracheal intubation mostly older than 65.[11] They had at least one comorbidity[11-15] including diabetes mellitus[11,13], asthma[16,17] or COPD[9,18], and hypertension.[18] Most tracheal intubation patients had r eceived HFNC because HFNC was suggested to improve oxygenation and reduce the need for intubation.[19,20]

In this study, anesthesiologists cannot evaluate the patient's airways to recognize the risk of complex airway management and plan for an appropriate airway strategy before intubation because 1) Most patients are hypoxic and require immediate emergency intubation, 2) Patients may be depressed or unconscious, not cooperating with an airway assessment, and 3) The patient may be transferred from the quarantined field hospital from the COVID-19 network. We used the CMAC-D (Karl Storz GmbH, Tuttlingen, Germany), a video laryngoscope designed for difficult intubation patients with Cormack and Lehane grades III-IV[21] to prevent multiple intubations or intubation failure. We achieved 100% success on the first intubation attempt, compared to Zheng and colleagues' study using the Macintosh laryngoscope at 70%, Airtraq video laryngoscope at 83.3%, and UE video laryngoscope at 93.5%.[12] Most patients were intubated at the cohort ward. This standard ward expanded critical care services during a shortage of available intensive care beds in the specialized hospital. Critical care management, such as emergency tracheal intubation and CPR in non-standard environments and by staff who do not typically work in the critical setting, were the most common problem during tracheal intubation.[22]

Hypotension, the most common adverse event during tracheal intubation[11], might be caused by the anesthetic effect. Vasopressors were necessary to maintain hemodynamics for 56% of patients in Lee and coworkers' trial[23] and 85.1% in Hernandez-Romieu and colleagues' study[24], consistent with our findings. A patient who survived to discharge had no problems or adverse events during emergency tracheal intubation. There is controversy about whether early or non-early intubation for hypoxemic

Table 5 Severity of illness and clinical course of intubated patient who had cardiac arrest after intubation

	Cardiac arrest within 24 hours (n=9)	Cardiac arrest after 24 hours (n=9)	*P*-value
Age (yr), median (IQR)	60.0 (26.0-96.0)	74.0 (60.0-89.0)	0.080
Female gender, n (%)	7 (77.8)	8 (88.9)	0.530
Comorbidities, n (%)			
Diabetes mellitus	6 (66.7)	8 (88.9)	0.288
Asthma/COPD	5 (55.6)	6 (66.7)	0.500
Dyslipidemia	6 (66.7)	8 (44.4)	0.288
Hypertension	4 (44.4)	5 (55.5)	0.500
Coronary artery disease	1 (11.1)	1 (11.1)	0.765
Cardiac arrhythmia	-	1 (11.1)	0.500
Immunocompromised	-	1 (11.1)	0.500
Morbid obesity	3 (33.3)	-	0.103
Complications, n (%)			
Septicemia	2 (22.2)	6 (66.7)	0.058
Septic shock	2 (22.2)	1 (11.1)	0.530
Myocardial infarction	-	2 (22.2)	0.134
Acute liver injury	4 (44.4)	-	0.023*
Acute kidney injury	1 (11.1)	7 (77.8)	0.004*
Acute respiratory distress syndrome	6 (66.7)	8 (88.9)	0.257
Unstable hemodynamic required vasopressor	6 (66.7)	3 (33.3)	0.160
Laboratory findings, median (IQR)			
D-Dimer test (ng/ml)	3,900 (2,590-5,946)	1,105 (389-6,881)	0.040*
Arterial blood gas before cardiac arrest			
pH	7.1 (6.9-7.4)	7.3 (7.1-7.5)	0.018*
PaO_2 (mmHg)	85.0 (53.0-134.0)	184.0 (63.0-280.0)	0.050*
$PaCO_2$ (mmHg)	42.5 (18.0-88.0)	36.0 (30.0-90.0)	0.780
HCO_3 (mmHg)	18.6 (3.0-24.0)	22.0 (16.0-29.6)	0.390
PaO_2/Fio_2	85 (53-134)	184 (105-280)	0.018*
Palliative care, n (%)	3 (33.3)	8 (88.9)	0.016*
CPR, n (%)	6 (66.7)	1 (11.1)	0.016*

COVID-19 management to decrease mortality.[23-25] In 2022, a meta-analysis showed that mortality was lower in patients undergoing early versus late intubation.[26] According to the difference in the "early" definition by the authors of each research. Comparing the intubation time of our study with others may be challenging because the intubation in the present study was done when the patients only met the institution's endotracheal intubation criteria, and all of the patients were not intubated or received critical management in the intensive care unit. Our shortage of intensive care units is comparable to the findings of Lee and coworkers' trial[23], where most intubated patients received treatment in non-intensive care units.

Despite the best efforts to provide advanced medical care, the survival rate after emergency tracheal intubation in the present study was low (4.2%) compared to Lee and coworkers' trial (56.2%) and Mughal and colleagues (60%).[29] The characteristics of cardiac arrest patients were consistent with the previous study, predominantly elderly patients with comorbidity and multiple organ failure due to adult respiratory distress syndrome (ARDS), sepsis, acute kidney injury, and acute liver injury.[30,31] Although most studies have found that morbid obesity is associated with cardiac arrest, our study did not find morbid obesity as a factor in cardiac arrest patients. In the present study, half of the patients who experienced sudden cardiac arrest developed the condition within 24 hours after intubation, which was higher than the rate reported in the study by Yao and colleagues (10.4%).[11] Patients who died within 24 hours had a more severe disease progression, as evidenced by significantly severe hypoxemia, transaminitis, acute kidney injury, and higher D-dimer levels than patients who experienced cardiac arrest later.

However, only 38% of patients with sudden cardiac arrest had CPR, whereas most families accept DNAR. The percentage of CPR patients was lower than in the previous study.[31,32] The differences in the rate of CPR between studies include age, disease burden, culture, and religious beliefs. Among those who received CPR, all of the patients were dead. The potential reasons for the high mortality rate may be the severity of the disease, the difficulty of critical management during the shortage of intensive care services[32], limited medical personnel and equipment resources.

Limitations of the study

The present study had several limitations. First, it was a retrospective study with a limited number of patients, which prevented us from attempting a multivariable analysis. Second, no patients underwent arterial blood gas testing to evaluate the PF ratio before tracheal intubation. Third, we could not track the outcomes of intubated patients after their referral to specialized hospitals for intensive care services. Despite these limitations, our study offers valuable insights into the management of specialized neurological hospitals to deal with a critical situation due to a shortage of intensive care systems, the challenges of obtaining limited resources during the pandemic, and clinical outcomes. These findings can serve as a lesson for future epidemics.

Conclusion

Tracheal intubation is an essential procedure in critically ill COVID-19 patients. However, even after receiving tracheal intubation for life-saving, the mortality rate is still high in COVID-19 patients during the pandemic.

References

1. World Health Organization. Coronavirus disease 2019 (COVID-19) situation reported 81. [internet]. Geneva; World Health Organization; 2020 [cited 2020 Apr 4]. Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200410-sitrep-81-covid-19.pdf [Accessed 2 September 2022].
2. World Health Organization Thailand, WHO Thailand situation report-170. [internet]. Nonthaburi; World Health Organization Thailand; 2021 [cited 2021 Apr 9]. Available from: https://cdn.who.int/media/docs/default-source/searo/thailand/2021_04_09_eng_sitrep_170-covid19.pdf?sfvrsn=eee4c530_8 [Accessed September 2, 2022].
3. World Health Organization Thailand, WHO Thailand situation report-179. [internet]. Nonthaburi; World Health Organization Thailand; 2021 [cited 2021 May 10]. Available from: https://cdn.who.int/media/docs/default-source/searo/thailand/2021_05_10_eng_sitrep-179-covid19.pdf?sfvrsn=ec3c7755_5 [Accessed September 2, 2022].
4. World Health Organization Thailand, WHO Thailand situation report-203. [internet]. Nonthaburi; World Health Organization Thailand; 2021 [cited 2021 Sep 30]. Available from: https://cdn.who.int/media/docs/default-source/searo/thailand/2021_09_30_eng-sitrep-203-covid19.pdf?sfvrsn=97de5f7b_5 [Accessed September 2, 2022].
5. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72,314 cases from the Chinese Center for Disease Control and Prevention. JAMA. 2020;323:1239-42.
6. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395:497-506.
7. Meng L, Qiu H, Wan L, et al. Intubation and ventilation amid the COVID-19 outbreak: Wuhan's experience. Anesthesiology. 2020;132:1317-32.
8. Grasselli G, Zangrillo A, Zanella A, et al. Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy region, Italy. JAMA. 2020;323:1574-81.
9. Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York city area. JAMA. 2020;323:2052-9.
10. Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med. 2020;8:475-81.
11. Yao W, Wang T, Jiang B, et al. Emergency tracheal intubation in 202 patients with COVID-19 in Wuhan, China: lessons learnt and international expert recommendations. Br J Anaesth. 2020;125:e28-37.
12. Zheng H, Li S, Sun R, et al. Clinical experience with emergency endotracheal intubation in COVID-19 patients in the intensive care units: a single-centered, retrospective, descriptive study. Am J Transl

Res. 2022;12:6655-64.
13. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet. 2020;395:507-13.
14. Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72314 cases from the Chinese center for disease control and prevention. JAMA. 2020;323:1239-42.
15. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet. 2020;395:497-506.
16. Wang L, Foer D, Bates DW, et al. Risk factors for hospitalization, intensive care, and mortality among patients with asthma and COVID-19. J Allergy Clin Immunol. 2020;146:808-12.
17. Feng Y, Ling Y, Bai T, et al. COVID-19 with different severities: a multi-center study of clinical features. Am J Respir Crit Care Med. 2020;201:1380-8.
18. Myers LC, Parodi SM, Escobar GJ, et al. Characteristics of hospitalized adults with COVID-19 in an integrated health care system in California. JAMA. 2020;323:2195-8.
19. Demoule A, Baron AV, Darmon M, et al. High-flow nasal cannula in critically ill patients with severe COVID-19. Am J Respir Crit Care Med. 2020;202:1039-42.
20. Duan J, Zeng J, Deng P, et al. High-flow nasal cannula for COVID-19 patients: a multicenter retrospective study in China. Front Mol Biosci. 2021;8:639100.
21. Serocki G, Neumann T, Scharf E, Dörges V, Cavus E. Indirect videolaryngoscopy with C-MAC D-Blade and GlideScope: a randomized, controlled comparison inpatients with suspected difficult airways. Minerva Anestesiol. 2013;79:121-9.
22. Cook TM, Woodall N, Frerk C. Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. Br J Anaesth. 2011;106:617-31.
23. Lee JY, Kim HA, Huh K, et al. Risk factors for mortality and respiratory support in elderly patients hospitalized with COVID-19 in Korea. J Korean Med Sci. 2020;35:e223.
24. Hernandez-Romieu AC, Adelman MW, Hockstein MA, et al. Timing of intubation and mortality among critically ill coronavirus disease 2019 patients: a single-center cohort study. Crit Care Med. 2020;48:e1045-53.
25. Papoutsi E, Giannakoulis VG, Xourgia E, et al. Effect of timing of intubation on clinical outcomes of critically ill patients with COVID-19: a systematic review and meta-analysis of non-randomized cohort studies. Crit Care. 2021;25:121.
26. Yamamoto R, Kaito D, Homma K, et al. Early intubation and decreased in-hospital mortality in patients with coronavirus disease 2019. Crit Care. 2022;26:124.
27. Fayed M, Patel N, Yeldo N, et al. Effect of intubation timing on the outcome of patients with severe respiratory distress secondary to COVID-19 pneumonia. Cureus. 2021;13:e19620.
28. Chong WH, Saha BK, Murphy DJ, Chopra A. Comparison of clinical characteristics and outcomes of COVID-19 patients undergoing early versus late intubation from initial hospital admission: a systematic review and meta-analysis. Respir Investig. 2022;60:327-36.
29. Mughal MS, Kaur IP, Jaffery AR, et al. COVID-19 patients in a tertiary US hospital: assessment of clinical course and predictors of the disease

severity. Respir Med. 2020;172:106130.
30. Sheth V, Chishti I, Rothman A, et al. Outcomes of in hospital cardiac arrest in patients with COVID-19 in New York City. Resuscitation. 2020;155:3-5.
31. Hayek SS, Brenner SK, Azam TU, et al. In-hospital cardiac arrest in critically ill patients with covid-19: multicenter cohort study. BMJ. 2020;371:m3513.
32. Shao F, Xu S, Ma X, et al. In-hospital cardiac arrest outcomes among patients with COVID-19 pneumonia in Wuhan, China. Resuscitation. 2020;151:18-23.