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nebulisers, with their open design, increase the risk of contamination because patient secretions can fall into the nebuliser's reservoir. Mesh nebulisers, with the mesh separating the medication from the patient interface, makes contamination less probable. Washing hands with soap and water for 20 s, or use of hand sanitiser containing at least 60% alcohol before and after aerosol therapy, is essential to minimise device contamination. Additionally, regularly cleaning the device will reduce the risk of contamination. According to the guideline of the Cystic Fibrosis Foundation, disposable nebulisers should be replaced every 24 h, and reusable jet nebulisers should be cleaned with soap and water, rinsed, disinfected, and air-dried after each therapy. Mesh nebulisers should be cleaned with reference to the manufacturers' guidelines. Following the manufacturers' guidelines for delivery technique, device preparation, and cleaning for each device improves treatment efficiency and safety in this patient population. Furthermore, as WHO recommended, isolating patients in well ventilated rooms with open windows, staying at least 1 m away from family members, covering the nose and mouth with a tissue when coughing, and discarding tissues in a rubbish bin placed in the patient's room are important lessons for patient education. Through the understanding of these options and rationales, aerosolised medications can be delivered safely and effectively in this global pandemic.

For more on the **guideline of the Cystic Fibrosis Foundation** see https://www.cff.org/Life-With-CF/Treatments-and-Therapies/Medications/Nebulizer-Care-at-Home/

For more on **patient education** see https://www.who.int/publications-detail/home-care-for-patients-with-suspected-novel-coronavirus-(ncov)-infection-presenting-with-mild-symptoms-and-management-of-contacts and https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-risk-assesment-hcp.html

Because of the pandemic's many unknowns that we cannot control, it can be easy to overlook the options available to improve the situation. While hospitals are under pressure, there is a widespread, global shortage of ventilators and crucial medical supplies. Therefore, improving health care at home is one of the most pressing needs in this pandemic. Proactive training of patients with pulmonary diseases and their caregivers is also crucial to effectively address this need in the era of COVID-19.

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# Delivering evidence-based critical care for mechanically ventilated patients with COVID-19

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As the COVID-19 pandemic has escalated, an unmatched surge of severe cases requiring intensive care unit (ICU) admission has been observed.[1] Currently, more than 50% of patients in the ICU require invasive mechanical ventilation and up to 20% need dialysis. ICU capacity has been increased in many hospitals; however, due to the increased severity of illness,[1,2] even ICUs that are adequately staffed for their usual routine might not have enough trained professionals to deliver the complex care required by ventilated patients with COVID-19-related acute respiratory failure or acute respiratory distress syndrome (ARDS). The challenges can be even greater in developing countries with limited resources. In Brazil, the surge of patients has overwhelmed the health system and worsened the already inadequate access to an ICU bed in a public hospital.

Despite promising results for the antiviral remdesivir,[3] no specific and effective treatment exists for the disease caused by severe acute respiratory syndrome

coronavirus 2 (SARS-CoV-2) infection. Patient care relies mainly on advanced life-sustaining therapies that support organ functions while the immune system controls and eliminates the viral infection.[1,4] The severity of clinical presentations and exceedingly high mortality rates have triggered discussions about the use of traditional adjunctive therapies (eg, corticosteroids) and novel interventions (eg, convalescent plasma infusion), but all lack strong evidence of efficacy and robust safety data in patients with COVID-19.[4] Improvements in the outcomes of patients with sepsis and non-COVID-19-related ARDS have been achieved by the use of quality-of-care measures to decrease the duration of mechanical ventilation and ICU length of stay, as well as ICU-acquired complications.[5]

The current pandemic is a significant burden on health-care systems worldwide and a strain on their ICUs. Strain can be associated with decreased adherence to the implementation of protocols and evidence-based care measures, and potentially worse patient outcomes.[6] Thus, it is crucial to focus on protocol implementation and adherence to basic care principles for mechanically ventilated patients.

The severity of COVID-19-associated lung injury can result in long periods of mechanical ventilation and prolonged stay in the ICU. Severe hypoxia can require more aggressive ventilation strategies to improve oxygenation in the short term. Higher tidal volumes ($V_T$) and driving pressures are more likely to be associated with prolonged ventilation, more profibrotic stimuli due to high $V_T$ in the dysregulated inflammatory response of the lungs, and increased mortality rates.[7,8] In this context, intensivists should aim to reduce the evidence-to-practice gap by implementing lung-protective ventilator strategies and building bedside protocols based on the most recent recommendations, ensuring that $V_T$ lower than 6 mL/kg and plateau pressures of less than 30 cm $H_2O$ are applied.[9] In severe ARDS, a short course of paralysis and deep sedation might be associated with improved outcomes.[10]

Aiming at light sedation strategies should be a goal for most ICU patients, as recommended by recent guidelines.[11] The use of deep sedation, even for a short duration, is independently and strongly associated with increased mortality rates for mechanically ventilated patients.[11] However, patients with severe COVID-19 might need sedation to avoid asynchrony and improve the application of invasive mechanical ventilation. In elderly patients with COVID-19-related ARDS and increased systemic inflammation, delirium and its complications are likely to develop. Moreover, studies show that in severe cases of COVID-19, SARS-CoV-2 can be identified in the central nervous system, potentially leading to direct brain injury. These factors might contribute to a high incidence of post-intensive care syndrome and decreased quality of life in survivors of COVID-19. Therefore, ICUs should, whenever possible, ensure the use of targeted sedation with strategies to reduce the use of sedatives and benzodiazepines, in order to limit the duration of mechanical ventilation and its associated complications, including the frequency of delirium.[12] The above-mentioned strategies should be applied judiciously, as the increased burden of care in the ICU might unintentionally be associated with a proportional reduction in patient monitoring, which could pose a safety issue in patients under light sedation.

Wise implementation of general preventive measures is of the utmost importance. Patients with COVID-19 present with hypercoagulable states and are particularly prone to vascular thrombosis, including venous thromboembolism (VTE).[12] Ensuring maximal implementation of VTE prophylaxis should thus be a priority goal of care. Hand hygiene and use of masks continue to be fundamental measures to protect patients and staff from nosocomial infections; the use of usual processes of care, such as checklists, before central venous line catheterisation must also be applied. Finally, there is evidence that a combination

| ICU admission | Standard of care* | Specific considerations in COVID-19 |
|---|---|---|
|  First do no harm | • Use of PPE<br>• Hand hygiene<br>• Protective mechanical ventilation<br>• Minimal use of sedatives<br>• Judicious use of fluids (conservative fluid-management strategy)†<br>• Avoidance of nephrotoxic drugs<br>• VTE prophylaxis<br>• Multidisciplinary rounds<br>• Checklists for prevention of ICU-acquired complications<br>• Infection prevention bundles<br>• Adjustments to standard of care (eg, drug dose for renal dysfunction, choice of sedative) on a case-by-case basis | **Mechanical ventilation strategies**<br>• $V_T$ <6 mL/kg (ideal body weight)<br>• Plateau pressure <30 cm $H_2O$<br>• Driving pressure <15 cm $H_2O$<br>• Consider short-term paralysis for severe ARDS<br>• More evidence is needed to tailor treatments to ARDS phenotypes<br>**Drugs**<br>• Consider evidence-based treatments for specific conditions (eg, anticoagulation for confirmed thrombosis)<br>• Consider new therapies exclusively in a research context (eg, tocilizumab, convalescent plasma, hydroxychloroquine) |

***Figure*: Effective care measures to improve outcomes in mechanically ventilated patients with COVID-19**
ARDS=acute respiratory distress syndrome. ICU=intensive care unit. PPE=personal protective equipment. $V_T$=tidal volume. VTE=venous thromboembolism. *Must be done if no contraindications are present. †Conservative fluid management is associated with reduced duration of mechanical ventilation.[16]

of evidence-based protocol implementation and multidisciplinary care is associated with improved outcomes and reduced length of stay for mechanically ventilated patients.[13,14] The application of such measures might allow early discharge of patients with COVID-19 and admission of new patients without the investment required to provide additional ICU beds. Optimising the use of scarce resources is even more challenging, but vital, in developing countries, where adherence to low $V_T$ and other process-of-care measures can be suboptimal.[15]

Considering the severity and unparalleled number of cases of COVID-19 pneumonia in ICUs, we must ensure the delivery of high-quality care for mechanically ventilated patients (figure). More than adjunctive treatments or expensive immune therapies, for which evidence of efficacy is lacking, the focus should be on the careful application of evidence-based approaches associated with improved outcomes in ARDS over the past three decades.

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# Health equity and distributive justice considerations in critical care resource allocation

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Amid the possibility of resource shortages in health care during a public health crisis, guiding principles established by several groups advocate for allocating life-sustaining treatments on the basis of a patient's chances of survival, resulting in an approach of saving the most lives possible.[1] To assist in this approach, many triage frameworks use acute illness scores to predict short-term mortality.[1] The sequential organ failure assessment (SOFA)[2] score has received attention as a mortality prediction tool during the COVID-19 pandemic and is likely to be used by hospitals in some manner as a triage tool. Although the SOFA score's use has been validated for a variety of purposes in studies done in dozens of countries,[2] two clear limitations exist. First, there are insufficient data on how the SOFA score performs as a predictor of COVID-19 outcomes and on outcomes in specific populations based on features such as race and ethnicity. Second, even if the SOFA score predicts outcomes reliably, it is far from clear that using it as a tool for allocating critical care resources is fair. For example,