European Respiratory Society International Congress 2018: highlights from Assembly 2 on respiratory intensive care

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ABSTRACT The respiratory intensive care Assembly of the European Respiratory Society is proud to present a summary of several important sessions held at the International Congress in Paris in 2018. For the highly esteemed reader who may have missed the Congress, a concise review was written on three topics: the state-of-the-art session on respiratory critical care, hot topics in weaning and the best abstracts in noninvasive ventilation.

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State-of-the-art session: respiratory critical care

In this session four experts in the field provided state-of-the-art lectures on topics that relate to the ventilatory and non-ventilatory management of patients with acute and chronic respiratory failure.

Ventilatory support in patients with acute respiratory distress syndrome

Laurent Brochard (Toronto, ON, Canada) covered the topic of ventilatory and non-ventilatory management in acute respiratory distress syndrome (ARDS), particularly in terms of preventing ventilator-induced lung injury (VILI). The Berlin definition of ARDS includes severity stratification and excludes the term "acute lung injury", and provides better mortality prediction than previous definitions [1]. The clinical significance of a "protective" ventilation strategy is well established as mortality is reduced by 22% when tidal volumes are reduced from 12 to 6 $mL \cdot kg^{-1}$ [2]. There is also evidence for benefit to keep plateau pressure below 35 cmH_2O to reduce VILI in mechanically ventilated ARDS patients. There is no unanimous consensus on how to titrate positive end-expiratory pressure (PEEP) to achieve safe alveolar recruitment; recent guidelines support using an individualised approach [3]. A recent study failed to show mortality reduction with the use of extracorporeal membrane oxygenation techniques, and this treatment option should be considered on a case-by-case basis if protective ventilation is likely to be sufficient [4]. The concept of the "baby lung" was discussed. Due to atelectasis and infiltration, a smaller portion of the lung is aerated. Tidal volumes are currently set based on predicted body weight and the presence of a "baby lung" would result in higher than expected tidal volumes per unit of open lung. Prone positioning increases the size of the open lung and has been shown to reduce mortality in severe ARDS. It was suggested that it may be better to tailor tidal volumes and pressures based on the size of the "baby lung" rather than on the currently used predicted body weight [5]. In many of the studies cited in this lecture, chest computed tomography (CT) scans were used to measure the size of the baby lung. This remains one of the challenges of using this concept as chest CT scans are not routinely carried out in all ARDS patients.

Difficult and prolonged weaning

Leo Heunks (Amsterdam, the Netherlands) provided an overview of various strategies for weaning from ventilation. As much as 40% of the time devoted to patients requiring invasive ventilation is spent on weaning [6]. There is an absence of evidence to indicate the best method for a spontaneous breathing trial (SBT). A survey of the attendants present in the lecture room showed that around half of the attendants prefer T-piece weaning to predict whether a patient is ready to be extubated, but it should be noted that this number is highly biased by selection bias due to physician preferences for attending such a session. There is an open debate over which SBT technique best predicts post-extubation work of breathing, and therefore the likelihood of extubation success. One systematic review suggested that pressure support ventilation was more successful in predicting post-extubation work of breathing than T-piece weaning [7], although biases due to the heterogeneity of the studies included in the meta-analysis should be considered. Another study did not find a difference between noninvasive pressure support ventilation (NIV) and noninvasive neutrally adjusted ventilatory assist (NAVA) in predicting extubation readiness [8]. NAVA was associated with better patient–ventilator synchrony and greater patient comfort; however, this study had a low statistical power. There is a clear need for good quality randomised clinical trials before we have a definitive answer on which SBT method is best used to inform decisions about weaning [9].

Diaphragm activity and morphology may be associated with outcome of extubation. The pressure-generating capacity of the diaphragm can be reduced after 3–4 days of mechanical ventilation [10]. Accordingly, in over 40% of invasively ventilated patients diaphragm thickness decreases by >10% at day 4 of mechanical ventilation, and this finding is associated with a prolonged weaning time and longer stay in the intensive care unit (ICU) [11]. Furthermore, after 3–4 days of controlled mechanical ventilation the capacity of the diaphragm to generate pressure decreases by 25% [10] and histologically the diaphragm develops atrophy with muscle protein loss and inflammation with muscle protein dysfunction [12]. Sepsis and malnutrition [13], in addition to mechanical ventilation either under-assisting (increase in patient effort) or over-assisting (rest and atrophy), are associated with diaphragm weakness. Diaphragm contractile activity progressively decreases with the increase in ventilator driving pressure applied. This supports the importance of using diaphragm-protective mechanical ventilation to improve outcomes for invasively ventilated ICU patients [14].

Leo Heunks discussed several pharmacological strategies and inspiratory muscle training as adjuncts to weaning from ventilation. As yet, there are no drugs licensed for improving respiratory muscle function. The calcium sensitiser levosimendan has been shown to improve diaphragm function, but there are no clinical trials to suggest its clinical benefit [15]. One systematic review suggests that inspiratory muscle training improves the strength of inspiratory and expiratory respiratory muscles; however, the effects on clinical outcomes remain to be established [16].

Noninvasive respiratory strategies for acute respiratory failure

Stefano Nava (Bologna, Italy) gave an overview of the most frequently used noninvasive respiratory support strategies for acute respiratory failure, which include supplementary conventional oxygen, high-flow nasal cannula (HFNC) and NIV. Invasive ways to support patients with acute respiratory failure include extracorporeal carbon dioxide removal ($ECCO_2R$) and invasive ventilation. The choice between these options depends on the type of respiratory failure, the severity of patients' conditions and the availability of resources.

Supplementary oxygen should be used with caution in hypercapnic chronic obstructive pulmonary disease (COPD) patients, especially in preclinical settings, due to the increased risk of death [17] and potentially fatal rebound hypoxaemia upon abrupt removal [18]. Conservative supplementary oxygen, targeting an arterial oxygen saturation measured by pulse oximetry of 95–97%, has favourable outcomes and the unnecessary use of a higher inspiratory oxygen fraction could decrease the probability of 60-day survival [19].

A physiological study comparing HFNC with NIV in stable COPD showed that a reduction in work of breathing was best achieved with NIV [20]. The only randomised clinical trial comparing HFNC with NIV in COPD with moderate hypercapnic failure showed that both strategies are equally effective [21]. HFNC has been tested in patients with community-acquired pneumonia [22], after cardiothoracic surgery [23], after extubation [24], and in acute hypoxaemic respiratory failure, but all trials failed to show more favourable outcomes with HFNC. It must be noted that a different control group was used in each of the studies, ranging from NIV to conventional supplemental oxygen therapy.

The use of NIV in COPD patients with acute or acute on chronic respiratory failure with acidosis (pH <7.35) remains the gold standard and is strongly recommended [25]. However, NIV should not be used in patients with severe hypoxic respiratory failure irrespective of the underlying diseases and should be used with extreme caution in patients with ARDS irrespective of the severity of the oxygenation [26]. NIV failure and delayed intubation increase the risk of death in acute *de novo* hypoxic respiratory failure [27, 28].

$ECCO_2R$ is still experimental in this patient population and is usually used as an adjunctive nonventilatory option in patients with COPD who are failing or are at high risk of failing NIV, and as a means to facilitate extubation in hypercapnic subjects. A systemic review showed that the combined use of $ECCO_2R$ and NIV leads to dramatic improvements in arterial carbon dioxide tension (P_{aCO_2}), pH and respiratory rates [29]; however, severe complications like bleeding, thrombocytopenia, circuit clotting and pump malfunction are major issues.

There is no lower limit of pH at which a trial of NIV is inappropriate in patients with COPD [25] and invasive ventilation should be used as a last resort. However, the lower the pH, the higher the risk of failure, and patients must be very closely monitored with the possibility for rapid intubation in a protected environment.

Noninvasive ventilatory strategies in stable COPD

The presentation by Wolfram Windisch (Cologne, Germany) focused on the evolution of ventilatory strategies in stable COPD, the effectiveness of long-term NIV with low and high pressures, and therapeutic outcomes of home NIV. The first consensus on use of long-term NIV in stable hypercapnic COPD patients dates back to 20 years ago [30]. One landmark trial on the use of long-term NIV showed that patients with slowly progressive restrictive diseases had fundamentally lower mortality rates when compared with COPD patients [31]. Earlier studies showed no benefit of long-term NIV in stable COPD [32–34], which may be due to the ventilatory strategy used at that time, based on the application of low pressures of ~12–15 cmH_2O.

Long-term NIV with low pressures (or "low-intensity NIV") is not capable of decreasing P_{aCO_2}, and may even worsen quality of life [35]. Long-term NIV with higher pressures ("high-intensity NIV") is much more capable of improving carbon dioxide retention, quality of life and even survival in selected stable patients [36]. In general, long-term high-intensity NIV does not adversely affect cardiac performance, but in patients with pre-existing heart failure, the application of very high pressures may result in a reduction in cardiac output [37]. Failure in the improvement of hypercapnia is clearly associated with the worst outcomes of long-term NIV. Long-term NIV in patients with persistent hypercapnia following acute NIV can prolong time to readmission, and even result in death [38].

New trends in the management of difficult-to-wean patients

This symposium provided profound insights into the potential of a multidisciplinary approach to patients with chronic critical illness. More specifically the topics of weaning and rehabilitation were discussed.

Prolonged mechanical ventilation: definition and outcome

Laurent Brochard discussed classifications, causes and long-term outcomes of weaning from mechanical ventilation.

The Consensus Conference on weaning [39] was reviewed. Weaning is classified into three categories: 1) simple weaning (defined as a patient being weaned on the first attempt with no difficulties); 2) difficult weaning (a patient who failed a first weaning attempt and subsequently required up to three attempts or up to 1 week in duration to be weaned); and 3) prolonged weaning (patients who are still ventilator-dependent after 1 week or more than three attempts).

Failing to promptly identify patients who fall into the "simple weaning" category will increase the probability of long-term mechanical ventilation dependence. Acknowledging and understanding the cause of a "difficult to wean" patient is a crucial issue to prevent a patient from transitioning into a "prolonged weaning" phase.

A more recent classification, based on a prospective multicentre study (the WIND study), was presented [40]. This new classification exhibits a progressive increase in mortality rate with the transition through weaning classifications: 6%, 17% and 29% for group 1 (simple weaning), group 2 (difficult to wean) and group 3 (prolonged weaning), respectively. Subsequent days of mechanical ventilation was associated with an increase in the probability of death, reaching up to 40% in patients who were still ventilated 10 days after the first weaning attempt. In contrast to the Consensus Conference classification [39], the WIND criteria [40] allows clear categorisation of all ventilated patients.

The cause of difficult weaning was attributed to a number of factors, with the diaphragm being a key focus. Diaphragm weakness has been found to be strongly associated with difficult or prolonged weaning [41]. This study included 76 patients, and at the time of a first weaning attempt, diaphragm weakness was reported in 63% of patients, whereas only 34% of patients had limb muscle weakness. Interestingly, only 21% of patients had a combination of both diaphragmatic and limb muscle weakness. The iatrogenic role of mechanical ventilation to induce early diaphragm weakness has been recently demonstrated [42]. In this study, patients with progressive diaphragm atrophy (assessed with ultrasound) showed a higher probability of not being separated from the ventilator, thus being classified as difficult to wean or prolonged weaning patients.

Regarding long-term outcomes, Herridge *et al.* examined outcome measures in ARDS [43] and ICU patients who had been ventilated for 1 week [44]. Time spent on mechanical ventilation (greater than or less than 2 weeks) and patient age (greater than or less than 65 years) were identified as the factors able to significantly influence long-term outcome, delineating four groups, which differed in terms of number of deaths and home discharge. A meta-analysis looking at all studies performed in critically-ill patients ventilated for at least 2 weeks, mirrored these findings [45].

A new ongoing multicentre prospective observational study endorsed by the European Respiratory Society (ERS) and European Society of Intensive Care Medicine (the WEAN SAFE study) aims to better understand weaning practices and outcomes in ICU patients. Results from this trial are expected soon.

Why can my patient not be weaned from the ventilator?

In the second presentation, Leo Heunks focused on the possible causes of weaning failure and the most appropriate solutions. Overall this presentation provided a holistic approach to considerations of weaning failure.

An ABC approach to difficult weaning was illustrated [46, 47], which aims to facilitate early recognition of the potential causes and factors associated with a failed SBT. It was highlighted that being able to identify the underlying causes of failure may significantly increase the chances of SBT success on subsequent attempts.

The ABC approach can be summarised in five domains: a) airway/lung, b) brain/cognition, c) cardiac dysfunction, d) diaphragm and respiratory muscles, and e) endocrine/metabolic. Examples of relevant causes and possible solutions for this ABC approach are provided in the following sections.

a) Airway/lung

Tracheostomy malposition, defined as greater than 50% occlusion of the distal lumen determined by the posterior tracheal wall, may contribute to difficult weaning [48]. Performing a bronchoscopy while the patient is disconnected from the ventilator could be useful to identify and correct it.

High airway resistances (such as those seen in COPD patients) can be solved by optimising bronchodilation therapy.

Low lung compliance can also cause SBT failure. Interestingly, pleural effusion eradication is recommended to reduce a patient's respiratory effort, despite a recent study failing to demonstrate if a difference in terms of success/failure of the SBT was associated with presence/absence of pleural effusions [49].

b) Brain/cognition

Patients suffering from depressive disorders were found to spend more time in the process of weaning [50], while treating them seemed to expedite liberation from mechanical ventilation.

c) Cardiac dysfunction

The transition from positive to negative intrathoracic pressure may favour the occurrence of weaning-induced pulmonary oedema [51]. This may be more pronounced in COPD patients because of higher airway resistances, which results in greater changes in intrathoracic pressure and the work of breathing [52].

Pulmonary capillary wedge pressure (PCWP) >18 mmHg is the gold standard to identify a pulmonary oedema occurring during an SBT, but it is not frequently used in clinical practice [51]. An increase in brain natriuretic peptide during weaning has 76% sensitivity and 78% specificity in detecting cardiac dysfunction and an increase in haemoglobin of 6% at the end of the SBT has a sensitivity of 81% and a specificity of 100% in detecting pulmonary oedema related to the SBT [53], and these might be more appropriate clinical measurements.

Maintaining a systolic blood pressure <140 mmHg (and a stable PCWP) during an SBT may increase the likelihood of passing it and being successfully extubated [54]. Even in the absence of a positive medical history for cardiac disorders, it could be worth considering cardiac failure in a difficult-to-wean patient.

d) Diaphragm and respiratory muscles

The development of respiratory muscle weakness is very frequent in weaning patients. In the section on "Difficult and prolonged weaning" we already described several causes for diaphragm weakness.

Diaphragm weakness can be screened by measuring maximal inspiratory pressures, or with ultrasound either measuring diaphragm excursion [55] or diaphragm thickness change during inspiration (thickening fraction). Changes in oesophageal pressure (measured with an oesophageal catheter) during an SBT, especially if combined with an electromyogram, were suggested to be useful, but the application of such techniques into routine practice needs to be questioned. Few strategies can be applied to improve diaphragm contractility. To date, no drug has been approved to improve respiratory muscle function [56], but pilot studies indicate that inspiratory muscle training may be an effective strategy.

e) Endocrine/metabolic

It was recommended to screen patients for adrenal insufficiency, thyroid dysfunction and to assess nutritional status, especially if weaning is transitioning from "difficult to wean" to "prolonged weaning".

Evaluation of swallowing dysfunction and treatment with Passy–Muir valve

Christina Iezzi (London, UK) provided detailed insights into ICU-acquired dysphagia. Aspiration, particularly silent, is the leading cause of pneumonia in ICU patients and contributes significantly to morbidity and mortality.

The prevalence of ICU-acquired dysphagia is high across a variety of patient groups; with the literature illustrating a prevalence of 91% in critical illness neuropathy [57], 42% in trauma patients intubated for over 48 h [58], 52% in tracheostomised patients [59], and up to a third in ARDS survivors [60]. The increasing prevalence has also been associated with less mortality during the acute phase of disease and consequent prolonged ICU stay, together with an increased awareness and understanding of dysphagia. The duration of invasive mechanical ventilation (in particular more than 7 days) and the occurrence of re-intubation were found to be significant risk factors for post-extubation dysphagia [61]. The presence of a tracheostomy is not a sole cause of dysphagia, but when *in situ* with an inflated cuff, symptoms may be exacerbated and cause an accumulation of secretions with laryngeal/pharyngeal desensitisation.

The most reliable method of assessing swallowing function in patients is fibre-optic endoscopic evaluation of swallowing (FEES) or videofluoroscopy. Videofluoroscopy is the gold standard but requires that patients be transported outside the ICU. FEES is a well-tolerated and safe diagnostic test, which provides information on secretion management, laryngopharyngeal reflux and airway patency. FEES is documented to have a role in weaning, through the decision about tracheostomy downsizing or decannulation it can facilitate to individualise the optimal feeding route for a patient.

The early introduction of one-way valves in the weaning process has multiple benefits. One such device, the "Passy–Muir", is able to restore verbal communication and physiological PEEP, improve taste and smell, and facilitate lung recruitment [62]. However, it was highlighted that, for a one-way valve to be tried, a patient must have a patent airway and be able to tolerate cuff deflation. As a result, factors such as upper airway obstruction and laryngeal oedema must be excluded first.

Challenges associated with whole body rehabilitation in difficult-to-wean patients

The final presentation was given by Michele Vitacca (Gussago, Italy) who addressed the challenges associated with whole body rehabilitation in difficult-to-wean patients.

Typically, difficult-to-wean patients are aged, highly dependent, isolated, and may experience pain and fatigue, a loss of functions, anxiety, depression and delirium. They are likely to have experienced prolonged mechanical ventilation and ICU stay and periods of bed rest. This group of patients is prone to developing infections, sepsis, malnutrition and muscle loss, complications and several comorbidities.

An early multidisciplinary rehabilitation programme can be safely and successfully started in both unconscious critically-ill patients and stable cooperative patients. Rehabilitation programmes have been found to have beneficial effects on ventilation, peripheral perfusion, metabolism, immunity, the prevention of deconditioning, ICU weakness, thrombosis, bedsores, delirium, and on improving the rate of weaning success [63–68]. Results seem to be influenced by the level of disability, comorbidities, type and stage of disease, critical illness, consciousness and cooperation.

For optimal outcomes a successful rehabilitation programme will have multiple components including bronchial hygiene techniques, peripheral and respiratory muscle training, and physical and occupational activity. Neuromuscular electrical stimulation could also be a useful synergic method of improving muscle effort, reducing muscle atrophy and maintaining muscle circumference [65]. There remains a lack of consensus regarding the timing, modality and duration of an optimal rehabilitation programme and therefore the benefits gained over time.

Several potential obstacles may bear upon the initiation and delivery of a rehabilitation programme, including the presence of vasoactive support, staff and equipment resources, safety, and ability to deliver early mobilisation.

Future developments in this important area include the identification of potential subgroups of patients who are more likely to benefit, and the development of guidelines for a tailored rehabilitation approach to include standardised timing, volumes and modalities of intervention.

Hot topics in NIV

Most abstracts in the "Hot topics in NIV" session focused on chronic hypercapnic respiratory failure in COPD patients. However, studies on other indications (acute respiratory failure), other patient cohorts (amyotrophic lateral sclerosis (ALS) and obesity hypoventilation syndrome (OHS)) and ventilator devices were also presented.

High-intensity NIV

In COPD patients with severe chronic hypercapnia, mortality may be decreased by NIV due to lowering P_{aCO_2} [69]. High-intensity NIV has been shown to be able to significantly decrease elevated P_{aCO_2} levels and thereby improve other outcome parameters such as quality of life. However, higher inspiratory positive airway pressure (IPAP) values may have side-effects such as excessive mask leakage. Guan *et al.* [70] investigated the physiological effects of high-intensity NIV in 12 COPD patients using a diaphragm electromyogram and other respiratory physiological parameters such as oesophageal pressure. Due to these measurements, a more individualised adjustment of pressure support was applicable in stable hypercapnic COPD patients.

Structured discharge and follow-up after discharge

Hospital readmission due to exacerbation is known to increase mortality in COPD [69]. Ergan *et al.* [71] presented the interim analysis of a structured discharge and follow-up protocol on readmission rate in 112 COPD patients receiving home mechanical ventilation (HMV) or long-term oxygen therapy. A trend towards a reduced hospital readmission rate within 90 days was detected if patients received education on the underlying disease and their NIV device, in combination with follow-up phone calls and a control visit within 30 days as compared to standard therapy alone.

Mental support for COPD patients with depression or anxiety

COPD patients commonly suffer from comorbidities such as depression and anxiety, both of which are related to dyspnoea [69]. Volpato *et al.* [72] provided their patients with short-term psychological support

such as counselling, relaxation and mindfulness-based exercises during adaption to NIV. Quality of life (EuroQol-5D) and illness perception were improved compared to the group without psychological support. Overall, this led to higher adherence to NIV with an increased rate of acceptance of the ventilator support.

A handheld NIV device limits anxiety but not dyspnoea

Dyspnoea is one of the contributing factors for anxiety and depression in patients with COPD, who can be extremely limited in their daily activities and experience social isolation. Bronchodilators and pulmonary rehabilitation (PR) improve patients' well-being by reducing dyspnoea and increasing exercise tolerance. More recently, a portable, handheld NIV device (Vitabreath, Philips Respironics, Eindhoven, the Netherlands), delivering patient-breath initiated fixed pressure (IPAP 18 cmH_2O, expiratory positive airway pressure 8 cmH_2O) was shown to decrease recovery time in patients with COPD following exercise in a PR centre [73]. Lane *et al.* [74] assessed the impact of the home use of Vitabreath in patients with moderate–severe COPD, who had previously undergone PR, over a 12-week period. The device was well accepted and reported to be easy to use. Furthermore, most patients described reduced anxiety around dyspnoea, and improved breathlessness recovery time, despite no real changes occurred in frequency of dyspnoeic events.

Long-term outcomes of OHS treated with NIV

OHS is among the most common indications for HMV, but it is unclear whether this condition needs to be treated with NIV or if continuous positive airway pressure (CPAP) could be sufficient. This issue has been previously tackled in short-term studies, which showed the superiority of NIV and CPAP compared to lifestyle modification, but no differences between these two treatments emerged [75–77]. Sanchez Quiroga *et al.* [78] presented the results of the Pickwick randomised controlled trial, a large multicentre study comparing long term outcome in patients with OHS and severe sleep apnoea treated with NIV or CPAP. No differences in healthcare resource utilisation were observed between groups. In particular, incidence of cardiovascular events was similar between arms, as well as the number of hospitalisations and hospital days for all-causes. In line with previous results, it was shown that adherent patients (usage $\geqslant$4 h per night) had better outcomes compared to poorly compliant patients.

Home initiation of NIV

HMV is often used in patients with neuromuscular diseases like ALS to improve quality of life [79]. However, HMV can have a significant psychological impact on patients and an increased burden on caregivers, especially as HMV initiation requires a dedicated hospital admission or several outpatient appointments [80]. Volpato *et al.* [72] presented a non-inferiority trial comparing NIV initiation at home and in the outpatient setting. All patients, regardless their randomisation arm, were started on NIV by the same group of experienced physiotherapists. No differences in the main respiratory outcomes and quality of life were observed, but a significant improvement in the caregiver burden was associated with NIV initiation in the home setting.

Dexmedetomidine for sedation during acute NIV

Another indication for NIV is acute respiratory insufficiency. Bielka *et al.* [81] compared adults with acute respiratory insufficiency due to ARDS (mild–moderate according to the Berlin definition) on NIV with and without the use of dexmedetomidine for sedation. This intervention led to improved patient comfort, and lower incidences of delirium and post-traumatic stress disorders after ICU discharge. However, common side-effects such as hypotension and bradycardia were seen in the treatment group.

Summary

In summary, this session highlighted the importance of a patient-centred approach to NIV for optimising adherence to treatment, which will also result in better outcomes in both the acute and chronic setting. Despite the different settings and patient cohorts, all the studies showed that it is very important to focus on physiological variables, but also on improving patients' education, comfort and overall wellbeing. All of this allows an increased compliance with treatment, which results in better short- and long-term outcomes.

Concluding remarks

The authors of this article hope that this comprehensive summary of recent advances in respiratory intensive care creates curiosity to follow-up on topics of interest to the reader. We are committed to meeting the needs of our members and it is our hope that they will want to get more closely involved in the society. We also hope to have encouraged the readership to attend the ERS International Congress 2019 in Madrid.

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