

## REVIEW

# The use of high flow oxygen therapy (Optiflow®) in critically ill patients: a pragmatic review

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## Abstract

The use of high flow oxygen therapy (Optiflow®) is increasing, but clear indications are lacking. This pragmatic review describes the current evidence for the use of high flow oxygen therapy in the intensive care unit in three different patient populations: acute hypoxaemic respiratory failure, (prevention of) post-extubation failure and during interventions.

## Introduction

The use of high flow oxygen therapy, more commonly known as Optiflow®, is rapidly increasing inside and outside the intensive care unit. Optiflow® is actually the trademark name of a device produced by Fisher & Payckel from Auckland, New Zealand. Unfortunately, there is no consensus on the scientific name of this kind of oxygen therapy, which results in an increasing number of terms and abbreviations: high flow oxygen by nasal cannula (HFNC), high flow oxygen (HFO), high flow oxygen therapy (HFOT), nasal high flow therapy (NHFT), transnasal humidified rapid insufflation ventilatory exchange (THRIVE), etc. In this review, we will use the term high flow oxygen therapy (HFOT). This term describes the actual therapy (high flow oxygen) without limiting its use to a nasal cannula. As HFOT can also be given connected to a tracheal cannula.

The concept of HFOT consists of two parts: the ability to deliver a high flow of oxygen (up to 60 O<sub>2</sub> l/min or up to 100 l/min in very high flow nasal therapy) and the use of heated and humidified air. The second part is necessary to make the first part possible; otherwise, the high flow used would not be tolerated by the patients and would damage the upper airways, especially the mucociliary outer layer of the airways.

The main result of using a high flow of oxygen is that it is possible to reduce the dead space by delivering a high fraction of inspired oxygen (FiO<sub>2</sub>) down to the alveolar space and thereby reducing the work of breathing.<sup>[1,2]</sup> The respiratory minute ventilation of patients in respiratory distress can easily

overcome the maximum flow of 15-20 O<sub>2</sub> l/min given by using a non-rebreather facial mask (NRBM), including the use of an extra small oxygen cannula. By using HFOT, a minute volume of 60 l/min oxygen can be reached easily. Furthermore, it was initially stated that HFOT could increase positive end-expiratory pressure (PEEP) and end-expiratory lung volume by increasing the pressure in the upper airways. This may be true in healthy volunteers and some patient groups, especially if they keep their mouth closed. However, these results are absent or very limited in critically ill patients, especially compared with the effects from continuous positive airway pressure (CPAP on ventilator or Boussignac) on PEEP.<sup>[1-8]</sup> The high concentration of oxygen that reaches the upper airways could facilitate a passive wash-out of carbon dioxide, though it is uncertain whether this occurs in critically ill patients.<sup>[6,9]</sup> This idea also accounts for the suggested effect of heated humidified air on mucolysis, which has yet to be confirmed.

Despite its popularity, it is uncertain where HFOT should be placed within the spectrum of treatment options for patients with or at risk of developing respiratory failure. This pragmatic review aims to clarify the indications for HFOT within critically ill adult patients. In the past, the results of studies on HFOT were often pooled.<sup>[10]</sup> We will review the results separately for the main groups of patients with conditions that HFOT is currently used for: acute respiratory failure, prevention of post-extubation failure, treatment for post-extubation failure and during interventions (intubation, bronchoscopy, etc.).

## HFOT in acute respiratory failure

HFOT was initially positioned in the area of acute respiratory failure, especially acute hypoxaemic respiratory failure (AHRF). The endpoint of using HFOT in acute hypoxaemic respiratory failure was to prevent intubation. There are numerous observational studies and a few trials on this subject.

The problems with the majority of these studies is that they use different definitions of acute hypoxaemic respiratory failure, different HFOT regimens (fixed or set flow and  $\text{FiO}_2$ ), comparisons with different devices (conventional oxygen therapy by nasal cannula, Venturi mask, facial mask, NRBM, Boussignac or CPAP/BiPAP on mechanical ventilator) and different chosen endpoints (patient comfort up to mortality). In this review, we only discuss the studies that included patients with acute hypoxaemic respiratory failure as we observed them in our intensive care units, with moderate or severe decreases in the P/F criteria ( $\text{P/F} < 200$ ), who would be treated with facial or Venturi masks with high flow  $\text{O}_2$ , NRBM or any type of non-invasive mechanical ventilation (NIV) in the absence of HFOT and with prevention of intubation as a minimal endpoint.

The results of the trials comparing conventional oxygen therapy (Venturi mask or NRBM) are conflicting. In a trial comparing a two-hour period of HFOT with Venturi masks in immunocompromised patients, there was no difference in intubation rate between groups.<sup>[11]</sup> In the largest study so far with patients who mainly suffered from pneumonia that was complicated by moderate acute hypoxaemic respiratory failure, an up to two-day trial of HFOT was compared with NRBM. There was no difference between groups in intubation rate (at day 28), but in a post hoc analysis of the patients with moderate to severe acute hypoxaemic respiratory failure, the intubation rate was significantly lower in patients treated with HFOT (35%) than by NRBM (53%). There was also a survival benefit at day 90 for patients treated with HFOT, even after correcting for disease severity. Although refractory shock was the main reason for death, this was significantly more present in the NRBM group.<sup>[12]</sup> The same study also compared HFOT with NIV-BiPAP (Pressure support set at TV 7-10 ml/kg predicted body weight, PEEP (2-10 cm  $\text{H}_2\text{O}$ ); minimal 8 hours/day, in between NRBM), and the results were again in favour of HFOT.<sup>[12]</sup> Some small observational studies have concluded that ventilatory characteristics favour NIV-BiPAP, but patient comfort favours HFOT.<sup>[13,14]</sup> In most observational studies, successful therapy with HFOT was associated with decreased mortality compared with conventional oxygen therapy or NIV. Successful therapy with HFOT is predicted by the severity of acute hypoxaemic respiratory failure, severity of disease, and presence of shock or renal failure. Furthermore, the lack of HFOT success within 6-24 hours is associated with increased mortality, probably due to delayed intubation.<sup>[15-19]</sup> This latter is a point of concern. Patients being treated for multiorgan failure do have a proper or high oxygenation rate as measured by  $\text{SpO}_2$  due to the high alveolar oxygen content with HFOT, but can still be exhausted. Close monitoring of work of breathing in patients on HFOT (including frequent arterial blood gas analysis) is pivotal to prevent delayed intubation.

A major problem with all this studies is that they contain populations of patients with different reasons for acute

hypoxaemic respiratory failure. The majority of the patients in these present studies suffer of pneumonia (of different origins), but also patients with exacerbation of chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), ARDS, etc. are present. To our knowledge there are no trials on the outcome of HFOT in a specific disease condition.

In conclusion, there is no clear benefit in using HFOT above conventional oxygen therapy or NIV for the prevention of intubation in patients with acute hypoxaemic respiratory failure. In patients with primary moderate acute hypoxaemic respiratory failure, a trial up to a maximal two days of HFOT could be considered to prevent intubation. This might even decrease mortality. It should be kept in mind that all the studies were performed in patients with respiratory failure with a pulmonary origin. There is no evidence for its use in patients with respiratory failure due to non-pulmonary conditions or multiorgan failure and, if used, HFOT might increase mortality. The same logic can be applied to the continuation of HFOT without respiratory improvement within 24 hours.

#### HFOT to prevent post-extubation failure

HFOT is also studied in the prevention of post-extubation failure. HFOT was used in two patient groups: patients who passed a spontaneous breathing trial (SBT) successfully and had an additional risk for post-extubation failure (obesity, COPD, CHF, etc.) and those without such a risk.

After cardiac surgery NRBM combined with NIV-BiPAP for at least 4 hours/day was compared with HFOT in the setting of post-extubation failure or prevention of post-extubation failure with and without failed SBT. No differences were found for re-intubation or any other clinical outcome.<sup>[20]</sup> NIV-BiPAP is a well-established strategy to prevent post-extubation failure in patients who passed a SBT but have an additional risk factor for re-intubation, and at the same time, NIV-BiPAP is known to be associated with increased mortality if used in the setting of post-extubation failure itself. In another study in which NIV-BiPAP for 24 hours was compared with HFOT to prevent post-extubation failure in patients who successfully passed an SBT but had an additional risk of post-extubation failure. The re-intubation rate was approximately 20% in both groups, and no other differences in clinical outcomes were found<sup>[23]</sup>. There is some evidence that HFOT prevents post-extubation failure in patients with a low risk of post-extubation failure compared with conventional oxygen therapy, although there are some methodological issues in the studies describing these results.<sup>[21-23]</sup> In conclusion, in the setting of preventing post-extubation failure in patients who successfully passed an SBT but had an additional risk, HFOT could be an alternative to NIV-BiPAP to be used if NIV-BiPAP is not tolerated by the patient or if it is contraindicated. Also in patients with a low risk for post-extubation failure, HFOT can be used, but this is an expensive alternative for conventional oxygen therapy.

### HFOT for post-extubation failure

In most studies, post-extubation failure is defined as respiratory failure within 48 or 72 hours after extubation. As these patients are mostly excluded from studies on the role of HFOT in acute hypoxaemic respiratory failure, this group of patients is still of interest. Currently, there is consensus that NIV should no longer be used in this setting, leaving re-intubation as the only therapeutic strategy. The only study on this subject is the earlier described study, with all its limitations, on the use of HFOT in the post-extubation setting that pooled data from patients with post-extubation failure with data from patients in whom HFOT was used to prevent post-extubation failure.<sup>[20]</sup> While HFOT is used frequently, there are currently no studies supporting this strategy.

### HFOT during interventions

HFOT could facilitate numerous interventions in the ICU in non-intubated patients. Most studies were performed on the use of HFOT during intubation and during bronchoscopy. HFOT seemed to be a promising strategy to prevent desaturation during intubation.<sup>[24,25]</sup> Some trials showed no difference in SpO<sub>2</sub>, time of severe hypoxaemia or any other outcome parameters by using HFOT before and throughout the complete intubation procedure, and neither could they find an additive effect during the apnoeic phase.<sup>[26,27]</sup> Nevertheless, other trials did find less desaturation during the apnoeic phase.<sup>[28,29]</sup> Outside the ICU, in the setting of elective intubation before surgery, there are studies confirming the improved oxygenation by using HFOT, most often called THRIVE, during intubation.<sup>[30,31]</sup> During bronchoscopy, HFOT was compared with NIV-BiPAP. During the procedure, SpO<sub>2</sub> remained above 85% in both groups, though the periprocedural P/F ratio was higher in the patients on NIV-BiPAP than those on HFOT.<sup>[32]</sup> Although there is no structural evidence to support the use of HFOT during intubation to prevent complications, the use of HFOT might shorten the period of decreased oxygenation and limit the degree of decreased oxygenation during the apnoeic phase. HFOT might be a reasonable alternative to NIV-BiPAP during bronchoscopy, but evidence on this topic is scarce.

### HFOT outside the ICU

Although not the scope of this review, we need to add some words on the subject of using HFOT outside the ICU for acute hypoxaemic respiratory failure, a practice now carried out on a large scale. There are no studies on the outcome of using HFOT outside the ICU, but there is one describing the effect of delayed intubation in patients unsuccessfully treated by HFOT outside the ICU, namely increased mortality.<sup>[33]</sup> Awaiting trials on the use of HFOT outside the ICU, it should be performed with great caution and only for a short period with clearly defined goals.

### Conclusion

HFOT is a promising therapeutic strategy but not with proven beneficial outcome. The current available evidence supports a short trial of HFOT with clearly set goals in patients with acute hypoxaemic respiratory failure due to a pulmonary cause and without the presence of shock or multiorgan failure. HFOT should be considered to be an alternative strategy to NIV to prevent post-extubation failure in patients who have passed an SBT successfully but who are at additional risk of post-extubation failure. In addition, HFOT might facilitate the intubation procedure by shortening and decreasing the phase of decreased oxygenation. However, for all these indications, more studies are needed to prove the use in daily practice in the intensive care unit. The ROX-index, (SpO<sub>2</sub>/FiO<sub>2</sub>)/RR might be a promising tool to decide whether to start HFOT and monitor the success of HFOT.<sup>[34]</sup>

### Disclosures

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