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REFERENCES

1 Kolodziej MA, Jensen L, Rowe B, *et al.* Systematic review of noninvasive positive pressure ventilation in severe stable COPD. *Eur Respir J* 2007; 30: 293–306.
2 Windisch W, Kostić S, Dreher M, *et al.* Outcome of patients with stable COPD receiving controlled noninvasive positive pressure ventilation aimed at a maximal reduction of Pa(CO_2). *Chest* 2005; 128: 657–662.
3 Windisch W, Haenel M, Storre JH, *et al.* High-intensity noninvasive positive pressure ventilation for stable hypercapnic COPD. *Int J Med Sci* 2009; 6: 72–76.
4 Lukácsovits J, Carlucci A, Hill N, *et al.* Physiological changes during low- and high-intensity noninvasive ventilation. *Eur Respir J* 2012; 39: 869–875.
5 Valipour A, Schneider F, Kössler W, *et al.* Heart rate variability and spontaneous baroreflex sequences in supine healthy volunteers subjected to nasal positive airway pressure. *J Appl Physiol* 2005; 99: 2137–2143.

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From the authors:

We would like to thank A.M. Esquinas and co-workers for their interest in our article [1] and the accurate analysis and comments.

Our study was designed to evaluate the changes in respiratory mechanical and cardiovascular parameters during a high intensity mechanical ventilation (Hi-NPPV) lasting 30 min.

Using similar ventilatory settings to those applied by WINDISCH and co-workers [2, 3] we demonstrated that Hi-NPPV in stable chronic obstructive pulmonary disease (COPD) patients is more effective than low intensity mechanical ventilation (Li-NPPV) at acutely improving gas exchange and reducing the patient's respiratory effort but the high inspiratory positive airway pressure values induced a marked lowering in cardiac output and oxygen transport. The oxygen transport mainly depends on the cardiac output, blood haemoglobin concentration and arterial oxygen saturation. During our trial haemoglobin was likely to be constant and the inspiratory oxygen fraction was set to achieve an arterial oxygen saturation of about 90–92%, therefore the calculated oxygen transport basically went in parallel with changes in cardiac output. The harmful effect of positive pressure ventilation on cardiac output is well known from previous studies [4, 5]. The ''negative'' effects on cardiac output depend on: 1) worsening of venous return in the right atrium; and 2) increasing the pulmonary vascular resistance caused by lung tissue expansion. The most important effect is probably the former that depends on the changes in intrathoracic pressure (pleural pressure). The amount of pressure transmitted from the airways into the pleural space depends on the ratio between the lung compliance and lung plus chest wall compliance ($\Delta P_{pl}/\Delta P_{aw} = C_L/(C_L+C_T)$; ΔP_{pl}: change in pleural pressure; ΔP_{aw}: change in airway pressure; C_L: lung compliance; C_T: thorax compliance) [5]. For instance in an emphysematous patient, with high lung compliance and rigid chestwall (*e.g.* emphysema), the airway pressure will be transmitted to a higher degree than in a patient with normal chest wall compliance with restrictive pulmonary disease (*e.g.* acute respiratory distress syndrome, pulmonary fibrosis). For this reason, in different types of lung disease patients the positive airway pressure will cause different changes in cardiac output.

Contrary to our investigation, where Hi-NPPV was applied briefly and rapidly, WINDISCH and co-workers [2, 3] used a very slow increase, lasting days, in inspiratory pressure at the maximum level tolerated by the patient. It is therefore to be demonstrated that the described changes in cardiac output are of the same magnitude when increasing levels of pressure are applied slowly.

Previous articles suggested that to avoid a decrease in cardiac output, the patient must be placed in supine or Trendelenburg position [4, 5]. Our subjects were studied in a semi-recumbent position in contrast with the patients of WINDISCH and co-workers [2, 3] who used the NPPV mostly during the night, probably in supine position, in this way facilitating venous return.

There are, however, some potential advantages in lowering venous return in some chronic patients. For example, the described ''reversal'' of pleural pressure (from negative to positive during inspiration) observed with Hi-NPPV, limiting venous return and lowering left ventricular afterload, can improve the cardiac output in patients with left ventricular failure [4]. For this reason we excluded the patients with left ventricular ejection fraction lower than 40% or with any signs of acute or chronic left ventricular insufficiency.

Indeed the pressure time product of the diaphragm in COPD patients during spontaneous breathing was, on average, about three times higher than in a normal subject, which means a notable oxygen consumption. Therefore, the loss in oxygen transport was probably partly compensated by the lower oxygen consumption caused by Hi-NPPV.

We agree with A.M. Esquinas and co-workers and we have already discussed the problem that dynamic hyperinflation and patient/ventilator asynchrony may occur during Hi-NPPV, leading to poor tolerance, volutrauma, barotrauma and cardiovascular interferences. Unfortunately, objective signs of dynamic hyperinflation (*e.g.* dynamic intrinsic positive end expiratory pressure) were not measurable, because of the complete rest of the respiratory muscles observed in the majority of patients during Hi-NIPPV.

In conclusion, Hi-NNPV is more effective than the traditional settings of noninvasive ventilation in improving gas exchange and reducing patient respiratory effort. Despite its beneficial effects, through high inspiratory pressure it can provoke a pronounced decrease in cardiac output and oxygen transport, for this reason it should be used with caution in patients with pre-existing decreased cardiac output, serious anaemia or severe hypoxaemia, but probably not in those with left

ventricular failure, in which Hi-NPPV may paradoxically improve the cardiac function. To clarify the clinical significance of this harmful effect, long term clinical studies are needed.

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REFERENCES

1 Lukácsovits J, Carlucci A, Hill N, *et al*. Physiological changes during low- and high-intensity noninvasive ventilation. *Eur Respir J* 2012; 39: 869–875.
2 Windisch W, Kostić S, Dreher M, *et al*. Outcome of patients with stable COPD receiving controlled noninvasive positive pressure ventilation aimed at a maximal reduction of Pa(CO_2). *Chest* 2005; 128: 657–662.
3 Windisch W, Haenel M, Storre JH, *et al*. High-intensity noninvasive positive pressure ventilation for stable hypercapnic COPD. *Int J Med Sci* 2009; 6: 72–76.
4 Shekerdemian L, Bohn D. Cardiovascular effects of mechanical ventilation. *Arch Dis Child* 1999; 80: 475–480.
5 Steingrub JS, Tidswell M, Higgins TL. Hemodynamic consequences of heart–lung interactions. *J Intensive Care Med* 2003; 18: 92–99.

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