Highlights from the Respiratory Failure and Mechanical Ventilation 2022 Conference

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Shareable abstract (@ERSpublications)
.@ERSAssembly2 gathered in Berlin to organise the second Respiratory Failure and Mechanical Ventilation Conference in June 2022. A conference summary is presented here. https://bit.ly/3tL5ItM

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Abstract

The Respiratory Intensive Care Assembly of the European Respiratory Society gathered in Berlin to organise the second Respiratory Failure and Mechanical Ventilation Conference in June 2022. The conference covered several key points of acute and chronic respiratory failure in adults. During the 3-day conference, ventilatory strategies, patient selection, diagnostic approaches, treatment and health-related quality of life topics were addressed by a panel of international experts. Lectures delivered during the event have been summarised by Early Career Members of the Assembly and take-home messages highlighted.

Introduction

In this summary of the second Respiratory Failure and Mechanical Ventilation Conference, held in Berlin, Germany, in June 2022, the Early Career Members of the Respiratory Intensive Care Assembly present the conference highlights. This report includes sessions on both acute and chronic respiratory failure delivered by international experts in the field. It covers symposia on the essentials of respiratory physiology, telemonitoring of patients with chronic respiratory failure, the role of respiratory muscle dysfunction in weaning failure, weaning from invasive ventilation, health-related quality of life (QoL) in mechanical ventilation, ventilatory management of hypercapnic respiratory failure, transitions in chronic noninvasive ventilation and controversies in acute respiratory failure.

Essentials of respiratory physiology

The introductory session of the Respiratory Failure and Mechanical Ventilation Conference 2022 focused on the importance of respiratory physiology in our clinical practice.

A reflection on the lessons learned from the COVID-19 pandemic was presented by Nicholas Hart. SARS-CoV2 triggers an inflammatory response that leads to systemic changes [1]. This may be associated with an increase in neural respiratory drive and a reduction in muscle capacity, which in combination may be associated with an increased respiratory load [2], that may result in patient self-inflicted lung injury (P-SILI) [3]. Throughout the pandemic, several lessons were learned, like the relevance of awake prone positioning [4, 5] and continuous positive airway pressure for the reduction of intubation rates [6]. Finally, he presented new and important evidence regarding aerosol-generating procedures [7, 8].

In the next session, Lise Piquilloud stressed the importance of respiratory mechanics like plateau pressure, the pressure–volume curve, the airway opening pressure, compliance and driving pressure. The compliance (C) equation:

$$c = \frac{\Delta V}{\Delta P}$$

(where V is volume and P is pressure) was revisited, alongside its applications in daily practice.

Following this talk, Leo Heunks discussed the respiratory drive [9] and its feedback mechanisms: chemical, cortical and reflex [10]. The clinical impact of respiratory drive was analysed; low drive can lead to muscle atrophy and asynchronies, and high drive can lead to haemodynamic consequences and lung injury [3, 11, 12]. The drive can be modulated [13] chemically, through extracorporeal membrane oxygenation and sedation with propofol, and mechanically, through ventilator adjustments: higher positive end-expiratory pressure (PEEP) leads to lung recruitment, decreased effort and less lung injury [14].

In the final lecture, Marieke Duiverman commented on the importance of patient–ventilator asynchrony and its universal presence. Patient–ventilator asynchrony can appear in the trigger phase (ineffective trigger, double triggering or autotriggering), inspiratory phase (flow asynchrony), cycling phase (delayed or premature cycling) and expiratory phase (figure 1) [16]. Patient–ventilator asynchrony leads to deleterious respiratory mechanics [17] and to sleep disturbances [18]. The measurement of patient–ventilator asynchrony should be undertaken through visual inspection of the ventilator curves, electromyography or polysomnography bands, to mitigate its effects on our patients.

Take-home messages

- COVID-19 triggers an inflammatory response that increases respiratory drive and decreases muscle capacity, altering respiratory physiology.
- High and low respiratory drive challenge lung and diaphragm protective ventilation, and careful monitoring and modulation are necessary.
- Patient–ventilator asynchrony should be assessed in difficult to ventilate patients.

Telemonitoring of patients with chronic respiratory failure

Anda Hazenberg presented how to achieve telemonitoring of home mechanical ventilation in patients with chronic respiratory failure. Telemonitoring systems require many different aspects: a well-organised team, a close interaction among different features (patient, caregiver, nurses, general practitioners and the hospital team), appropriate equipment, a "24/7" help service, and the possibility to collect data and change settings remotely. She showed how home mechanical ventilation can be feasible, safe and cost reducing, and noninferior to in-hospital initiation of home mechanical ventilation [19–21].

Maxime Patout emphasised the necessity of improving telemonitoring for long-term follow-up of chronic respiratory failure, to improve quality of care [22] and reduce hospitalisation [23]. Telemonitoring can be used to identify some targets [24], like arterial partial pressure of carbon dioxide, QoL, sleep quality, adherence to treatment and side-effects. Adherence in home mechanical ventilation is an important target as an adherence $\geqslant 4\ h \cdot day^{-1}$ to noninvasive ventilation (NIV) resulted in a lower mortality in patients with chronic respiratory failure [25]. He also described some essential requirements for successful long-term NIV, like appropriate legislation, funding, dedicated staff, connected devices with reliable data [26, 27] and remote settings [28]. To conclude, the benefits of telemonitoring are promising but the best way to deliver it remains to be established.

Marieke Duiverman talked about the evidence for reduction of exacerbation [23] by telemonitoring during home mechanical ventilation and pointed out that this subject is still controversial [29–31]. Early detection of COPD exacerbation is a prerequisite for timely treatment, which leads to improved outcomes. She also underlined the cruciality of choosing the right patients [32] to make telemonitoring more effective. Even if they are still to be established, some of the most effective data to prevent exacerbations are represented by treatment adherence, leaks, curves, expired tidal volume and breathing frequency [28]. Moreover, to get more reliable information, other parameters should be analysed (like gas exchange, lung mechanics [33] and neural drive [34]).

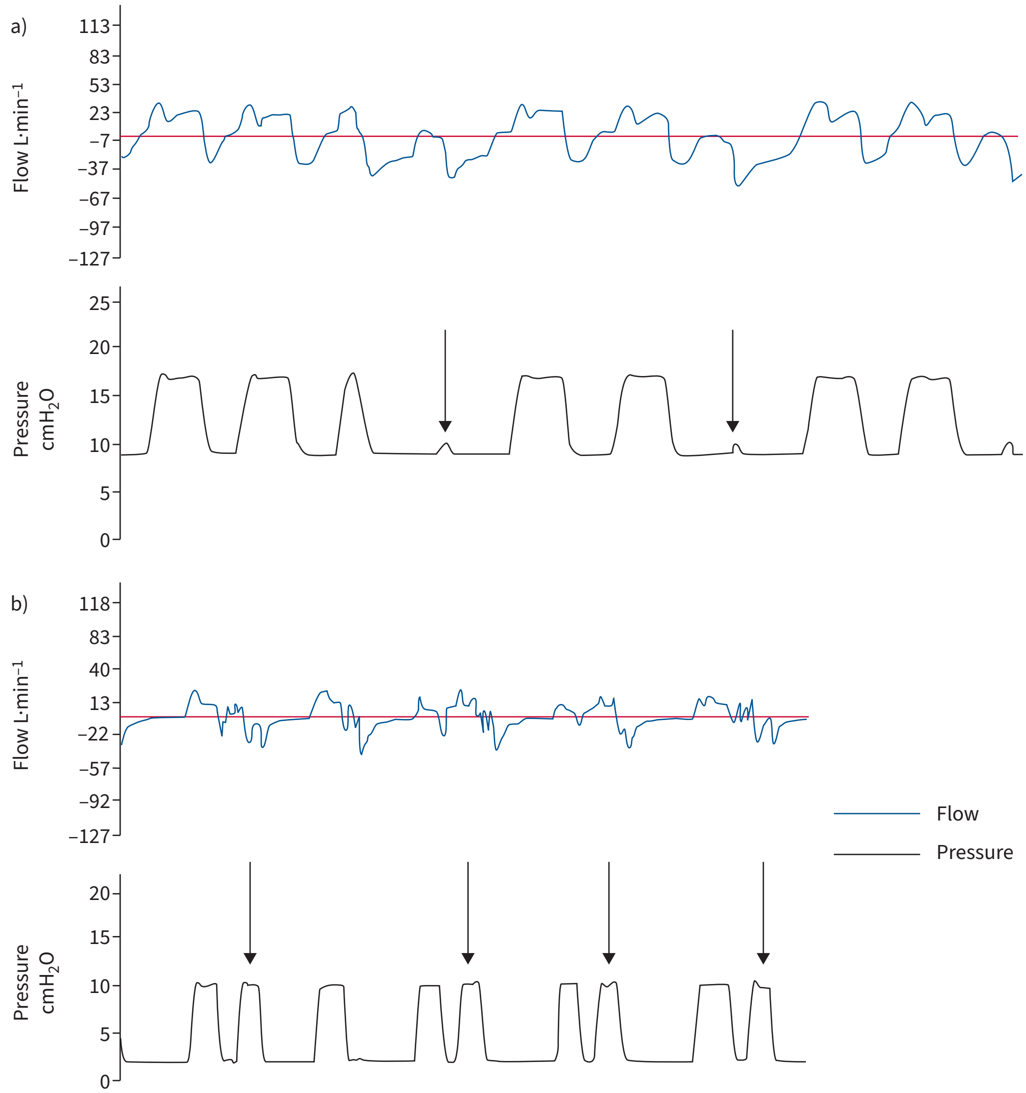

FIGURE 1 Examples of patient–ventilator asynchrony (arrows) revealed in pressure and flow waveforms (data from the software ResScan version 5.6.0.9419). a) Ineffective effort; b) double triggering. Reproduced and modified from [15] with permission.

Take-home messages

- Telemonitoring of home mechanical ventilation is feasible, safe and cost reducing, and noninferior to in-hospital initiation.
- The benefits of telemonitoring are promising but the best way to deliver it remains to be established.
- It is crucial to select the right patients to make telemonitoring more effective.

The role of respiratory muscle dysfunction in weaning failure

Martin Dres gave us an overview of the anatomy and physiology of the respiratory muscles, and how to assess their activity to better understand the role of dysfunction in ventilator weaning failure. The diaphragm is not the only respiratory muscle. Extradiaphragmatic inspiratory muscles (scalene, sternocleidomastoid and external parasternal intercostal muscles) and expiratory muscles (transversus abdominis, internal/external oblique and internal parasternal intercostal muscles) also play an important role in the balance between respiratory load and respiratory capacity. Two-thirds of the patients may have a diaphragm dysfunction at any time during their stay on an intensive care unit [35]. In cases of diaphragmatic weakness, patients recruit extradiaphragmatic muscles. Measurement of the thickening fraction [36]:

$$\frac{t_{\text{end of inspiration}} - t_{\text{end of expiration}}}{t_{\text{end of expiration}}}$$

as well as electromyography activity or measurement of the gastric pressure are tools to assess the activity of these muscles and may help to predict extubation failure [37].

Annemijn Jonkman showed us techniques to monitor the respiratory muscles and highlights the difference between assessing the activation of the muscles *versus* contraction. Measurement of the electrical activation of the diaphragm is the most specific invasive technique to assess the respiratory drive but it is difficult to translate to a measurement of force output [38, 39], which is also true for surface electromyography [40] (because of important interindividual variations in the signal amplitude). Magnetic stimulation of the phrenic nerve is the reference standard to measure the diaphragm strength by measuring the pressure generated by the diaphragm. Other invasive techniques can surrogate force output using pressures signals (oesophageal pressure and transpulmonary pressure [41, 42]) or advanced analyses [43]. Noninvasive measurement tools always need to be interpreted according to the clinical context. Occlusion pressures are reasonably reliable for detecting the diaphragmatic effort [44, 45]. Maximal inspiratory and expiratory pressures are global measurements of inspiratory and expiratory muscle strength. Effort of breathing can be identified by means of diaphragm ultrasound. If respiratory muscle dysfunction is suspected as a main cause of weaning failure, applying specific techniques is recommended but still complex.

In the final talk, Daniel Langer reflected on the importance of inspiratory muscle training in difficult to wean patients [46], using the "frequency, intensity, time, type, progression, volume" strategy. By using such a strategy in the design of patients' inspiratory muscle training, we can enhance their maximal inspiratory pressure, optimising the outcomes. He reviewed the techniques, such as the use of pressure threshold loading, using fixed resistances, and "tapered-flow resistive loading" [47], which applies varying resistances, with greater improvement of volume expansion and flow rates, and greater tolerability by our patients [48]. New respiratory muscle function assessment methods are emerging, such as ultrasound and measurements of muscle oxygenation [49].

Take-home messages

- Measurement of the thickening fraction, electromyography or measurement of the gastric pressure are tools to assess the activity of the respiratory muscles and may help us to predict extubation failure.
- Noninvasive measurement tools always need to be interpreted according to the clinical context.
- Respiratory muscle conditioning is feasible and improves respiratory function, even though the optimal training regimen is still to be identified.

New insights in weaning from invasive ventilation

Successful weaning is critical for recovery. Timely and successful weaning is a key challenge because of the complications of prolonged mechanical ventilation. Inversely, the need for reintubation is associated with increased mortality [50].

Ventilated patients are grouped based on the difficulty and duration of the weaning process [51]. Up to 80% fall into the simple weaning group. Therefore, daily screening to identify ready-to-wean patients reduces the duration of mechanical ventilation, complication rate and costs [52]. The screening must be followed by a spontaneous breathing trial (SBT) to assess a patient's ability to breathe with minimal or no respiratory support [53].

John Laffey introduced the yet-to-be-published WEANSAFE study, showing worse outcomes with prolonged weaning. A delayed separation attempt was independently associated with weaning failure.

Alexandre Demoule compared the different SBTs in use. Pressure support ventilation reduces respiratory effort more than the T-piece trial. The T-piece trial reflects the breathing after extubation more accurately [54]. It has, however, been shown that 30-min pressure support ventilation SBT has no higher risk of post-extubation respiratory failure than 2-h T-piece SBT, supporting the use of a shorter, less demanding strategy [55].

The weaning process is not well defined and geographic variations are seen in practices (use of written directives for screening and SBTs, sedation level, *etc.*) but not in success rate [56]. The severity of the disease, sedation and the presence of a protocol seem to be independent factors associated with success.

American Thoracic Society/European Respiratory Society guidelines suggest using NIV to prevent post-extubation respiratory failure in high-risk patients [57]. Alexandre Demoule summarised that high-flow nasal cannula is not inferior to NIV [58]. Furthermore, high-flow nasal cannula in combination with NIV is more effective in preventing reintubation than high-flow nasal cannula alone [59].

Trials of spontaneous breathing also challenge the circulation [53]. Martin Dres reported on weaning-induced pulmonary oedema, a frequent cause of SBT failure [60, 61]. Increases in extravascular lung water, plasma protein concentration and B-type natriuretic peptide (BNP) are of diagnostic value [62]. Echocardiography and lung ultrasound also allow accurate diagnosis [63, 64]. An increase in haemoglobin level by 5% is diagnostic and convenient to use [62]. Treatment considerations include BNP-driven fluid management and nitroglycerine infusion [65, 66].

Annemijn Jonkman investigated the role of neurally adjusted ventilatory assist (NAVA) mode. It is known that NAVA improves patient–ventilator interaction [67]. NAVA appears to be equally as safe as pressure support ventilation. It is associated with less frequent application of post-extubation NIV [68]. In another study, NAVA decreased the duration of weaning and improved the success of weaning [69]. It seems to achieve a shorter mechanical ventilation duration with no difference in survival [70]. Both studies have several limitations.

Take-home messages

- Successful weaning is critical and a weaning protocol may improve weaning outcome.
- Daily screening to identify ready-to-wean patients is advisable. SBTs should be performed in those patients.
- Independent factors for successful weaning are the severity of the disease, the level of sedation and the application of a weaning protocol.
- Post-extubation failure in high-risk patients can be reduced by the application of high-flow nasal cannula and/or NIV.
- NAVA can be used to improve patient–ventilator interactions and possibly clinical outcome.

Health-related QoL in mechanical ventilation

Anita Simonds highlighted that QoL questionnaires are multidimensional tools, including but not restricted to assessing physical, psychological and social domains, that attempt to measure how the disease affects a patient's life. They should be sensitive to changes related to progression of disease or treatment interventions. This can be achieved with generic (such as Short Form-36 or EuroQol-5 Dimension), disease-specific (such as the St George's Respiratory Questionnaire for COPD) or condition-specific tools (such as the Maugeri Respiratory Failure 28 or Severe Respiratory Insufficiency questionnaires for chronic respiratory failure). They should be obtained directly from the patient as they correlate poorly to physiological measures.

Marieke Duiverman discussed whether NIV affects QoL in COPD patients as results of randomised controlled trials are controversial, highlighting the importance of evaluating whether NIV was successful and setting the right expectations. NIV improves QoL in patients with amyotrophic lateral sclerosis (although the strength of evidence is low) but the disease is rapidly progressive and it will eventually impact QoL [71]. Thus, it is of utmost importance to identify the timing of NIV initiation and the appropriate parameters for NIV success, and to discuss expectations (in some patients, the goal might just be to prevent decay in QoL or delay it) [72].

Sarah Schwarz demonstrated QoL in invasive ventilated patients is quite heterogeneous, and patients' satisfaction with their degree mobility and communication is the most severely impaired [73, 74]. She presented a study showing that patients' and caregivers' perspectives related to satisfaction related to tracheostomy might be very divergent [75]. She defended the need for strategies that identify patients with poor QoL and develop specific strategies for support.

Stefano Nava addressed the problem of "pain of breathing" (dyspnoea) in terminally ill patients and revised the evidence of its management. Guidelines recommend nonpharmacological therapies and opioids to control dyspnoea, whereas supplemental oxygen has failed to prove benefits in nonhypoxic patients [76–78].

NIV can be used, even in patients with otherwise no indication, to palliate symptoms of dyspnoea [79] and to gain time to communicate with relatives, and a trial of NIV can be offered to a willing patient with no contraindications after discussion of its objectives [80].

Take-home messages

- QoL questionnaires are multidimensional tools that attempt to measure the impact of the disease and that should be obtained directly from the patient.
- It is of utmost importance to identify the timing of NIV initiation and the appropriate parameters for NIV success, and to discuss expectations.
- There is a need for strategies that identify patients with poor QoL and develop specific strategies for support.
- NIV can be used, even in patients otherwise with no indication, to palliate symptoms such as dyspnoea.

Ventilatory management of severe acute exacerbation of hypercapnic respiratory failure

The session started with Paolo Navalesi reviewing the initiation of NIV. Our approach should be guided by arterial blood gas measurement and an effort must be made to determine reversible causes of respiratory failure [57, 81]. NIV should be initiated in all COPD patients if respiratory acidosis is present [82, 83], otherwise oxygen titrated to 88–92% saturation should be the chosen approach [84]. Ventilatory management of these patients can be done safely on a medical ward [85]. NIV should be stopped in cases of success, or early or late failure [81]. There is still no consensus on how to wean from NIV [86, 87].

Annalisa Carlucci focused on high-flow nasal cannula oxygen. To date, there is no indication for this as the first choice of treatment for acute hypercapnic respiratory failure. The latest guidelines suggest a trial of NIV prior to using a high-flow nasal cannula in patients with acute hypercapnic respiratory failure and respiratory acidosis [86, 88].

High-flow nasal cannula might have a complementary role by using it in the breaks from NIV, improving the comfort [89] and dyspnoea [90].

Several physiological effects of high-flow nasal cannula may support its use by reducing work of breathing, mainly counterbalancing intrinsic positive end-expiratory pressure and reducing respiratory rate [86, 91, 92]. However, high-flow nasal cannula does not guarantee support for the respiratory muscles. So far, physiological studies on high-flow nasal cannula are still required.

Christian Karagiannidis presented on extracorporeal carbon dioxide removal (ECCO_2R) in acute hypercapnic respiratory failure. Acute exacerbation of COPD is common. Reducing the arterial partial pressure of carbon dioxide with ECCO_2R can lower the strongest stimulus of the respiratory drive. Moreover, ECCO_2R might improve right heart function by reducing the mean pulmonary arterial pressure. Among the ongoing trials, various ECCO_2R settings have been chosen as well as the pump technology or the inclusion criteria among the exacerbated COPD patients, but they all share the primary outcome of early extubation or avoidance of invasive mechanical ventilation. Technical settings, such as pump blood flow, must be considered to predict the efficacy of carbon dioxide removal [93, 94].

Take-home messages

- NIV should be initiated in all COPD with respiratory acidosis and can be safely done on medical wards.
- High-flow nasal cannula has a strong physiological rationale for use in acute hypercapnic respiratory failure, mainly in the breaks from NIV.
- ECCO_2R represents a promising complementary therapy for acute hypercapnic respiratory failure as an adjunctive treatment to NIV to avoid invasive mechanical ventilation or promote early extubation.

Transitions in chronic NIV

Alessandro Amaddeo reported the increase in home long-term ventilation in children [95], for which the main indications are neuromuscular diseases [96], cranial-facial abnormalities and obstructive sleep apnoea [97, 98]. Some important differences must be evidenced between ventilated children [99] and adults, like the necessity of life-support ventilators with internal batteries, a low availability of interfaces, and the weight and the growth of the patient [100]. Moreover, as they grow, it should be evaluated whether the child can be weaned [101] or if their needs changes. Indeed, the transition from adolescence to adult care is a challenging process [102, 103] that can lead to a negative impact on the patient's compliance to therapies [104]. The most common issue is a difficult passage from paediatric to adult-centred care [105, 106]. Since all patients require individualised plans of transition, collaboration between these two care sectors should be improved to achieve a smoother transition process [107].

In some ventilated patients, tracheostomy should be considered [105, 108, 109] (especially those with neuromuscular diseases). As explained by Lara Pisani, it is important to identify those who can be decannulated and switched to NIV [110]. Lara Pisani showed the main steps of decannulation [111], like cuff deflation and assessing airway permeability. Weaning from tracheostomy may also require noninvasive support or airway clearance techniques. In conclusion, she emphasised the importance of an appropriate preparation of adult services for these kinds of patients.

For elderly people, Anita Simonds showed a lower mortality in intensive care unit patients treated with NIV. Unlike younger people, the most common indication for NIV is COPD. It is proven that NIV in the elderly has a positive impact on survival and respiratory function [112] but with a high risk of neuropsychological impairment that can lead to a lower compliance [113]. Home long-term ventilation in old people is a difficult topic and there are a lot of controversial data [114, 115]; however, emerging research shows that QoL is influenced by the underlying disease in most patients [114, 116–119]

Take-home messages

- The use of home long-term ventilation is increasing in children and important differences must be adequately managed.
- Transition from adolescence to adult care is a challenging process that can lead to a negative impact on the patient's compliance.
- In some ventilated patients, tracheostomy should be considered, especially in neuromuscular disease.
- NIV in the elderly has a positive impact on survival and respiratory function.

Controversies in acute respiratory failure

The discussion on whether delayed intubation results in P-SILI opened with Stefano Nava stating that strong efforts are associated with high tidal volumes and lung injury [13]. He concluded that volumes that are harmful in an animal study [120] cannot be translated to proportional tidal volumes in humans. Severity of the disease, rather than tidal volume >9.5 $mL \cdot kg^{-1}$, might cause NIV failure [121]. Increased patient effort is not necessarily deleterious, depending on the subphenotype [122] and cause [123] of acute respiratory distress syndrome. NIV can maintain transpulmonary pressure within the range of safety [124]. Oesophageal pressure determines risk of intubation [125]. Paolo Navalesi argues that the animal model [120] strongly links hyperventilation with P-SILI. Lung-protective ventilation can limit progression of P-SILI [3]. Unlike NIV failure, avoiding delayed intubation can reduce mortality [126]. Several studies support tidal volumes >9.5 $mL \cdot kg^{-1}$ as a predictor of NIV failure [121, 127].

Prone positioning has a strong physiological rationale and is generally accompanied by an improvement in gas exchange due to better ventilation/perfusion matching (figure 2) [129]. The efficacy of prone positioning has been proven in intubated patients [130] but little is known about its efficacy in awake, spontaneously breathing patients. Ehrmann *et al.* [5] conducted a study demonstrating that awake proning reduces the need for intubation in patients with COVID-19 acute respiratory failure.

John Laffey pointed out that, even though prone positioning of awake patients is feasible and associated with a significant benefit in gas exchange [131], to date, no trial has demonstrated its effect on important clinical outcomes in non-COVID-19 patients. Regarding the COVID-19 population, a reduced intubation rate was found only in a specific subgroup of patients: those receiving advanced respiratory support (high-flow nasal cannula or NIV) in the intensive care unit but not in those receiving conventional oxygen therapy or in nonintensive care unit settings [132].

The role of corticosteroids in treating severe infections has been an enduring controversy and the pandemic has been a potent stimulus for clinical research [133]. Charlotte Summers summarised the data favouring the use of corticosteroids; its administration is associated with lower mortality in critically ill patients with COVID-19, in patients with moderate-to-severe acute respiratory distress syndrome without COVID and in patients with severe community-acquired pneumonia [133–135].

Antonio Artigas pointed out the possible side-effects related to the use of corticosteroids, also underlining the heterogeneity of the studies considered and their treatment protocols (doses, duration and choice of

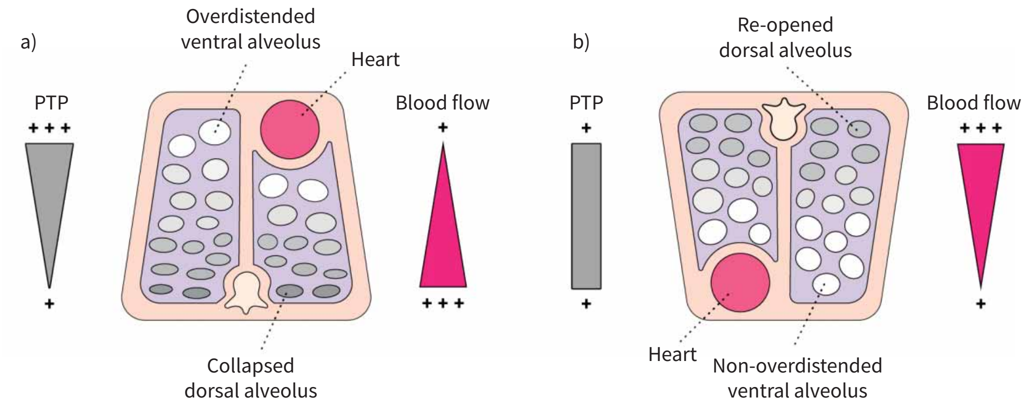

FIGURE 2 Effects of a) supine positioning and b) prone positioning on lung mechanics. PTP: transpulmonary pressure. Reproduced from [128] with permission.

glucocorticoid). In some cases, the use of corticosteroids is associated with significantly higher mortality [136] and side-effects, such as hyperglycaemia, gastrointestinal bleeding and increased risk of ventilator-associated pneumonia, must be considered [137].

Take-home messages

- Avoiding delayed intubation can reduce mortality.
- The efficacy of prone positioning has been proved in intubated patients but little is known about its efficacy in awake, spontaneously breathing patients.
- The role of corticosteroids in treating severe infections has been an enduring controversy. They can be associated with lower mortality in critically ill patients but side-effects may occur.

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