Endotracheal Intubation in Patients With COVID-19 By Emergency Physicians in The Tokyo Metropolitan Area

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Research Article

Abstract

Background: Patients with COVID-19 may require emergency tracheal intubation for mechanical ventilation by emergency physicians. However, the success rate, complications, operator safety, and issues around personal protective equipment (PPE) and barrier enclosure use are not known in this context.

Methods: This was a retrospective study of data for adult patients with COVID-19 who underwent endotracheal intubation performed by emergency physicians at four hospitals in the Tokyo Metropolitan Area between January 2020 and September 2020. Patient characteristics, intubation-related factors, and intubation success and complications rates were obtained. Two analyses were then performed. In analysis 1, the intubation success rate in patients was compared among four groups using different types of PPE. In analysis 2, patients were compared by those intubated with or without barrier enclosure.

Results: In total, 46 patients met the inclusion criteria, of whom 85% were successfully intubated at the first attempt, 27% experienced hypotension, and 27% experienced hypoxia. No muscle relaxants were used in 8.7% and the Macintosh blade was used in 37%. The four PPE types and the intubation confirmation methods varied considerably, but all met the WHO recommendations. A barrier enclosure device was used in 26%, with a success rate of approximately 80% irrespective of its use.

Conclusions: The success rate at the first attempt of intubation was relatively high, albeit with a moderately high complication rate. All PPE types were safe, including when barrier enclosures were used. Success was not affected by using barrier enclosures.

1. Background

Patients with coronavirus disease 2019 (COVID-19) sometimes require emergency intubation for mechanical ventilation [1–3]. Given the risks of infection transmission, several protocols and safety devices are recommended for use in this context [4–7]. To date, there have only been two observational studies regarding emergency tracheal intubation by anesthesiologists in China [8, 9], one prospective study from the UK [10], and one international cohort study among emergency physicians [11], though only 1.6% of patients with COVID-19 underwent tracheal intubation in the latter study. However, the success rate, complications, barrier enclosure use, type of personal protective equipment (PPE), and operator safety are unknown when emergency tracheal intubation is performed by emergency physicians for patients with COVID-19. In the present study, we aimed to clarify these details based on data available from four general hospitals in Tokyo [12].

2. Methods

2.1 Study design and Patients

This retrospective study included data for adult patients with COVID-19 who underwent endotracheal intubation by emergency physicians at one of four hospitals in the Tokyo Metropolitan Area between January 2020 and September 2020. The exclusion criteria were intubation by a non-emergency doctor, cases where a non-emergency doctor initially failed to intubate, and cases where a surgeon changed to an emergency doctor (or vice versa). The study was approved by local ethics committee (approved number 20-R044).

2.2 Data collection

The following parameters were recorded: age, sex, body mass index (BMI), intubation location (emergency department or hospital room), laryngoscopy method (McGrath video laryngoscope, Macintosh direct laryngoscope, 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 use (rocuronium or none), PPE combination, intubation confirmation, whether intubation was successful first time, complications, patient outcomes (discharge home, transfer to another hospital, or in-hospital death), and whether the intubator was infected with COVID-19. Operator experience was recorded as emergency medicine resident (postgraduate year 1–6), attending physician, or change of surgeon from resident to attending physician. The following PPE combinations were considered (Fig. 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 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. Complications during intubation included oxygen desaturation (i.e., $SpO_2 < 90\%$), systolic hypotension (i.e., < 90 mmHg), requiring ≥ 2 intubation attempts, difficulty confirming the glottis, inability to ventilate, and poor visibility due to protective glasses.

2.3 Definitions

The diagnosis of COVID-19 was dependent on a positive reverse transcription-polymerase chain reaction test from nasal swab, pharyngeal swab, or sputum samples confirming the presence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [7]. If an intubator had a confirmed COVID-19 infection up to 30 days after intubation, it was considered "intubator infection."

2.4 Study endpoints

The primary endpoint of the present study was the clinical characteristics of emergency tracheal intubation in patients with COVID-19.

2.5 Data analysis

Statistical analysis was performed using JMP version 11 (SAS, Cary, NC, USA).Two analyses were performed. In analysis 1, patients were divided by the four combinations of PPE used, that is, Types A, B,

C, and D. Comparison between PPE type and the success of endotracheal intubation or method of intubation confirmation was performed by chi-squared tests. In analysis 2, patients were divided into two categories by whether a barrier enclosure was used or not. Patient characteristics, intubation-related factors, and outcomes were compared by the use and non-use of a barrier enclosure, using the Mann–Whitney U or Fisher exact tests for categorical variables, as appropriate. Two-tailed P-values < 0.05 were considered statistically significant.

We confirmed that all methods were performed in accordance with the relevant guidelines and regulations.

3. Results

3.1 Baseline characteristics

In total, 55 patients with COVID-19 were intubated across the four hospitals during the study period. Among these, 9 were excluded because endotracheal intubation was not performed by emergency physicians. The remaining 46 patients were included in the two analyses (Fig. 2). Their ages ranged from 26 to 85 years (median, 63.5 years) and their BMI ranged from 16.8 to 35.4 kg/m^2 (median, 25.4 kg/m^2) (Table 1). Overall, 15 (32.6%) were intubated in the emergency department and 84.8% were successfully intubated on the first attempt. Most intubations were performed by emergency medicine residents (52.2%; n = 24), followed by attending physicians (43.5%; n = 20). McGrath video laryngoscopy was used in 27 (58.7%), and neuromuscular blockade was used in 36 (78.3%). Regarding complications, there was desaturation (SpO$_2$ < 90%) in 10 (27.8%) and hypotension (systolic blood pressure < 90 mmHg) in 12 (27.3%). In-hospital mortality was 23.9% and none of the operators became infected with SARS-CoV-2.

Table 1
Characteristics of intubation in the emergency department

Characteristic	(n = 46)
Age	63.5 (26–85)
Sex (Male)	38 (82.6)
BMI	25.4 (16.8–35.4)
Intubation location	
Emergency department	15 (32.6)
hospital room	31 (67.4)
Laryngoscopy method	
McGrath video laryngoscope	27 (58.7)
Macintosh direct laryngoscope	17 (37.0)
Macintosh → McGrath	2 (4.3)
Barrier Enclosure	
Used	12 (26.1)
Operator experience	
Emergency medicine resident	24 (52.2)
Attending physician	20 (43.5)
Resident → Attending physician	2 (4.3)
Analgesia before intubation	
Fentanyl	42 (91.3)
None	2 (2.9)
Sedative before intubation	
Propofol	36 (78.3)
Midazolam	7 (15.2)
Propofol + Midazolam	1 (2.2)
Neuromuscular blockade before intubation	

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, complication of $SpO_2 < 90\%$ = 6, Systolic blood pressure < 90 mmHg = 2

Characteristic	(n = 46)
Rocuronium	40 (87.0)
None	4 (8.7)
PPE Combinations	
N95 + Plastic gown + Eye shield	13 (28.3)
N95 + Surgical gown + Eye shield	17 (37.0)
N95 + Tyvek suits + PAPR	12 (26.1)
N95 + Tyvek suits + Eyewear	4 (8.7)
Post-intubation confirmation	
Stethoscope + Capnometer + Portable X-ray	19 (41.3)
Capnometer + Portable X-ray	23 (50.0)
Stethoscope + Portable X-ray	3 (6.5)
Portable X-ray only	1 (2.2)
First-attempt intubation success	39 (84.8)
Any complications	
$SpO_2 < 90\%$	10 (27.8)
Systolic blood pressure < 90 mmHg	12 (27.3)
>2 intubation attempts	7 (15.2)
Difficult to confirm the glottis	5 (10.9)
Unventilated	1 (2.2)
Poor visibility due to protective glasses	1 (2.2)
Outcome	
Discharged home	26 (56.5)
Transfer	9 (19.6)
Death	11 (23.9)
Intubator infection	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, complication of $SpO_2 < 90\%$ = 6, Systolic blood pressure < 90 mmHg = 2

3.2 Analysis 1: comparison of baseline characteristics by PPE type

The 46 patients were divided by type of PPE in analysis 1, as follows: Type A (28.3%; n = 13), Type B (37.0%; n = 17), Type C (26.1%; n = 12), and Type D (8.7%; n = 4). Types A and B were considered light PPE, whereas Types C and D were considered heavy PPE (Fig. 1). No significant differences were evident in age, sex, BMI, intubation location, pre-intubation analgesia, or pre-intubation neuromuscular blockade (Table 2). By contrast, desaturation ($SpO_2 < 90\%$) and hypotension (systolic blood pressure < 90 mmHg) rates differed significantly among the four groups. There was no statistically significant difference in the success rate of tracheal intubation by the type of PPE (p = 0.17), with rates at 69.2% for Type A, 88.2% for Type B, 100% for Type C, and 75.0% for Type D (Fig. 3A). However, there were significant differences among the four PPE types by the confirmation method after intubation (p < 0.01). (Fig. 3B)

Table 2
Comparison of laryngoscopy characteristics by type of protective equipment used

	A	B	C	D	p
	(n = 13)	(n = 17)	(n = 12)	(n = 4)	
Age	56 (26−77)	68 (40−85)	62.5 (37−79)	54.5 (41−66)	0.08
Sex (Male)	11 (84.6)	12 (70.6)	11 (91.7)	4 (100)	0.35
BMI	25.6 (21.2−35.4)	24.8 (16.8−34.3)	24.93 (18.8−32.6)	29.0 (22.3−35.2)	0.57
Intubation location					0.38
Emergency department	6 (46.2)	5 (29.4)	4 (33.3)	0 (0.0)	
Hospital room	7 (53.9)	12 (70.6)	8 (66.7)	4 (100)	
Operator experience					< 0.01
Emergency medicine resident	7 (53.9)	16 (94.1)	0 (0.0)	1 (25.0)	
Attending physician	5 (38.5)	0 (0.0)	12 (100)	3 (75.0)	
Resident → Attending physician	1 (7.7)	1 (5.9)	0 (0.0)	0 (0.0)	
Laryngoscopy method					< 0.01
McGrath video laryngoscope	9 (69.2)	2 (11.8)	12 (100)	4 (0.0)	
Macintosh direct laryngoscope	3 (23.1)	14 (82.4)	0 (0.0)	0 (0.0)	
Macintosh → McGrath	1 (7.7)	1 (5.9)	0 (0.0)	0 (0.0)	
Analgesia used					0.33
Fentanyl	12 (92.3)	16 (94.1)	10 (83.3)	4 (100)	
None	1 (7.7)	1(5.9)	0 (0.0)	0 (0.0)	
Sedation used					< 0.01
Propofol	8 (61.5)	16 (94.1)	9 (75.0)	3 (75.0)	

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.

	A	B	C	D	p
	(n = 13)	(n = 17)	(n = 12)	(n = 4)	
Midazolam	5 (38.5)	1 (5.9)	1 (8.3)	0 (0.0)	
Propofol + Midazolam	0 (0.0)	0 (0.0)	0 (0.0)	1(25.0)	
Neuromuscular blockade used					0.05
Rocuronium	12 (92.3)	17 (100)	7 (58.3)	4 (100)	
None	1 (7.7)	0 (0.0)	3 (25.0)	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.

3.3 Analysis 2: comparisons of characteristics by use and non-use of barrier enclosures

The 46 patients were divided into a group of 12 (26.1%) where a barrier enclosure was used and a group of 34 (73.9%) where a barrier enclosure was not used (n = 34). We identified no differences in the following parameters: age, sex, or BMI; intubation location; the pre-intubation analgesia, sedative, or neuromuscular blockade used; whether intubation was successful first time; the complications; or the intubator infection rate. By contrast, the laryngoscopy method, operator experience, PPE combination, and post-intubation confirmation method differed significantly by the use of barrier enclosure or not (p < 0.01) (Table 3).

Table 3
Comparisons of laryngoscopy characteristics by use and non-use of barrier enclosure

	Barrier Enclosure + (n = 12)	Barrier Enclosure − (n = 34)	p value
Age	61.5 (41−79)	64 (26−85)	0.67
Sex (Male)	11(91.7)	27 (79.4)	0.66
BMI	26.7 (18.8−35.2)	25.6 (16.8−35.4)	0.79
Intubation location			1.00
ER	4 (33.3)	11 (32.4)	
hospital room	8 (66.7)	23 (67.6)	
Operator experience			< 0.01
Emergency medicine resident	3 (25.0)	22 (64.7)	
Attending physician	9 (75.0)	10 (29.4)	
Resident → Attending physician	0 (0.0)	2 (5.9)	
Laryngoscopy method			< 0.01
McGrath video laryngoscope	11(91.7)	16 (47.1)	
Macintosh direct laryngoscope	0 (0.0)	17 (50.0)	
Macintosh → McGrath	1 (8.3)	1 (2.9)	
Analgesia			0.52
Fentanyl	10 (83.3)	33 (97.1)	
None	1 (8.3)	1 (2.9)	
Sedative			0.27
Propofol	9 (75.0)	28 (82.4)	
Midazolam	1 (8.3)	6 (17.6)	
Propofol + Midazolam	1 (8.3)	0 (0.0)	
Neuromuscular blockade			0.36
Rocuronium	11(91.7)	30 (88.2)	

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, complication of $SpO_2 < 90\%$ = 6, Systolic blood pressure < 90 mmHg = 2

	Barrier Enclosure + (n = 12)	Barrier Enclosure − (n = 34)	p value
None	0 (0.0)	4 (11.8)	
PPE Combinations			< 0.01
N95 + Plastic gown + Eye shield	2 (16.7)	11 (32.4)	
N95 + Surgical gown + Eye shield	0 (0.0)	17 (50.0)	
N95 + Tyvek suits + PAPR	6 (50.0)	6 (17.6)	
N95 + Tyvek suits + Eyewear	4 (33.3)	0 (0.0)	
Confirmation after intubation			< 0.01
Stethoscope + Capnometer + Portable X-ray	1 (8.3)	18 (52.9)	
Capnometer + Portable X-ray	10 (83.3)	13 (38.2)	
Stethoscope + Portable X-ray	0 (0.0)	3 (8.8)	
Portable X-ray only	1 (8.3)	0 (0.0)	
First-attempt intubation success	10 (83.3)	29 (85.3)	1.00
Any complications			
$SpO_2 < 90\%$	5 (41.7)	5 (14.7)	0.15
Systolic blood pressure < 90 mmHg	6 (50.0)	6 (17.6)	0.08
>2 intubation attempts	2 (16.7)	5 (14.7)	1.00
Difficult to confirm the glottis	1 (8.3)	4 (11.8)	
Unventilated	0 (0.0)	1 (2.9)	
Poor visibility due to protective glasses	1 (8.3)	0 (0.0)	
Outcome			0.05
Discharged home	10 (83.3)	16 (47.1)	
Transfer	2 (16.7)	7 (20.6)	
Death	0 (0.0)	11 (32.4)	
Intubator infection	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, complication of $SpO_2 < 90\%$ = 6, Systolic blood pressure < 90 mmHg = 2

4. Discussion

The success rate for the first attempt at intubation was quite high at 85%, but this was relatively lower than that reported in three earlier studies on this topic [8–10]. Hypotension and hypoxia each occurred in approximately 27% of cases, which was clinically relevant.

The use of muscle relaxants and video laryngoscopy was also lower than anticipated (Appendix 1). It is recommended that, whenever possible, intubation should be performed after preoxygenation and under rapid-sequence induction of sedation and neuromuscular blockade [13]. A reason for the low usage of muscle relaxants may be that emergency physicians feared that the patient would progress to CICV (cannot intubate, cannot ventilate) if muscle relaxants stopped spontaneous breathing completely. Regarding video laryngoscopy, although it may afford the operator a better view of the airway, it is recommended that operators use the technique they believe is most likely to be successful at the first attempt [14]. We believe this accounts for the low utilization in this study.

Regarding operator experience, the percentage of inexperienced emergency medicine residents was high (52.2%) in the current study compared with that reported previously [11]. The lack of experience among operators may also explain why the success rate fell below 90%. It is recommended that the most skilled operator available should perform endotracheal intubation in patients with COVID-19 [13]. Several factors contribute to the difficulty of intubation, not least of which are the lack of familiarity with PPE, the risk of acquiring infection, and the presence of severe hypoxemia. Failure to comply with the recommendation for the most experienced practitioners to perform intubation in the current study likely reflects a unique problem of physician availability in the emergency department.

All four institutions in this study performed tracheal intubation using the various PPE strategies advocated by the World Health Organization [11]. The rate of successful intubation did not decrease even when heavy PPE was equipped, but desaturation did occur in all four patients intubated using Type D PPE. An issue with both heavy PPE methods is that the ears were not exposed; therefore, air entry in the airway could not be confirmed by stethoscope immediately after intubation. PPE styles that allow auscultation, such as Type A and Type B, may be better suited for allowing post-intubation checks, while also being easier to perform and more cost effective. Thus, although there was no association between the light and heavy PPE types and intubation success, we advocate light-type PPE (Type A and Type B) for use in emergency settings given their simplicity and the lower desaturation rate compared with the heavier types.

The barrier enclosure ("aerosol box") has been widely adopted for tracheal intubation in patients with COVID-19 or suspected COVID-19 [15, 16]. It is an approach that is useful for preventing direct droplet exposure during awake intubation when coughing is inevitable. Despite these benefits, the approach restricts the intubator's hand movements and prevents the screen of the video laryngoscope from being seen clearly, thereby increasing the procedure time [17]. When performed by experienced anesthesiologists, it has been reported that the time to successful intubation was no different to that without the use of a barrier enclosure [18]. However, experienced senior doctors are not always available

for emergency tracheal intubation in emergency departments and wards, with the responsibility typically falling on junior staff. This is compounded by the fact that exposure may not be reduced. Indeed, aerosol particles of various sizes are generated during tracheal intubation [19], potentially exposing the operator to a large amount of virus when the barrier enclosure is released [20]. There was also a difference in the confirmation method after intubation. Although we found that the success of tracheal intubation was not affected by using a barrier enclosure in the current study, it seems prudent to limit their use to experienced operators.

Several limitations of this study should be addressed. First, because of the retrospective nature, it is possible that the details of all complications were not obtained. Second, the number of included patients was relatively small, increasing the risk of beta error. Third, this study was limited to the central Tokyo area, meaning that the results may not be applicable to the whole of Japan.

5. Conclusions

The rate at which intubation was achieved successfully at the first attempt was relatively high, albeit with a moderately high complication rate. All four types of PPE adopted in this study met with the WHO recommendations, and it was interesting that the success rate when using a barrier device was comparable to that when not using a barrier device. Evidence points to issues with barrier devices and heavy-type PPE, especially when used by junior staff. On balance, we therefore advocate light-type PPE (Type A or B) for use in most emergency settings.

Abbreviations

COVID-19 Coronavirus disease 2019

PPE Personal protective equipment

WHO World Health Organization

Declarations

Ethics approval and consent to participate

The institutional review board of St. Luke's International Hospital (Tokyo, Japan) has approved this survey-based study (approved number 20-R044). The requirement for patient informed consent was waived by the institutional review board of St. Luke's International Hospital due to the retrospective nature of the study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

Authors' contributions

MS and TH were responsible for the conception of the article and drafted and revised the manuscript. MM, KM, and JH helped to correct the data. KK, MH, TK, and SI helped to design the study and draft the manuscript. NO revised the manuscript. All authors read and approved the final manuscript.

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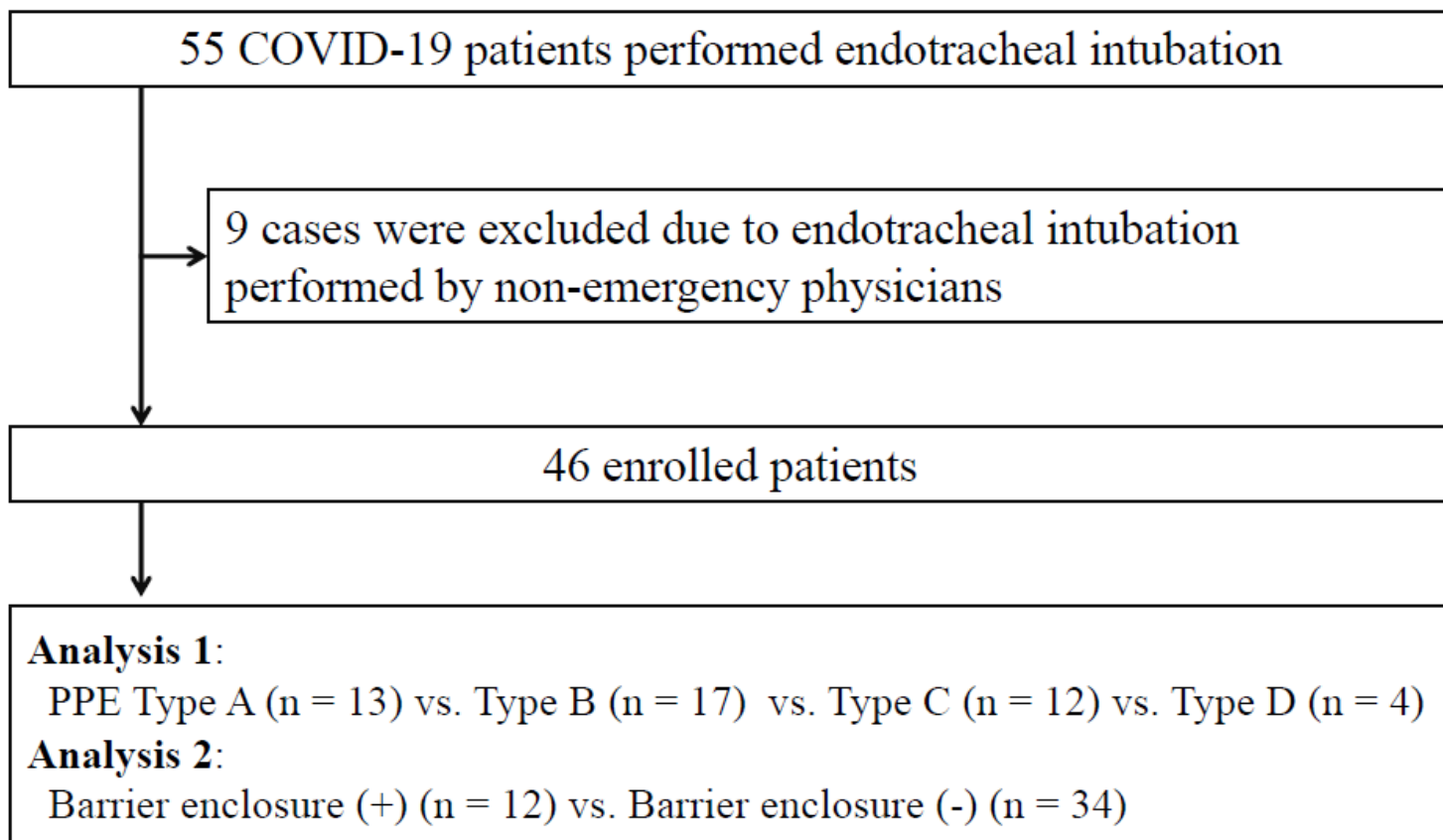
Figures

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│            55 COVID-19 patients performed endotracheal intubation         │
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        ├─────▶│ 9 cases were excluded due to endotracheal intubation     │
        │      │ performed by non-emergency physicians                     │
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│                          46 enrolled patients                             │
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│ Analysis 1:                                                               │
│   PPE Type A (n = 13) vs. Type B (n = 17)  vs. Type C (n = 12) vs. Type D (n = 4) │
│ Analysis 2:                                                               │
│   Barrier enclosure (+) (n = 12) vs. Barrier enclosure (-) (n = 34)       │
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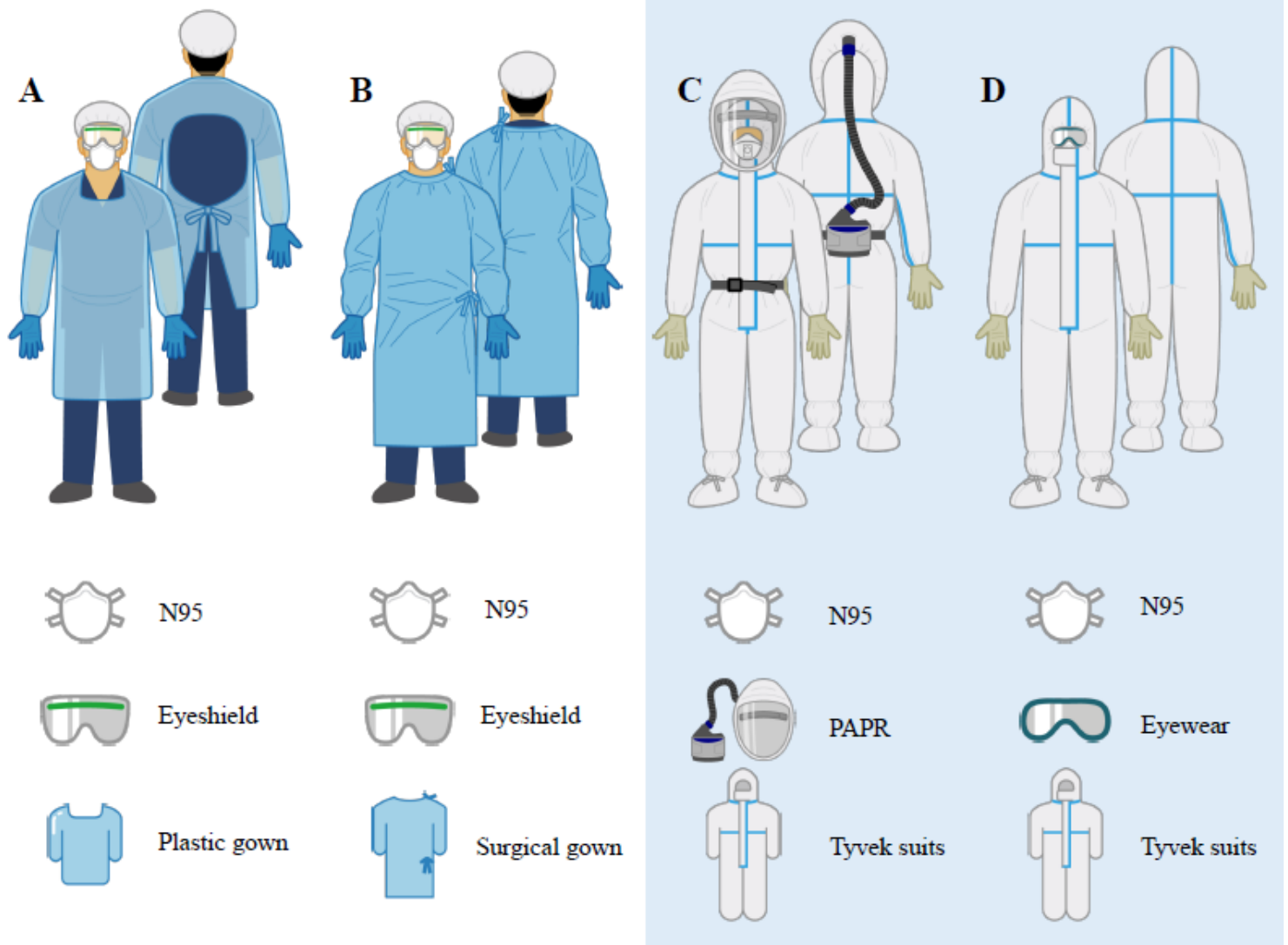
Figure 1

Patients flow

Figure 2

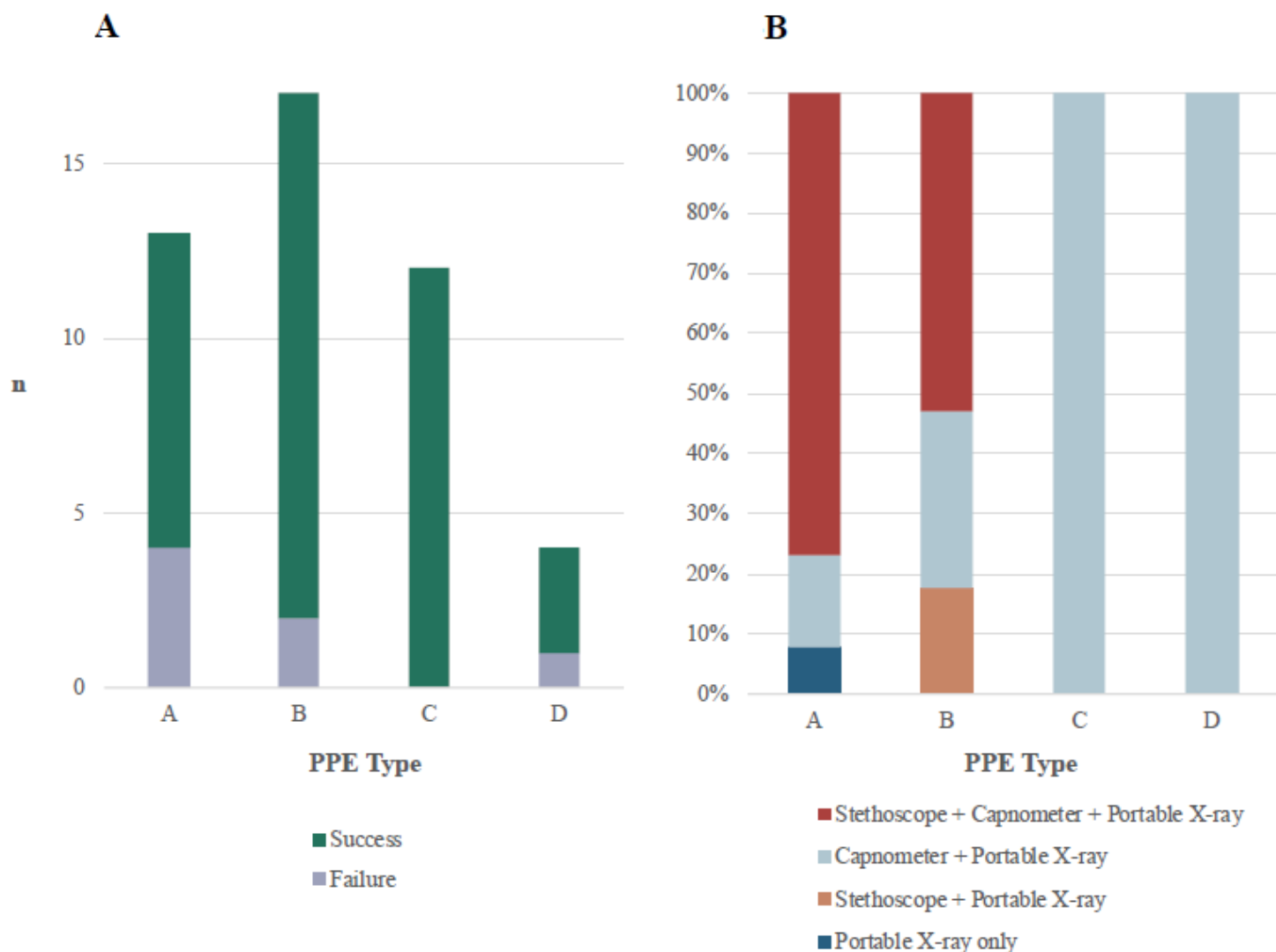Details of personal protective equipment

Figure 3

Association between types of personal protective equipment and (a) intubation success or (b) methods of confirmation (a) Association with intubation success (b) Association with methods of confirmation after intubation

Supplementary Files

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- Appendixfinalv1.docx