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Trends in endotracheal intubation for patients with COVID-19 by emergency physicians

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Abstract: Emergency physicians perform endotracheal intubations for patients with COVID-19. However, the trends in the intubation for COVID-19 patients in terms of success rate, complications, personal protective equipment (PPE) information, barrier enclosure use, and its transition have not been established. We conducted a retrospective study of COVID-19 cases that required tracheal intubation at four hospitals in the Tokyo metropolitan area between January 2020 and August 2021. The overall intubation success rate, operator experience, and infection control methods were investigated. We then compared the early and late phases of the pandemic for a period of 8 months each. A total of 211 cases met the inclusion criteria, and 133 were eligible for analysis. The intubation success rate increased from 85% to 94% from early to late phase, although the percentage of intubations performed by emergency medicine residents increased significantly in the late phase ($p = 0.03$). The percentage of light PPE use significantly increased from 65% to 91% from early to late phase ($p < 0.01$), whereas the percentage of barrier enclosure use significantly decreased from 26% to 0% ($p < 0.01$). Furthermore, the infection prevention methods during intubation became more simplified from early to late phase.

Keywords: COVID-19, emergency physician, endotracheal intubation, Japan

Introduction

Patients with coronavirus disease 2019 (COVID-19) sometimes require emergency intubation for mechanical ventilation (*1-3*). Several observational studies have assessed emergency tracheal intubations for patients with COVID-19 mainly performed by anesthesiologists in China (*4,5*), the UK (*6*), the United States (*7*), Canada (*8*), and one international cohort study (*9*). The intubation success rate, complications, method of endotracheal intubation, types of personal protective equipment (PPE), and operator safety have not been described.

In the arduous fight against COVID-19 over the past year and a half, method of endotracheal intubation and types of PPE have been changed for various reasons (*10,11*), and their trends have not been examined at all. Considering those trends may contribute to the preparedness for the next pandemic, as well as to the current clinical practice. For example, a retrospective study in Brazil examined 112 COVID-19 cases with emergency intubations; however, only patients in the early phase of COVID-19 were included (*12*).

In the present study, we aim to describe the trends in the endotracheal intubations performed by emergency physicians for COVID-19 cases in terms of the success rate, complications, intubation method (including video laryngoscopy), types of PPE, and operator safety.

Materials and Methods

Study design and patients

This retrospective study includes data for adult patients with COVID-19 who underwent endotracheal intubation performed by emergency physicians at four hospitals (Supplementary Table S1, *https://www.globalhealthmedicine.com/site/supplementaldata.html?ID=44*) in the Tokyo metropolitan area between January 2020 and August 2021. The emergency departments of these four hospitals meet once a month to discuss issues to be solved in daily medical care. Data from medical records obtained from the four hospitals were collected, organized into datasets, and analyzed. The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the local ethics committee (Approval Number 20-

R044). This observational study was conducted in compliance with the Strengthening the Reporting of Observational Studies in Epidemiology or STROBE statement (*13*).

Data collection

The following parameters were recorded: age, sex, body mass index (BMI), laryngoscopy method (McGrath video laryngoscope (Aircraft Medical Ltd., Edinburgh, UK), Macintosh direct laryngoscope (Teleflex, Morrisville, NC), or change from Macintosh to McGrath), barrier enclosure use, operator experience, pre-intubation analgesia (fentanyl or none), pre-intubation sedative use (propofol, midazolam, or propofol and midazolam combined), pre-intubation neuromuscular blockade (rocuronium) use, intubation success rate on the first attempt, reasons for failed tracheal intubation, complications, confirmation after intubation, PPE combinations, patient outcomes (discharge, transfer to another hospital, in-hospital death, or still in hospital), and whether the operator contracted COVID-19.

Operator experience was recorded as emergency medicine resident (postgraduate year 1-6), attending physician, or change of operator from resident to attending physician. Reasons for intubation failure/difficulty were difficulty to confirm the glottis, closure of the glottis, inability to ventilate, damage to the cuff, and poor visibility due to protective glasses. Complications during intubation included oxygen desaturation (SpO_2 < 90%), systolic hypotension (< 90 mmHg), intubation of the main bronchus, and arrhythmia (atrial fibrillation and sinus bradycardia). The following PPE combinations were considered (Figure 1): Type A comprised an N95 mask, plastic gown, and eye shield; Type B comprised an N95 mask, surgical gown, and eye shield; Type C comprised an N95 mask, a Tyvek suit, and a powered air-purifying respirator; and Type D comprised an N95 mask, a Tyvek suit, and eyewear. Confirmation after intubation was performed by one of four approaches: stethoscope, capnometer, and portable X-ray; capnometer and portable X-ray; stethoscope and portable X-ray; or portable X-ray only.

Definitions

The diagnosis of COVID-19 was dependent on a positive reverse transcription-polymerase chain reaction test confirming the presence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a nasal swab, pharyngeal swab, or sputum sample (*12*). Emergency physicians in Japan have a 3 to 4 year residency training program which has been established with a curriculum similar to that of the US program (*14*). But some emergency physicians working in the designated tertiary emergency hospitals usually have training in one additional specialty, such as Trauma Surgery and Critical Care (*15*). Therefore, Japanese emergency physicians have a high level of competence in dealing with hospitalized acutely injured and ill patients, and are sometimes required to provide in-patient care (*16*). Emergency tracheal intubation was performed by personnel authorized by the in-charge doctor at the time. If an operator had a confirmed COVID-19 infection up to 30 days after intubation, it was considered "operator infection". The target period was divided into two 8-month periods: early phase from January 1, 2020, to August 31, 2020 (first and second waves), and late phase from September 1, 2020, to April 31, 2021 (third and fourth waves).

Study endpoints

The primary focus of this study is to describe the

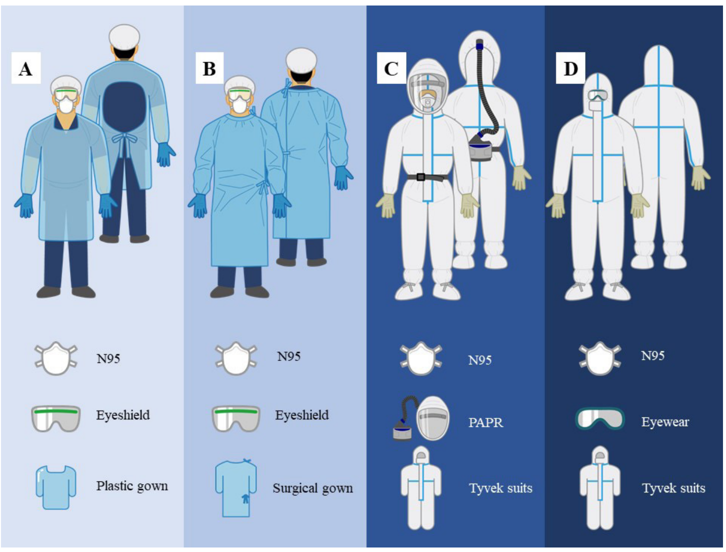

Figure 1. Types of personal protective equipment used during intubation.

overall success rate of emergency tracheal intubation, operator experience, and infection control methods, in patients with COVID-19. A secondary objective is to compare the early (initial 8 month) and late (the subsequent 8 month) phases of the study period.

Data analysis

Statistical analysis was performed using JMP version 11 (SAS, Cary, NC, USA). Patient characteristics, intubation-related factors, and outcomes were compared between the early and late phases using the Mann-Whitney *U* or Fisher exact tests for categorical variables, as appropriate. Two-tailed *p*-values < 0.05 were considered statistically significant. Imputation of missing values was not performed.

Results

Baseline characteristics

In total, 211 COVID-19 cases with intubation were retrieved. The data are shown in Table 1. The excluded cases consisted of 76 cases intubated by a non-emergency doctor (intensivist: 42 cases; respiratory physician: 27 cases; infectious disease physician: 5 cases and anesthesiologist: 2 cases,) and 2 cases in which the operator was changed (from emergency doctor to intensive care doctor, and from infectious disease physician to emergency doctor). A final total of 133 cases were thus included in further analyses (Figure 2). The median age was 66 years (range, 26 to 96 years), and the mean BMI was 24.8 kg/m^2 (range, 15.6 to 53.3 kg/m^2) (Table 1). Overall, 42 intubations (31.6%) were performed in the emergency department, and 91.0% were successful on the first attempt. Most intubations were performed by emergency medicine residents (66.9%; n = 89), followed by attending physicians (30.8%; n = 41). The percentages of Macintosh glass and Macintosh direct laryngoscopes used were the same (48.8%; n = 65). Neuromuscular blockade was used in 122 cases (91.7%). Desaturation was observed in 25 cases (18.8%) and hypotension in 29 (21.8%). In-hospital mortality was 21.1%, and none of the operators became infected with SARS-CoV-2.

Comparison of early and late phase outcomes

The 133 patients were divided between the early and late phases, based on when they were intubated. In both phases, about 30% of the intubations were performed in the emergency department, and 70% in the intensive care unit (ICU) and general ward. The use of the McGrath video laryngoscope decreased from early to late phase (58.7% to 43.7%), whereas that of the Macintosh direct laryngoscope increased correspondingly (37.0% to 55.2%). Of the 87 cases in the late phase, none were intubated using a barrier enclosure, significantly reducing the rate of use (p < 0.01) (Figure 3A). A significant increase was observed in intubation cases by emergency medicine residents (p = 0.03). The percentage of first-attempt intubation success rose from 84.8% to 94.3%. Difficulty to confirm the glottis and inability to ventilate were the common reasons for failed or difficult intubation in both phases. The rate of SpO_2 decrease was significantly reduced in the late phase (p < 0.01). Confirmation after intubation was mostly with the stethoscope, capnometer, and portable X-ray, which was significantly increased in the late phase compared with the early phase (p < 0.01). The proportion of light PPE types A and B increased significantly from early to late phase, whereas those of heavy PPE types C and D decreased (p < 0.01) (Figure 3B).

Discussion

The success rate of first-attempt intubation for the entire study period was high at 91% and the success rate increased from 85% to 94% in the early to late phase. All tracheal intubations in the previous studies were performed in the early phase (Table 2). This success rate was almost equal to the success rate performed by anesthesiologists (*4-6*) and higher than the success rates of emergency physicians in other studies (*7,12*). Patient BMI and years of operator experience were not comparable between the two phases.

Hypoxia and hypotension each occurred in approximately 20% of cases, which was clinically relevant. The percentage of hypoxia occurrence decreased significantly from the early to late phase (from 27.8% to 17.2%; p < 0.01), as well as that of hypotension, although not significantly (from 27.3 to 19.5%; p = 0.09). Although no significant difference was observed, propofol was used as a sedative in 72.4% of cases in which hypotension occurred, and midazolam, which is less likely to affect circulatory dynamics, was used in 17.2% (p = 0.36).

In this study, the overall percentage of emergency resident operators who performed intubations was as high as 67%, rising to about 75% in the late phase, a significant increase when compared with the early phase (p = 0.03). Thus, the most skilled operator available should perform endotracheal intubation in patients with COVID-19 (*17*). Several factors contribute to the difficulty of intubation, not least of which is the lack of familiarity with PPE (*18*), the risk of acquiring infection, and the presence of severe hypoxemia (*19*). Failure to implement the said recommendation in the current study likely reflects a unique problem of physician availability in the emergency department. However, the success rate increased significantly from the early phase to the late phase. This may be due to the fact that the operators, especially the emergency residents, improved as they gained intubation experience.

Table 1. Patient characteristics

Characteristic	Total (*n* = 133)	Early phase (*n* = 46)	Late phase (*n* = 87)	*p*
Age	66 (26-96)	63.5 (26-85)	68 (36-96)	
Sex (Male)	106 (79.7)	38 (82.6)	68 (78.2)	0.65
BMI	24.8 (15.6-53.3)	25.4 (16.8-35.4)	24.6 (15.6-53.3)	
Intubation location				0.85
Emergency department	42 (31.6)	15 (32.6)	27 (31.0)	
Intensive Care Unit/general ward	91 (68.4)	31 (67.4)	60 (69.0)	
Laryngoscopy method				0.09
McGrath video laryngoscope	65 (48.8)	27 (58.7)	38 (43.7)	
Macintosh direct laryngoscope	65 (48.8)	17 (37.0)	48 (55.2)	
Macintosh → McGrath	3 (2.3)	2 (4.3)	1 (1.2)	
Barrier Enclosure				< 0.01
Used	12 (9.0)	12 (26.1)	0 (0.0)	
Operator experience				0.03
Emergency medicine resident	89 (66.9)	24 (52.2)	65 (74.7)	
Attending physician	41 (30.8)	20 (43.5)	21 (24.1)	
Resident → Attending physician	3 (22.6)	2 (4.3)	1 (1.2)	
Analgesia before intubation				0.02
Fentanyl	129 (97.0)	42 (91.3)	87 (100)	
None	2 (1.5)	2 (2.9)	0 (0.0)	
Sedative before intubation				0.16
Propofol	113 (85.0)	36 (78.3)	77 (88.5)	
Midazolam	15 (15.2)	7 (15.2)	8 (9.2)	
Propofol + Midazolam	3 (2.3)	1 (2.2)	2 (2.3)	
Neuromuscular blockade before intubation				0.11
Rocuronium	122 (91.7)	40 (87.0)	82 (94.3)	
None	9 (6.8)	4 (8.7)	5 (5.8)	
Success/failure of tracheal intubation				0.11
First-attempt intubation success	121 (91.0)	39 (84.8)	82 (94.3)	
> 2 intubation attempts	12 (9.0)	7 (15.2)	5 (5.8)	
Reasons for failed tracheal intubation				
Difficult to confirm the glottis	6 (4.5)	5 (10.9)	1 (1.2)	0.02
Closure of the glottis	2 (1.5)	0 (0.0)	2 (2.3)	0.54
Inability to ventilate	2 (1.5)	1 (2.2)	1 (1.2)	1.00
Damage to the cuff	1 (0.8)	0 (0.0)	1 (1.2)	1.00
Poor visibility due to protective glasses	1 (0.8)	1 (2.2)	0 (0.0)	0.36
Complications				
SpO_2 < 90%	25 (18.8)	10 (27.8)	15 (17.2)	< 0.01
Systolic blood pressure < 90 mmHg	29 (21.8)	12 (27.3)	17 (19.5)	0.09
Intubation of the main bronchus	1 (0.8)	0 (0.0)	1 (1.2)	1.00
atrial fibrillation	1 (0.8)	0 (0.0)	1 (1.2)	1.00
sinus bradycardia	1 (0.8)	0 (0.0)	1 (1.2)	1.00
Confirmation after intubation				< 0.01
Stethoscope + Capnometer + Portable X-ray	99 (74.4)	19 (41.3)	80 (92.0)	
Capnometer + Portable X-ray	30 (22.6)	23 (50.0)	7 (8.1)	
Stethoscope + Portable X-ray	3 (2.3)	3 (6.5)	0 (0.0)	
Portable X-ray only	1 (0.8)	1 (2.2)	0 (0.0)	
PPE type				< 0.01
N95 + Plastic gown + Eye shield	39 (29.3)	13 (28.3)	26 (30.0)	
N95 + Surgical gown + Eye shield	70 (52.6)	17 (37.0)	53 (61.0)	
N95 + Tyvek suits + PAPR	20 (15.4)	12 (26.1)	8 (9.2)	
N95 + Tyvek suits + Eyewear	4 (3.0)	4 (8.7)	0 (0.0)	
Patient outcome				0.36
Discharged home	66 (50.0)	26 (56.5)	40 (46.5)	
Transfer	37 (28.0)	9 (19.6)	28 (32.6)	
Death	28 (21.1)	11 (23.9)	17 (19.8)	
In the hospital	1 (0.8)	0 (0.0)	1 (1.2)	
Operator infection	0 (0.0)	0 (0.0)	0 (0.0)	

Data are presented as median (interquartile range) for continuous variables and *n* (%) for categorical variables. Emergency medicine residents are those in postgraduate years 1-6. Missing data: Analgesia before intubation = 2; sedative before intubation = 2; neuromuscular blockade before intubation = 2; SpO_2 < 90% = 6; and systolic blood pressure < 90 mmHg = 2. BMI; body mass index, PAPR; powered air purifying respirator.

Not only that, the simplification of PPE used from the early to the late phase (Figure 3B) and the significant decrease in the rate of hypoxia also support this result.

The barrier enclosure ("aerosol box") was introduced in the early phase to prevent droplet exposure during tracheal intubation in patients with COVID-19 or

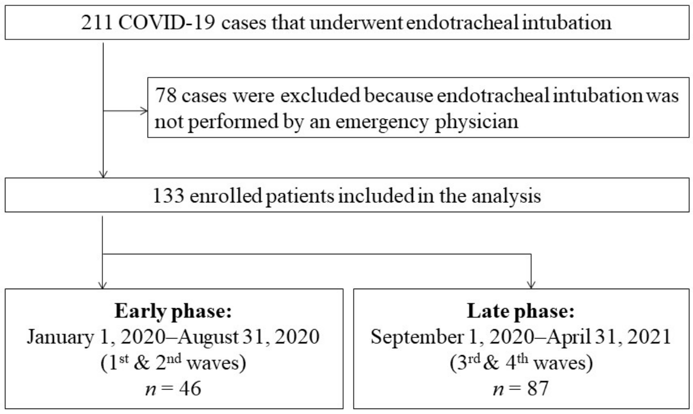

Figure 2. Flow diagram of the selection of COVID-19 cases with endotracheal intubation.

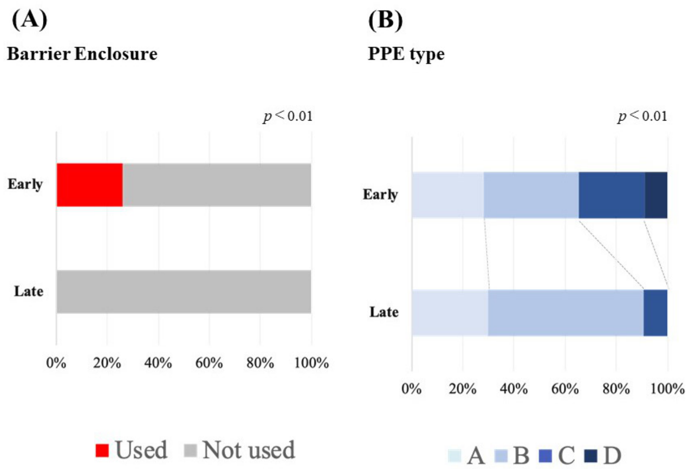

Figure 3. Comparison between the early and late phases of the COVID-19 pandemic on (A) barrier enclosure used and (B) percentage of each PPE type used.

Table 2. First-attempt intubation success, neuromuscular blockade use, and video laryngoscope use reported studies in the literature

Study and included patients (*Ref.*)	Total number of intubations	Proportion of emergency physicians	First-attempt intubation success	Neuromuscular blockade use	Video laryngoscope
Wuhan, China (*4*)	20	0	100	100	100
Wuhan, China (*5*)	202	0	89.1	99.0	89.6
London, United Kingdom (*6*)	150	0	88.0	N/A	91.3
Boston, United States (*7*)	123	22.8	89.4	100	91.7
	28		63.6	100	36.4
Vancouver, Canada (*8*)	227	41.4	85.9	N/A	83.7
	94		N/A	N/A	N/A
503 hospitals in 17 countries (*9*)	1,718	1.6	N/A	N/A	76.1
	28		N/A	N/A	N/A
Sao Paulo, Brazil (*12*)	112	100	82.0	100	62.0
Tokyo, Japan	133	100	91.0	91.7	48.8

The first three studies (*4-6*) all involved tracheal intubation by an anesthesiologist.

suspected COVID-19 (*11*). Barrier enclosure was not used in any of the cases in the late phase semester, which was a significant decrease ($p < 0.01$) (Figure 3A).

Several limitations of this study should be addressed. First, because of the retrospective nature, the details of all complications were possibly not obtained. Second, no specific protocols for intubation were used. Therefore, the selection of the drug administered at the time of intubation, the laryngoscopy method, and the confirmation after intubation were made based on the operator and the doctor-in-charge's judgment. Third, the number of included patients was relatively small, increasing the risk of beta error.

Conclusions

The current study showed a high success rate in emergency endotracheal intubation in patients with COVID-19 by emergency physicians using laryngoscopy and simple PPE. Furthermore, the success rate increased and complications became fewer toward the late phase with increased operator experience. With the rapid spread of COVID-19 infection, emergency tracheal intubation has become necessary even in facilities where it was not previously needed. Thus, the results of the current study will be highly relevant to the ongoing efforts to manage the COVID-19 pandemic in terms of improving the intubation success rate while lessening the occurrence of complications.

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Conflict of Interest: The authors have no conflicts of interest to disclose.

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