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.

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Practical strategies for airway clearance in patients with severe COVID-19

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Background

Since it was first identified, COVID-19 has presented significant challenges to healthcare workers around the world. This has particularly been the case in critical care units, which have seen significant surges in admission numbers over the course of the pandemic. Due to the extreme severity of illness, patients admitted to an intensive care unit (ICU) with COVID-19 have often required prolonged periods of mechanical ventilation, coupled with prone positioning and paralysis to achieve adequate gas exchange and oxygenation (Chang et al., 2021, McWilliams et al., 2021). Whilst optimising ventilation, this strategy increases the risk of secretion retention and creates a number of challenges for respiratory physiotherapy.

The challenge of secretion clearance

In patients receiving invasive mechanical ventilation, normal secretion clearance mechanisms are significantly impaired. The delivery of gas under positive pressure inhibits cilia action and is associated with the embedding of secretions within the deeper airways (Konrad et al., 1994). The use of artificial airways bypasses the glottis and hinders the ability to generate an efficient cough (Gal, 1980). This bypassing of the upper airways also inhibits humidification and warming of inspired gases, causing damage to the airway epithelium and further promoting impairment of airway clearance (Kilgour et al., 2004).

For patients with severe COVID-19 infection, ventilation is challenging due to the heterogeneous lung pathology and associated severe hypoxaemia, often requiring high peak inspiratory and plateau pressures to achieve adequate oxygenation (National Institutes of Health, 2021). Prone positioning is also recommended and often utilised as a part of lung protective ventilation to optimise gas exchange (Alhazzani et al., 2020). Guidelines suggest for maximal effect patients should spend a minimum of 16 hours in the prone position, with a 30-degree reverse Trendelenburg tilt to prevent pressure damage or facial oedema. Whilst the prone position can aid in proximal secretion drainage (Scholten et al., 2017), this prevents use of traditional postural drainage positions during chest physiotherapy such as alternate side lying. In addition, neuromuscular blocking agents subsequently render the respiratory and abdominal muscles inactive meaning cough becomes absent.

Physiotherapy treatment

Respiratory physiotherapy is widely implemented in ICU to improve airway clearance, using techniques aiming to displace mucus from distal to proximal airways and enhance cough efficacy.

In patients who are mechanically ventilated, the challenge for secretion clearance becomes dependent on the mechanism of two-way gas liquid flow and the interplay between inspiratory and expiratory flow rates. As highlighted previously, the need for high ventilatory pressures, in combination with poor lung compliance and impaired or absent cough, result in an imbalance and subsequent inspiratory flow bias (see Fig. 1a). This further serves to restrict secretion clearance and has the potential to move secretions deeper into the lungs.

Physiotherapy techniques focus on generating an expiratory flow bias to clear secretions. This often encompasses the use of positioning to promote gravity assisted drainage of secretions in combination with manual techniques such as ‘shaking’ or ‘vibrations’ applied during expiration (see Fig. 1b). In order to achieve an expiratory flow bias and clear mucus, mean expiratory flow rate needs to be at least 10% higher than inspiratory flow. Careful timing of manual techniques is essential to achieve this, with optimal timing being the point at which the ventilator cycles from the inspiratory to expiratory phase, maximising peak expiratory flow without impacting peak inspiratory pressures (Shannon et al., 2010). On completion, a rapid release of the hands, also termed ‘rib springing’, will stimulate a larger volume breath in the next cycle. An immediate repeat of the chest wall vibration can therefore be even more effective, utilising the increased volume gained to further enhance PEF. Lung volumes may also be increased through the use of ventilator or manual hyperinflation (MHI). Despite initial concerns regarding the potential increased risk of aerosol generation through MHI, this can be avoided with the use of optimal personal protective equipment (Lormans et al., 2021). In reality, these techniques are contraindicated in patients with severe COVID-19 due to the risk of exceeding recommended safety parameters for lung protection.

As secretions move higher, manual techniques must be performed to

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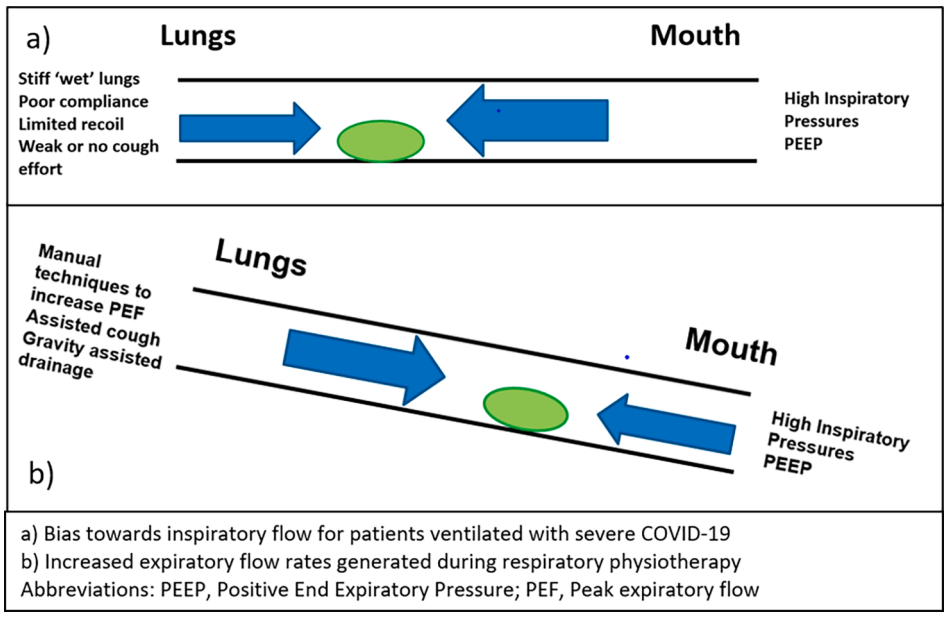

Fig. 1. Factors impacting inspiratory and expiratory flow rates.

assist with generating an effective cough. These should be performed at the peak of inspiration, as the ventilator cycles into expiration, in combination with deep suctioning. The assisted cough can be achieved through hard compression of the thoracic cage, or in supine via an abdominal thrust, and has been demonstrated to achieve significant increases to peak expiratory flow rates (Marti et al., 2013). The effects of manual techniques and assisted coughs are further enhanced when combined with gravity assisted drainage (Ntoumenopoulos et al., 2002). For patients prone, this can be achieved by adjusting the bed to a flat or even head down position if clinical stability allows. The transition from prone to supine can be a particular time of instability in this patient group. It can be useful to perform secretion clearance just prior to this time to clear any accessible secretions and optimise lung function prior to repositioning.

Adequate airway humidification is highly recommended as a routine strategy to ensure optimal mucus properties and outward clearance in ventilated patients (Restrepo and Walsh, 2012). Even with humidified circuits, patients with COVID-19 have been found to have high secretion loads, with tenacious secretions and episodes of tube blockage reported (Wang et al., 2020). This has led to increased use of mucolytics such as carbocysteine to further aid loosening of secretions, or the instillation of 0.9% saline solution. Whilst the use of saline in this way is still open to debate, targeted use in conjunction with physiotherapy has been shown to reduce the incidence of ventilation associated pneumonia (Ntoumenopoulos et al., 2002) and increase sputum volumes cleared (Pattanshetty and Gaude, 2010). Saline should only be used when clinically indicated due to thick and tenacious secretions, targeted to the problem area and combined with manual techniques. When treating a patient in the prone position, saline should be instilled in the reverse Trendelenburg position before the patient is repositioned into flat or head down.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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