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LETTER

High-flow oxygen via tracheostomy improves oxygenation in patients weaning from mechanical ventilation: a randomised crossover study

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Weaning tracheostomised patients from prolonged mechanical ventilation (PMV) is challenging and at great financial cost. PMV is associated with significant morbidity and mortality which increases with the period of mechanical ventilation [1]. Moreover, patients receiving PMV account for 6% of all ventilated patients but consume 37% of intensive care unit (ICU) resources [2].

High-flow nasal cannulae (HFNC) have demonstrated clinical benefits; however, these effects may not translate to high-flow tracheal oxygen (HFT) as mechanisms of action may differ between the two delivery modes. Limited evidence guides HFT use in clinical practice. Therefore, we undertook a randomised crossover study examining HFT's effects on lung volumes [end-expiratory lung volume (EELV), tidal volume], airway pressure (P_{aw}), oxygenation (SpO_2/FiO_2 ratio), ventilation [end-tidal carbon dioxide ($etCO_2$)], respiratory rate (RR), heart rate and subjective dyspnoea compared with low-flow oxygen [T-piece (TP)].

After ethics approval and informed consent, 20 tracheostomised patients were studied on HFT at 50 L/min and TP at 15 L/min in a randomised crossover fashion. Data was collected at 5 and 15 min of each 15-min treatment period. Supplementary Material (SM) contains study methods, patient flow (SM Fig. 1) and demographics (SM Table 1). Table 1 displays results for measured outcomes. SpO_2/FiO_2 ratio significantly improved with HFT compared to TP (5 min, $P = 0.02$; 15 min, $P = 0.01$; SM Fig. 2). Mean P_{aw} during HFT was statistically significantly higher 15 min after HFT initiation than TP (mean difference +0.7 cmH_2O, $P = 0.01$), but not at 5 min (SM Fig. 3). Delivered FiO_2 was lower with HFT ($P < 0.001$). No significant differences were found between other variables. No significant independent predictors of effect were detected when patient characteristics were analysed.

This study is the first examining HFT during weaning from PMV compared with low-flow TP. HFT improves oxygenation and generates modest levels of positive airway pressure. These findings add to the limited evidence around HFT use in ICU, which appears to be increasing. Consistent with our findings, an abstract [3] also describes improvements in PaO_2/FiO_2 ratio with HFT. Benefits of high-flow therapy appear consistent across both tracheal and nasal delivery routes; however, as a result of non-significant differences in EELV seen in this study, we hypothesize that increases in oxygenation associated with HFT use is due to more accurate FiO_2 delivery. Post hoc analysis showed significantly lower delivered FiO_2 with HFT, supporting this hypothesis. We believe that the small increase in mean P_{aw} observed with HFT would be of limited clinical benefit. HFNC generate larger increases of 2.7–3.3 cmH_2O [4, 5]; however, this effect does not translate to HFT, most likely as a result of the bypassing of the larynx and upper airway with tracheal oxygen delivery. Additionally, the HFT system componentry results in a more open circuit during inspiration and expiration than during HFNC, further

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Table 1 Outcome measures

Outcome	HFT (mean, SD)	T-piece (mean, SD)	Mean difference HFT – TP (95% CI)	*P* value
EELV, impedance units				
5 min	651.2 (701.3)	662.4 (884.0)	−11.2 (−525.0, 502.6)	0.97
15 min	883.4 (961.6)	874.5 (1161.1)	−30.2[a] (−592.9, 532.2)	0.98
Tidal volume, impedance units				
5 min	1445.8 (903.5)	1744.0 (987.0)	−231.6[a] (−432.8, −30.4)	0.33
15 min	1455.2 (944.3)	1669.1 (951.1)	−257.6[a] (−421.1, −94.1)	0.49
Mean airway pressure, cmH_2O				
5 min	−0.07 (1.13)	−0.43 (0.38)	0.33 (−0.18, 0.84)	0.21
15 min	−0.23 (0.55)	−0.41 (0.34)	0.65[a] (0.36, 0.94)	0.01*
SpO_2/FiO_2 ratio				
5 min	241.5 (40.3)	211.0 (35.1)	30.5 (13.6, 47.6)	0.02*
15 min	244.4 (38.4)	210.3 (35.2)	34.1 (17.5, 50.7)	0.01*
End-tidal CO_2, mmHg				
5 min	34.8 (5.5)	35.5 (5.8)	−0.7 (−1.4, 0.1)	0.07
15 min	35.3 (6.0)	35.0 (6.1)	0.3 (−0.8, 1.3)	0.79
Respiratory rate, breaths/min				
5 min	29.5 (9.3)	28.0 (8.6)	1.5 (−0.7, 3.8)	0.60
15 min	28.8 (9.6)	28.7 (8.9)	0.1 (−1.5, 1.8)	0.96
Heart rate, beats/min				
5 min	96.2 (15.8)	96.6 (14.7)	−0.4 (−1.9, 1.0)	0.94
15 min	96.4 (16.3)	96.7 (14.6)	−0.3 (−2.0, 1.4)	0.96
Patient reported dyspnoea, 0–10				
5 min	1.64 (1.37)	1.56 (1.16)	0.08 (−0.47, 0.63)	0.85
15 min	1.47 (1.19)	1.64 (1.23)	−0.17 (−0.64, 0.30)	0.68

* $P < 0.05$

[a] These results take into account the presence of unpaired data

reducing the positive P_{aw} effect. RR and $etCO_2$ were unchanged with HFT, indicating that airway resistance and work of breathing are also unchanged. Currently, it is not known if HFT offers similar physiological benefits as HFNC and further research is warranted.

Our results suggest that HFT could be useful in augmenting oxygenation during weaning from PMV. However, bypassing of the larynx and upper airway appears to negate some of the beneficial effects of HFNC. Randomised controlled trials measuring long-term benefits including ventilator-free days and ICU length of stay are needed to establish if HFT is useful in liberating patients from PMV.

Electronic supplementary material

The online version of this article (doi:10.1007/s00134-016-4634-7) contains supplementary material, which is available to authorized users.

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Compliance with ethical standards

Conflicts of interest

JFF and AC have received assistance from Fisher and Paykel Healthcare Ltd to support travel and accommodation costs to attend research meetings. Fisher and Paykel Healthcare Ltd had no part in the current study. Other authors declare they have no conflicts of interest.

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