Oxygen delivery through high-flow nasal cannulae increase end-expiratory lung volume and reduce respiratory rate in post-cardiac surgical patients.

AIM:

To assess the effects of high-flow oxygen therapy (HFOT) using high-flow nasal cannulae (HFNCs) compared with low-flow oxygen therapy on airway pressure (Paw) and end-expiratory lung volume (EELV). To identify a relationship, if any, between peak airway pressure and EELV.

METHOD:

In this prospective, non-randomised, interventional study, adult patients requiring HFOT after cardiac surgery (n=20) had a local anaesthetic nasal spray and nasal feeding tube fitted while sitting upright. Paw was measured using a precision pressure transducer [PPT-001, DWWW2V, Honeywell International Ltd] that was attached to the feeding tube. Changes in EELV were assessed indirectly via measurement of end-expiratory lung impedance (EELI) using an electrical impedance tomography (EIT) kit [EIT Evaluation Kit 2, Dräger Medical].

Air pressure and lung volume 2 min readings were taken simultaneously, first during low-flow oxygen therapy (face mask [FM] oxygen or nasal oxygen cannula) and then, following a 15 min washout period, during HFOT with the Optiflow™ system (MR850 heated and humidified, RT202 delivery tubing and RT050/051 nasal cannulae) [Fisher & Paykel Healthcare].

The Optiflow™ humidifier temperature was set to 37 °C and the fraction of inspired oxygen (FiO_2) titrated on an individual basis to maintain blood oxygen saturation (measured via pulse oximetry [SpO_2]) of ≥95%, with the flow rate initiated at 35 L/min and uptitrated to a maximum of 50 L/min. Measurements were taken with the patient's mouth both open and closed.

FiO_2 was also estimated during low-flow oxygen therapy. Other variables included respiratory rate, tidal impedance variation (VARt), oxygenation (ratio of partial pressure of arterial oxygen [PaO_2] to FiO_2) and subjective rating of dyspnoea (modified Borg score).

RESULTS:

HFOT with HFNC significantly increased mean Paw, EELI, VARt and oxygenation compared with low-flow oxygen therapy (table). The respiratory rate was lowered significantly with HFOT, and there was a trend to improved subjective dyspnoea.

There was a strong positive correlation between Paw and EELI (correlation coefficient=0.7; p<0.001). The mean percentage increase in EELI with HFOT as compared with low-flow oxygen therapy was greater in patients with a higher body mass index (BMI) [13.3% in those with BMI of 25 kg/m^2 versus 24.4% in thus with BMI of 40 kg/m^2].

VARIABLE	LOW-FLOW OXYGEN	HFOT WITH HFNC	DIFFERENCE		P VALUE
	Mean (SD)	Mean (SD)	Mean (SD)	95% CI	
EELI (units)	419 (212.5)	1936 (212.9)	1517 (46.6)	1425, 1608	<0.001
Paw (cm H_2O)	-0.3 (0.9)	2.7 (1.2)	3.0 (1.3)	2.4,3.7	<0.001
Respiratory rate (beats/min)	20.9 (4.4)	17.5 (4.6)	-3.4 (2.8)	−2.0, −4.7	<0.001
Borg score 0–10	2.7 (2.6)	1.9 (2.3)	-0.8 (1.2)	−0.1, −1.4	0.023
Tidal variation (units)	1512 (195.0)	1671 (195.1)	159 (21.6)	117, 201	<0.001
PaO_2/FiO_2 (mm Hg)	160 (53.7)	190.6 (57.9)	30.6 (25.9)	17.9, 43.3	<0.001

95% CI = 95% confidence interval; EELI = end-expiratory lung impedance; FiO_2 = fraction of inspired oxygen; HFOT = high-flow oxygen therapy; HFNC = high-flow nasal cannula; PaO_2 = partial pressure of arterial oxygen; Paw = airway pressure; SD = standard deviation.

DISCUSSION:

Pulmonary complications after cardiac surgery are common. HFNCs are used to deliver high-flow humidified air and oxygen via wide-bored nasal cannulae at a set FiO_2. This is the first study to show that HFOT delivered by HFNC after cardiac surgery increases EELI in adults, suggesting increased lung volumes and functional residual capacity. Furthermore, increases in EELI were significantly influenced by BMI, suggesting that patients with a higher BMI may benefit from HFNC-induced low-level positive Paw and increases in lung volume.

HFNC use also increased Paw by 3.0 cm over that achieved with low-flow oxygen therapy. This increase was correlated with the increase in EELI. Positive airway pressure then improves lung volume, and concomitantly improves respiratory rate, subjective dyspnoea and oxygenation.

Further research is required to confirm these study results because gas flow rates were not standardized across patients, and the sample size was small.

CONCLUSION:

HFOT with HFNCs provides a modest increase in oropharyngeal Paw that appears to result in clinically significant increases in EELV as compared with low-flow oxygen therapy. Patients experiencing respiratory dysfunction after cardiac surgery, particularly those with a high BMI or who cannot tolerate non-invasive ventilation, may benefit from HFNC.

KEY POINTS:

- HFNCs increase airway pressure as compared with low-flow oxygen therapy, and this increase is significantly correlated with increases in EELV.
- Lung tidal volume, respiratory rate, subjective dyspnoea and oxygenation were also improved after HFOT versus low-flow oxygen therapy.
- Benefits of HFOT were greatest in patients with a higher BMI.

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