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Hospital respiratory care

The distinct and complementary role of humidified high-flow oxygen therapy and noninvasive ventilation for acute respiratory failure

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With the increased utilization of noninvasive ventilation for the treatment of life-threatening respiratory failure, as well as the increasing utilization of humidified high-flow oxygen therapy (HFT) for the treatment of various forms of respiratory compromise, clinicians now have a broader range of noninvasive tools aimed at managing acute respiratory failure. This paper is intended to provide a more detailed comparative understanding of the clinical application of HFT and noninvasive ventilation (NIV), differences and similarities in modes of action, and the clinical benefits in treating acute respiratory failure when using HFT and NIV in a complementary fashion.

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Respiratory failure

Respiratory failure is the inability to maintain either the normal delivery of oxygen to the blood (oxygenation) or the normal removal of carbon dioxide from the blood (ventilation)[1], and is classified as chronic or acute. Chronic respiratory failure develops over weeks, months or years, whereas acute respiratory failure develops over a course of minutes, hours or days.[2]

Acute hypoxemic respiratory failure, historically termed **type I respiratory failure**, is primarily an oxygenation issue and commonly defined as a PaO_2 less than 60 mmHg (8 kPa) with a corresponding $PaCO_2$ less than 45 mmHg (6 kPa).[1] Supplemental oxygen delivery in the form of a wide range of devices (nasal cannula, non-rebreather mask, humidified high-flow oxygen), has the potential to increase levels of PaO_2.[3] However, most patients need continuous positive airway pressure (CPAP) to increase functional residual capacity (FRC) and increase oxygenation ratio (PaO_2/FiO_2).

Acute hypercapnic respiratory failure, historically termed **type II respiratory failure**, is primarily a ventilation issue and commonly defined as a $PaCO_2$ greater than 50 mmHg (6.7 kPa).[1] Assisted ventilation in the form of invasive ventilation and/or noninvasive ventilation, such as BiPAP, has the potential to reduce levels of $PaCO_2$, thus reducing the associated acidemia that accompanies acute hypercapnia.[1,3]

The severity, signs and symptoms of acute respiratory failure vary according to the underlying cause. The therapeutic approach to acute respiratory failure aims to support gas exchange while the underlying cause improves. At the same time, clinicians are attentive to minimizing the potential injurious effects of therapy, such as ventilator-induced lung injury and pneumonia, particularly associated with more invasive interventions. It is recommended to escalate respiratory interventions depending on the patient's response to therapy.[4]

Some patients exhibiting signs and symptoms of mild respiratory distress may initially be treated with low-flow oxygen support via a nasal cannula device. If the patient does not respond favorably, clinicians may need to escalate therapy **(Figure 1)**.

HFT

Adult low-flow oxygen devices require the clinician to set a flow rate delivery setting. A nasal cannula is commonly set between a flow rate of 1–6 lpm and may deliver an FiO_2 up to 44%, whereas a non-rebreather mask may be set up to 15 lpm, delivering an FiO_2 closer to 100%.

Adult humidified high-flow oxygen devices deliver therapy via a high-flow nasal cannula, and requires the clinician to set not only a flow rate, but also a desired FiO_2 and a temperature/humidity setting. Primarily, humidified high-flow oxygen is a form of oxygenation therapy used to treat acute hypoxemic respiratory failure **(Figure 2)**. Applying heated humidity allows patients to tolerate higher flow rates up to and in excess of 40 lpm and has been shown to induce a CPAP effect and favors CO_2 washout[5] from the upper airway, which may reduce the work of breathing.[6,7] However, the levels of positive end-expiratory pressure (PEEP) and CO_2 washout are relatively low and uncertain.[8]

There are several systems clinically available to deliver humidified oxygen at high flow rates. They generally have the following characteristics:

- An air and oxygen blender to deliver a wide range of FiO_2
- A gas flow meter to set and deliver the mixed gas at a constant flow rate
- An active heated and humidification system ensuring the adequate conditioning of the delivered gas flow

The success and broad utilization of HFT today is highly related to its relative ease of application, high patient tolerance, and benefits versus standard oxygen therapy in selected cases.

Unlike NIV, HFT settings do not include inspiratory positive airway pressure (IPAP), expiratory positive airway pressure (EPAP), a backup respiratory rate or a backup inspiratory time, nor is patient monitoring data available on HFT devices. The mode of action differs from NIV and is not recommended as a substitute for NIV in cases where NIV has strong indications, such as respiratory failure caused by COPD exacerbation and/or cardiogenic pulmonary edema.[9]

NIV

The use of NIV to treat various forms of acute respiratory failure has expanded over the world in terms of the spectrum of successful disease management, including but not limited to COPD, CHF, OSHA, pneumonia, post-op respiratory failure, palliative care and chest trauma.[4] It is the standard of care for decreasing morbidity and mortality in patients hospitalized with an exacerbation of COPD and acute respiratory failure.[10-13]

Moreover, NIV has been used as a means of escalation from alternative therapies, such as oxygen delivery, to provide additional levels of respiratory support and prevent further escalation to intubation. Similarly, clinicians have used NIV as a means to wean patients from invasive mechanical ventilation[14] and prevention of reintubation in at-risk patients.[15,16]

Unlike HFT, the success of NIV is in its ability to titrate the respiratory parameters (level of inspiratory support and PEEP) and its ability to achieve the same physiological effects as invasive ventilation while avoiding complications associated with an artificial airway.[4]

Although commercially available NIV devices share similar basic characteristics, their ability to synchronize with patient-triggered breaths, deliver accurate inspiratory and expiratory pressures, and adapt to patient leaks differ from one device to another.[17] These differences, along with optimizing humidification and interface fitting, influence NIV-related outcomes.[18]

HFT as complementary to NIV

Early observations of clinical application indicate that humidified high-flow oxygen therapy is a superior form of oxygen delivery versus conventional oxygen therapy for patients in whom low-flow oxygen is insufficient to support oxygenation and work-of-breathing needs.[19] However, compared to NIV, the published evidence of the use of high-flow oxygen therapy in adults is less conclusive, and there is as yet no corresponding clinical guideline. Therefore, further research with appropriately sized and homogeneous study groups is required to determine the long-term effects of HFT and to identify the patient groups for whom HFT is most beneficial.[20]

Many clinicians use HFT in a fashion that is complementary to NIV. Clinicians have reported escalating HFT patients who failed to NIV to prevent further deterioration and escalation to intubation. This was observed in one trial in which 104 patients with undifferentiated respiratory failure were assigned to humidified high-flow oxygen. Of the 27 patients (26%) who failed, four were intubated and the other 23 were placed on NIV. Results of the trial indicate that NIV prevented further escalation to intubation in 87% of patients who previously failed humidified high-flow oxygen therapy.[21] It appears that when high-flow therapy is liberally applied as a substitute for NIV in cases where NIV is strongly recommended, clinicians should be prepared to escalate quickly to manage further respiratory decompensation.

Furthermore, in cases where the underlying cause of respiratory failure improves and the patient's need of NIV decreases, weaning to HFT may extend the break from NIV temporarily or permanently and potentially reduce NIV duration of therapy and its associated risks.[22] HFT used in this way facilitates oral feeding, and communication with the family.

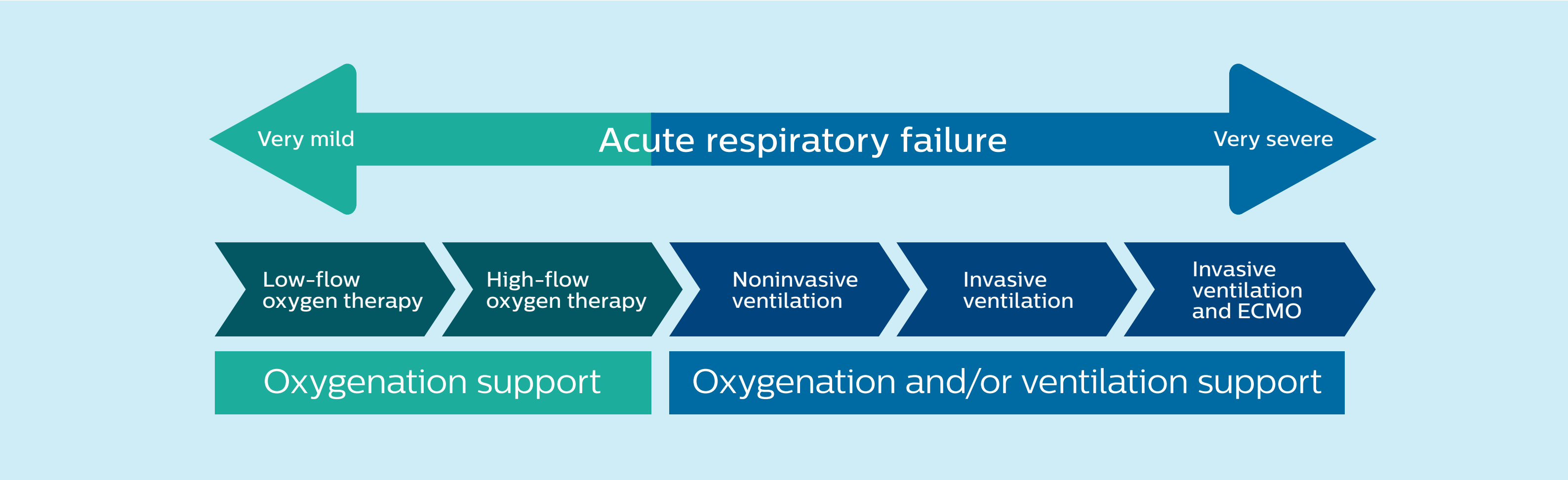

Figure 1: Respiratory intervention applies across the spectrum of acute respiratory failure

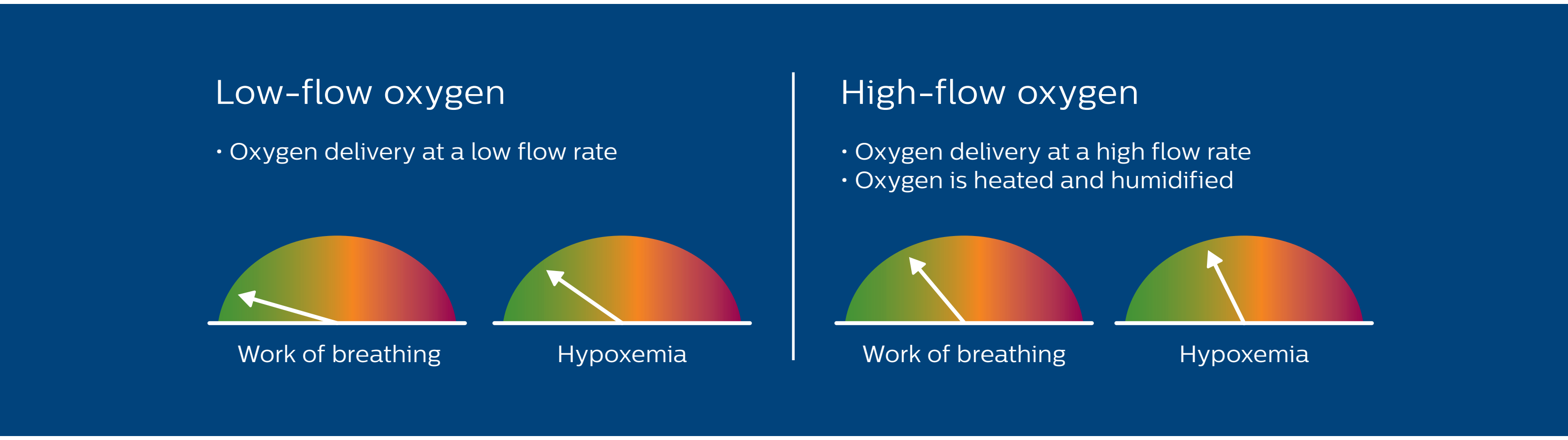

Figure 2: Example of intervention for hypoxemia based on clinical presentation

Conclusion

HFT is a form of oxygenation therapy used to treat acute hypoxemic respiratory failure. Its use is not established as a substitute for NIV in cases where NIV is strongly recommended, such as respiratory failure caused by COPD exacerbation and/or cardiogenic pulmonary edema. In particular, NIV is the standard of care for decreasing morbidity and mortality in patients hospitalized with acute respiratory failure from an exacerbation of COPD. The Philips V60, a dedicated noninvasive ventilator, offers advanced NIV synchrony technology and when used with HFT provides a solution for the treatment of acute respiratory failure that respects the complementary nature of HFT and NIV therapies.

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