Research work

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Advanced airway management in the intensive care unit during the COVID-19 era. Prospective observational study of a single center cohort

Manejo avanzado de la vía aérea durante la era de COVID-19. Estudio prospectivo de cohorte observacional de un solo centro

Manejo avançado de vias aéreas durante a era da COVID-19. Estudo de coorte observacional prospectivo em um único centro

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ABSTRACT

Introduction: patients with COVID-19 may develop hypoxemic respiratory failure and require invasive mechanical ventilation. Given that tracheal intubation has been identified as the procedure with the highest risk of SARS-CoV-2 infection for healthcare personnel, it is crucial to standardize the technique to ensure safety and increase the likelihood of successful intubation on the first attempt.

Objective: it is important to describe our experience with the use of an institutional protocol for advanced airway management in patients with COVID-19.

Methods and results: we collected data after performing tracheal intubation by intubation teams trained in advanced airway management protocols. We analyzed 109 procedures of tracheal intubation. In 95 procedures, tracheal intubation was successful on the first attempt. The most frequent complication was hypoxemia (65.1%), followed by systemic arterial hypotension (45.9%). We recorded one death (0.9%) during the procedure. We did not identify any positive cases of SARS-CoV-2 among providers who performed the procedures.

Conclusion: tracheal intubation was a common procedure in our patients, with a high success rate on the first attempt. Implementing protocols for airway management in this patient population increases the probability of success on the first attempt while minimizing the risk of contagion for healthcare personnel involved in the procedure.

Keywords: COVID-19, airway, tracheal intubation, airway procedure, critical care unit.

RESUMEN

Introducción: *los pacientes con COVID-19 pueden desarrollar insuficiencia respiratoria hipoxémica y requerir ventilación mecánica invasiva. Dado que la intubación traqueal se ha identificado como el procedimiento con mayor riesgo de infección por SARS-CoV-2 para el personal de salud, es crucial estandarizar la técnica para garantizar la seguridad y aumentar la probabilidad de éxito en la intubación en el primer intento.*

Objetivo: *es importante describir nuestra experiencia con el uso de un protocolo institucional para el manejo avanzado de la vía aérea en pacientes con COVID-19.*

Métodos y resultados: *recopilamos datos tras realizar la intubación traqueal por equipos de intubación capacitados en protocolos de manejo avanzado de la vía aérea. Analizamos 109 procedimientos de intubación traqueal. En 95 procedimientos, la intubación traqueal fue exitosa en el primer intento. La complicación más frecuente fue la hipoxemia (65.1%), seguida de la hipotensión arterial sistémica (45.9%). Registramos una muerte (0.9%) durante el procedimiento. No identificamos ningún caso positivo de SARS-CoV-2 entre los proveedores que realizaron los procedimientos.*

Conclusión: *la intubación traqueal fue un procedimiento común en nuestros pacientes, con una alta tasa de éxito en el primer intento. La implementación de protocolos para el manejo de la vía aérea en esta población de pacientes aumenta la probabilidad de éxito en el primer intento, al tiempo que minimiza el riesgo de contagio para el personal de salud involucrado en el procedimiento.*

Palabras clave: *COVID-19, vía aérea, intubación traqueal, procedimiento de vía aérea, unidad de cuidados críticos.*

RESUMO

Introdução: *pacientes com COVID-19 podem desenvolver insuficiência respiratória hipoxêmica e necessitar de ventilação mecânica invasiva. Dado que a intubação traqueal foi identificada como o procedimento com maior risco de infecção por SARS-CoV-2 para os profissionais de saúde, é crucial padronizar a técnica para garantir a segurança e aumentar a probabilidade de intubação bem-sucedida na primeira tentativa.*

Objetivo: *é importante descrever nossa experiência com o uso de protocolo institucional para manejo avançado de vias aéreas em pacientes com COVID-19.*

Métodos e resultados: *coletamos dados após a realização da intubação traqueal por equipes de intubação treinadas em protocolos avançados de manejo de vias aéreas. Analisamos 109 procedimentos de intubação traqueal. Em 95 procedimentos, a intubação traqueal foi bem- sucedida na primeira tentativa. A complicação mais frequente foi a hipoxemia (65.1%), seguida de hipotensão arterial sistêmica (45.9%). Registramos um óbito (0.9%) durante o procedimento. Não identificamos nenhum caso positivo de SARS-CoV-2 entre os provedores que realizaram os procedimentos.*

Conclusão: *a intubação traqueal foi um procedimento comum em nossos pacientes, com alto índice de sucesso na primeira tentativa. A implementação de protocolos para manejo das vias aéreas nesta população de pacientes aumenta a probabilidade de sucesso na primeira tentativa, ao mesmo tempo em que minimiza o risco de contágio para as pessoas de saúde envolvidas no procedimento.*

Palavras-chave: *COVID-19, via aérea, intubação traqueal, procedimento de via aérea, unidade de terapia intensiva.*

INTRODUCTION

Patients with COVID-19 can progress from a mild or asymptomatic disease to hypoxemic respiratory failure and/or multiple organ dysfunction. These patients may require admission to the intensive care unit (ICU) and invasive mechanical ventilation (IMV).[1] Because tracheal intubation (TI) has been identified as the procedure with the highest healthcare personnel risk of infection by SARS-CoV-2, it is necessary to standardize the technique, so that the procedure is safe and has the highest probability of success on the first attempt.[2,3] According to the Royal College of Anesthetists and other United Kingdom (UK) associations, advanced airway management in COVID-19 patients should be performed in accordance with the acronym SAS. S (safe) - for health personnel and for the patient; A (accurate) - precise, avoiding repeated, unknown, or dangerous techniques and S (swift) - fast, at the right time, without haste, but without delay.[4] Based on this, we proposed a protocol for advanced airway management in patients with COVID-19.[5] The protocol consists of a structured guideline of the elements necessary to intubate a patient under the acronym SAS

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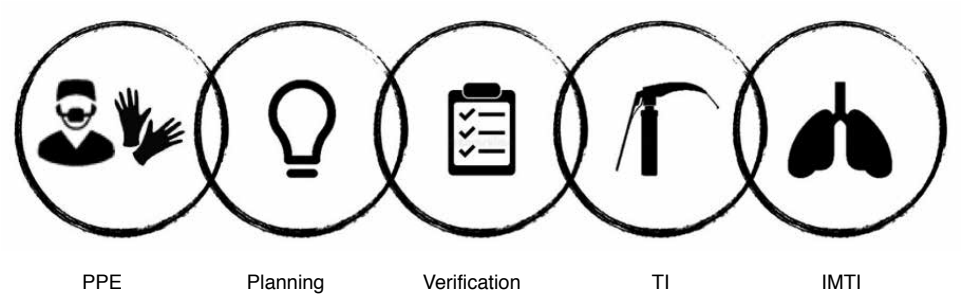

Figure 1:

Practical metaphor of the elements necessary to intubate a patient under the acronym SAS. PPE = personal protective equipment. TI = tracheal intubation. IMTI = post intubation and mechanical integrated care.

(Figure 1). The protocol proposes an airway management chain that is described below:

1. Personal protective equipment (PPE). It must be complete and in adequate condition.
2. Planning. All the team involved in the procedure must know the steps to follow, especially if the patient has predictors of difficult airway or if they have previously been classified as such.
3. Verification. The supplies and equipment necessary for advanced airway management should be in the intubation room and working properly before starting the procedure. Once the procedure has started, it is not recommended to open the intubation room.
4. TI. It should be carried out by personnel who are experts in advanced airway management.
5. Integrated management after TI. Adequate analgesia and sedation and protective IMV.

The purpose of creating this chain of TI was that the health personnel involved in the procedure could remember the images and carry out each of the steps in a systematic and standardized way. This protocol has been used in our institution during advanced airway management procedures in patients with COVID-19.

The objective of the present study is to describe our experience with the use of the protocol, by analyzing each of the steps of the intubation chain.

MATERIAL AND METHODS

Study design

Observational prospective cohort study that was carried out from July 1 to October 15, 2020, in a tertiary care teaching hospital in Mexico City. The protocol was approved by the Ethics Committee of the National Institute of Medical Sciences and Nutrition Salvador Zubirán.

Scenario, definition of the study, and data collection

Since March 2020, our Institution has been designated as a referral center in Mexico City for the care of patients with COVID-19 who require hospitalization. The strategy for advanced airway management in these patients consisted of creating TI teams made up of personnel with the most experience in performing this procedure (anesthesiologists and intensivists), who became familiar with the advanced airway management protocol in patients with COVID-19. The protocol was developed by physicians assigned to the areas of critical care and anesthesiology at INCMNSZ during May and June, coinciding with the first cases of COVID-19 treated at the institute and the first publications on the subject.

All critically ill adult patients who were admitted during the study period with a suspected or confirmed diagnosis of COVID-19 and who required advanced airway management were included in the report. Pediatric, pregnant, and trauma patients were excluded. Immediately after performing the procedure, the TI team leader filled out a 40-questions online questionnaire. The following data were collected: patient characteristics (gender, presence of predictors of difficult airway, and indication of TI), characteristics of the provider (specialty and academic degree), PPE used during the procedure (use of medical protective coverall, scrub, goggles, face shield, surgical hood, P100 filters, N95 respirators, and number of pairs of gloves), procedures carried out during the planning phase (verification of the material and equipment used and examination of the patient's airway), procedures carried out during the execution of TI (number of participating providers, pre-oxygenation, drugs used for anesthetic induction, type of device used for laryngoscopy, number of attempts made, and use of other aids for airway management) and adverse events associated with the procedure (cough, hypoxemia [oxygen saturation measured by pulse oximetry (SpO_2) < 80%], systemic arterial hypotension [< 90/60mmHg], arrhythmias, and death). Problems with PPE and the provider's feeling of discomfort with it were also recorded. Subsequently, from July 1 to November 1, 2020, reports of laboratory-confirmed SARS-CoV-2 infection were searched in the epidemiological database of Anesthesiology and Critical Medicine, of the health personnel who participated in the procedures of TI.

An TI attempt was defined as the insertion of the laryngoscope/video laryngoscope blade and the

tracheal tube through the oral cavity. According to the American Society of Anesthesiology (ASA) guidelines for the management of complex airways,[6] the provider had to hand over the procedure to another provider after a second failed intubation attempt and call the Anesthesiology and General Surgery medical team.

Protocol development and implementation

The protocol for advanced airway management in patients with COVID-19 was developed by physicians assigned to the areas of critical care and anesthesiology at INCMNSZ. It was created during May and June, coinciding with the first cases of COVID-19 treated at the institute and the first publications on the subject. The training of the TI teams consisted of integrative sessions with attending physicians from the critical care and anesthesiology departments, residents, and nursing staff from critical care areas. These sessions provided detailed explanations of the advanced airway management protocol for patients with COVID-19. Additionally, the protocol was printed and made available in all critical care areas. It was considered that personnel were aware of the protocol after the integrative session. The protocol was included in the emergency procedure manuals and no changes were made to the original protocol over time.

Statistical analysis

The data is presented using descriptive statistics. Continuous variables with normal distribution are expressed as mean ± standard deviation, whereas non-normally distributed variables are expressed as medians with interquartile range. To assess the normality of data, we used the Kolmogorov-Smirnov test. Categorical variables are presented as percentages and were compared using either the χ^2 test or Fisher's exact probability test, as appropriate. SPSS (IBM-Statistics, version 22, IBM Inc.) was used for data processing.

RESULTS

During the study period, advanced airway management was required for 109 COVID-19 patients. Most of them (82 [75.2%]) were male and 27 (23.8%) had predictors of difficult airway (12 [44.4%]), including a wide neck, inter incisor distance < 3 cm (6 [22.2%]), a foreign body in the oral cavity (6 [22.2%]), and a history of difficult airway (3 [11.1%]). The primary indications for the TI procedure were hypoxemia (85.3%), tracheal tube exchange (6.4%), and surgical intervention (4.6%). Of the procedures performed, 103 (94.5%) took place in critical care areas, and only 6 (5.5%) were performed in the operating room.

Out of the 109 procedures analyzed, 59 (54.1%) were conducted by anesthesiologists, 48 (44%) by intensivists, and only 2 (1.8%) by internists. *Table 1* details the academic qualifications of the providers involved in the tracheal intubations. Among anesthesiologists, the majority (62.7%) were attending physicians, whereas most of the procedures performed by intensivists (85.6%) were carried out by fellows. It is noteworthy that among the critical care residents, 11 were from internal medicine and 1 from pulmonology.

During all tracheal intubation procedures, the participants followed the Personal Protective Equipment (PPE) guidelines recommended by the World Health Organization for performing aerosol-generating procedures. The frequency of use for each component of PPE is shown in *Table 2*. Most participants wore a medical protective coverall (72.5%), high-efficiency respirators (62.4%), and double pairs of gloves (69.7%) during the procedure.

The procedures performed during the TI planning and execution phases are shown in *Table 3*. The median number of participants involved in the procedure was 3. Prior to beginning the procedure, the necessary materials and equipment for the TI were meticulously verified in 105 (96.3%) cases, and the patient's airway was assessed in 91 (83.5%) instances.

All procedures included in the study had 100% compliance with pre-oxygenation, using different devices including a bag-valve-mask (BVM) in 45% of cases, a Bain circuit in 40.4%, and a non-invasive mechanical ventilator (NIMV) in 14.7%. Pre-oxygenation time was typically 4-10 minutes in over half of cases (56%), while the Bain circuit had a pre-oxygenation time of 1-3 minutes in 61.4% of procedures. *Table 4* presents the SpO_2 levels achieved based on the device used, both after pre-oxygenation and after anesthetic induction. NIMV achieved the highest SpO_2 levels, with over 62.5% of cases reaching $SpO_2 > 91\%$ before

Table 1: Specialty and academic degree of the provider who performed tracheal intubation.

	Total n (%)	Attending n (%)	F1 n (%)	F2 n (%)	F3 n (%)
Anesthesiologist	59 (54.1)	37 (62.7)	14 (23.7)	4 (6.8)	4 (6.8)
Intensivist	48 (44)	7 (14.6)	27 (56.3)	14 (29.2)	0 (0.0)
Internist	2 (1.8)	0 (0.0)	1 (50)	0 (0.0)	1 (50)

F1 = first degree fellow. F2 = second degree fellow. F3 = third degree fellow.

Table 2: Frequency of use of PPE components during tracheal intubation.

	n (%)
Medical protective coverall	79 (72.5)
Scrub	109 (100)
Eye protection	109 (100)
Surgical hood	11 (10.1)
P100 filter	68 (62.4)
N95 respirator	46 (42.2)
Number of gloves	
1	7 (6.4)
2	76 (69.7)
3	26 (23.9)

PPE = personal protective equipment.

Table 3: Procedures performed during the planning and execution phases of tracheal intubation.

	n (%)
Number of providers*	3 (3-4)
Review of material and equipment	105 (96.3)
Airway exploration	91 (83.5)
Pre-oxygenation	109 (100)
Use of video laryngoscope	61 (56)
Use of metal guide	95 (87.2)
Use of antiviral filter	101 (92.7)
Use of oral gauze	12 (11)
Use of laryngeal mask	1 (0.9)
Use of box against aerosols	1 (0.9)
Use of capnography	16 (14.7)
Nasogastric tube placement	38 (34.9)
Cleaning of internal gloves	106 (97.2)
Number of attempts	
1	95 (87.2)
2	11 (10.1)
3	1 (0.9)
≥ 4	2 (1.8)

* median and interquartile range.

anesthetic induction. However, no statistically significant differences were found between devices. The frequency of desaturation after anesthetic induction was lower when NIMV was used (37.5%), compared to BVM (69.4%) and Bain (70.5%).

The mnemonics described in our protocol for advanced airway management in patients with COVID-19 were used to predict difficult airway and prepare the appropriate management strategy. The providers estimated a 23.8% probability of difficult airways, but only 3 (2.7%) cases met the criteria for a difficult airway. A stylet was used in 95 (87.2%) procedures to achieve successful TI on the first attempt. Of the procedures, 61 (56%) utilized a video laryngoscope, while 48 (44%) used direct laryngoscopy.

In 95 (87.2%) of the procedures, successful TI was achieved on the first attempt, with only 3 (2.7%) cases requiring 3 or more attempts *(Table 3)*. The number of TI attempts did not significantly differ when using the video laryngoscope or direct laryngoscopy, and there were no significant differences according to the academic grade of the provider *(Table 5)*. However, for patients without predictors of difficult airway, TI was successful on the first attempt in 91.5% of cases, compared to 74.1% for those with predictors (p = 0.027).

During TI, neuromuscular blockers were used in all procedures, and fentanyl was administered as a pretreatment in almost all cases (95.4%). Lidocaine was administered in 59.6% of the procedures. Propofol was the preferred sedative (44.9%), followed by the combination of propofol and midazolam (34.8%). Etomidate was not available at our hospital. Anesthesiologists used propofol (96.6 vs 75%, p = 0.001) and lidocaine (89.8 vs 25%, p = 0.001) significantly more frequently than intensivists.

Table 6 presents the incidence of complications related to the TI procedure. The most common complication was hypoxemia during laryngoscopy, which occurred in 65.1% of the cases, followed by systemic arterial hypotension (45.9%). The incidence of arterial hypotension was significantly higher in patients who experienced desaturation compared to those who did not (56.3 vs 26.3%, respectively, p = 0.003). One death (0.9%) occurred during the procedure. Among providers, 17 (15.6%) reported discomfort while wearing PPE, and 7 (6.4%) had issues with PPE, mainly due to fogging of eye protection devices. No instances of SARS-CoV-2 infection were detected among the providers who performed the procedures.

The adherence to the tracheal intubation (TI) chain was robust throughout the study. Specifically, compliance was high with each step: 95.4% for Personal Protective Equipment (PPE) use, 83.4% for planning, 96.3% for verification of equipment and materials, and 99% for post-

Table 4: SpO_2 level reached according to the oxygenation device used.

SpO_2 (%)	BVM, n (%)	Bain circuit, n (%)	NIMV, n (%)	p
After pre-oxygenation				
≤ 60	1 (2.0)	0 (0.0)	1 (6.3)	
61-70	2 (4.1)	2 (4.5)	0 (0.0)	
71-80	10 (20.4)	8 (18.2)	0 (0.0)	0.473
81-90	15 (30.6)	15 (34.1)	5 (31.3)	
91-100	21 (42.9)	19 (43.2)	10 (62.5)	
Post induction				
≤ 60	13 (26.5)	10 (22.7)	0 (0.0)	
61-70	8 (16.4)	4 (9.1)	2 (12.5)	
71-80	13 (26.5)	17 (38.7)	4 (25.0)	0.105
81-90	15 (30.6)	13 (29.5)	10 (62.5)	
91-100	0 (0.0)	0 (0.0)	0 (0.0)	

SpO_2 = oxygen saturation by pulseoximetry. BVM = bag-valve-mask. NIMV = non-invasive mechanical ventilator.

Table 5: Number of attempts of tracheal intubation according to the type of device used, academic degree of the provider and presence of predictors of difficult airway.

	Type of device used for tracheal intubation		
	Video laryngoscope, 61 (56) n (%)	Direct laryngoscope, 48 (44) n (%)	p
1	54 (88.5)	41 (85.4)	
2	5 (8.2)	6 (12.5)	
3	0 (0.0)	1 (2.1)	0.498
4	1 (1.6)	0 (0.0)	
5	1 (1.6)	0 (0.0)	
	Academic degree of the provider who performed tracheal intubation		
	Attending, 44 (40.4) n (%)	Fellow, 65 (59.6) n (%)	p
1	37 (84.1)	58 (89.2)	
2	6 (13.6)	5 (7.7)	
3	0 (0.0)	1 (1.5)	0.265
4	0 (0.0)	1 (1.5)	
5	1 (2.3)	0 (0.0)	
	Presence of predictors of difficult airway		
	Without predictors, 82 (75.3) n (%)	With predictors, 27 (24.7) n (%)	p
1	75 (91.5)	20 (74.1)	
2	6 (7.3)	5 (18.5)	
3	0 (0.0)	1 (3.7)	0.027
4	1 (1.2)	0 (0.0)	
5	0 (0.0)	1 (3.7)	

intubation care. These high adherence rates underscored the meticulous approach taken in ensuring the safety and effectiveness of tracheal intubation procedures for COVID-19 patients in critical care settings.

DISCUSSION

This prospective study describes our experience implementing an advanced airway management protocol for critically ill adult patients with COVID-19 in a Mexican academic reference center for this disease. While some consensus statements have been published regarding advanced airway management in these patients[1,4,6] to our knowledge, this is the first study to investigate this approach in an intensive care setting in Mexico.

TI has been identified as a high-risk procedure for the generation of aerosols, with an odds ratio (OR) of 6 for transmitting SARS-CoV-2 to healthcare personnel compared to those who do not perform this procedure.[3,7] Most consensus statements recommend that the operator with the most experience should perform the procedure. However, in our study, we found no significant differences in the success rate of TI on the first attempt between fellows and attending physicians. This may be attributed to the advanced airway management training that all operators received, ensuring proper technique and minimizing the risk of transmission.

Consensus statements recommend reducing the number of people exposed during the procedure and having two experienced operators in airway management.[4,6,8,9] Our study found that the median number of health professionals exposed during the procedure was 3 and in all cases, two experienced operators were involved in airway management. Planning of the procedure was usually done with the entire team, and the necessary items to perform the TI were verified, which has also been described as a useful maneuver to improve performance.[10]

Severely ill patients are more susceptible to hypoxemia during TI. Adequate pre-oxygenation can increase the functional residual capacity of the lungs, leading to improve PaO2.[11] The Practice Guidelines for Management of Difficult Airway recommend pre-oxygenate with 100% oxygen for three to five minutes and do not prioritize any specific equipment.[12] Previous studies have found that pre-oxygenation with NIMV may be beneficial.[11,13] However, in this study, pre-oxygenation with NIMV did not eliminate episodes of deep desaturation, although they were less frequent compared to the group that received pre-oxygenation with a face mask. Despite these results, we recommend avoiding the use of NIMV due to the high risk of aerosol generation, in agreement with other authors.[14,15]

In our study, we employed the COVID mnemonics tool as described by Mercado et al.[5] (C for Head or neck injury, O for Loose object in the oral cavity, V for Visible wide neck, I for History of difficult airway, and D for Thyromental distance < 6 cm and/or interincisor distance < 3 cm) to predict difficult airways while minimizing the risk of viral transmission. This tool facilitated a comprehensive exploration of key factors related to difficult airway prediction without necessitating close examination of the patient's oral cavity. While it was initially estimated that 23.8% of patients would present with a difficult airway, only 2.7% met the

Table 6: Frequency of complications associated with tracheal intubation.

	n (%)
Hypoxemia	71 (65.1)
Systemic arterial hypotension	50 (45.9)
Provider discomfort	17 (15.6)
Fogging of eye protection devices	7 (6.4)
Arrhythmias	5 (4.6)
Cough	4 (3.7)
Difficult intubation	3 (2.7)
Death	1 (0.9)
Contagion in health personal	0 (0.0)

criteria for difficult airway management. Our findings align with those reported in other studies on airway management.[16]

However, it is important to note that while most reference guides[4,6,8,9] recommend the routine use of video laryngoscopy, the cost of this equipment may not be feasible in all healthcare settings. In our study, we found that 56% of the procedures were performed using a video laryngoscope, while the rest were performed using direct laryngoscopy. Interestingly, we did not observe significant differences in the number of attempts to achieve TI or in the frequency of complications associated with the procedure between these two groups, which is consistent with previous research.[17] It is worth noting that the fourth report from the UK National Audit Project identified poor planning, recognition of difficult airways, and lack of adequate equipment as contributing factors to brain injury and death following TI. Therefore, internal protocols and risk assessments may be useful for improving patient safety. In our study, the compliance with each step of the TI chain was high (95.4% for PPE use, 83.4% for planning, 96.3% for verification, and 99% for post-intubation care), which may have contributed to the overall success of the procedure.

Rapid sequence induction and intubation (RSII) is recommended to prevent cough and eliminate the need for mask ventilation. In our study, RSII was the main strategy used, which is in line with current guidelines.[4,6] The frequency of drug use for anesthetic induction was consistent with that reported in other studies.[18] Almost all patients received propofol, often in combination with other sedatives. Before TI, sedation followed by neuromuscular blockade was administered in all patients. Intravenous lidocaine has been shown to be an effective adjunct to prevent cough during airway instrumentation,[19,20] but in our study, only 59.6% of patients received it during anesthetic induction, and in most cases, it was recommended by anesthesiologists.

Complications associated with the procedure were observed in 50.4% of cases, which is higher than the rates reported in other studies (10-18%). The most frequent complication was hypoxemia, followed by systemic arterial hypotension, consistent with previous reports.[18] Cardiac arrest during the procedure occurred in one patient, also in agreement with prior studies.[16] The incidence of SARS-CoV-2 infection in healthcare workers has been reported to be as high as 10.7%.[2] However, none of the healthcare professionals involved in airway management in this study were suspected or confirmed to be infected with the virus. This could be attributed to the use of N95 or higher respirators by the operators during all procedures. These findings suggest that taking maximum precautions against aerosols and droplets can prevent transmission of the infection, as described by Yao et al.[16] However, these results may be underestimated as asymptomatic carriers may not have been detected by regular testing.

During the study, operators participated in group training sessions for advanced airway management. These integrative sessions focused on clarifying the protocol steps and ensuring the proper use and disposal of materials. Each operator attended a dedicated session, and all personnel received comprehensive training on the correct use of Personal Protective Equipment (PPE). Led by the authors of this article, these sessions facilitated open discussion and addressed any queries regarding procedural steps. The primary goal was to enhance team awareness of materials and procedures, rather than introducing new manual skills. Due to the health emergency, no post-training evaluation was conducted.

This study has several limitations that should be taken into consideration when interpreting the results. First, it was conducted in a single tertiary care center, which limits the generalizability of the findings to other settings. Second, the sample size was relatively small, which may affect the statistical power of the analysis and the precision of the estimates. Third, the absence of an independent observer, to limit the number of people exposed, may have introduced reporting bias, as the TI team leader was responsible for completing the data collection form. Despite these limitations, we believe that the study provides valuable insights into the clinical practice of TI in critically ill patients with COVID-19, using a comprehensive airway management protocol, in a resource-limited setting in Mexico.

CONCLUSIONS

In conclusion, our study provides valuable insights into the management of tracheal intubation (TI) in critically ill COVID-19 patients. We observed a high success rate of first-attempt TI, although accompanied by notable risks of complications. The implementation of advanced airway management protocols, such as the COVID mnemonics, showed promise in enhancing first-attempt success rates and potentially mitigating viral transmission risks to healthcare personnel. However, it is important to emphasize that our study does not establish a direct cause-effect relationship between protocol use and first-attempt success rates in TI, nor does it definitively link the protocol to low or absent COVID-19 transmission rates. Further research with rigorous study designs is necessary to validate these findings and refine optimal practices for TI in critically ill COVID-19 patients.

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REFERENCES

1. Shang Y, Pan C, Yang X, Zhong M, Shang X, Wu Z, et al. Management of critically ill patients with COVID-19 in ICU: statement from front-line intensive care experts in Wuhan, China. *Ann Intensive Care*. 2020;10(1):73.
2. El-Boghdadly K, Wong DJN, Owen R, Neuman MD, Pocock S, Carlisle JB, et al. Risks to healthcare workers following tracheal intubation of patients with COVID-19: a prospective international multicentre cohort study. *Anaesthesia*. 2020;75(11):1437-1447.
3. Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS ONE*. 2012;7(4):e35797.
4. Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19: guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists. *Anaesthesia*. 2020;75(6):785-799.
5. Mercado-Velázquez P, Acosta-Nava V, Baltazar-Torres JA, Hernández-Oropeza JL, Rivero-Sigarroa E, Domínguez-Cherit G. Manejo avanzado de la vía aérea en pacientes con sospecha o diagnóstico de COVID-19. *Med Crit*. 2021;35(1):47-53. doi: 10.35366/99153.
6. Brewster DJ, Chrimes N, Do TB, Fraser K, Groombridge CJ, Higgs A, et al. Consensus statement: Safe Airway Society principles of airway management and tracheal intubation specific to the COVID-19 adult patient group. *Med J Aust*. 2020;212(10):472-481.
7. Weissman DN, de Perio MA, Radonovich LJ. COVID-19 and risks posed to personnel during endotracheal intubation. *JAMA*. 2020;323(20):2027.
8. Brown CA, Mosier JM, Carlson JN, Gibbs MA. Pragmatic recommendations for intubating critically ill patients with suspected COVID-19. *J Am Coll Emerg Physicians Open*. 2020;1(2):80-84.
9. Wax RS, Christian MD. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. *Can J Anesth Can Anesth*. 2020;67(5):568-576.
10. Cook TM, Woodall N, Frerk C. 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(5):617-631.
11. Benumof JL, Dagg R, Benumof R. Critical hemoglobin desaturation will occur before return to an unparalyzed state following 1 mg/kg intravenous succinylcholine. *Anesthesiology*. 1997;87(4):979-982.
12. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology*. 2013;118(2):251-270.
13. Mace SE. Challenges and advances in intubation: rapid sequence intubation. *Emerg Med Clin North Am*. 2008;26(4):1043-1068.
14. Ñamendys-Silva SA. Respiratory support for patients with COVID-19 infection. *Lancet Respir Med*. 2020;8(4):e18.
15. Schunemann HJ, Khabsa J, Solo K, Khamis AM, Brignardello-Petersen R, El-Harakeh A, et al. Ventilation techniques and risk for transmission of coronavirus disease, including COVID-19. *Ann Intern Med*. 2020;173(3):204-216.
16. Yao W, Wang T, Jiang B, Gao F, Wang L, Zheng H, 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(1):e28-37.
17. Lewis SR, Butler AR, Parker J, Cook TM, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation. *Cochrane Database Syst Rev*. 2016;11:CD011136.
18. de Alencar JCG, Marques B, Marchini JFM, Marino LO, Ribeiro SC da C, Bueno CG, et al. First-attempt intubation success and complications in patients with COVID-19 undergoing emergency intubation. *J Am Coll Emerg Physicians Open*. 2020;1(5):699-705.
19. Aminnejad R, Salimi A, Saeidi M. Lidocaine during intubation and extubation in patients with coronavirus disease (COVID-19). *Can J Anesth Can Anesth*. 2020;67(6):759.
20. Clivio S, Putzu A, Tramer MR. Intravenous lidocaine for the prevention of cough: systematic review and meta-analysis of randomized controlled trials. *Anesth Analg*. 2019;129(5):1249-1255.

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