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ORIGINAL RESEARCH

Airway

First-attempt intubation success and complications in patients with COVID-19 undergoing emergency intubation

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Abstract

Objectives: To evaluate the first-attempt success rates and complications of endotracheal intubation of coronavirus disease 2019 (COVID-19) patients by emergency physicians.

Methods: This prospective observational study was conducted from March 24, 2020 through May 28, 2020 at the emergency department (ED) of an urban, academic trauma center. We enrolled patients consecutively admitted to the ED with suspected or confirmed COVID-19 submitted to endotracheal intubation. No patients were excluded. The primary outcome was first-attempt intubation success, defined as successful endotracheal tube placement with the first device passed (endotracheal tube) during the first laryngoscope insertion confirmed with capnography. Secondary outcomes included the following complications: hypotension, hypoxemia, aspiration, and esophageal intubation.

Results: A total of 112 patients with confirmed or suspected COVID-19 were enrolled. Median age was 61 years and 61 patients (54%) were men. The primary outcome, first-attempt intubation success, was achieved in 82% of patients. Among the 20 patients who were not intubated on the first attempt, 75% were intubated on the second attempt and 20% on the third attempt; cricothyrotomy was performed in 1 patient. Forty-eight (42%) patients were hypotensive and required norepinephrine immediately post-intubation. Fifty-eight (52%) experienced peri-intubation hypoxemia, and 2 patients (2%) had cardiac arrest. There were no cases of failed intubation resulting in death up to 24 hours after the procedure.

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Conclusion: Emergency physicians achieve high success rates when intubating COVID19 patients, although complications are frequent. However, these findings should be considered provisional until their generalizability is assessed in their institutions and setting.

KEYWORDS
COVID-19, emergency physician, intubation

1 | INTRODUCTION

1.1 | Background

Patients with severe coronavirus disease 2019 (COVID-19) may become critically ill with acute respiratory distress syndrome.[1] Deciding when a patient with severe COVID-19 should receive endotracheal intubation is an essential component of care.[1] As the COVID-19 pandemic spreads across the world, teams must develop airway management strategies that protect both patients and staff.[2] In many settings, emergency physicians are responsible for airway management of acutely ill COVID-19 patients presenting to the emergency department.[3]

Emergency intubation of critically ill patients carries complication rates of over 40% in some series.[4] An alarmingly high percentage of patients suffer an associated cardiac arrest.[5-6] Numerous factors may contribute to this, including hypoxemia and arterial hypotension before intubation.[6] The current scientific literature reports on the additional difficulties that COVID-19 represents to securing the airway. Among the difficulties are performing the procedure using full personal protective equipment and reports of rapidly desaturating patients. Unfortunately, early data suggest high mortality in this subset of patients.[7]

1.2 | Importance

ED intubation techniques for critically ill patients are largely extrapolated from operating room practice.[4] Despite insufficient or no data for many aspects, there are important differences between elective non-COVID-19 and emergency COVID-19 intubation, such as the risk to the patient of aspiration, desaturation, or hypotension and the risk of difficult laryngoscopy to medical personnel, who should wear personal protective equipment including an N95 respirator, goggles, and plastic face shields.[4,7]

1.3 | Goals of this investigation

The objective of this study was to evaluate the first-attempt success rates and complications of endotracheal intubation of COVID-19 patients by emergency physicians.

2 | METHODS

2.1 | Study design and setting

This prospective observational study was conducted from March 24, 2020 through May 28, 2020 at the ED of Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo, São Paulo, Brazil. It is a quaternary academic medical center with 2200 beds with 5 buildings and 2 auxiliary hospitals. During the pandemic, it has been designated by the state government to be the center for severe and moderate cases of COVID-19.

All endotracheal intubations are performed by either emergency medicine residents (usually postgraduate year 2 or higher) or attending physicians. This protocol was approved by the local ethics committee under the number 3.990.817 (CAAE: 30417520.0.0000.0068) that waived the need for written informed consent. We adhered to the STROBE guidelines.

2.2 | Selection of participants

We enrolled patients consecutively admitted to the ED with suspected or confirmed COVID-19 submitted to endotracheal intubation. We considered patients with compatible clinical and computed tomography findings suspect for COVID-19. We either confirmed COVID-19 with nasopharyngeal or tracheal secretion reverse transcription polymerase chain reaction (RT-PCR). We used a Macintosh laryngoscope blade, either direct or videolaryngoscopy. No patients were excluded.

2.3 | Exposures

Our preoxygenation strategy consisted mainly of 5 minutes of tidal volume breathing of 100% oxygen with a tightly fitted nonrebreather (NRB) mask or manual bag-valve-mask ventilation at a 15 L/minute rate with the patient upright. If the patient remained hypoxemic (<93%), a non-invasive positive pressure ventilation (NIPPV) mask connected to an in-line high-efficiency particulate air (HEPA) filter and a closed dual-limb ventilator circuit were used. Positive pressure preoxygenation was maintained until the patient was apneic. The ventilator was shut down just before removing the mask to reduce aerosolization. All

patients were intubated with SpO2 >93% after preoxygenation. Also, to reduce aerosolization, we avoided the nasal cannula for apneic oxygenation.

We used wave capnography to confirm all intubations. If the initial intubation attempt was unsuccessful, we used a supraglottic airway fitted with a HEPA filter, connected directly to a ventilator, or bag-valve mask, for rescue ventilation in all cases.

2.4 | Outcomes

The primary outcome was first-attempt intubation success, defined as successful endotracheal tube placement with the first device passed (endotracheal tube) during the first laryngoscope insertion confirmed with capnography. If the endotracheal tube was not inserted into the mouth during the first laryngoscope insertion, the attempt was counted as a failure.

Secondary outcomes included the following complications: hypotension, hypoxemia, aspiration, and esophageal intubation. Hypotension was defined by a decrease of 30 mmHg or more in systolic blood pressure or a mean arterial pressure (MAP) <65 mmHg after the procedure. Hypoxemia was defined as an oxyhemoglobin saturation <90%.

2.5 | Analysis

Unplanned subgroup analyses were performed for variables of clinical interest. These analyses were exploratory in nature, and a test of interaction for each subgroup was performed. Missing data were left as such; imputation was not performed.

We used the 2-tailed Student's *t* test and Kruskal-Wallis test for parametric and non-parametric values, respectively. Data were analyzed using were in Stata 13 software (College Station, Texas, USA).

3 | RESULTS

3.1 | Characteristics of study subjects

A total of 112 patients with confirmed or suspected COVID-19 were enrolled. From these, 99 patients (88%) had confirmed (RT-PCR) COVID-19, and 13 (12%) had clinical diagnoses. In these cases, symptoms, exposures, and presence of lung imaging features consistent with COVID-19 pneumonia.

Median age was 61 years; 61 patients (54%) were men. The procedures were performed by 30 emergency physicians. The main indication for intubation was hypoxemia (98%); only 2 patients (2%) were intubated for decreased level of consciousness. Indications for intubation (Table 1) and procedural details (Table 2) are displayed in the tables.

Sedation followed by neuromuscular blockade was performed in all patients before intubation. The preferred sedatives were ketamine (72%) and etomidate (25%), succinylcholine was used for neuromuscular blockade (61%). Pretreatment with fentanyl was used in only 14% of indicated cases. Table 1 shows drug doses. We performed rapid sequence intubation (RSI) in 96% of patients, modified RSI (delayed sequence intubation) in 3%, and 1 patient was submitted to a cricothyroidotomy.

The mean PaO2/FiO2 immediately after intubation was 107. Fifty-nine percent of patients required continuous neuromuscular blockade and 5% prone positioning while still in the ED.

The Bottom Line

Intubation of coronavirus disease 2019 (COVID-19) patients is difficult because of the need to minimize pathogen exposure and spread. The course and outcomes of emergency department COVID-19 intubation are unknown. In this series of 112 COVID-19 ED intubations in Brazil, first-pass success was high (82%), but peri-intubation complications such as hypotension (42%) and hypoxemia (52%) were common. Clinicians should anticipate complications when intubating COVID-19 patients.

TABLE 1 Baseline characteristics of patients intubated in the emergency department

Characteristic	No. (%) (n = 112)
Age, mean (years), IQR	61 (50–69)
Male sex	61 (54%)
Heart rate, mean (bpm), IQR	100 (90–110)
Systolic blood pressure, mean (mmHg), IQR	127 (112–140)
Shock index, mean, IQR	0.79 (0.68–0.94)
Shock index >0.90, (%)	33 (29%)
Respiratory rate, mean (breaths/minutes), IQR	36 (30–40)
Received supplemental oxygen, (%)	112 (100%)
Nasal canula 6L/minutes	15 (14%)
Venturi mask 50%	3 (3%)
High-flow nasal oxygen 60L/minutes	4 (3%)
Non-rebreathing mask 15L	73 (65%)
Non-invasive positive pressure ventilation 100%	17 (15%)
Oxygen saturation, median (%), IQR	89% (84%–92%)
Indication for intubation	
Hypoxemia	110 (98%)
Altered mental status	2 (2%)

IQR, interquartile range

TABLE 2 Intubation process measures among patients admitted to the emergency department

Measure	No. (%) (n = 112)
Method	
Rapid sequence intubation	108 (96%)
Delayed sequence intubation	4 (3%)
Cricothyroidotomy	1 (<1%)
Preoxygenation	112 (100%)
Non-rebreather mask	28 (25%)
Bag-valve mask	12 (11%)
Non-invasive positive pressure ventilation	72 (64%)
Pretreatment	
Fentanyl 100 μg	16 (14%)
Lidocaine 1.5 mg/kg	12 (10%)
Sedative before intubation, (%)	
Etomidate 0.3 mg/kg	8 (25%)
Ketamine 1.5 mg/kg	81 (72%)
Neuromuscular blockade before intubation, (%)	112 (100%)
Succinylcholine 1.5 mg/kg	68 (61%)
Rocuronium 1.2 mg/kg	44 (39%)
Oxygen saturation at start of first intubation attempt (%)	
>93%	112 (100%)
Operator experience	
Emergency medicine senior resident (postgraduate year 3) or attending physician	73 (65%)
Emergency medicine junior resident (postgraduate year 2 or below)	39 (35%)
Laryngoscopy method	
McGrath videolaryngoscope	62 (55%)
Macintosh direct laryngoscope	50 (45%)
Bougie used in first attempt	45 (40%)

TABLE 3 Outcomes among patients intubated in the emergency department

Outcome	No. with event/Total no. patients
Primary outcome	
First-attempt intubation success	92 (82%)
Secondary outcome	
Any complications	83 (74%)
>2 intubation attempts	4 (3%)
Hypotension	48 (42%)
Peri-intubation hypoxemia	58 (52%)
Esophageal intubation	3 (2%)
Cardiac arrest	2 (1%)
PaO2/FiO2 post-intubation, mean, interquartile range	107 (66;125)
Continuous neuromuscular blockade immediately after intubation	66 (59%)
Prone position immediately in ED	6 (5%)

3.2 | Main results

The primary outcome, first-attempt intubation success, was achieved in 82% of patients. Among the 20 patients who were not intubated on the first attempt, 75% were intubated on the second attempt and 20% on the third attempt; cricothyrotomy was performed in 1 patient. The first attempt success rate was 85% in senior and 76% in junior physicians ($P = 0.5$). These subsequent rescue attempts used a bougie or laryngeal mask or were performed with the most experienced emergency physician available. Table 3 describes primary and secondary outcomes.

Forty-eight (42%) patients were hypotensive and required vasopressors (norepinephrine) immediately post-intubation. Fifty-eight (52%) experienced peri-intubation hypoxemia, and 3 patients had an esophageal intubation. Two patients (2%) had cardiac arrest, both after esophageal intubation. Return of spontaneous circulation was obtained after successful intubation. There were no cases of failed intubation resulting in death up to 24 hours after the procedure. No aspiration was reported. (Table 4)

4 | LIMITATIONS

This study has several limitations. First, as data were obtained at a single institution, findings may not be generalizable. Second, interpretation of the results of this study is limited by the small size of the cohort, the relatively short duration of follow-up, and potential missing data owing to the nature of the program, Third, there was no standardized approach to emergency intubation among attending physicians. Forth, studies show that videolaryngoscopy increases the rate of first attempt intubation in the ED;[8] however, in our study, use of the videolaryngoscope was not associated with first-attempt intubation. We believe this may have occurred because the device was first acquired during the COVID-19 pandemic and the ED staff did not have enough practice, with team members still on the learning curve.

5 | DISCUSSION

We report a cohort of 112 patients with laboratory-confirmed severe acute respiratory syndrome coronavirus 2 infection or suspicion of COVID-19 (due to compatible clinical and radiological findings) who needed emergency intubation and analyzed success rates for first-attempt intubation by emergency physicians, as well as complications.

TABLE 4 Efficacy and outcomes

	First -Attempt	>1 intubation attempts	*P*	Hypotension	No Hypotension	*P*	Hypoxemia	No Hypoxemia	*P*
Age (y) ± SD	60 ± 1.6	56 ± 3.0	0.32	63 ± 2.3	56 ± 1.7	0,03	58 ± 1.9	61 ± 2.2	0.26
Operator									
Emergency medicine senior resident (postgraduate year 3) or attending physician	65%	68%	0.75	66%	64%	0.77	72%	57%	0.09
Emergency medicine junior resident (postgraduate year 2 or below)	35%	32%		33%	35%		43%	28%	
Heart rate (bpm)) ± SD	101 ± 1.8	102 ± 4.8	0.95	100 ± 2.9	102 ± 2.1	0.76	101 ± 2.4	101 ± 18.1	0.84
Systolic blood pressure prior intubation ± SD	129 ± 2.5	130 ± 6.4	0.81	124 ± 3.9	133 ± 2.8	0.05	129 ± 3.5	130 ± 3.1	0.85
Shock index >0.90	0.81	0.81	0.97	0.8	0.78	0.06	0.81	0.80	0.83
Respiratory rate (bpm) ± SD	35 ± 0.9	38 ± 1.5	0.22	34 ± 1.1	36 ± 1.1	0.25	36 ± 1.1	35 ± 1.2	0.68
Preoxygenation									
Nasal canula	14%	10%	0.87	8%	17%	0.25	22%	5%	**0.01**
High-flow nasal oxygen	3.2%	5.3%		4.2%	3.1%		2%	5%	
Non-rebreather mask	62.4%	73.7%		64%	64%		61%	67%	
Venturi mask	3.2%	0%		0%	6.3%		6%	0%	
Non-invasive positive pressure ventilation	16.1%	10.5%		14%	16%		9%	21%	
Fentanyl used	8%	16%	0.25	8%	9%	0.84	8%	9%	0.9
Bougie used	40%	63%	0.06	43%	43%	1	37%	50%	0,19
Videolaryngoscopy used	59%	37%	0.07	58%	53%	0.58	60%	50%	0,27
FiO2 post-intubation ± SD	79 ± 2.4	88 ± 3.9	0.13	81 ± 3.0	80 ± 3.1	0.94	87 ± 2.3	73 ± 3.5	**0.003**
PaO2/FiO2 post-intubation	110 ± 6.7	89 ± 8.1	0.16	99 ± 7.0	113 ± 8.8	0.33	97 ± 7.4	119 ± 9.0	**0.01**

The success rate for orotracheal intubation by emergency physicians was 82% on the first attempt, whereas the overall success rate was 99%. This is consistent with the findings of the National Emergency Airway Registry (NEAR II), a multicenter airway registry based in the United States. The NEAR II first-attempt success rate was 81% of cases,[9] showing no difference to our COVID-19 series. The success rate for emergency orotracheal intubation of patients with COVID-19 by anesthesiologists in China was 89% on first attempt and 100% overall.[10]

A striking feature of COVID-19 is the rapid progression of respiratory failure soon after the onset of dyspnea and hypoxemia.[1] As expected, the main indication for endotracheal intubation in our cohort was hypoxemia (98%). Only 2 patients, diagnosed with both COVID-19 and an acute stroke, were intubated because of decreased level of consciousness.

Guidelines from the Difficult Airway Society recommends that intubation should be performed after preoxygenation and RSI.[11] In this study, the main intubation method was RSI (96%). However, 4 patients were intubated with a delayed sequence because of psychomotor agitation, and 1 patient required cricothyroidotomy. The preferred sedatives ketamine and etomidate, and succinylcholine for neuromuscular blockade, were already the drugs of choice at our facility before the COVID-19 pandemic.

We had a complication rate of 74%. The current scientific literature reports that patients with COVID-19 often become hypotensive soon after intubation owing to positive-pressure ventilation and systemic vasodilation from sedatives.[1,11] In our study, hypotension occurred in 42% patients. Despite previous reports of the usefulness of the shock index (SI) $\geq$ 0.9 in predicting hypotension, in this series of COVID-19 patients the SI was not a reliable predictor of hypotension after procedure. The mean SI in hypotensive patients after intubation was 0.78 prior to procedure. No patient had systolic blood pressure <90 mmHg before the passage of the orotracheal tube.

Hypoxemia occurred in 52% patients. Patients who experienced hypoxemia received non-invasive ventilation and had a lower PaO_2/FiO_2 ratio post-intubation, which suggests that the indication for intubation was established late, with greater pulmonary impairment.

Three patients (2%) had esophageal intubation. In the first case, performed under direct laryngoscopy, this was rapidly identified because of the absence of a capnography curve; a laryngeal mask was passed, the patient was ventilated, and the second attempt at intubation was successful. In the second and third cases, performed via videolaryngoscopy, the bougie passed through the vocal cords, but resistance was encountered when passing the tube over the tube introducer, presumably from the tip catching on the arytenoid cartilages. The bougie was inadvertently removed, patients desaturated and went into cardiorespiratory arrest, which was reversed after a second attempt at orotracheal intubation.

In conclusion, first-attempt intubation success was obtained in 82% of patients. Emergency intubation of COVID-19 patients is associated with a high risk of complications. Most complications occurred when the airway was managed by trainees or less experienced physicians. However, these findings should be considered provisional until their generalizability is assessed in other institutions and settings.

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Bruno Marques, Julio Cesar Garcia de Alencar and Julio Flavio Meirelles Marchini contributed equally to this work. Bruno Marques, Julio Cesar Garcia de Alencar, Julio Flavio Meirelles Marchini, Cauê Gasparotto Bueno, Victor Paro da Cunha, Felippe Lazar Neto, Rodrigo Antonio Brandão Neto, Lucas Oliveira Marino, and Heraldo Possolo Souza wrote the manuscript. All authors provided critical feedback and helped shape the research, analysis, and manuscript. COVID USP Registry Team did the Registry

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