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EDITORIAL

**Emmanuel Futier**
**Samir Jaber**

# High-flow nasal cannula following extubation: is more oxygen flow useful after surgery?

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E. Futier
Department of Anesthesiology and Critical Care Medicine, Estaing Hospital, University Teaching Hospital of Clermont-Ferrand, Clermont-Ferrand, France

E. Futier
Retinoids, Reproduction and Developmental Disease (R2D2) Unit (EA 7281), University of Clermont-Ferrand 1, 63000 Clermont-Ferrand, France

S. Jaber
Department of Anesthesiology and Critical Care Medicine B (DAR B), Saint Eloi Hospital, University Teaching Hospital of Montpellier, Montpellier, France

S. Jaber
Institut National de la Santé et de la Recherche Médicale (INSERM U-1046), 34295 Montpellier, France

E. Futier (✉)
Pôle Médecine Périopératoire (MPO), Hôpital Estaing, CHU Clermont-Ferrand, 1 place Lucie Aubrac, 63003 Clermont-Ferrand cedex 1, France
e-mail: efutier@chu-clermontferrand.fr
Tel.: +33473750476

Oxygen is one of the most widely available and prescribed therapies in medicine, especially in the perioperative field. General anesthesia for both elective and emergency surgery approximates 15–20 million per year in the European countries, and most, if not all, patients receive oxygen as routine supportive therapy following extubation after surgery. Notwithstanding, although it is well established that postoperative pulmonary complications remain a leading cause of postoperative morbidity and mortality after major surgery [1], previous observational studies have noted that critical respiratory events including severe arterial hypoxemia during the early postextubation period are relatively rare events in this specific context [2]. Recent large randomized controlled trials have shown that postoperative pulmonary complications are mainly observed within the first week after surgery (with a peak frequency around postoperative day 2), and are heavily influenced by the use of intraoperative lung-protective ventilation strategies (Fig. 1) [3, 4].

Oxygen therapy after surgery is used to correct residual impairment in oxygenation after removal of the endotracheal tube (or, in some circumstances, the laryngeal mask) resulting from alveolar hypoventilation caused by respiratory depression and inability to maintain an adequate airway and/or from ventilation-to-perfusion mismatch. After extubation, and with spontaneous breathing at atmospheric pressure, functional residual capacity, which was maintained with the use of positive end-expiratory pressure (PEEP) during invasive ventilation, may rapidly decrease with a concomitant reduction in pulmonary oxygen transfer. As indicated by the alveolar gas equation, because the alveolar partial pressure of oxygen mainly relates to the inspired oxygen fraction under steady-state conditions, hypoxemia that might occur secondary to hypoventilation is usually readily corrected by supplemental oxygen. In contrast, although this may normalize oxygen saturation, oxygen therapy alone may not be sufficient to correct the underlying pathophysiologic disturbance when a loss in lung volume is present, as occurs with atelectasis formation. An increasing body of evidence suggests that early

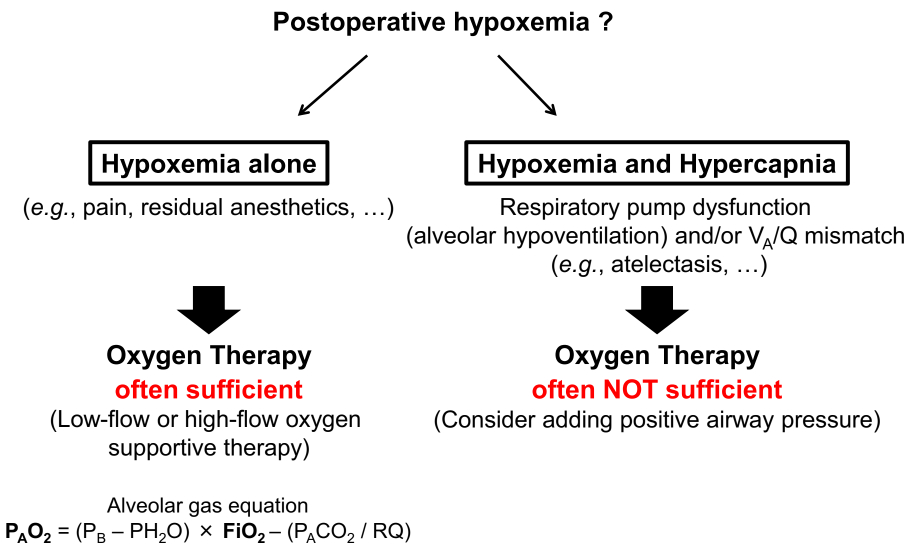


**Fig. 1** Main mechanisms of postoperative hypoxemia following tracheal extubation. Please note that, as indicated by the alveolar gas equation, the alveolar partial pressure of oxygen ($PAO_2$) mainly depends on the inspired oxygen concentration. *$PAO_2$* Alveolar partial pressure of oxygen, *PB* barometric pressure *$PH_2O$* water vapor pressure (at 37 °C, $PH_2O$ = 47 mmHg), *RQ* respiratory quotient (its value is typically 0.8but can range from 0.7 to 1.0), *VA/Q* ventilation-to-perfusion ratio

administration of prophylactic non-invasive respiratory support after extubation, ranging from continuous positive airway pressure to non-invasive positive pressure ventilation, can prevent acute respiratory failure and reintubation following major surgery [5, 6]. Nonetheless, the fact remains that non-invasive ventilation is not the silver bullet for all patients and affects healthcare utilization, since its application usually requires admission of patients into structures capable of providing high levels of monitoring.

Recently, the high-flow nasal cannula (HFNC) has attracted significant attention from several clinical research groups and has been proposed as a supportive therapy in critically ill patients with acute respiratory failure [7–9], during bronchoscopy [10], or to prevent severe desaturation during intubation of patients with mild-to-moderate hypoxemia [11]. HFNC, which delivers up to 100 % heated and humidified oxygen at a maximum gas flow of 60 l/min via a nasal cannula, offers several physiological advantages that might encourage its use instead of routine oxygen therapy after tracheal extubation. This includes, but is not limited to, improvements in oxygenation, the generation of a flow-dependent PEEP, and an increase in end-expiratory lung volume (EELV) [12, 13]. A recent study in critically ill patients mechanically ventilated for more than 24 h has shown that HFNC applied after tracheal extubation results in better oxygenation than oxygen therapy using a Venturi mask and, more importantly, also significantly reduces the reintubation rate [14].

So why should one not simply do the same in surgical patients? This might be of particular interest, at least theoretically, in this context in view of the importance of strategies aimed at minimizing the reduction in lung volume [15]. In their recent article in *Intensive Care Medicine*, Corley et al. [16] attempt to do just that. On the basis of previous data in cardiac surgical patients for whom HNFC was found to improve oxygenation and EELV following extubation in a more pronounced way in those with higher BMI [13], they randomized 155 patients with a BMI $\geq$30 kg/m$^2$ to receive HFNC therapy (gas flow titrated on patient comfort and up to 50 l/min) or standard oxygen therapy (delivered at 2–4 l/min via nasal cannula or 6 l/min via simple facemask) after tracheal extubation (using well-defined criteria) with the objective in the two arms to maintain $SpO_2$ $\geq$95 %. The authors hypothesized that HFNC may enhance respiratory status and, consequently, may reduce the degree of atelectasis (the primary endpoint) as assessed by a radiological atelectasis score. In the end, despite moderate improvement in oxygenation in the first 8 h of treatment, they found that HFNC did not confer any statistically, nor clinically relevant, differences in the primary and prespecified secondary endpoints, including the need for escalation to other respiratory support modalities. At first glance, there appears to be little positive that can be taken from this trial, with most of the results being already brought to our attention by another study in cardiac surgical patients [17]. We should, however, not be too hasty in throwing out the baby with the bathwater, given the multiplicity of causative factors that can contribute to explain some of the discrepancies with data in ICU patients [14]. The most obvious of these lies in the characteristics of patients subjected to oxygen therapy whose impairment in lung function might have been insufficient to expect a significant benefit of any kind whatsoever. Even among those who meet weaning criteria and successfully perform a weaning test, 10–20 % of ICU patients can experience postextubation respiratory failure, which has obviously little connection with the perioperative context. It should be borne in mind that, although attractive, only a few data support direct use of HFNC after extubation and, because failure of HNFC may delay intubation and increase mortality [18], its use as routine therapy deserves further evaluation.

More relevant to the question at hand, clinicians must be aware that postextubation respiratory support should ideally complement what comes before, since most postoperative respiratory events are above all influenced by intra-operative determinants [15]. Unfortunately, the present study does not provide information on patients' individual risk factors for postoperative pulmonary complications and intra-operative ventilator settings. The last point in particular is, from our point of view, an important limitation of the study. Indeed, as efficient as it may be, it is difficult to conceive a benefit of HFNC therapy in the surgical context outside the framework of a multifaceted approach of lung-protection. In this particular respect, the data of the multicenter OPERA study recently completed (ClinicalTrials.gov Identifier: NCT01887015) will hopefully provide valuable additional information. In addition, although most patients are suspected to be at low or moderate preoperative risks, it cannot be ruled out that there may be an additional benefit of HFNC in patients with higher risks of complications. Finally, the authors may have been somewhat ambitious in envisaging a substantial reopening of atelectasis from the application of no more than 3–4 $cmH_2O$ of PEEP with HNFC [12], when PEEP levels up to 10 $cmH_2O$ may be required with the use of NIV.

In summary, the authors have to be praised for the ambition of conducting this study, and the conclusion we should draw is that the use of HNFC should not be recommended after extubation of obese cardiac surgical patients. This, however, cannot be considered definitive and some important questions remain unanswered before concluding that we need to remove our old-fashioned nasal cannulas from our arsenal or, in contrast, that they are still up to it.

**Conflicts of interest** Dr. Futier reports receiving consulting fees from General Electrics Medical System and Dräger, and travel reimbursement for meeting from Fisher and Paykel Dr. Jaber reports receiving consulting fees from Dräger, Maquet, Hamilton and Fisher & Paykel.

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