REVIEW ARTICLE

Airway management and ventilation considerations in the critically-ill patient with the COVID-19

Consideraciones sobre el manejo de vía aérea y ventilación en el paciente crítico con la COVID-19

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ABSTRACT

Introduction: airway management and artificial ventilation play an indispensable role in maintaining vital functions in the critically-ill patient, in those infected with the COVID-19 this management has specific particularities.
Objective: to describe airway management in the critically-ill patient with the COVID -19
Methods: a medical literature review was conducted, using articles retrieved from MEDLINE, Scopus, ClinicalKey and ScienceDirect published up to May 2020.
Development: oxygen therapy is useful for maintaining oxygen saturation levels above 96% in the less advanced stages; using conventional oxygenation systems and high frequency nasal cannula. Early tracheostomy should be performed in stable patients with low oxygen demand where prolonged mechanical ventilation is expected; and in patients with confirmed COVID-19, 14 days after the starting of orotracheal intubation. Non-invasive mechanical ventilation showed a lower intubation rate than other oxygenation variants. Optimal parameters should be set, taking into account the different characteristics of the patient.
Conclusions: intubation should be performed through a rapid induction sequence, minimizing exposure time, tracheostomy is preferably performed late in the infected patient, and non-invasive mechanical ventilation should be performed avoiding aerosolization as much as possible. In invasive mechanical ventilation, strategies for lung protection, reduction of tidal volumes individualized to the characteristics and phenotypes of the patient, desired plateau pressure and distension pressure along with the use of prone ventilation are useful.
Keywords: COVID-19; Coronavirus; Mechanical ventilation; Tracheotomy; Intensive care unit; Oxygen therapy.

RESUMEN

Introducción: el manejo de la vía aérea y la ventilación artificial juega un papel indispensable para mantener las funciones vitales en el paciente crítico, en los infectados por la COVID-19 este manejo posee peculiaridades específicas.
Objetivo: Describir el manejo de la vía aérea en el paciente crítico con la COVID-19
Métodos: se realizó una revisión de la literatura, mediante artículos recuperados en MEDLINE, Scopus, ClinicalKey y ScienceDirect publicados hasta mayo de 2020.
Desarrollo: la oxigenoterapia resulta útil para mantener niveles de saturación de oxígeno superiores al 96 % en estadios poco avanzados; mediante los sistemas de oxigenación convencional, y la cánula nasal de alta frecuencia. La traqueostomía precoz se debe realizar en pacientes estables con baja demanda de oxígeno en los que se prevea ventilación mecánica prolongada; y en pacientes con la COVID-19 positivos 14 días posteriores al inicio de la intubación orotraqueal. La ventilación mecánica no invasiva mostró menor tasa de intubación con respecto a otras variantes de oxigenación. Se deben configurar parámetros óptimos, teniendo en cuenta las particularidades del paciente.
Conclusiones: la intubación se debe realizar mediante una secuencia de inducción rápida, minimizando el tiempo de exposición, la realización de la traqueostomía es de preferencia tardía en el paciente infectado, y la ventilación mecánica no invasiva debe realizarse evitando al máximo la aerosolización. En la ventilación mecánica invasiva resultan útiles estrategias de protección pulmonar, disminución de volúmenes corrientes individualizada a las características y fenotipos del paciente; presión meseta y presión de distensión deseados y la utilización de la ventilación en decúbito prono.
Palabras clave: COVID-19; Coronavirus; Ventilación mecánica; Traqueotomía; Unidad de cuidados intensivos; Oxigenoterapia.

INTRODUCTION

Viral diseases have had an increasing incidence in recent years, with outbreaks leading the health systems to complex situations. However, they have led to their detailed study, understanding and predicting their real impact in the short and long term. [1]

Intensive Care Medicine, Critical Care Medicine or Emergency Medicine have not been exempt from these challenges, having to face their impact from the front line. Similarly, they have had to face other situations such as microbial resistance, designing new protocols and modes of action.

In December 2019, the Wuhan Municipal Health Commission in the People's Republic of China released a report of 27 human cases of viral pneumonia. Of these, seven patients were in critical condition. [2] The disease had as etiology a new human pathogen with high zoonotic capacity; it was provisionally designated as novel coronavirus 2019 (2019-nCoV).

The disease caused by the new SARS-CoV-2 *(severe acute respiratory syndrome coronavirus-2)* was declared by the World Health Organization (WHO) as an international public health emergency in January 2020, [3] and as a pandemic on March. [4]

Sequencing of the genome and phylogenetic analysis of SARS-CoV-2 found similarity with respect to betacoronavirus associated with human severe acute respiratory syndrome (SARS) and Middle Eastern respiratory syndrome (MERS). The similarity was 80% for SARS-CoV and 50% for MERS-CoV. [5, 6]

COVID-19 has been classified in the betacoronavirus 2b line. Generically, coronaviruses are RNA viruses, which genome has the largest size among currently known RNA viruses. With a helical shape, and consisting of a single strand, the genome is packaged together with a protein (nucleocapsid). At least three protein structures are found in the viral envelope: membrane M protein, E protein responsible for viral assembly and the S protein in the spines *(spikes)* involved in the penetration of the virus into the attacked host cells. [7, 8]

Effective transmission patterns pick up person-to-person transmission through body secretions, mainly those of the oral mucosa and respiratory tract; it can also be aerosolized *(Flügge droplets)*. [6, 9, 10] Its detection has been achieved in other body substances and mucous membranes; [11, 12] however, the highest viral loads are reported in the lower respiratory tract (sputum or endotracheal aspiration). [13]

It has been reported that about 80% of those infected have mild symptoms, 15% severe symptoms (dyspnea, polypnea ≥ 30 breaths per minute, oxygen saturation ≤ 93 %, PaO_2/FiO_2 ratio <300, with or without the appearance of pulmonary infiltrates >50% in 24-48 hours); 5 % were considered critical, who presented acute respiratory failure syndrome or respiratory distress, septic shock and dysfunction or multiple organ failure. The most frequent complications are pneumonia and multiple organ failure, which sometimes lead to death. Other possible complications that have been described are: respiratory distress syndrome of the adult, renal failure, acute lung damage and septic shock. [14, 15]

Airway management and artificial ventilation play an indispensable role in maintaining vital functions in the critical patient. In those infected by COVID-19 this management has specific peculiarities. The research was developed with the objective of describing airway management in the critically-ill patient suffering from COVID-19.

METHODS

A narrative review was conducted using the articles retrieved from the databases Scopus, SciELO, PubMed, ClinicalKey, Lilacs and DIALNET. Access was made during the months of April and May 2020. Filters were used for the collection of articles in English and Spanish languages; as well as articles published in the period 2019-2020. The following terms were used: "coronavirus", "COVID-19", "SARS-CoV-2", "Intensive Care", "Airway" and "airway management"; as well as their translations into English. "coronavirus", "COVID-19", "SARS-CoV-2"; "critical care", "airway", "airway management". The structures of the search formulas were specific to each database. Articles published in Health Science Journals were chosen.

DEVELOPMENT

Thanks to current technological advances, the detection of viral infections has been achieved more efficiently, increasing the detection of respiratory viral diseases in ICU patients from 17% to 50%. [7, 16] The administration of oxygen and ventilatory support in acute respiratory distress syndrome (ARDS) is similar in patients with viral and other infections; however, there are differences to be taken into account.

OXYGEN THERAPY

In primary hypoxemia, one of the main therapeutic strategies is the administration of oxygen (O_2). Its main objective is to achieve oxygen saturation of around 96%, although in situations such as chronic obstructive pulmonary disease, saturation of approximately 88% is expected. Its administration is quantified by the inspired fraction of oxygen (FiO_2). [17]

Therapeutic O_2 delivery devices include conventional oxygenation systems (nasal cannula, single mask, partial re-breathing mask, Venturi system, etc.), and high flow nasal cannula. According to the experience obtained from research on patients in China, [18] Chica-Meza *et al*., [19] recommend that patients with an oxygenation rate of less than 200 mmHg should be transferred to a medical center to begin O_2 administration preferably with conventional oxygenation systems over non-invasive ventilation, achieving an O_2 saturation of more than 90% in men and non-pregnant women; and between 92% and 95% in pregnant women. It should be administered at 3 L/min; and if saturation is observed to be lower than the previous parameters, consideration should be given to increasing FiO_2 to achieve the expected saturation.

Gattinoni [20] recommends, when starting with oxygen therapy, whether or not O_2 saturation is increased, the mechanics of the respiratory muscles and thoracoabdominal asynchrony should be evaluated because they will determine the progression of the disease.

The authors consider that in order to initiate oxygen therapy the patient must show one of the following elements: to be dyspneic or have oxygen saturation below the desired levels and the patient begins to show decreased PCO_2 levels as a result of an increase in minute volume to maintain the desired volumes. This increase in minute volume is generated with increased negative pleural pressure, which increases venous return and the risk of developing pulmonary edema and self-induced lung damage described by Brochard [21] as *patient self-induced lung injury* (P-SILI).

Similarly, they consider that once conventional oxygenation or non-invasive ventilation (NIV) has begun, if there is no improvement in breathing work, to immediately proceed to endotracheal intubation.

The high-flow cannula has been shown to be efficient in patients to prevent intubation, and cross-infection, as well as to treat patients where conventional oxygenation has failed. [22]

There is concern about the risk of transmission due to the spreading of particles from the use of these devices, which is contraindicated by some researchers. However, it has been suggested that there is no difference in risk between these techniques. [23] However, based on models derived from the transmission of SARS, it has been considered that workers who administer these techniques to infected patients do not show an increased risk, [24] on condition that they apply all the established protective measures.

Li [25] recommends that, if the high flow nasal cannula is used, 20 L/min should be administered, gradually increasing to 50-60 L/min, with FiO_2 adjustments based on O_2 saturation. This technique is contraindicated in patients with loss or alteration of consciousness, hypercapnia and moderate or severe acidosis.

TRACHEOSTOMY

Tracheostomy (TST) is a common procedure performed in ICUs, with patients needing prolonged ventilatory support. The requirements for mechanical ventilation (MV) vary in the different series, being reported between 9.8 % and 15.2 %. [26, 27] Due to the generation of micro droplets during intubation and MV, it is necessary to adjust the airway management protocols.

Medical practice has not achieved conclusive results on the optimal time for performing TST. This may be due to the diverse number of entities treated in the ICU, the heterogeneity of the groups studied, as well as the different definitions of early and late tracheostomy. The consensus document of the Spanish Society of Intensive, Critical Medicine and Coronary Units (SEMICYUC), the Spanish Society of Otolaryngology and Head and Neck Surgery (SEORL-CCC) and the Spanish Society of Anesthesiology and Resuscitation (SEDAR) on tracheostomy in patients confirmed with COVID-19 defines early TST as that performed in the first 10 days, and late TST as that performed after that time. [28]

The current evidence only allows relating the use of sedatives to the time of the TST. [29] There are recommendations from the *Canadian Society of Otolaryngology Head and Neck Surgery* [30] which establish the criteria for negative PCR examination to carry out the procedure, considering as an exception the patient in whom orotracheal intubation does not secure the airway.

Because of this, early tracheostomy has been recommended only for stable patients with low oxygen demand where prolonged mechanical ventilation is expected due to concomitant diseases or associated risk factors; or if intensive resource optimization is needed. Otherwise, it is recommended to perform in confirmed COVID-19 patients after 14 days of commencement of orotracheal intubation, if necessary. [30]

The use of closed circuit suction systems with anti-viral filters is recommended, limiting the use of electrical, ultrasonic or any other cutting and coagulation systems that disseminate aerial micro-particles. Only indispensable personnel should be present during the procedure, and if possible it should be carried out by the most trained personnel and in the shortest time. [31,32] To the consideration of the authors, a percutaneous tracheostomy performed by the Seldinger method, carry out by trained professionals, would be the best option, as it reduces the exposure of health personnel and the risks of contagion.

Intubation should be performed by a rapid induction sequence, to decrease exposure time and mask ventilation should be avoided, but if necessary, it should be performed by two persons, with one serving as a mask seal and the other ventilating,[31,32] decreasing the risk of transmission to personnel. [33]

If pre-oxygenation is carried out with a self-inflating bag (Ambu®), it is advisable to use a HEPA (High Efficiency Particulate Air), filter between the mask and the Ambu®.

NON-INVASIVE MECHANICAL VENTILATION

The use of non-invasive mechanical ventilation (NIVMV) is widely used in ICUs worldwide, even in patients with hypoxemic respiratory failure; hence, it constitutes another viable resource in the treatment of patients with COVID-19. [34]

Due to air leakage, and therefore dispersion of particles from the mask, there is controversy in its use; the greater the leakage, the greater the patient's requirement for ventilatory support. [35]

Due to the low arrangement of interfaces such as the head covering (Helmet) with double branch respirator, adapted with double tubing and anti-viral/anti-bacterial HEPA filters on both branches (inspiratory/ expiratory); [36] other measures should be adopted. Therefore, existing equipment should be adapted, reducing leaks around the mask as much as possible. This reduces the risk of exposure and infection by particle dispersion resulting from (NIV). [34]

Although high-flow oxygenation has been designated as the first choice modality and NIV has been taken as a second option in patients where the first does not meet the demand, but who also do not have intubation criteria; [37] it is still a fact that gives rise to discrepancies.

An example of this discrepancy is represented by Zhan's study, [38] where NIVMV decreased intubation in patients with Acute Respiratory Infection. Similarly, data from Wang *et al*; [39] analyzed and reported by González-Castro *et al*.,[40] in a letter published in *Intensive Care Medicine*; showed that using a Beta-Binomial model, applying an *a priori* non-informative one, the probability of a lower intubation rate with NIVMV than with high flow oxygenation is 0.9993 (Rate difference = 0.444; CI 95% = 0.097 -0.706). This result suggests that NIVMV and high-flux oxygenation may need to be placed at the same height.

However, it is necessary to point out that when the patient has intubation criteria, its performance should not be delayed; if the oxygenation objectives are not achieved through the high flow cannulas, this could bring more harm than good by delaying the intubation and causing self-induced lung damage.

INVASIVE MECHANICAL VENTILATION

The rapid evolution of some patients with COVID-19 has led to complicated ARDS or multiple organ failure due to dyspnea and hypoxia. [41] In these patients, factors such as advanced age, neutrophilia, organic dysfunction, elevated LDH, elevated ferritine and coagulation dysfunction have been associated with a worse progression and a greater probability of death. [42]

In severe cases of COVID 19, hypoxemia compatible with ARDS can be observed, however, compliance may occur with normal or decreased values, with two different phenotypes being considered: L and H. The L type is characterized by low elastance (high distensibility), low ventilation-perfusion ratio and low recruitment potential, and the H type is characterized by high elastance, with low recruitment potential. [20, 43]

The ventilatory strategy to be employed must be planned taking these phenotypes into account. In the event that a phenotype L is present, it is not necessary to limit the tidal volume, always keeping a watchful eye on the plateau pressure, distension pressure and mechanical power if these are maintained at the desired values, there will be no risk of lung injury induced by ventilation with a tidal volume of up to 8 mL/Kg, thus avoiding the risk of severe hypoventilation and the development of atelectasis. However, type H would be managed as a classical ARDS with emphasis on the protective MV strategy, it is recommended starting with a tidal volume of 6 mL/Kg, where the ideal weight for MV in men is 50+0.91 (h-52.4) and in women 45.5+0.91 (h-52.4).

The *plateau* pressure should range from 25-30 cm H_2O, where these measures have been associated with a reduction in mortality rate. Similarly, a strain pressure of less than 15 cm H_2O, an initial PEEP of 10-14 cm H_2O and a FiO_2 that achieves a $SatO_2$ between 88 and 92% have been recommended. [43] Protocols guided by sedation and analgesia goals should be maintained; and if deep sedation is necessary due to frequent asynchronies, prone ventilation or elevated *plateau* pressure levels, infused neuromuscular relaxation should be preferred, and should be carried out within 48 hours. [44]

During the management of mechanical ventilation, pressure control or volume control can be used. Dual modes of ventilation are not recommended and bronchodilator therapy should only be indicated by inhalation therapy if extremely necessary. It is also suggested to define early mobilization action plans, as the disease allows, to treat muscle hypotonia. [43, 44]

Inhalation of nitric oxide has been considered as a rescue measure in patients with persistent refractory hypoxemia due to COVID 19. Recommended values range from 5 to 20 ppm and there is speculation on the improvement of oxygenation. However, its routine use in the patient is not recommended, since in ARDS the duration of the positive effect is less than 24 hours; it can also cause acute renal injury. [45]

PRONE POSITION

The prone position emerges as a useful tool during ARDS patient care by SARS-CoV-2. In a protocol in Jiangsu, different therapies were used, showing an IMV rate of less than 1%, where pronation was one of the techniques. [46] It is recognized that in ARDS, lung-dependent areas are more prone to collapse; this leads to a decrease in lung tissue available for exchange. [47] A meta-analysis [48] evaluating the effects of pronation in adults, compared to mechanical ventilation in the supine position in patients with ARDS, showed a reduction in mortality rated in patients ventilated prone when ARDS is moderate or severe ($PaO2/FiO2<200$ mmHg) and for more than 12 hours. After the technique, the ventilation/perfusion ratio balance is improved by increasing lung volume at the end of expiration and preventing ventilator-induced lung injury, through a more uniform distribution, not only of tidal volume through lung recruitment, but also of *"stress and strain"*; [49] as well as draining any secretion that may occur.

The use of several long cycles has been considered, with durations between 18 and 20 hours [7] and in 16/8 or 18/6 ratios [50]. Chica-Meza *et al.* [19]. Suggest that, given the current evidence and experience, the prone ventilation cycle should be 24 hours and alveolar recruitment maneuvers should be implemented with the aim of decreasing the number of prone cycles.

Among the recommendations during the application of this technique are the monitoring of perfusion, the change of position every 2 hours to avoid pressure injuries, the use of mechanical protective ventilation. [43] Close attention should also be paid to the condition of the endotracheal tube and the lines placed in the patient.

CONCLUSIONS

Oxygen therapy ensures adequate levels of oxygen saturation in less critical stages of the disease. Orotracheal intubation should be performed through a rapid induction sequence to decrease exposure time. Tracheostomy is preferably performed late in the infected patient. Non-invasive mechanical ventilation should be performed in a controlled manner, decreasing mask leakage. It is useful to use strategies for lung protection, decrease tidal volumes individualized to the characteristics and phenotypes of the patient; as well as achieve desired *plateau* pressure and distension pressure and the use of prone ventilation.

Declaration of conflict Of interest

The authors declare that there is no conflict of interest.

Author's contribution

AAVC, HRA and AEDR were responsible for the conception and design of the article. All authors participated in the writing, review and approval of the article and its final version.

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BIBLIOGRAPHIC REFERENCES

1. Millan-Oñate J, Rodríguez-Morales AJ, Camacho-Moreno G, Mendoza Ramírez H, Rodríguez-Sabogal IA, Álvarez-Moreno C. A new emerging zoonotic virus of concern: the 2019 novel Coronavirus (COVID-19). Infectio [Internet]. 2020 [15/05/2020]; 24(3). Disponible en: https://revistainfectio.org/index.php/infectio/article/view/848/922

2. Palacios Cruz M, Santos E, Velázquez Cervantes MA, León Juárez M. COVID-19, una emergencia de salud pública mundial. Rev Clin Esp [Internet]. 2020 [15/05/2020. Disponible en: https://www.revclinesp.es/en-pdf-S2254887420300333

3. World Health Organization. 2019-nCoV outbreak is an emergency of international concern [Internet]. World Health Organization, Regional Office for Europe; 2020 [citado 31 Ene 2020]. Disponible en: https://www.euro.who.int/en/health-topics/health-emergencies/international-health-regulations/news/news/2020/2/2019-ncov-outbreak-is-an-emergency-of-international-concern

4. World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020 [Internet]. World Health Organization; 2020 [citado 11 Mar 2020]. Disponible en: https://www.who.int/dg/speeches/detail/whodirector-general-s-opening-remarks-at-the-mediabriefing-on-covid-19---11-march-2020

5. Cui J, Li F, Shi ZL. Origin and evolution of pathogenic coronaviruses. Nat Rev Microbiol [Internet]. 2019 [15/05/2020]; 17(3): [aprox. 11p.]. Disponible en: https://www.nature.com/articles/s41579-018-0118-9

6. Moreno-Martínez FL, Moreno-López F, Oroz-Moreno R. Repercusión cardiovascular de la infección por el nuevo coronavirus SARS-CoV-2 (COVID-19). CorSalud [Internet]. 2020 [15/05/2020]; 12(1): [aprox. 13p.]. Disponible en: http://www.revcorsalud.sld.cu/index.php/cor/article/view/

7. González-Castro A, Escudero-Acha P, Peñasco Y, Leizaola O, Martínez de Pinillos Sánchez V, García de Lorenzo A. Cuidados intensivos durante la epidemia de coronavirus 2019. Med Intensiva [Internet]. 2020 [15/05/2020]. Disponible en: https://doi.org/10.1016/j.medin.2020.03.001

8. Li F. Structure Function, and Evolution of Coronavirus Spike Proteins. Annu Rev Virol [Internet]. 2016 [15/05/2020]; 3: [aprox. 20p.]. Disponible en: http://dx.doi.org/10.1146/annurev-virology-110615-042301

9. Iglesias-Osores S, Saavedra-Camacho JL. Riesgo de contagio por SARS-CoV-2 en estomatólogos. Univ Méd Pinareña [Internet]. 2020 [15/05/2020]; 16(2): [aprox. 3p.]. Disponible en: http://www.revgaleno.sld.cu/index.php/ump/article/view/496

10. van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. N Engl J Med [Internet]. 2020 [15/05/2020]; 382(16): [aprox. 3p.]. Disponible en: https://www.nejm.org/doi/full/10.1056/nejmc2004973

11. Hussin A, Rothan E, Siddappa N, Byrareddy T. The epidemiology and pathogenesis of coronavirus disease (COVID-19). Journal of Autoimmunity [Internet]. 2020 [15/05/2020]; 102(433): [aprox. 1p.]. Disponible en: https://doi.org/10.1016/j.jaut.2020.102433

12. Belasco AGS, Fonseca CD. Coronavírus 2020. Rev Bras Enferm [Internet]. 2020 [15/05/2020]; 73(2): [aprox. 5p.]. Disponible en: http://dx.doi.org/10.1590/0034-7167-2020730201

13. Huang Y, Chen S, Yang Z, Guan W, Liu D, Lin Z, et al. SARS-CoV-2 Viral Load in Clinical Samples of Critically Ill Patients. Am J Respir Crit Care Med [Internet]. 2020 [15/05/2020]; 201(11): [aprox. 4p.]. Disponible en: https://doi.org/10.1164/rccm.202003-0572le

14. Serra Valdés MA. Infección respiratoria aguda por COVID-19: una amenaza evidente. Rev haban cienc méd [Internet]. 2020 [15/05/2020]; 19(1): [aprox. 5p.]. Disponible en: http://www.revhabanera.sld.cu/index.php/rhab/article/view/317

15. Aragón-Nogales R, Vargas-Almanza I, Miranda Novales MG. COVID-19 por SARS-CoV-2: la nueva emergencia de salud. Rev Mex Pediatr [Internet]. 2019 [15/05/2020]; 86(6): [aprox. 5p.]. Disponible en: https://doi.org/10.35366/91871

16. Arabi YM, Fowler R, Hayden FG. Critical care management of adults with community-acquired severe respiratory viral infection. Intensive Care Med [Internet]. 2020 [15/05/2020]; 46(2): [aprox. 13p.]. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7079862/

17. Grensemann J, Fuhrmann V, Kluge S. Oxygen Treatment in Intensive Care and Emergency Medicine. Dtsch Arztebl Int [Internet]. 2018 [15/05/2020]; 115(27-28): [aprox. 7p.]. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6111205/

18. Xu K, Cai H, Shen Y, Ni Q, Chen Y, Hu S, et al. Management of corona virus disease-19 (COVID-19): the Zhejiang experience. J Zhejiang Univ Med Sci [Internet]. 2020 [15/05/2020]; 49(1): [aprox. 1p.]. Disponible en: https://read.qxmd.com/read/32096367/-management-of-corona-virus-disease-19-covid-19-the-zhejiang-experience

19. Chica-Meza C, Peña-López LA, Villamarín-Guerrero HF, Moreno-Collazzos JE, Rodríguez-Corredor LC, Mauricio Lozano W, et al. Cuidado respiratorio en COVID-19. Acta Colomb Cuid Intensivo [Internet]. 2020 [15/05/2020]; [aprox.10p.]. Disponible en: https://doi.org/10.1016/j.acci.2020.04.001

20. Gattinoni L. COVID-19 pneumonia: different respiratory treatment for different phenotypes? Intensive Care Medicine [Internet]. 2020 [15/05/2020]; 46: [aprox. 4p.]. Disponible en: https://doi.org/10.1007/s00134-020-06033-2

21. Brochard L, Slutsky A, Pesenti A. Mechanical Ventilation to Minimize Progression of Lung Injury in Acute Respiratory Failure. Am J Respir Crit Care Med [Internet]. 2017[15/05/2020]; 195(4): [aprox. 8p.]. Disponible en: https://www.atsjournals.org/doi/10.1164/rccm.201605-1081CP

22. Alhazzani W, Møller MH, Arabi YM, Loeb M, Gong MN, Fan E, et al. Surviving Sepsis Campaign: guidelines on the management of critically ill adults with Coronavirus Disease 2019 (COVID-19). Soc Crit Care Med [Internet]. 2020 [15/05/2020]; [aprox. 34p.]. Disponible en: https://sepsis-one.org/wp-content/uploads/2020/04/Campa%C3%B1a-Sobrevivir-a-la-sepsis.pdf

23. Leung CCH, Joynt GM, Gomersall CD, Wong WT, Lee A, Ling L, et al. Comparison of high-flow nasal cannula versus oxygen face mask for environmental bacterial contamination in critically ill pneumonia patients: a randomized controlled crossover trial. J Hosp Infect [Internet]. 2019 [15/05/2020]; 101(1): [aprox. 3p.]. Disponible en: https://www.sciencedirect.com/science/article/pii/S0195670118305425

24. Raboud J, Shigayeva A, McGeer A, Bontovics E, Chapman M, Gravel D, et al. Risk Factors for SARS Transmission from Patients Requiring Intubation: A Multicentre Investigation in Toronto. Canada. PLOS ONE [Internet]. 2010 [15/05/2020]; 5(5): [aprox. 11p.]. Disponible en: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0010717

25. Li T. Diagnosis and clinical management of severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) infection: an operational recommendation of Peking Union Medical College Hospital (V2.0). Emerg Microbes Infect [Internet]. 2020 [15/05/2020]; 9(1): [aprox. 5p.]. Disponible en: http://dx.doi.org/10.1080/22221751.2020.1735265

26. Wu Z, Mc Googan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China. JAMA [Internet]. 2020 [15/05/2020]; 323(13): [aprox. 3p.]. Disponible en: https://jamanetwork.com/journals/jama/fullarticle/2762130

27. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet [Internet]. 2020 [15/05/2020]; 395(10223): [aprox. 9p.]. Disponible en: http://dx.doi.org/10.1016/S0140-6736(20)30183-5

28. Delgado MCM, Avilés-Jurado FX, Escudero J, Álvarez-Santuyano CA, de Haro López C, de Cerio Canduela PD, et al. Documento de consenso de la Sociedad Española de Medicina Intensiva, Crítica, y Unidades Coronarias (SEMICYUC), la Sociedad Española de Otorrinolaringología y Cirugía de Cabeza y Cuello (SEORL-CCC) y la Sociedad Española de Anestesiología y Reanimación (SEDAR) sobre la traqueotomía en pacientes con COVID-19. Medicina intensive [Internet]. 2020 [15/05/2020]: [aprox. 7p.]. Disponible en: https://doi.org/10.1016/j.medin.2020.05.002

29. Wang R, Pan C, Wang X, Xu F, Jiang S, Li M. The impact of tracheotomy timing in critically ill patients undergoing mechanical ventilation: A meta-analysis of randomized controlled clinical trials with trial sequential analysis. Heart Lung [Internet]. 2019 [citado 15/05/2020]; 48(1): [aprox. 8p.]. Disponible en: https://www.sciencedirect.com/science/article/abs/pii/S0147956318301730

30. Canadian Society of Otolaryngology - Head and Neck Surgery / Société Canadienne d'oto-rhino-laryngologie et de chirurgie cervico-faciale. Recommendations from the CSO-HNS Taskforce on Performance of Tracheotomy During the COVID-19 Pandemic. Journal of Otolaryngology - Head & Neck Surgery [Internet]. 2020 [citado 15/05/2020]; 49(23). Disponible en: https://journalotohns.biomedcentral.com/articles/10.1186/s40463-020-00414-9

31. Wax RS, Christian MD. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. Can J Anaesth [Internet]. 2020 [citado 15/05/2020]; 67: [aprox. 9p.]. Disponible en: https://link.springer.com/article/10.1007/s12630-020-01591-x

32. Jin Y-H, Cai L, Cheng Z-S, Cheng H, Deng T, Fan YP, et al. A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019-nCoV) infected pneumonia (standard version). Mil Med Res [Internet]. 2020 [citado 15/05/2020]; 7: [aprox. 4p.]. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7003341/

33. Cheung JC, Ho LT, Cheng JV, Cham EYK, Lam KN. Staff safety during emergency airway management for COVID-19 in Hong Kong. Lancet Respir Med [Internet]. 2020 [citado 15/05/2020]; 8(4): [aprox. 19p.]. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7128208

34. Hernández Garcés H, Belenguer Muncharaz A, Zaragoza Crespo R. Ventilación mecánica no invasiva y COVID-19. Minimizando la dispersión. Med Intensiva [Internet]. 2020 [citado 15/05/2020]; [aprox. 2p.]. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7177060/

35. Hui DS, Chow BK, Lo T, Ng SS, Ko FW, Gin T, et al. Exhaled air dispersion during noninvasive ventilation via helmets and a total facemask. Chest [Internet]. 2015 [citado 15/05/2020]; 147(5): [aprox. 7p.]. Disponible en: https://www.sciencedirect.com/science/article/pii/S0012369215383598

36. Patel BK, Wolfe KS, Pohlman AS, Hall JB, Kress JP. Effect of noninvasive ventilation delivered by helmet vs face mask on the rate of endotracheal intubation in patients with acute respiratory distress syndrome. JAMA [Internet]. 2016 [citado 15/05/2020]; 315(22): [aprox. 6p.]. Disponible en: http://jamanetwork.com/journals/jama/article-abstract/2522693

37. Cinesi Gómez C, Peñuelas Rodríguez Ó, Luján Torné M, Egea Santaolalla C, Masa Jiménez JF, García Fernández J, et al. Clinical consensus recommendations regarding non-invasive respiratory support in the adult patient with acute respiratory failure secondary to SARS-CoV-2 infection. Revista Española de Anestesiología y Reanimación [Internet]. 2020 [citado 15/05/2020]; 67(5). Disponible en: https://www.sciencedirect.com/science/article/pii/S234119292030069X?via%3Dihub

38. Zhan Q, Sun B, Liang L, Yan X, Zhang L, Yang J, et al. Early use of noninvasive positive pressure ventilation for acute lung injury: A multicenter randomized controlled trial. Crit Care Med [Internet]. 2012 [citado 15/05/2020]; 40: [aprox. 5p.]. Disponible en: http://dx.doi.org/10.1097/CCM.0b013e318232d75e

39. Wang K, Zhao W, Li J, Shu W, Duan J. The experience of high-flow nasal cannula in hospitalized patients with 2019 novel coronavirus-infected pneumonia in two hospitals of Chongqing, China. Ann Intensive Care [Internet]. 2020 [citado 15/05/2020]; 10(37). Disponible en: https://annalsofintensivecare.springeropen.com/articles/10.1186/s13613-020-00653-z

40. González-Castro A, Fajardo Campoverde A, Medina A, i Alapont VM. Ventilación mecánica no invasiva y oxigenoterapia de alto flujo en la pandemia COVID-19: El valor de un empate. Med Intensiva [Internet]. 2020 [citado 15/05/2020]; [In press]. Disponible en: https://www.sciencedirect.com/science/article/pii/S021056912030156X?via%3Dihub

41. Gattinoni L, Coppola S, Cressoni M, Busana M, Chiumello D. Covid-19 Does Not Lead to a "Typical" Acute Respiratory Distress Syndrome. Am J Respir Crit Care Med [Internet]. 2020 [citado 15/05/2020]; 201(10): [aprox. 1p.]. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7233352/

42. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet [Internet]. 2020 [citado 15/05/2020]; 395(10229): [aprox. 8p.]. Disponible en: https://www.sciencedirect.com/science/article/pii/s0140673620305663

43. Accini Mendoza JL, Beltran N, Estrada VHN, Bolaños ER, Gómez CP, Rebolledo MCE, et al. Declaración de consenso en medicina critica para la atención multidisciplinaria del paciente con sospecha o confirmación diagnóstica de covid-19. Acta Colombiana de Cuidado Intensivo [Internet]. 2020; [In press]. Disponible en: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7164846/

44. The national heart, Lung, and Blood Institute PETAL Clinical Trials Network, Moss M, Huang DT, Brower RG, Ferguson ND, Ginde AA, et al. Early neuromuscular Blockade in the Acute Respiratory Distress Syndrome. N Engl J Med [Internet]. 2019 [citado 15/05/2020] 380: [aprox. 11p.]. Disponible en: https://www.nejm.org/doi/full/10.1056/nejmoa1901686

45. Matthay MA, Aldrich JM, Gotts JE. Treatment for severe acute respiratory distress syndrome from COVID-19. Lancet Respir Med [Internet]. 2020 [citado 15/05/2020]. Disponible en: https://alatorax.org/es/biblioteca/treatment-for-severe-acute-respiratory-distress-syndrome-from-covid-19

46. Sun Q, Qiu H, Huang M, Yang Y. Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province. Ann Intensive Care [Internet]. 2020 [citado 15/05/2020]; 10(1): [aprox. 2p.]. Disponible en: https://annalsofintensivecare.springeropen.com/track/pdf/10.1186/s13613-020-00650-2

47. Mezidi M, Parrilla FJ, Yonis H, Riad Z, Böhm SH, Waldmann AD, et al. Effects of positive end-expiratory pressure strategy in supine and prone position on lung and chest wall mechanics in acute respiratory distress syndrome. Ann Intensive Care [Internet]. 2018 [citado 15/05/2020]; 8(1): [aprox. 1p.]. Disponible en: https://link.springer.com/article/10.1186/s13613-018-0434-2

48. Munshi L, Del Sorbo L, Adhikari NKJ, Hodgson CL, Wunsch H. Prone Position for Acute Respiratory Distress Syndrome. A Systematic Review and MetaAnalysis. Ann Am Thorac Soc [Internet]. 2017 [citado 15/05/2020]; 14(4). Disponible en: www.atsjournals.org/doi/abs/10.1513/annalsATS.201704-343OT

49. Fernández Cordero R, Catarinella Gómez C, Chacón Prado L. Soporte ventilatorio no invasivo y posición prono despierto en paciente con COVID-19. Rev Méd Costa Rica [Internet]. 2020 [citado 15/05/2020]; 85(629): [aprox. 5p.]. Disponible en: http://revistamedicacr.com/index.php/rmcr/article/viewFile/294/271

50. Guérin C. Prone positioning acute respiratory distress syndrome patients. J Thorac Dis [Internet]. 2018 [citado 15/05/2020]; 10(Suppl 17): [aprox. 2p.]. Disponible en: http://dx.doi.org/10.21037/atm.2017.06.63

