CLINICS

REVIEW ARTICLE

Physiotherapy Care of Patients with Coronavirus Disease 2019 (COVID-19) - A Brazilian Experience

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Some patients with coronavirus disease (COVID-19) present with severe acute respiratory syndrome, which causes multiple organ dysfunction, besides dysfunction of the respiratory system, that requires invasive procedures. On the basis of the opinions of front-line experts and a review of the relevant literature on several topics, we proposed clinical practice recommendations on the following aspects for physiotherapists facing challenges in treating patients and containing virus spread: 1. personal protective equipment, 2. conventional chest physiotherapy, 3. exercise and early mobilization, 4. oxygen therapy, 5. nebulizer treatment, 6. non-invasive ventilation and high-flow nasal oxygen, 7. endotracheal intubation, 8. protective mechanical ventilation, 9. management of mechanical ventilation in severe and refractory cases of hypoxemia, 10. prone positioning, 11. cuff pressure, 12. tube and nasotracheal suction, 13. humidifier use for ventilated patients, 14. methods of weaning ventilated patients and extubation, and 15. equipment and hand hygiene. These recommendations can serve as clinical practice guidelines for physiotherapists. This article details the development of guidelines on these aspects for physiotherapy of patients with COVID-19.

KEYWORDS: COVID-19; Physiotherapy; Mechanical Ventilation; Oxygen Therapy; Severe Acute Respiratory Syndrome Coronavirus 2.

INTRODUCTION

The current outbreak of coronavirus disease 2019 (COVID-19) originated in the Hubei Province of the People's Republic of China (1,2), and on March 11, 2020, it was declared a pandemic by the World Health Organization Emergency Committee (2).

The most common symptoms include fever (89%), cough (68%), fatigue (38%), sputum production (34%), and shortness of breath (19%) (3). A considerable proportion of the population with COVID-19 will not require hospitalization as the patients present a mild or uncomplicated form of the disease with a favorable prognosis. However, older patients and those with chronic underlying conditions can develop severe illness and present complications such as acute respiratory disease syndrome (ARDS), sepsis, septic shock, and kidney and cardiac failure, which require treatment in an intensive care unit (ICU) with invasive support (4). Approximately 14% of patients develop a severe form of COVID-19, requiring hospitalization, and 5% require admission to an ICU (5).

Physiotherapists are recognized in several countries as professionals working in primary and tertiary care (6-8) who play a fundamental role in multi-professional teams providing ventilatory support during the acute illness phase and rehabilitation interventions thereafter to promote functionality (9,10).

This paper describes the different actions and practices adopted by the Rehabilitation Service of Hospital Sírio-Libanês (São Paulo, Brazil) to face the challenges in treating and containing the spread of COVID-19. Issues pertaining to clinical practice in the adult hospital setting were identified on the basis of the experience and opinions of front-line experts as well as a review of the relevant literature.

To provide the maximum level of care and ensure staff protection, recommendations were developed regarding protective equipment, conventional chest physiotherapy, exercise and early mobilization, oxygen therapy, nebulizer treatment, non-invasive ventilation and high-flow nasal oxygen, endotracheal intubation, protective mechanical ventilation, management of mechanical ventilation in severe and refractory cases of hypoxemia, prone positioning, cuff pressure, tube and nasotracheal suction, humidifier use for ventilated patients, methods of weaning ventilated patients, and equipment and hand hygiene.

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PERSONAL PROTECTIVE EQUIPMENT (PPE)

Several procedures performed by physiotherapists may generate aerosols and droplets, which are sources of lung and respiratory pathogens. These procedures include non-invasive ventilation, high-flow oxygenation, endotracheal intubation, airway tracheostomy and endotracheal tube suction, cardiopulmonary resuscitation, high-frequency oscillatory ventilation, chest physiotherapy, prone patient positioning, disconnection of the ventilator, administration of nebulized treatment, and sputum induction (11-14). Furthermore, severe acute respiratory syndrome coronavirus 2 can remain in the air for hours and on surfaces of various materials for days upon aerosolization, with risks of possible human infection (15). However, when aerosol-generating procedures cannot be avoided, they should be performed in a negative-pressure room. In the absence of negative-pressure rooms, the procedures must be performed in a room with closed doors and open windows; with minimum number of qualified professionals to perform the procedures; with appropriate PPE; and avoiding the presence other people (16,17). Therefore, physiotherapists must adopt protective measures to avoid aerosol exposure and for contact isolation by using adequate PPE, namely, surgical caps, safety goggles, face shields, N95 masks or equivalent, gowns, and gloves (17-19).

CONVENTIONAL CHEST PHYSIOTHERAPY

Currently, no evidence exists indicating that conventional chest physiotherapy changes the course of COVID-19 in the acute phase of the disease in patients with hypoxemic respiratory failure and dry cough. However, some patients with productive cough may benefit from bronchial hygiene maneuvers and techniques that stimulate coughing (20,21). Patients with a mild form of the disease should be instructed to perform breathing exercises independently. Patients with moderate and severe conditions should be constantly monitored for pulmonary disease (22). In these cases, physiotherapists should contact the patient only for respiratory and pulmonary assessments, especially during orotracheal intubation and oxygen supplementation and for patients who are candidates for non-invasive ventilation or high-flow oxygen administration (22,23). The professional exposure time should be the minimum necessary for evaluation and assistance (22,24).

EXERCISE AND EARLY MOBILIZATION

Patients usually present with a debilitated physical condition because of the disease, which reduces their exercise capacity, especially when they present with fever, dyspnea, myalgia, and fatigue (20); the debilitated physical condition can also be a result of prolonged mechanical ventilation and immobilization. Hospitalized patients, even those with moderate disease severity, can spend weeks in hospital isolation, with a significant decrease in their activity levels, and are thus prone to a reduction in their muscle strength and cardiorespiratory capacity (25). Therefore, patients in the acute phase with mild disease should be encouraged to perform light-intensity exercises to maintain minimal functional capacity. The exercises can be tailored for maintenance of a Borg rating of <3 (on a 10-point scale) (22). Although there are no studies specific to patients with COVID-19, classically critical patients who underwent early mobilization showed a reduction in delirium and duration of mechanical ventilation (26); thus, early mobilization should be started as soon as possible, as long as the patient presents suitable clinical conditions (27). This mobilization can include neuromuscular stimulation, therapeutic exercises, and early verticalization (28-31).

OXYGEN THERAPY

The prevalence of hypoxic respiratory failure in adults with COVID-19 is 19%; thus, oxygen therapy represents a major treatment intervention for patients with severe pulmonary dysfunction (2,32). Adults with COVID-19 should be started on supplemental oxygen if the peripheral oxygen saturation (SpO_2) is $<93\%$ and maintained oxygen saturation is no higher than 96% (23). Mechanical ventilation may be necessary in cases of respiratory failure refractory to oxygen therapy (2,23).

The interfaces used for oxygen supplementation can generate aerosols. Therefore, health care workers should take adequate precautions and wear proper PPE when providing respiratory support to patients with COVID-19 complicated by respiratory failure (19,33). Oxygen humidification should not be used (34). The prescription of moisturizers such as self-applied nasal sodium chloride gel may be suggested for complications such as dryness of the upper airways or epistaxis. The oxygen supply device should be changed if these complications persist.

Figure 1 shows our institutional proposal for oxygen therapy and early transfer to the ICU for patients with respiratory distress and hypoxemia on the basis of the Surviving Sepsis Campaign: Guidelines on the Management of Critically Ill Adults with Coronavirus Disease 2019 (COVID-19).

NEBULIZER TREATMENT

All forms of nebulization (including inhalation) are potential aerosol generators and should be avoided (2,35). Bronchodilators should be administered with metering units (puff or spray) in an air chamber/spacer (2).

NON-INVASIVE VENTILATION AND HIGH-FLOW NASAL OXYGEN

For the treatment of acute hypoxemic respiratory failure, the use of high-flow nasal oxygen is suggested over conventional oxygen therapy and non-invasive positive pressure ventilation (36-38). If high-flow nasal oxygen is not available, a trial of non-invasive ventilation is suggested (39). An experiment in a human model showed that non-invasive ventilation or high-flow nasal oxygen, when well applied with an optimal fit, resulted in minimal aerosolization of exhaled air (40). However, the specific models of masks and interfaces tested in the study are not universally used in all hospitals. Therefore, to avoid potential harm, we recommend using adequate precautions and PPE and discourage the use of this procedure if an airborne infection isolation room is unavailable (2,16). Monitoring for worsening respiratory status and subsequent early intubation is recommended (39).

Patient candidates for non-invasive ventilation admitted to the ICU in negative-pressure rooms must be ventilated with positive end-expiratory pressure (PEEP) $\geqslant 8$ cmH_2O, support

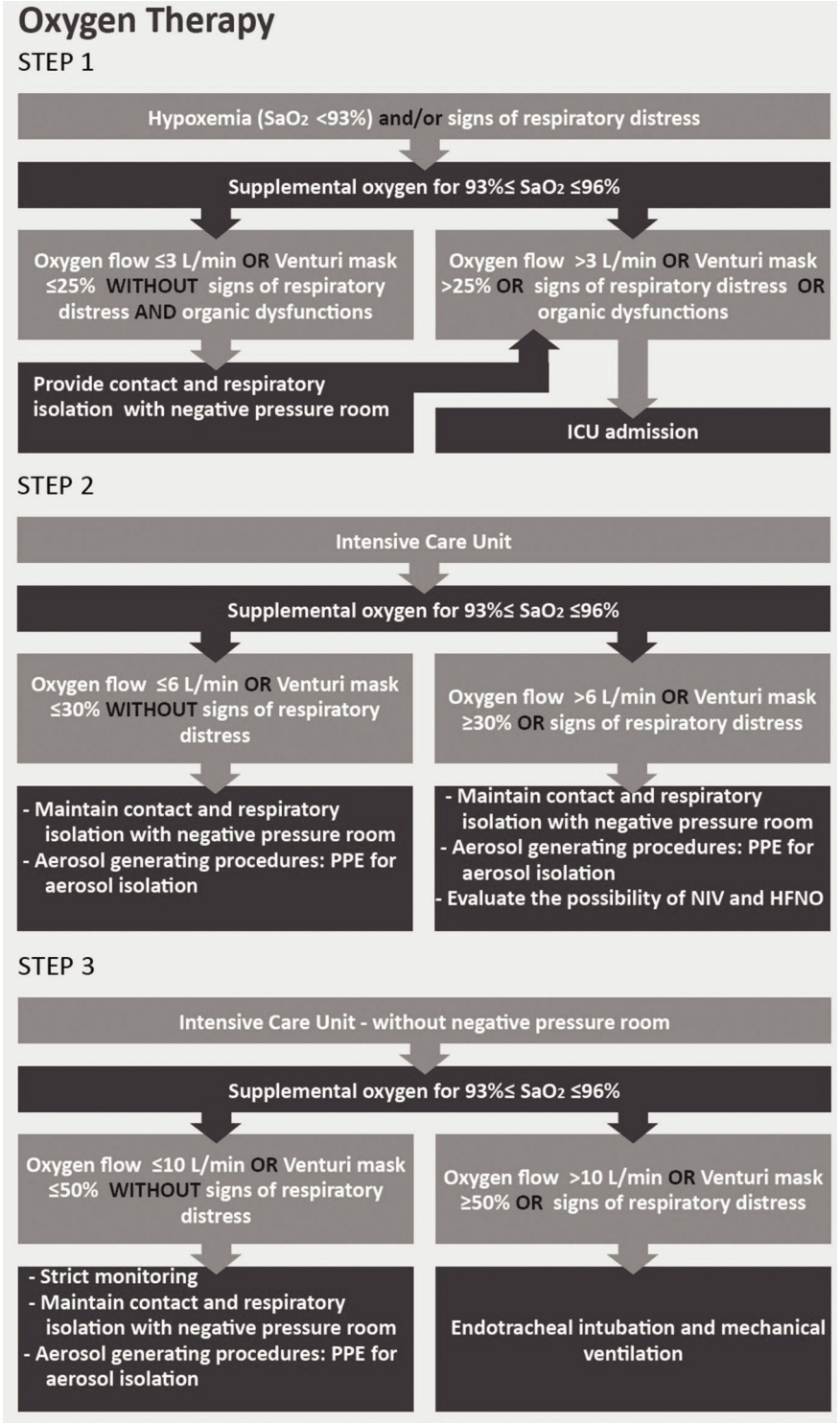

Figure 1 - Proposal for oxygen therapy and early transfer to intensive care units for patients with respiratory distress and hypoxemia based on Surviving Sepsis Campaign: Guidelines on the Management of Critically Ill Adults with Coronavirus Disease 2019 (COVID-19). SaO_2: arterial oxygen saturation; ICU: intensive care unit; PPE: Personal protective equipment; NIV: non-invasive ventilation; HFNO: high-flow nasal oxygen.

pressure for a tidal volume (TV) $\leqslant 8$ mL/kg of the predicted weight, and fraction of inspired oxygen (FiO_2) to maintain SaO_2 $>92\%$. Facial or full-face masks must be used during application of the ventilator. Devices with double branches for ventilation are indicated in these cases, with a heat moisture exchange filter (HMEF) between the face mask and the device and another high-efficiency particulate arrestance (HEPA) filter on the exhalation outlet of the ventilator. For high-flow oxygen, a flow rate of 40 to 50 L/min should be maintained, and FiO_2 to maintain SaO_2 $>92\%$ should be started.

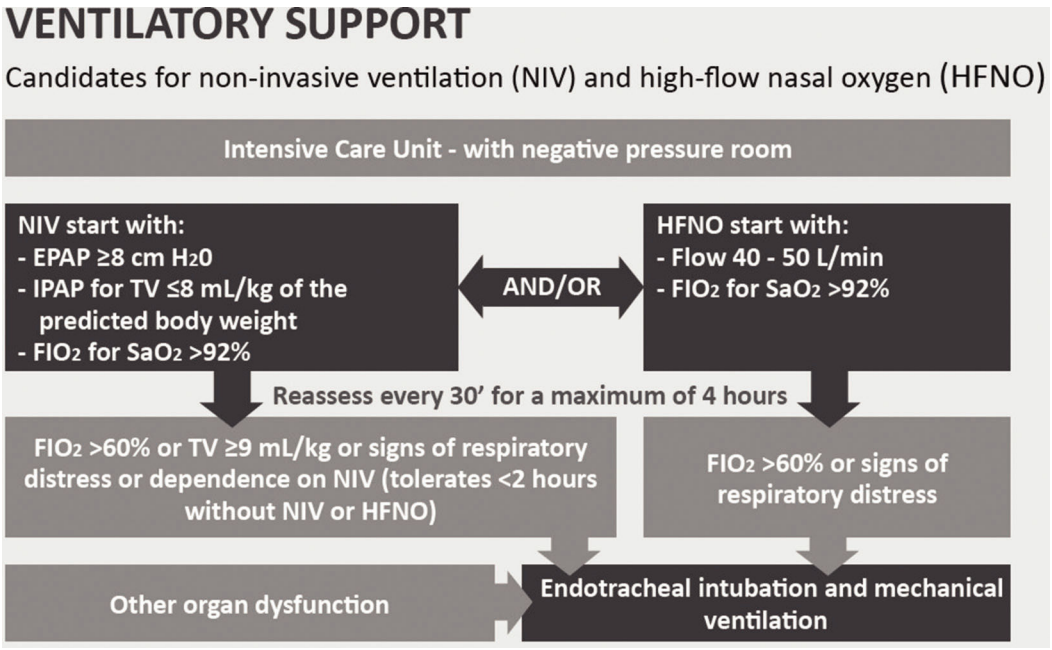

Figure 2 - Proposal for non-invasive ventilation and high-flow nasal oxygen for patients with COVID-19. NIV: non-invasive ventilation; EPAP: expiratory positive airway pressure; IPAP: inspiratory positive airway pressure; TV: tidal volume; FiO_2: fraction of inspired oxygen; HFNO: high-flow nasal oxygen; SaO_2: arterial oxygen saturation.

The criteria for orotracheal intubation and invasive mechanical ventilation are FiO_2 >60% in non-invasive ventilation or TV ⩾9 mL/kg or inability to tolerate <2 hours without non-invasive ventilation or presence of other organic dysfunctions. For high-flow oxygen, the criteria for orotracheal intubation are FiO_2 >60% or signs of respiratory distress, or other organic dysfunctions. It is important to reassess the patient after 30 to 60 minutes; if there is no improvement or if there is worsening of ventilatory parameters, endotracheal intubation and invasive mechanical ventilation should be considered (Figure 2) (2,23,36-38).

■ ENDOTRACHEAL INTUBATION

When aerosol-generating procedures are required, they are recommended to be performed in a negative-pressure room and with the use of appropriate PPE (16). Only the professionals needed to perform orotracheal intubation should remain in the room.

Patients with COVID-19 are at risk of a rapid decrease in arterial oxygen levels; therefore, effective pre-oxygenation is mandatory. Patients must be administered a sufficient oxygen flow to maintain SpO_2 >93%, and intubation should be performed with a rapid sequence of induction and intubation. Pre-oxygenation with a non-rebreather mask with the lowest possible airflow to maintain effective oxygenation (SpO_2 >93%) (41) is required. It is also important to avoid assisted ventilation with the Bag-Valve-Mask device or the use of a supraglottic device because of the potential for aerosolization and contamination of health workers. However, if necessary, we suggest adding a filter between the simple respirator and the Bag-Valve-Mask or artificial airway during use (Figure 3) to reduce the spread of the virus in the patient's airway to the indoor air (19).

After orotracheal intubation, checking the proper positioning of the orotracheal tube and inflating the cuff are recommended. The patient can then be connected to the ventilator associated with the HMEF and with a HEPA filter in the expiratory valve of the mechanical ventilator. These filters can filter bacteria and viruses and reduce room contamination (2,41-43). Airway interventions must be carried out by experienced individuals. After each procedure, appropriate hand hygiene is required (41).

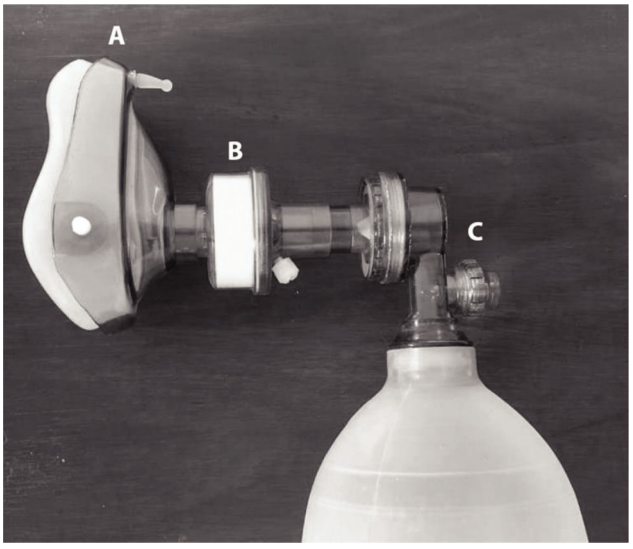

Figure 3 - Bag-Valve-Mask device: (A) face mask, (B) heat moisture exchange filter, and (C) Bag-Valve-Mask.

■ PROTECTIVE MECHANICAL VENTILATION

Invasive mechanical mode volume-controlled ventilation (in the presence of neuromuscular block or the absence of

inspiratory effort) or pressure-controlled ventilation (in the absence of neuromuscular block and mild respiratory effort and asynchrony) should be performed with lower TVs (4 to 6 mL/kg predicted body weight) and lower inspiratory pressures, reaching a plateau pressure (Pplat) of <28-30 cmH_2O (44). The PEEP must be as high as possible to maintain the driving pressure (Pplat − PEEP) as low as possible (<15 cmH_2O) and SpO_2 88-95% (44,45). Moreover, disconnection from the invasive mechanical ventilator must be avoided to prevent loss of PEEP and consequent atelectasis.

MANAGEMENT OF MECHANICAL VENTILATION IN SEVERE AND REFRACTORY CASES OF HYPOXEMIA

For patients with PaO_2/FiO_2 <150 and an inability to maintain protective ventilation or with the presence of asynchrony or severe hypercapnia (pH <7.25), we suggest sedation and continuous neuromuscular block to reduce respiratory drive and maintain protective ventilation. The multidisciplinary team can discuss the following: 1. prone positioning; 2. alveolar recruitment maneuvers and PEEP adjustment for better pulmonary compliance; 3. recruitment in the prone position for patients who responded to the supine recruitment maneuver; 4. nitric oxide administration in cases with a clinical history of "cor pulmonale" or as a recruitment maneuver for hypoxemia; and 5. extracorporeal membrane oxygenation (ECMO) (2,44,46,47).

PRONE POSITION

Prone ventilation for 12 to 16 hours a day is recommended in adult patients with severe ARDS (PaO_2/FiO_2 <150), (2,44). It is strongly recommended for adult patients with severe ARDS but requires sufficient human resources and knowledge to be performed safely. Protocols and videos are available in the study by Guérin et al., 2013. A satisfactory response is defined as a patient achieving an increase of 10 mmHg in PaO_2 or an increase of 20 mmHg in the PaO_2/FiO_2 ratio. Prone positioning should be repeated when a PaO_2/FiO_2 ratio <150 mmHg is observed after 6 hours in the supine position. PaO_2/FiO_2 reductions of 20% in the supine position should be considered criteria for interrupting the prone position after two consecutive attempts at pronation or hemodynamic instability (48,49).

CUFF PRESSURE

Invasive mechanical ventilation is a risk factor for aerosols (50). Therefore, it is important to maintain a cuff pressure between 20 and 30 cmH_2O or 25 and 35 mmHg, with sufficient pressure to prevent leakage and aerosol spread (51). We suggest cuff measurement either at every shift or at least daily (51).

TUBE AND NASOTRACHEAL SUCTION

Suction of the artificial airway because of ventilator disconnection must be avoided so that there is no loss of pressure in the respiratory system, atelectasis, or spread of aerosols in the room. The use of a closed suction system in all cases of intubation and invasive mechanical ventilation is recommended (2,50). In situations requiring open suction, we suggest the use of the "stand by" mode of the mechanical ventilator to minimize the spread of aerosols. Nasotracheal suction should be performed with careful evaluation by the physiotherapist because of the generation of aerosols. To perform these procedures, the use of proper PPE is recommended. Whenever possible, this procedure should be performed in a negative-pressure room.

HUMIDIFIERS FOR VENTILATED PATIENTS

Heat and moisture exchangers or heated humidifiers are more effective in preventing complications such as airway blockages and pneumonia in adults who receive invasive mechanical ventilation (52). Therefore, patients with COVID-19 should use devices that humidify and filter their inhaled and exhaled air, respectively. Thus, HMEF is more suitable for the humidification of exchanged air as it also has filtering capacity for viruses and bacteria, thus reducing air contamination. Additional protection can be provided by placing a HEPA filter on the exhalation valve of the mechanical ventilator. The use of heated humidifiers is discouraged in these patients (43).

WEANING FROM MECHANICAL VENTILATION AND EXTUBATION

All patients must be evaluated daily regarding the eligibility criteria for the spontaneous breathing test, considering adequate oxygenation: PaO_2/FiO_2 >200 with PEEP ⩽5-7 cmH_2O, hemodynamic stability with low and stabilized doses or without vasopressor drug infusion, an adequate level of consciousness (easily awake or wakened), and adequate cough and secretion management with the presence of a cough reflex during closed aspiration (53,54).

To wean patients with COVID-19 from mechanical invasive ventilation, we recommend the use of the pressure support ventilation (PSV) mode for spontaneous breathing tests. The use of the T-tube method should be avoided as it can increase aerosolization (43). Table 1 shows the parameters suggested for the spontaneous breathing test in PSV (A), success criteria (B), and failure criteria (C) (55-60). The cuff leak test should not be performed routinely before extubation because of the risk of aerosolization. However, its use should be considered for the clinical suspicion of upper airway edema or the presence of risk factors for post-extubation stridor (61).

Patients who pass the spontaneous breathing test should preferably be extubated in a negative-pressure room or in respiratory isolation. Physiotherapists and other health professionals present in the environment during extubation must follow PPE aerosol isolation precautions. During the procedure, extra care must be taken during extubation, including keeping the HMEF and closed endotracheal suction (e. g. Trach-Care®) connected to the endotracheal tube when deflating the cuff. The endotracheal tube should be removed as gently as possible to avoid vigorous manipulation and coughing. If it is necessary to stimulate the patient's cough, the patient should be instructed to adopt cough etiquette. The tube must be discarded in the infectious waste collector. In the ICU, the availability of a professional with experience in intubation is always recommended during the extubation of patients diagnosed with COVID-19, in case rapid reintubation is necessary. The rate of reintubation of these patients should be as low as possible; therefore, we recommend that the

Table 1 - Parameters suggested for the spontaneous breathing test in pressure support ventilation (PSV) (A), success criteria (B), and failure criteria (C).

A
Spontaneous breathing test parameters
Mode of ventilation: Presure Support Ventilation
Pressure support: 5 to 7 cmH_2O
PEEP: 5 to 7 cmH_2O
FiO_2: 30%
Test time: 1 hour
B
Criteria for success
Respiratory rate $<$35 bpm
Good tolerance to spontaneous breathing trials
Heart rate $<$120 per minute or heart rate variability of $<$20%
SaO2 $>$90% or PaO_2 $>$60 mmHg with FiO_2 $<$30% (preferably)
Systolic blood pressure $>$80 and $<$170 mmHg or $<$20% change from baseline
No signs of labored breathing or distress
Rapid shallow breathing index $<$100
C
Criteria for failure
Decreased level of consciousness
Nostril flaring
Diaphoresis
Apnea
Tachycardia with increased heart rate $>$40 per minute
Hypotension
Cardiac arrhythmias
Increasing respiratory effort
Increase of $PetCO_2$ $>$10 mmHg
Decrease of arterial pH $<$7.32
Decline in arterial pH $>$0.07
PaO_2 $<$60 mmHg with FiO_2 $>$30% (PaO_2/FiO_2 ratio $<$150)
Fall in SpO_2 $>$5% compared to the basal value

Legends: PEEP: positive end-expiratory pressure; FiO_2: fraction of inspired oxygen; bpm: breaths per minute; SaO_2: arterial oxygen saturation; $PetCO_2$: end-tidal carbon dioxide pressure; pH: ptential of hydrogen; PaO_2: arterial oxygen pressure; SpO_2: peripheral oxygen saturation.

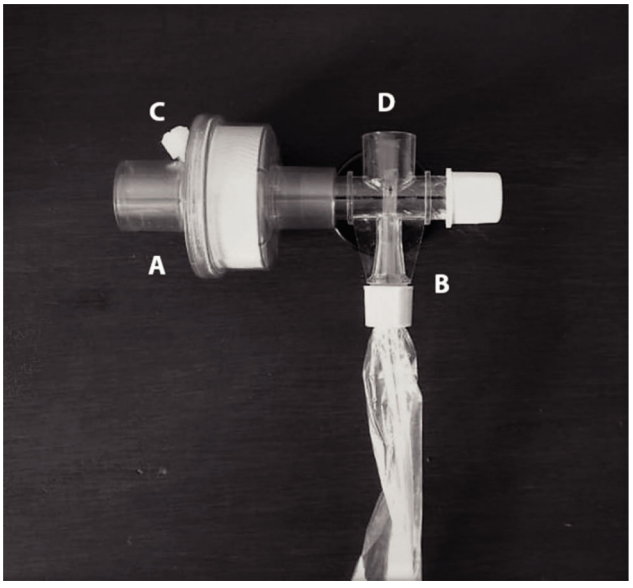

Figure 4 - Spontaneous breathing test device for tracheostomized patients: (A) heat moisture exchange filter (HMEF), (B) closed endotracheal suction (Trach-care), (C) site for connection of oxygen therapy in HMEF. (D) connection for the tracheostomy.

decision regarding the patient's extubation be rigorously discussed within the multidisciplinary team (62,63).

Tracheostomy may be indicated for patients who consecutively fail to wean or with long periods of intubation. Tracheostomy is considered a high-risk procedure for the formation of aerosols. Weaning patients using tracheostomy masks (e.g., Trach-Vent® and T-tube) is not recommended for patients with COVID-19. Rather, for spontaneous breathing training periods, the use of HMEF connected to Trach-Care® (Figure 4), with oxygen supplementation directly in the HMEF to maintain SpO2 between 93 and 96%, is recommended. If aspiration is required during the spontaneous breathing test, the closed suction system must be used. We emphasize that the use of HMEF to wean tracheostomized patients requires constant assessment of clinical signs of discomfort or instability. Spontaneous breathing time should be progressive as patients improve breathing performance and resistance (64).

EQUIPMENT AND HAND HYGIENE

The cleaning of the equipment with 70% alcohol or chlorine-based substances is recommended immediately after use. Health workers should wash their hands frequently, especially after contact with infected people or their environment (2).

CONCLUSION

COVID-19 is a new disease that presents challenges to inpatient care. These recommendations can serve as clinical practice guidelines for physiotherapists. Physiotherapy plays a fundamental role throughout patient hospitalization. However, the hospital physiotherapy team must be well-oriented regarding specific care to both reduce infection risk and provide the best patient care. The Appendix section presents cards from our institution, Hospital Sírio-Libanês, in English and Portuguese languages for the respiratory management of patients with suspected or confirmed COVID-19 infection.

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AUTHOR CONTRIBUTIONS

Righetti RF, Onoue MA, Politi FVA, Teixeira DT, Souza PN, Kondo CS, Moderno EV, Moraes IG, Maida ALV, Pastore Junior L and Silva FD helped in the manuscript design and drafting. Righetti RF and Yamaguti WP were responsible for the study conception and manuscript design and drafting. Brito CMM, Baia WRM and Yamaguti WP are the senior authors who were responsible for study supervision and revision of the final manuscript version. All authors approved the final manuscript version.

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APPENDIX

GUIDELINES FOR THE ASSISTANCE TEAM MANAGEMENT OF THE PATIENT WITH SUSPECTED OR CONFIRMED INFECTION BY COVID-19

CRITERIA FOR SUSPECTED COVID-19

- Hypoxemia - SaO_2 <93% in room air
  - value depending on clinical conditions, age, etc.
- Dyspnea
  Any sign of respiratory distress, including:
  - Tachypnea, especially if respiratory rate (RR) ≥28
  - Use of accessory musculature
  - Nose wing flap
  - Sweating
  - Change in the level of consciousness (drowsiness, agitation and mental confusion)

PERSONAL PROTECTION EQUIPMENT (PPE)

- Surgical cap
- N95 mask or equivalent
- Safety goggles and face shield
- gown
- gloves

AEROSOL GENERATING PROCEDURES

- Huffing
- Inhalation
- Intubation and manipulation procedure of the endotracheal tube
- Nasotracheal aspiration, endotracheal tubes and tracheostomies
- Secretion collections
- Bronchoscopy and endoscopy
- Non-invasive ventilation (NIV)
- High-flow nasal oxygen (HFNO)
- Bronchial hygiene maneuvers
- Cardiopulmonary resuscitation
- Ventilation and maneuvers with the bag-valve-mask device

TYPE OF INSOLATION

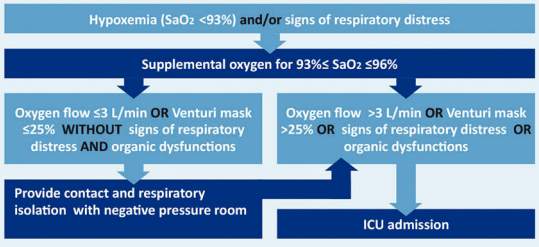
- Respiratory droplet isolation and negative pressure room (if available)
- Aerosol generating procedures: respiratory aerosol isolation

CRITERIA FOR ICU STAY (one of the criteria below is required to maintain SaO_2 between 93-96%)

- Signs of respiratory distress
- Flow >3 L/minO_2
- Venturi mask >25%
- Organic dysfunctions

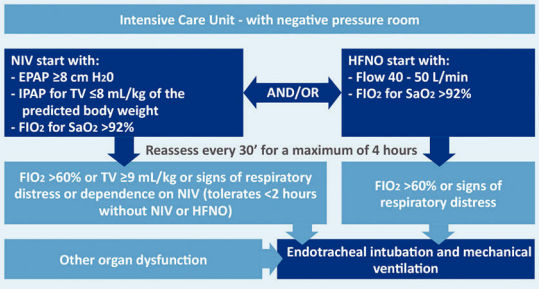
Oxygen Therapy

STEP 1



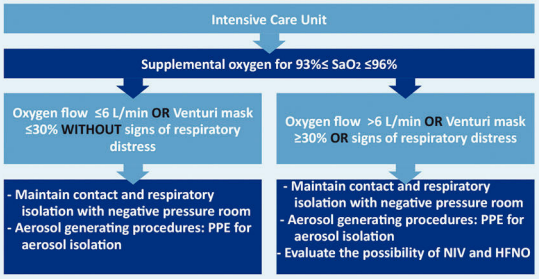
VENTILATORY SUPPORT

Candidates for non-invasive ventilation (NIV) and high-flow nasal oxygen (HFNO)

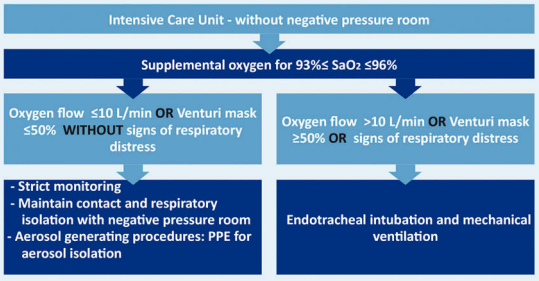


Oxygen Therapy

STEP 2



STEP 3



* DO NOT USE HUMIDIFICATION TO SUPPLEMENT OXYGEN

CONSIDERATIONS

- The application of NIV or HFNO should preferably be performed in a room with negative pressure and an ICU environment
- Patients worsening, do not insist on NIV and HFNO
- If within 1 hour during the application of NIV or HFNO there is no improvement or there is worsening, the team should consider OTI and mechanical ventilation
- Use NIV equipment with double circuit, heat and humidity exchanger filter (HMEF) and filter at the expiratory outlet
- In exceptional situations, NIV or HFNO may be indicated in beds without negative pressure, for the shortest possible time
- Give preference to the high-flow catheter to NIV
- When adapting the NIV mask, we suggest switching on the device only after adapting the interface to the patient
- To turn off, we recommend turning off the equipment before removing the interface, to reduce the emission of aerosols

RAPID SEQUENCE INTUBATION

- All patients should be intubated in a rapid sequence of intubation
- It should preferably be performed in respiratory isolation rooms with negative pressure
- Professionals: physician, physiotherapist, nursing technician and nurse
- Perform pre-oxygenation with a reservoir mask with the lowest possible air flow to maintain effective oxygenation
- Do not perform assisted ventilation with the Bag-Valve-Mask device or the use of supraglottic devices, due to the potential for aerosolization and contamination of the environment and professionals
- Cuff inflation and maintenance of cuff pressure between 20-30 cmH_2O and without leak
- Use Heat moisture exchanger filter (HMEF) and placement of appropriate filter in the expiratory circuit
- All patients must use a closed suction system (trach-care)
- When fixing the tube, it is recommended to use the Tensoplast® associated with the shoelace-like fixator fixator the endotracheal tube

INVASIVE MECHANICAL VENTILATION

Evaluation parameters:

- Calculation of respiratory mechanics
- Tidal volume: 4-6 mL/Kg of the predict body weight
- Plateau pressure <28 – 30 cmH_2O
- Driving Pressure <13 to 15 cmH_2O
- PEEP for FiO_2 <60% and SaO_2 >92% (PEEP table - ARDSNET - 2017)
- Permissive hypercapnia for pH >7,20 [AV=RRx(TV-DS)]
  Alveolar ventilation (AV); Respiratory rate (RR); Tidal volume (TV); dead space (DS)
- PEEP table - *ARDS Network:* Low PEEP/High FiO_2

FIO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FIO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18 - 24

SERIOUS HYPOXEMIA

Preferred indication sequence for PaO_2 / FiO_2 <100:

1. Prone position - **2.** Alveolar recruitment maneuvers and PEEP adjustment for better pulmonary compliance - **3.** Consider ECMO

Special considerations:

- Maintain protective ventilation on average for at least 3 to 5 days
- Avoid disconnections so as not to increase the spread of aerosols. If necessary, it must be done with a clamped tube
- Use HMEF. Do not use active humidification
- If inhalation medication is necessary, use spray with spacer
- For the spontaneous breathing test, when weaning from MV, use pressure support mode with minimum parameters (do not use T tube)
- More information and guidance on alveolar recruitment maneuver alveolar, PEEP adjustment, prone position, and nitric oxide, see General ICU Guidelines - Invasive and Non-Invasive Mechanical Ventilation

INITIAL MECHANICAL FAN SETTINGS

- Ventilation mode: controlled volume (if neuromuscular block or absence of inspiratory effort) or controlled pressure (if without neuromuscular block and mild respiratory effort without asynchrony)
- Tidal volume: 6 mL/kg of the predict body weight
- Respiratory rate: 20 - 28 cpm
- Maintain Plateau pressure <28 – 30 cmH_2O
- Driving Pressure <13 to 15 cmH_2O
- PEEP: 10 cmH_2O
- FiO_2 100%

PRONE POSITION

- Consider for patients with severe ARDS (PaO_2 / FiO_2 <150)
- Prone ventilation is recommended for 12 to 16 hours a day
- Recruit enough people to ensure the safety of the procedure
- Protocols and our institutional video available on the ICU Ward 1 computers Hospital Sírio-Libanês (Bela Vista Unit) and also in the Workplace (Rehabilitation Group) or another video on the website:
- https://www.nejm.org/doi/full/10.1056/NEJMoa1214103
- **Criteria for assessing the response to the prone position:**
- Responders: 10 mmHg increase in PaO_2 or increase in 20 in the PaO_2 / FiO_2 ratio. It will be repeated when a PaO2 / FiO_2 ratio <150 mmHg after 6 (six) hours in supine position
- Non-responders: 20% reductions in the PaO_2 / FiO_2 ratio in relation to the supine position, after two consecutive attempts of pronation or hemodynamic instability

MECHANICAL MANAGEMENT IN REFRACTORY CASES

PaO2 / FiO2 ratio <150, or inability to maintain protective ventilation, or the presence of asynchrony or severe hypercapnia (pH <7.25):

- Sedation and continuous neuromuscular block (reduce respiratory drive and maintain protective parameters)
- Prone Position
- Alveolar recruitment maneuvers and PEEP adjustment for the best complacency
- Recruitment in the prone position, if response to the maneuver of bench press recruitment
- Consider nitric oxide if history of “cor pulmonale” or as rescue maneuver for hypoxemia
- Remove unnecessary dead space from the mechanical fan, checking pipe and connection reductions
- Maintain HMEF due to the risk of spreading aerosols
- Control of CO_2 production at temperature at 36 °C
- Consider extracorporeal membrane oxygenation (ECMO)

OTHER GUIDELINES

- Do not inhale, give preference to puff and spray with spacer chamber
- Endotracheal intubation:
  - When the procedure is necessary, PPE for aerolsols and contact isolation should be used
  - Whenever possible, this procedure should be performed on negative pressure room
- Endotracheal intubation + mechanical ventilation:
  - Endotracheal duction with closed suction systems (trach-care)
  - Use the “stand by” system and not the “assisted breathing” device of the mechanical ventilator to minimize the spread of aerosols
  - Change the HME filters every 72 hours or if they are dirty

EQUIPMENT CLEANING

- It is recommended that the cleaning of the equipment takes place immediately after use using 70% alcohol or chlorine-based substance
- For equipment in continuous use and which remains within the isolation environment, maintain the concurrent cleaning routine recommended by the institution

GUIDELINES FOR THE ASSISTENCIAL TEAM MANAGEMENT OF THE PATIENT WITH SUSPECTED OR CONFIRMED INFECTION BY COVID-19

CARDIORESPIRATORY ARREST

- Treatment plans should be a priority
- Patients who are not candidates for cardiopulmonary resuscitation must be signed and well documented in medical records and shared with the multiprofessional team and patient's family

For the assistance of cardiorespiratory arrest:

- Check responsiveness
- Recognize cardiac arrest due to the absence of the carotid pulse or not visualizing the breathing. Do not try to hear the breath if approaching the patient's face - risk of contamination
- Cardiorespiratory arrest identified:
- **ACTIVATE BLUE CODE (Extension 333) + DIFFICULT AIRWAY RESPONSE TEAM (Extension 2222 + option 4) - emergency room and non-critical units**
- Team:
  Physicians + nurse + physiotherapist + nurse assistant
- The team must be dressed before approaching the bed with Personal Protective Equipment (PPE):
- **Surgical cap + safety goggles and face shield + gown + gloves + N95 mask or equivalent**
- The materials needed for the intubation procedure should be checked in advance, including preparation of the bag-valve-mask (Ambu®), following:
  face mask > HMEF and Ambu® connected with oxygen (Figure 1)
- Heart monitoring should start as early as possible
- After intubation, the ventilation check must be performed using the Ambu® + heat and moisture exchanger filter (HMEF) + closed suction system (Figure 2). The capnography curve can be used at this time to check ventilation. If cardiac arrest persists, this device should be used for ventilation.
- It is necessary to defibrillate shockable rhythms quickly. At the time of defibrillation, keep the tube connected to the HMEF and do not clamp or connect to the mechanical ventilator
- Early restoration of circulation prevents the need of pathways for artificial airways and ventilatory support
- The insertions of the supraglottic airways (laryngeal mask) or endotracheal intubation must be performed by experienced physicians
- Identify and treat reversible causes (for example, hypoxemia) before considering resuscitation arrest
- Materials used for intubation should not be supported without protection on the patient's bed and must be disposed of in the trash appropriate waste in the isolation environment
- Equipment must be disposed of or sanitized in accordance with with manufacturers' instructions and institutional guidelines
- After the procedure, the cleaning of the entire environment and equipment must be performed
- Remove disposable PPE (apron and gloves) and throw them in the trash appropriate waste in accordance with the institutional and Hospital Infection Control Commission (HICC)
  Safety goggles and *face shield* must be sanitized with soap and water or chlorine. The surgical cap must be discarded at the end of the workday. N95 or equivalent masks must be changed every 7 days or if soiled

For patients who are not in orotracheal intubation, avoid ventilation with the bag-valve-mask device (Ambu®) and always recommend the mask with a reservoir attached to the patient's face, as this can limit the spread of the aerosol

Note: the use of the bag-valve-mask (Ambu®) will be avoided due to the rapid intubation sequence technique, but in certain situations it may be necessary, and the proper connection must be at least prepared and tested (avoiding surprises of non-functioning) in case of need for ventilation)

At the end of resuscitation, all professionals involved must record the procedures involved in the cardiopulmonary resuscitation maneuver on medical records.

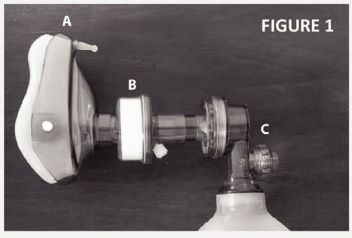


FIGURE 1

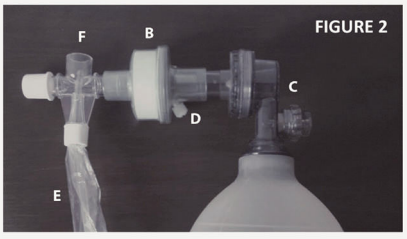


FIGURE 2

Ventilation devices

- (A) Face mask
- (B) Heat and moisture exchanger filter (HMEF)
- (C) Bag-valve-mask device (Ambu®)
- (D) Capnograph connection location
- (E) Closed secretion suction system (Trach-Care)
- (F) Endotracheal tube connection site

ENDOTRACHEAL INTUBATION

1. HEALTH-CARE TEAM

- The team should be made up of as few people as possible. In controlled situations, it must consist of a single professional, following:
- **physicians + nurse + physiotherapist**
  Note: a second physician and a nursing technician must be on standby if necessary.
- In emergency situations, in cases of airway known to be difficult, or whenever the doctor deems it necessary, the team must be constituted by 2 physicians, a nurse, a nursing assistant and a physiotherapist
- **For the emergency room environment, of non-critical and semi-critical inpatient units, the airway team should be called whenever the need for intubation is identified, using Extension 2222, option 4**
- Orotracheal intubation (OTI) should be performed by the most experienced doctor on the team

2. PERSONAL PROTECTIVE EQUIPMENT

- All team members must be dressed before entering the isolation bed with:
  Gown + gloves + N95 mask or equivalent + Safety goggles and Face shield + Surgical cap

3. MATERIAL PREPARATION

- Videolaryngoscope (there is an exclusive difficult airway bag available in wing I and the Emergency Room, in addition to the standard locations, as quality document NOR-CORP-NOR-014), if available
- Orotracheal cannula / guide
- Vacuum
- Mask-bag (Ambu®), HMEF filter, closed secretion suction system and face mask.
- The connection order:
  Ambu® > HMEF > face mask (Figure 1)
  Note: outside the ICU, if a capnograph is available, it must be connected between the Ambu® and the HMEF or to the HMEF for new capnograph models:
  Ambu® > capnograph (or directly on HMEF) > HMEF > closed secretion suction system (Figure 2)
- Drugs for sedation and neuromuscular block
- Sedation should be performed with drugs defined by the doctor
- Neuromuscular block in order to facilitate intubation and prevent the patient from coughing should be performed with:
  Succinylcholine 1 to 1.5 mg / kg (each ampoule has 100 mg) or Rocuronium 1.2 mg / kg (each ampoule has 50 mg and it is usually necessary to aspirate 2 ampoules), depending on the characteristics of each patient
- Whenever possible, the material should be prepared outside the patient's box. In emergency cases, use available emergency cart

4. INTUBATION PROCESS

- Appropriate patient positioning and monitoring
- Pre-oxygenation with a non-rebreather mask at the lowest oxygen flow required to ensure adequate patient saturation. If the patient is already using non-invasive ventilation (NIV) or high-flow nasal catheter (HFNC) in a negative pressure environment, you can have these devices can be used for pre-oxygenation
- Airway ventilation should be avoided as much as possible with the bag-mask valve (Ambu®). If necessary, ventilation can be done with the face mask firmly attached to the patient's face to prevent leakage
- **In cases of difficult airway, use the Bougie available in the airway bag when the physicians deems it necessary**
- A plastic disposal bag should be positioned next to the patient's headboard, so that all the material used is discarded
- After introduction, the cuff of the orotracheal tube must be inflated and the tube connected to the set by the closed suction system:
  Ambu® > (capnograph, if available) > HMEF > closed secretion suction system (Figure 2)
- To confirm ventilation: chest expansion and capnography curve
- After confirming ventilation, plug the tube with HMEF and connect it to the mechanical ventilator
- Only start ventilation after the cuff is inflated
- Leave the ventilator regulated before the procedure, connect it on standby mode and switch on after connecting to the patient
- Measure cuff pressure as soon as possible

INTRAHOSPITAL TRANSPORT		INTER-HOSPITAL TRANSPORT
Transport from emergency room to the hospital inpatient unit or ICU	**Transport for imaging exams**	**Transport to other institutions**
• Critical cases should be transferred directly to the ICU	• Avoid CT scans, prioritize ultrasound	• Anticipate transfers before the worsening of clinical condition
• Critically ill patients: check the need for OTI before transport • Transport team: physician; nurse and physiotherapist (according to institutional transport flow) • Monitor blood pressure, SpO2 and cardiac tracing		
Protection of health-care professionals		
• Use PPE: surgical cap, safety goggles, face shield, N95 mask or equivalent and gown • Transport: prioritize SERVO-i® with HMEF in the tube and high efficiency particulate air (HEPA) filter at the outlet valve exhalation. Single-branch ventilator, use HMEF between the tube and the ventilator • Spontaneous breathing patients should be transported with a surgical mask (even on oxygen therapy). Do not use NIV or high flow during transportation • Avoid unnecessary disconnections as they generate aerosols • If disconnecting, clamp the tube with the clamp forceps		• All transport recommendations in-hospital, plus opening the windows of the ambulance
Security professional on the way		
• The security team must ensure that no spectators are on the route and must wear a surgical mask		
Anticipation of transport complications		
• Unstable patients should be intubated before transportation and preferably in an ICU environment and in a room with negative pressure • All materials and drugs used for cardiorespiratory arrest, accidental extubation and hypotension must be checked in advance • If necessary, use the mask-bag to connect it to the HMEF		
Post-transport decontamination		
• PPE withdrawal as recommended by the HICC • Equipment cleaning: 70% alcohol or chlorine • It is recommended that the environment be cleaned (corridors and elevators) after each transportation and competing cleanings maintained as recommended by the institution		• Cleaning of routes and elevators recommended by HICC • Cleaning: 70% alcohol or chlorine • Discard insulation gloves and apron after • accommodating the patient in the final institution • Put on new PPE when return back • Terminal ambulance cleaning

GUIDELINES FOR THE ASSISTANCE TEAM MANAGEMENT OF THE PATIENT WITH SUSPECTED OR CONFIRMED INFECTION BY COVID-19

WEANING FROM MECHANICAL VENTILATION

- The need for the weaning and extubation process can still occur at times when the patient has an active virus infection. Therefore, it is necessary to adopt some procedures and precautions so that there is no increase in the formation of aerosols in the hospital environment and prolonging the stay on invasive mechanical ventilation and ICU stay days in these patients

Eligibility criteria for the spontaneous breathing test (SBT):

- Patients should be screened daily
- Adequate oxygenation: PaO_2 / FiO_2 >200 with PEEP ≤5 to 7 cmH_2O
- Hemodynamic stability: low doses stabilized or without vasopressor infusion
- Adequate level of consciousness: awake or easily awake
- Cough and secretion management: presence of cough reflex during closed suction

- Patients who meet the eligibility criteria are SBT candidates
- Perform the SBT on the mechanical ventilator with the system closed
- Do not test with T-tube - risk of aerosol formation and environmental contamination

Note: To reduce the risk of reintubation, it is recommended that a clinical margin be adopted, as the extubation of borderline patients increases the need for noninvasive ventilation and high-flow nasal oxygen after extubation, thus increasing the chances of aerosol formation.

The cuff leak test should not be performed routinely before extubation due to the risk of aerosolization. However, its use should be weighed due to the clinical suspicion of edema of the upper airways or by the presence of risk factors for post-extubation stridor

Patients who are successful in SBT should preferably be extubated in environments with negative pressure and in an environment of respiratory isolation

Parameters for the spontaneous breathing test

- Perform preferably in a negative pressure room
- Ventilation mode: Pressure support ventilation
- Pressure support: 5 - 7 cmH_2O
- PEEP: 5 to 7 cmH_2O
- FiO_2: 30%
- Test time: 1 hour
- Assess success or failure criteria

Criteria of success:

- Respiratory rate <35 bpm
- Good tolerance to SBT
- Heart rate <120 bpm or cardiac frequency variability <20%
- SaO_2> 90% or PaO_2 >60 mmHg with FiO_2 <30% (preferably)
- Systolic blood pressure >80 and <170 mmHg <20% change in relation to basal
- Absence of respiratory distress, characterized by absence of signs: use of accessory muscles, paradoxical breathing or with the presence of asynchrony, intense sweating and agitation
- Rapid and shallow breathing index (RR/ TV) <100 (performed in ventilation with support pressure)
- SaO_2 >90% or PaO_2 >60 mmHg with FiO_2<30% (preferably)

Criteria of failure:

- Lowering the level of consciousness and agitation
- Severe sweating
- Nasal wing beat
- Increased respiratory distress
- Tachycardia: increase of 40 bpm compared to baseline
- Cardiac arrhythmias
- Hypotension
- Apnea
- Increase in $PetCO_2$> 10 mmHg
- Arterial pH reduction <7.32
- Reduction of arterial pH >0.07
- PaO_2 <60 mmHg with FiO_2 >30% (PaO_2 / FiO_2 ratio <150)
- 5% drop in SpO_2 compared to baseline

EXTUBATION

- Physiotherapists and other health professionals present in the environment during extubation must follow isolation precautions for aerosols, including: Gown + Gloves + Surgical cap + N95 masks or equivalent + Safety goggles and face shield

Pre-extubation care:

1. Turn off the mechanical ventilator before disconnecting from the patient
2. Keep the heat and moisture exchanger filter (HMEF) and the suction system closed (Trach-Care®) connected to the endotracheal tube at the moment of deflating the cuff
3. If aspiration is required use Trach-Care®
4. The endotracheal tube should be removed as smoothly as possible to avoid vigorous manipulation and cough stimulation
5. If it is necessary to stimulate the patient's cough, the patient should be instructed to adopt cough etiquette
6. The tube must be discarded as recommended by the Hospital Infection Control Committees (HICC)
7. It is always recommended that during extubation of patients diagnosed with COVID-19 have a doctor with experience in stand by intubation on stand by if reintubation is required quickly
8. The rate of reintubation of these patients must be the lowess possible, then it is recommended that the extubation decision be discussed with the multiprofessional team

Post extubation care:

1. The application of supplemental oxygen in the smallest possible fraction of inspired oxygen (FiO_2), preferably by nasal cannula low-flow
2. As patients are often extubated while still presenting active infection, we recommend the adoption of asimilar approach to oxygen delivery to that before intubation
3. The use of high-flow nasal cannula and non-invasive ventilation should be considered and we guide its use in the indications classic for the risk of extubation failure:
   - Obese patients
   - Diagnosis of chronic obstructive pulmonary disease
   - Cardiac insufficiency
   - Ineffective cough
   - Consecutive bankruptcy at weaning
   - Presence of more than one comorbidity
   - Patient aged >65 years
   - APACHE >12 on the day of extubation
   - Patients with more than 72 hours of invasive mechanical ventilation

Note: If it is necessary to use NIV, it should preferably be done in an environment with negative pressure and the use should be in double branch fans and the use of HMEF between the mask and the mechanical fan circuit and an additional high efficiency particulate air (HEPA) filter at the outlet of the expiratory valve to prevent the formation of aerosols

Tracheostomized patients:

For patients who fail consecutively to wean or with long periods of intubation, tracheostomy may be indicated. Tracheostomy is considered a high risk procedure for the formation of aerosols and must follow the institutional guidelines of "Care for the Surgical Patient"

Cautions when weaning from mechanical ventilation:

- Do not use the devices: tracheostomy masks, Trach-Vent® and T-tube - risk of aerosol formation and contamination of the environment
- For spontaneous breathing training periods we suggest using the system:
  HMEF + *Trach-Care*® (Figure 1) – connected to tracheostomy
- Oxygen supplementation should be performed directly at the HMEF to keep SpO_2 between 93-96%
- If aspiration is required during the spontaneous breathing test, use Trach-Care®

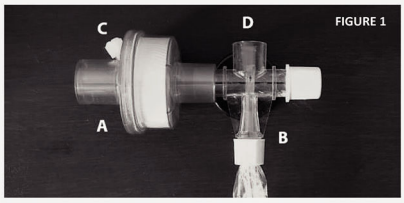


FIGURE 1

HMEF-mounted device connected to Trach-care® for testing spontaneous breathing in tracheostomized patients
(A) HMEF
(B) Trach-care®
(C) Connection of oxygen therapy
(D) Connection for the tracheostomy

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ORIENTAÇÕES PARA A EQUIPE ASSISTENCIAL NO MANEJO DO PACIENTE COM INFECÇÃO SUSPEITA OU CONFIRMADA PELA COVID-19

CRITÉRIOS PARA SUSPEITOS DE COVID-19

- Hipoxemia - SaO_2 <93% em ar ambiente
  - valor relativo a depender das condições clínicas, idade, etc.
- Dispnéia
- Qualquer sinal de desconforto respiratório, dentre eles:
  - Taquipnéia, principalmente se frequência respiratória (FR) ≥28
  - Uso de musculatura acessória
  - Batimento de asa de nariz
  - Sudorese
  - Alteração do nível de consciência (sonolência, agitação e confusão mental)

EQUIPAMENTOS DE PROTEÇÃO INDIVIDUAIS (EPI)

- Gorro
- Máscara de proteção para aerossóis (N95 ou equivalente)
- Óculos de proteção e protetor facial (*face shield*)
- Avental de isolamento
- Luvas de procedimento

PROCEDIMENTOS QUE GERAM AEROSSÓIS

- *Huffing*
- Inalação
- Procedimento de intubação e manipulação do tubo endotraqueal
- Aspiração nasotraqueal, tubos endotraqueais e traqueostomias
- Coletas de secreção
- Broncoscopia e endoscopia
- Ventilação não-invasiva
- Sistemas de alto fluxo
- Manobras de higiene brônquica
- Ressuscitação cardiopulmonar
- Ventilação e manobras com o dispositivo bolsa-válvula-máscara

TIPO DE ISOLAMENTO

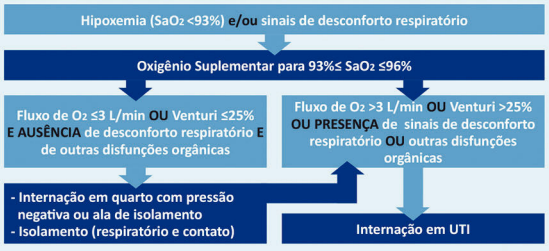
- Isolamento respiratório por gotícula em ambiente com pressão negativa (se disponível)
- Na formação de aerossóis, alterar o isolamento para aerossóis

CRITÉRIOS PARA INTERNAÇÃO NA UTI (necessário um dos critérios abaixo para manter SaO_2 entre 93-96%)

- Sinais de desconforto respiratório
- Fluxos > 3 L/minO_2
- Máscara de Venturi >25%
- Disfunções orgânicas

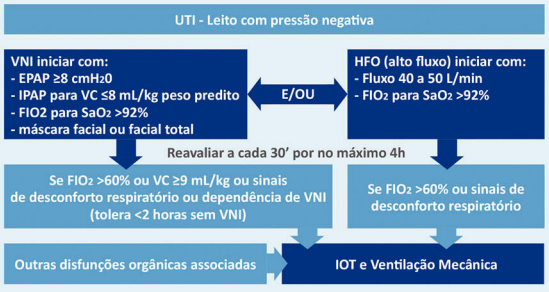
OXIGENOTERAPIA NA UNIDADE DE INTERNAÇÃO

Avaliação e início da oxigenoterapia



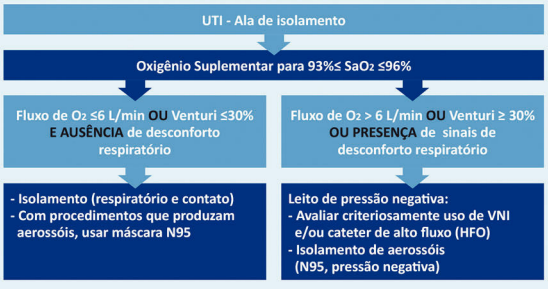
SUPORTE VENTILATÓRIO

Candidatos à ventilação não-invasiva e sistemas de alto fluxo

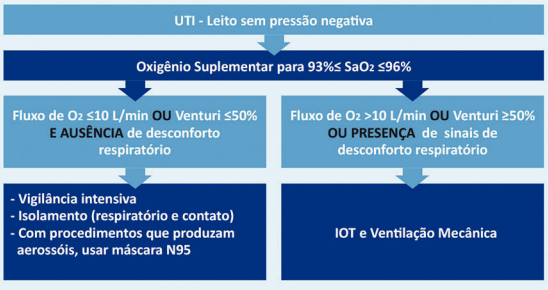


OXIGENOTERAPIA NA UTI

Início do suporte ventilatório



Intubação orotraqueal (IOT) precoce



* NÃO UTILIZAR UMIDIFICAÇÃO NA SUPLEMENTAÇÃO DE O_2

CONSIDERAÇÕES

- Pacientes apresentando piora, não insistir com VNI e HFO
- A aplicação da VNI ou HFO deve ser preferencialmente realizada em quarto com pressão negativa e ambiente de UTI
- Se em até 1 hora durante a aplicação da VNI ou HFO não houver melhora ou houver piora, a equipe deve considerar a IOT e ventilação mecânica
- Utilizar equipamento de VNI com circuito duplo, trocador de calor e umidade (HME) e filtro na saída expiratória
- Em situações de exceção pode ser indicado VNI ou HFO em leitos sem pressão negativa, pelo menor tempo possível
- Dar preferência para o cateter alto fluxo à VNI
- Na adaptação da máscara de VNI sugerimos ligar o aparelho somente após a adaptação da interface no paciente
- Para desligar, recomendamos desligar o equipamento antes da retirada da interface, para reduzir a emissão de aerossóis

SEQUÊNCIA RÁPIDA DE INTUBAÇÃO

- Todos os pacientes devem ser intubados em sequência rápida de intubação
- Deve ser preferencialmente realizado em salas de isolamento respiratório com pressão negativa
- Profissionais: médico, fisioterapeuta, técnico de enfermagem e enfermeiro
- Realizar a pré-oxigenação com máscara reservatório com o menor fluxo de ar possível para manter oxigenação efetiva
- Não realizar ventilação assistida com o dispositivo de Bolsa-Válvula-Máscara ou o uso de dispositivos supraglóticos, pelo potencial de aerossolização e contaminação do ambiente e profissionais
- Insuflação do balonete e manutenção da pressão de cuff entre 20-30 cmH_2O e sem escape
- Utilizar filtro HME e colocação de filtro apropriado no circuito expiratório
- Todos os pacientes devem usar sistema de aspiração fechado (*trach-care*)
- Na fixação do tubo, recomenda-se a utilização do *Tensoplast*® associado com o cadarço para a fixação do tubo endotraqueal

VENTILAÇÃO MECÂNICA INVASIVA

Parâmetros de avaliação:

- Cálculo da mecânica respiratória
- Volume corrente de 4-6 mL/Kg de peso ideal
- Pressão de platô <28 – 30 cmH_2O
- *Driving Pressure* <13 a 15 cmH_2O
- PEEP para FiO_2 <60% e SaO_2 >92% (tabela ARDSNET - 2017)
- Hipercapnia permissiva para pH >7,20 [VA=FRx(Vt-Vd)]
- Tabela *ARDS Network*
  - Baixa PEEP/Alta FiO_2

FIO_2	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7
PEEP	5	5	8	8	10	10	10	12

FIO_2	0.7	0.8	0.9	0.9	0.9	1.0
PEEP	14	14	14	16	18	18 - 24

HIPOXEMIA GRAVE

Sequência preferencial de indicação para relação PaO_2/FiO_2 <100:

1. Posição Prona - **2.** Manobras de recrutamento alveolar e ajuste da PEEP pela melhor complacência - **3.** Considerar ECMO

Considerações especiais:

- Manter ventilação protetora em média por pelo menos 3 a 5 dias
- Evitar desconexões para não aumentar a disseminação de aerossóis Caso seja necessário, deve-se realizar com tubo clampeado
- Usar HME. Não usar umidificação ativa
- Se necessário medicação inalatória, usar spray com espaçador
- Para o teste de respiração espontânea, no desmame da VM, utilizar a modalidade pressão de suporte com parâmetros mínimos (não utilizar tubo T)
- Maiores informações e orientações sobre Manobra de Recrutamento alveolar, Ajuste da PEEP, Posição Prona e Óxido Nítrico, ver Diretrizes da UTI Geral – Ventilação Mecânica Invasiva e Não Invasiva

AJUSTES INICIAIS DO VENTILADOR MECÂNICO

- Modo ventilatório: volume controlado (se bloqueio neuromuscular ou ausência de esforço inspiratório) ou pressão controlada (se sem bloqueio neuromuscular e esforço respiratório leve e sem assincronia)
- Volume corrente de 6 mL/kg de peso predito
- Frequência respiratória entre 20 a 28 ciclos por minuto
- Manter Pressão de platô <28 – 30 cmH_2O
- Driving Pressure <13 a 15 cmH_2O
- PEEP de 10 cmH_2O
- FiO_2 100%

POSIÇÃO PRONA

- Considerar para pacientes com SDRA grave (PaO_2/FiO_2 <150)
- Recomenda-se ventilação prona por 12 a 16 horas por dia
- Recrutar pessoas o suficiente para garantir a segurança do procedimento
- Protocolos e vídeos disponíveis no vídeo institucional que encontra-se disponível nos computadores da UTI Ala 1 do Hospital Sírio-Libanês (Unidade Bela Vista) e também no Workplace (Grupo Reabilitação) ou no site: https://www.nejm.org/doi/full/10.1056/NEJMoa1214103

Critérios de avaliação da resposta da posição prona:

- Respondedores: aumento de 10 mmHg na PaO_2 ou aumento de 20 na relação PaO_2/FiO_2. Será repetido quando observada uma relação PaO_2/FiO_2 <150 mmHg após 6 (seis) horas em posição supina
- Não respondedores: reduções de 20% na relação PaO_2/FiO_2 em relação a posição supina, após duas tentativas consecutivas de pronação ou instabilidade hemodinâmica

MANEJO DO VENTILADOR MECÂNICO EM CASOS REFRATÁRIOS

Relação PaO_2/FiO_2 <150, ou impossibilidade de manter ventilação protetora, ou presença de assincronias ou hipercapnia grave (pH <7,25):

- Sedação e bloqueio neuromuscular contínuo (reduzir drive respiratório e manter parâmetros protetores), caso ainda não estiver em uso
- Posição Prona
- Manobras de recrutamento alveolar e ajuste da PEEP pela melhor complacência
- Recrutamento na posição prona, se responder à manobra de recrutamento em supino
- Considerar óxido nítrico se histórico de "*cor pulmonale*" ou como manobra de resgate para hipoxemia
- Retirar o espaço morto desnecessário do ventilador mecânico, checando reduções de tubos e conexões
- Manter HME pelo risco de disseminação de aerossóis
- Controle da produção de CO_2 em temperatura em 36°C
- Considerar oxigenação por membrana extracorpórea (ECMO)

OUTRAS ORIENTAÇÕES

- Não realizar inalações, dar preferência para *puff* e *spray* com espaçador
- Pacientes em IOT:
  - Quando o procedimento for necessário deve-se utilizar as EPIs para isolamento de contato e para aerossóis (máscara N95), além da *face shield*
  - Sempre que possível, esse procedimento deve ser realizado em leitos com pressão negativa e isolamento de aerossóis
- Pacientes em IOT+VM:
  - Manter sistema de aspiração fechado (*trach-care*)
  - Utilizar o sistema "*stand by*" e não o dispositivo de "aspiração assistida" do ventilador mecânico para minimizar a disseminação de aerossóis
  - Trocar os filtros HME a cada 72h ou se apresentarem sujidade

LIMPEZA DOS EQUIPAMENTOS

- Recomenda-se que a limpeza dos equipamentos ocorra imediatamente após o uso utilizando-se substância alcoólica à 70% ou a base de cloro
- Para equipamentos em uso contínuo e que permanecem dentro do ambiente de isolamento, manter a rotina de limpeza concorrente preconizada pela instituição

ORIENTAÇÕES PARA A EQUIPE ASSISTENCIAL NO MANEJO DO PACIENTE COM INFECÇÃO SUSPEITA OU CONFIRMADA PELA COVID-19

PARADA CARDIORESPIRATÓRIA

- Os planejamentos de escalonamento de tratamento devem ser prioridade
- Pacientes não candidatos à ressuscitação cardiopulmonar devem estar sinalizados e bem documentados em prontuário, além disso deve ser compartilhado com a equipe multiprofissional, acompanhantes e familiares

Para a assistência da parada cardiorrespiratória, devemos:

- Checar responsividade
- Reconhecer a parada cardíaca por ausência do pulso carotídeo ou não visualização da respiração. Não tente ouvir a respiração se aproximando do rosto do paciente - risco de contaminação
- Identificada a parada cardiorrespiratória, conforme fluxo institucional:
  ACIONAR CÓDIGO AZUL (Ramal 333) + TIME DE VIA AÉREA DIFÍCIL (Ramal 2222 + opção 4) - PA e unidades não críticas
- Equipe envolvida:
  Médico + Enfermeiro + Fisioterapeuta + Técnico de enfermagem
- Paramentação com EPIs antes de entrar no leito:
  Gorro + Óculos de proteção e face shield + Avental de isolamento + Luvas + Máscara para aerossóis (N95 ou similar)
- Os materiais necessários para o procedimento de intubação devem ser verificados antecipadamente, incluindo a preparação da bolsa-valva-máscara (Ambu®), seguindo a seguinte ordem:
  Máscara > filtro HMEF e Ambu® conectado no oxigênio (Figura 1)
- Monitorização do ritmo cardíaco deve ser iniciada rapidamente
- Após a IOT, verificar a ventilação com o dispositivo Ambu® + HMEF + *Trach-care* (Figura 2). A curva de capnografia pode ser utilizada nesse momento para a verificaçao da ventilação.
- É necessário desfibrilar ritmos chocáveis rapidamente.
  - No momento da desfibrilação, manter o tubo conectado ao HMEF, não clampear e não conectar ao ventilador mecânico
- A restauração precoce da circulação impede necessidades de vias aéreas artificais e suporte ventilatório
- As inserções das vias aéreas supraglóticas (máscara laríngea) ou IOT devem ser realizadas por médicos experientes
- Identifique e trate causas reversíveis (por exemplo, hipoxemia grave) antes de considerar a parada da ressuscitação

- Os materiais utilizados na intubação não devem ser apoiados sem proteção no leito do paciente e devem ser descartados no lixo apropriado no ambiente do isolamento
- Os equipamentos devem ser descartados e higienizados de acordo com as instruções dos fabricantes e orientações institucionais
- Ao final do procedimento, deve-se realizar a limpeza de todo o ambiente e equipamentos
- Remova EPIs descartáveis (avental e luvas) e jogue-as no lixo apropriado de acordo com a recomendação institucional e da Comissão de Controle de Infecção Hospitalar (CCIH)
  - **Óculos de proteção/face shield higienizados com água e sabão ou cloro**
  - **O gorro deve ser descartado ao final do plantão**
  - **Máscaras para aerossol devem ser trocadas a cada 14 dias ou se sujidade**

Para pacientes que não estão em intubação orotraqueal evitar a ventilação com o dispositivo bolsa-valva-máscara (Ambu®) e sempre preconizar a máscara com reservatório acoplado à face do paciente durante a sequência rápida de intubação, pois isso pode limitar a propagação do aerossol Obs: o uso da bolsa-valva-máscara (Ambu®) será evitada devido à técnica de sequência rápida de intubação, mas em determinadas situações pode ser necessária, e a devida conexão deve ser ao menos preparada e testada (evitando surpresas de não funcionamento em eventual necessidade de ventilação)

Ao final da ressuscitação todos os profissionais envolvidos devem registrar em prontuário os procedimentos envolvidos na manobra de ressuscitação cardiopulmonar

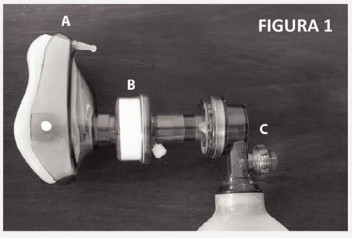


FIGURA 1

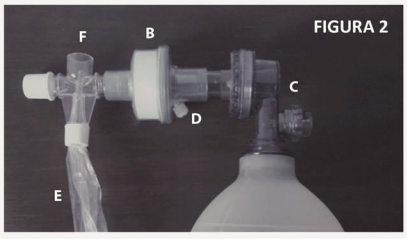


FIGURA 2

Dispositivos de ventilação

- (A) Máscara facial
- (B) Filtro trocador de calor e umidade (HMEF)
- (C) Dispositivo bolsa-valva-máscara (Ambu®)
- (D) Local de conexão do capnógrafo
- (E) Sistema de aspiração fechado (*Trach-Care*)
- (F) Local de conexão tubo endotraqueal

INTUBAÇÃO OROTRAQUEAL

1. FORMAÇÃO DA EQUIPE

- A equipe deve ser formada pelo menor número de pessoas possíveis. Em situações controladas deve ser constituída por um único profissional das seguintes áreas:
  Médico + Enfermeiro + Fisioterapeuta Obs: um segundo médico e um técnico de enfermagem devem ficar de prontidão caso seja necessário.
- Nas situações emergenciais, em casos de via aérea sabidamente difícil, ou sempre que o médico julgar necessário, a equipe deverá ser constituída por 2 médicos, um enfermeiro, um técnico de enfermagem e um fisioterapeuta
- **Para o ambiente do pronto-atendimento, das unidades de internação não críticas e semicríticas, o time de via aérea deverá ser chamado sempre que se identificar necessidade de intubação, utilizando-se o Ramal 2222, opção 4**
- A intubação orotraqueal deverá ser realizada pelo médico mais experiente da equipe

2. PARAMENTAÇÃO

- Todos os membros da equipe devem estar paramentados antes de entrar no leito de isolamento com:
  Avental impermeável + Luvas + Máscara N95 ou similar + Óculos de proteção e *Face shield* + Gorro

3. PREPARAÇÃO DO MATERIAL

- Videolaringoscópio (existe uma mala exclusiva de via aérea difícil disponível na ala I e no Pronto-Atendimento, além dos locais padrão, conforme documento de qualidade NOR-CORP-NOR-014), se disponível
- Cânula orotraqueal/guia
- Aspirador
- Bolsa-valva-máscara (Ambu®), filtro HMEF, sistema de aspiração fechada e máscara facial.
- A ordem de conexão é:
  Ambu® > filtro HMEF > máscara facial (Figura 1)
  Obs.: fora da UTI, se houver capnógrafo disponível, ele deve ser conectado entre o ambu e o filtro HMEF ou no filtro HMEF para os modelos novos de capnógrafos:
  Ambu® > capnógrafo (ou diretamente no HMEF) > HMEF > sistema de aspiração fechada (Figura 2)
- Drogas para sedação e bloqueio neuromuscular
- Deve-se realizar a sedação com as drogas definidas pelo médico
- O bloqueio neuromuscular com o intuito de facilitar a intubação e evitar a tosse do paciente deve ser realizado com:
  Succinilcolina 1 a 1,5 mg/Kg (cada ampola tem 100 mg) ou Rocurônio 1,2 mg/Kg (cada ampola tem 50 mg e geralmente são necessárias aspirar 2 ampolas), dependendo das características de cada paciente
- Sempre que possível o material deve ser preparado fora do box do paciente. Em casos emergenciais, utilizar carrinho de parada disponível

4. PROCESSO DE INTUBAÇÃO

- Posicionamento e monitorização adequada do paciente
- Pré-oxigenação com máscara reservatório no menor fluxo de oxigênio necessário para garantir saturação adequada do paciente. Caso o paciente já esteja usando ventilação não invasiva (VNI) ou cateter nasal de alto fluxo (CNAF) em ambiente de pressão negativa, pode-se dispor desses dispositivos para a pré-oxigenação
- Deve-se evitar o máximo possível a ventilação da via aérea com a bolsa-valva-máscara (Ambu®). Caso necessário a ventilação pode ser feita com a máscara facial firmemente acoplada à face do paciente, para evitar vazamentos
- **Em casos de Via Aérea Difícil (VAD) deve-se utilizar o *Bougie* disponível na mala de via aérea quando o médico julgar necessário**
- Deve-se posicionar um saco plástico de descarte ao lado da cabeceira do paciente, para que todo o material utilizado seja descartado
- Após a introdução, o *cuff* do tubo orotraqueal deve ser insuflado e o tubo conectado pelo sistema de aspiração fechada ao conjunto:
  Ambu® > (capnógrafo, se disponível) > filtro HMEF > sistema de aspiração fechada (Figura 2)
- Para confirmação da ventilação: expansibilidade torácica e curva da capnografia
- Após a confirmação da ventilação, camplear o tubo com HMEF e conectá-lo ao ventilador mecânico
- Somente iniciar a ventilação após o *cuff* estar insuflado
- Deixar o ventilador regulado antes do procedimento, conectá-lo em modo de espera e ligar após a conexão com o paciente
- Medir a pressão do *cuff* assim que possível

TRANSPORTE INTRA-HOSPITALAR		TRANSPORTE INTER-HOSPITALAR
Transporte do PA para a UI ou UTI	**Transporte para exames de imagem**	**Para outros serviços**
• Casos graves devem ser transferidos diretamente para UTI	• Evitar tomografias, priorizar ultrassom	• Antecipar transferências antes da piora do quadro clínico
• Pacientes graves: verificar a necessidade de IOT antes do transporte • Equipe no transporte: médico; enfermeira e fisioterapeuta (conforme fluxo de transporte institucional) • Monitorar pressão arterial, SpO_2 e traçado cardiológico		
Proteção dos profissionais da saúde		
• Utilizar EPI: gorro, óculos de proteção, *face shield*, máscara N95 ou similar e avental de isolamento • Ventilador de transporte: priorizar SERVO-i® (com HMEF no tubo e filtro *HEPA* na saída exalatória). Ventiladores de ramo único, utilize o HMEF entre o tubo e o ventilador • Pacientes em respiração espontânea devem ser transportados com máscara cirúrgica (mesmo em oxigenoterapia). Não utilizar VNI ou alto fluxo durante o transporte • Evitar desconexões desnecessárias porque geram aerossóis • Se for desconectar, deve-se clampear o tubo com a pinça clamp		• Todas as recomendações que constam no transporte intra-hospitalar, acrescidas da abertura das janelas da ambulância
Profissional da segurança no trajeto		
• A equipe de segurança deve garantir que não ocorra expectadores no trajeto e deve utilizar máscara cirúrgica		
Antecipação de intercorrências no transporte		
• Pacientes instáveis devem ser intubados antes do transporte e preferencialmente em ambiente de UTI e em sala com pressão negativa • Todos os materiais e drogas utilizadas na parada cardiorrespiratória, extubação acidental e hipotensão devem ser verificados antecipadamente • Se necessário o uso da Bolsa-valva-máscara conectá-la no HMEF		
Descontaminação pós-transporte		
• Retirada das EPI conforme preconizada pela CCIH • Limpeza dos equipamentos: álcool 70% ou cloro • É preconizado que ocorra a limpeza do ambiente (corredores e elevadores) após cada transporte e as limpezas concorrentes mantidas conforme preconizadas pela instituição		• Limpeza de rotas e elevadores preconizados pela CCIH • Limpeza: álcool à 70% ou cloro • Descartar luvas e avental de isolamento após acomodar o paciente na instituição final • Colocar novas EPIs no retorno • Limpeza terminal da ambulância

ORIENTAÇÕES PARA A EQUIPE ASSISTENCIAL NO MANEJO DO PACIENTE COM INFECÇÃO SUSPEITA OU CONFIRMADA PELA COVID-19

DESMAME DA VENTILAÇÃO MECÂNICA

- A necessidade do processo de desmame e extubação pode ocorrer ainda em momentos em que o paciente apresenta infecção ativa pelo vírus. Com isso, torna-se necessária a adoção de algumas condutas e cuidados para que não ocorra aumento da formação de aerossóis no ambiente hospitalar e um prolongamento da permanência em ventilação mecânica invasiva e dias de internação na UTI nestes pacientes

Critérios de elegibilidade para a realização do teste de respiração espontânea (TRE):

- Os pacientes devem ser triados diariamente
- Oxigenação adequada: PaO_2 / FiO_2 >200 com PEEP ≤5 a 7 cmH_2O
- Estabilidade hemodinâmica: doses baixas estabilizadas ou sem infusão de vasopressores
- Nível de consciência adequado: acordado ou desperta facilmente
- Manejo da tosse e secreção: presença de reflexo de tosse durante a aspiração fechada

- Pacientes que atenderem aos critérios de elegibilidade são candidatos ao TRE
- Fazer o TRE no ventilador mecânico com o sistema fechado
- Não fazer o teste com tubo T - risco de formação de aerossóis e contaminação ambiental

Obs: Para reduzir o risco de reintubação, é recomendado que uma margem clínica seja adotada, pois a extubação de pacientes limítrofes aumenta a necessidade de ventilação não invasiva e cânula nasal de alto fluxo após a extubação, aumentando assim as chances de formação de aerossóis

O uso do teste de vazamento do balonete não deve ser realizado rotineiramente antes da extubação pelo risco de aerossolização. No entanto, seu uso deve ser ponderado pela suspeita clínica de edema das vias aéreas superiores ou pela presença de fatores de risco para estridor pós-extubação

Pacientes que apresentam sucesso no TRE devem preferencialmente ser extubados em ambientes com pressão negativa e em ambiente de isolamento respiratório

Parâmetros para o teste de respiração espontânea

- Realizar preferencialmente em ambiente com pressão negativa
- Modalidade ventilatória: Ventilação com pressão de suporte
- Pressão de suporte: 5 a 7 cmH_2O
- PEEP: 5 a 7 cmH_2O
- FiO2: 30%
- Tempo de avaliação: 1 hora
- Avaliar os critérios de sucesso ou falha

Critérios de sucesso:

- Frequência respiratória <35 rpm
- Boa tolerância no teste
- Frequência cardíaca <120 bpm ou variabilidade da frequência cardíaca <20%
- SaO_2 >90% ou PaO_2 >60 mmHg com FiO_2 <30% (preferencialmente)
- Pressão arterial sistólica >80 e <170 mmHg <20% de mudança em relação ao basal
- Ausência de desconforto respiratório, caracterizado por ausência dos sinais: uso de musculatura acessória, respirações paradoxais ou com presença de assincronias, sudorese intensa e agitação
- Índice de respiração rápida e superficial (f/VT) <100 (realizada em ventilação com pressão de suporte)

Critérios de falha:

- Rebaixamento do nível de consciência e agitação
- Sudorese intensa
- Batimento de asa nasal
- Aumento do desconforto respiratório
- Taquicardia – aumento de 40 bpm comparado ao basal
- Arritmias cardíacas
- Hipotensão
- Apneia
- Aumento do $PetCO_2$ >10 mmHg
- Redução do pH arterial <7,32
- Redução do pH arterial >0,07
- PaO_2 < 60 mmHg com a FiO_2 >30% (relação PaO_2/FiO_2 <150)
- Queda de 5% na SpO_2 comparado ao basal

EXTUBAÇÃO

- Fisioterapeutas e outros profissionais da saúde presentes no ambiente durante a extubação devem seguir as precauções de isolamento por aerossóis, incluindo: Avental de isolamento + Luvas + Gorro + Máscaras N95 ou similar + Proteção para os olhos (óculos de proteção e *face shield*)

Cuidados antes da extubação:

1. Desligar o ventilador mecânico antes de desconectar do paciente
2. Manter o HMEF e o sistema de aspiração fechado (*Trach-Care®*) conectados ao tubo endotraqueal no momento de desinsuflar o *cuff*
3. Se for necessária a aspiração: utilizar o *Trach-Care®*
4. O tubo endotraqueal deve ser removido de forma mais suave possível para evitar manipulações vigorosas e estímulo da tosse
5. Se for necessário estimular a tosse do paciente o mesmo deve ser orientado a adotar as medidas de etiqueta da tosse
6. O tubo deve ser descartado conforme preconizado pela CCIH
7. É sempre recomendado que durante a extubação de pacientes com diagnóstico de COVID-19 tenha um médico com experiência em intubação de prontidão, caso seja necessária uma reintubação rápida
8. A taxa de reintubação desses pacientes deve ser a mais baixa possível, então é preconizado que a decisão de extubação do paciente seja discutida entre a equipe multiprofissional

Cuidados pós extubação:

1. A aplicação de oxigênio suplementar na menor fração possível de oxigênio inspirado (FiO_2), preferencialmente por cânula nasal de baixo fluxo
2. Como os pacientes são frequentemente extubados enquanto ainda apresentam infecção ativa, aconselhamos a adoção de uma abordagem semelhante ao fornecimento de oxigênio como antes da intubação
3. O uso da cânula nasal de alto fluxo e a ventilação não invasiva deve ser ponderado e orientamos o seu uso nas indicações clássicas para o risco de falha de extubação, que são:
   - Pacientes obesos
   - Diagnóstico de doença pulmonar obstrutiva crônica
   - Insuficiência cardíaca
   - Tosse ineficaz
   - Falência consecutiva no desmame
   - Presença de mais de uma comorbidade
   - Paciente com idade >65 anos
   - APACHE > 12 no dia da extubação
   - Pacientes com mais de 72 horas de ventilação mecânica invasiva

Obs: Caso seja necessário o uso de VNI, deve preferencialmente ser feita em ambiente com pressão negativa e o uso deve ser em ventiladores com ramo duplo e a utilização do HMEF entre a máscara e o circuito do ventilador mecânico e um filtro HEPA adicional na saída da válvula expiratória para evitar a formação de aerossóis

Pacientes traqueostomizados:

Para pacientes que falham consecutivamente no desmame ou com períodos longos de intubação, a traqueostomia pode ser indicada. A traqueostomia é considerada um procedimento de alto risco para a formação de aerossóis e deve seguir as orientações intitucionais de "Cuidados com o Paciente Cirúrgico"

Cuidados no desmame da ventilação mecânica:

- Não utilizar os dispositivos: máscaras de traqueostomia, *Trach-Vent®* e tubo T – risco de formação de aerossóis e contaminação do ambiente
- Para os períodos de treinamento em respiração espontânea sugerimos o uso do sistema:
  HMEF + *Trach-Care®* (Figura 1) – conectado na traqueostomia
- A suplementação de oxigênio deve ser realizada diretamente no HMEF para manter a SpO_2 entre 93-96%
- Caso seja necessária a aspiração durante o teste de respiração espontânea, deve-se utilizar o *Trach-Care®*

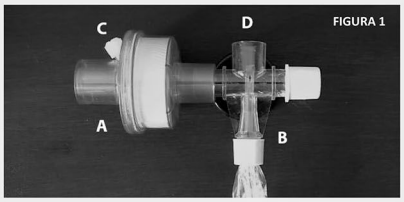


FIGURA 1

Dispositivo montado com HMEF conectado ao *Trach-care®* para teste de respiração espontânea em pacientes traqueostomizados

- (A) HMEF
- (B) *Trach-care®*
- (C) Local de suplementação de O_2
- (D) Local de conexão com a traqueostomia

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