Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

of NIV versus invasive mechanical ventilation, as well as intubation timing and criteria. Future research should aim to clarify the best ventilation strategy for individual patients (eg, phenotypes and response to PEEP), to describe disease mechanisms associated with the pathophysiological patterns and clinical course of COVID-19 (eg, early *vs* late presentation; vascular *vs* parenchymal), to identify biomarkers (eg, cytokines, ferritin, D-dimer, or procalcitonin) that could help to guide management, and to establish the efficacy and optimum timing of promising therapeutics. In the meantime, in an era of big data and large databases, it would be worth using machine learning and other approaches to try to identify the link between observed patterns of physiology, interventions, and outcomes before clinical trials have been completed.

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Use of aerosolised medications at home for COVID-19


Colin Cuthbert/Science Photo Library

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For more on the **guidelines from the Global Initiative for Chronic Obstructive Lung Disease** see http://www.goldcopd.org

For more on the **guidelines from the Global Initiative for Asthma** see https://ginasthma.org/recommendations-for-inhaled-asthma-controller-medications/

Respiratory viruses are the most common trigger for pulmonary disease exacerbations and infection can result in deterioration in patient symptoms. Although inhaled medications are commonly used, many clinicians have questioned whether inhaled corticosteroids (ICS) affect acute respiratory infection and disease progression caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Because ICS are considered immunosuppressive, some clinicians are unsure about using these medications during the COVID-19 pandemic. Patients also hesitate to use inhaled medications that are seen as a potential source of viral transmission and immunosuppression. Despite many discussions on COVID-19 having taken place, little attention has been brought to patients with pulmonary diseases treated at home. There is an urgent need for guidance on treating such patients (with and without COVID-19) to minimise the use of hospitals under pressure with admissions.

Patients with pulmonary diseases are considered to have an increased risk of having COVID-19. However, the prevalence of COVID-19 is lower in this patient population than in populations of other chronic illnesses, and treatments used in pulmonary diseases might reduce the risk of infection and the development of disease symptoms.[1] Although ICS are associated with an increased risk of upper respiratory infections[2] and pneumonia,[3] these medications might have beneficial effects in viral infections,[4] and might reduce the severity of COVID-19 by blocking SARS-CoV-2 RNA replication.[5] Guidelines from the Global Initiative for Chronic Obstructive Lung Disease and the Global Initiative for Asthma recommend the use of prescribed ICS in pulmonary diseases to prevent the worsening of pulmonary disease severity during the pandemic. Increasing the dose of ICS at the beginning of exacerbation might prevent disease progression and the need for oral corticosteroids; however, patients should

avoid experimental treatments without consulting their physicians.

Although adhering to prescribed medications is essential in the era of COVID-19, clinicians should recognise that aerosol therapy generates fugitive emissions that are not inhaled by the patient and are released from the device during expiration.[6] Fugitive emissions are medical aerosols generated by aerosol devices, whereas bioaerosols are produced by patients.[6] 50% of medical aerosols generated during therapy are fugitive emissions.[7] SARS-CoV-2 transmits through droplets, generated as bioaerosols, that remain viable and infectious for several hours.[8] The dispersion distance of fugitive emissions varies with the aerosol-generating procedures used during therapy. Intubation or bronchoscopy produce contaminated bioaerosols; coughing without a mask on makes the dispersion much wider than coughing with a mask on. A retrospective pooled analysis of risk with various aerosol-generating procedures showed that the risk of infection of clinicians increased by 6·6 times with intubation, as opposed to 0·9 times with nebulisers.[9] Unlike other aerosol-generating procedures that carry contaminated particles derived from patients, the medication in the nebuliser is considered a non-patient source that might not generate bioaerosols carrying pathogens, unless the nebuliser is contaminated. Tang and colleagues[10] simulated a spontaneously breathing adult receiving therapy with a jet nebuliser attached to a face mask.[10] Using a live-attenuated influenza vaccine as a surrogate virus tracer, Tang and colleagues collected air samples from three different locations, including 612 viruses per L near the head, 174 viruses per L near the abdomen, and 118 viruses per L near the feet. The results showed aerosols spreading at a decreasing concentration with increasing distance from the patient in an isolation room with 12 air changes per h. This spread can be an issue in patients' homes where airborne virus concentration might gradually increase with time.[10]

Therefore, avoiding unnecessary aerosol therapy is essential in patients with COVID-19 and pulmonary diseases treated at home.[6] Successful administration of aerosol therapy in these patients requires a clear understanding of the options and rationales on device selection, interface selection, delivery technique, device preparation, and cleaning. If aerosolised medications must be used, clinicians should prefer inhalers over nebulisers, unless the patient cannot perform the specific breathing techniques the inhaler requires or the drug formulation is unavailable as an inhaler.[6] Exhaled air dispersion and virus transmission with inhalers are less than with jet nebulisers because inhalers have lower emitted doses and generate less aerosol mass. Pressurised metered dose inhalers should be used with valved holding chambers to minimise oropharyngeal deposition and the need for hand-breath coordination. Also, exhaling into valved holding chambers might decrease the dispersion of exhaled bioaerosol to the environment. Effective therapy with pressurised metered dose inhalers requires optimum technique by priming the inhaler before initial use, having good hand-breath coordination, actuating the inhaler at the beginning of inspiration, breathing slowly, and holding the breath at the end of inspiration. For patients who cannot provide these steps with pressurised metered dose inhalers, but can reach the high inspiratory flow rate needed to disperse the drug particles and draw the drug from the device, dry powder inhalers could be an option.[6] However, if dry powder inhalers cause airway irritation or cough that increase exhaled air dispersion and virus transmission, these inhalers should not be used for aerosol therapy.[6] When the drug formulation is unavailable as an inhaler or patients cannot do the breathing techniques with inhalers, aerosols can be delivered with nebulisers.[6] Two-thirds of the aerosols that jet nebulisers generate are released into the environment, which might increase the risk of infection for family members. Therefore, mesh nebulisers might be a good alternative. Through the mesh, the nebulisers separate the medication from the patient interface and operate without external gas flow that disperses patient-generated bioaerosols. Although placing a filter on a nebuliser's outlet captures exhaled droplets and reduces aerosol concentration, the filter's effectiveness in preventing viral transmission is unknown.[6] A mouthpiece should be preferred over a face mask to improve treatment efficiency and reduce the concentration of fugitively emitted aerosols because a mouthpiece does not force aerosols out of the interface during therapy.[6] Delivering aerosols outside on a patio, porch, or in a garage, where the air is not circulated into the house, minimises the dispersion of exhaled air and the transmission of virus in the home.

Proper device preparation and cleaning is as important as device and interface selection. Inhalers, which enclose the drug, enable safe preparation of the device. Jet

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