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Effects of extracorporeal carbon dioxide removal on work of breathing in patients with chronic obstructive pulmonary disease

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Dear Editor,

We congratulate Sklar et al. for their systematic review of extracorporeal carbon dioxide removal ($ECCO_2R$) in patients with chronic obstructive pulmonary disease (COPD) [1]. We would like to complete the discussion of the review in the light of recent preliminary data obtained to study the effects of $ECCO_2R$ in COPD patients under invasive mechanical ventilation (IMV) [2]. We discuss herein the physiological mechanisms by which $ECCO_2R$ could exert beneficial clinical effects in these patients.

In the adult respiratory distress syndrome $ECCO_2R$ permits one to counteract hypercapnia that results from lung protective ventilation. However, in spontaneously breathing COPD patients with severe acute exacerbations $ECCO_2R$ could exert additional benefits by sparing a significant amount of work of breathing (WOB). Reduction in WOB may also directly contribute to minimize CO_2 production (VCO_2) by reducing respiratory muscle energy expenditure.

We obtained measurements in two acutely exacerbated COPD patients (61 and 88 years old) during the weaning process of IMV. Both patients were treated with $ECCO_2R$ (Hemolung, Alung Technologies, Pittsburgh, USA) shortly after intubation with the main goals of controlling hypercapnia, diminishing hyperinflation, and promoting a rapid weaning process. By measuring VCO_2 on the respirator (Engström Carestation, GE Healthcare) with and without $ECCO_2R$, we had the unique

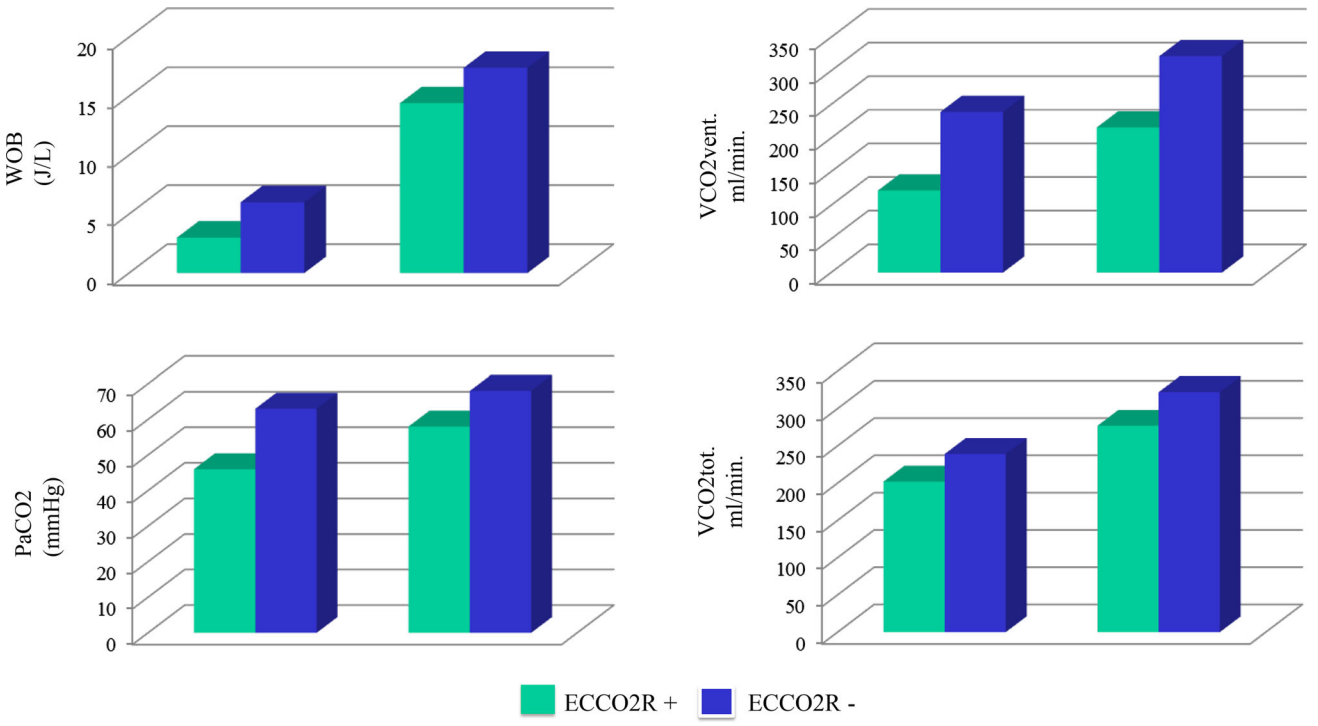

Fig. 1 Measurements and calculations obtained in two severe IMV COPD patients during the weaning process. Patients were ventilated under the pressure support mode at fixed low levels of assistance. Data were obtained under $ECCO_2R$ at a sweep gas flow rate of 10 L/min (ECCO2R+) and 0 L/min (ECCO2R−) after 1 h of stabilization. *WOB* inspiratory work of breathing, calculated using Campbell's method, expressed in joules per liter of ventilation. *VCO_2vent* respiratory CO_2 elimination (equal to total CO_2 elimination at a sweep gas flow rate of 0 L/min). *VCO_2tot* total CO_2 elimination (equal to respiratory plus extracorporeal CO_2 eliminations)

opportunity to indirectly assess CO_2 production related to respiratory muscle activity change. Data were obtained at low levels of pressure support (10 cmH_2O) mimicking a spontaneous breathing trial (SBT). Inspiratory WOB was calculated as previously described, and based on simultaneous esophageal and gastric pressure measurements (Nutrivent catheter, Sidam, Mirandola, Italy) [3]. Data were obtained under $ECCO_2R$ at a sweep gas flow rate of 10 and 0 L/min after 1 h of stabilization. Main results are presented in Fig. 1: $ECCO_2R$ decreased both WOB (40 and 24 %) and $PaCO_2$ (32 and 16 %). Total VCO_2 (ventilator and extracorporeal) decreased during $ECCO_2R$, probably related to the decrease in WOB which is a major determinant of the total VCO_2 in decompensated spontaneously breathing COPD patients. The subsequent clinical course was uneventful.

Our data indicate that $ECCO_2R$ is associated with a decreased WOB, at least in the specific context of our measurements. Similar results have been obtained by Pisani et al. during SBT [4]. It can be concluded that $ECCO_2R$ can limit the level of hypercapnia not only by direct removal of CO_2 but also by sparing some level of respiratory muscle effort, as confirmed by our CO_2 measurements.

Finally, Sklar et al. suggested that improvement in pH between 1 and 24 h after initiation of $ECCO_2R$ may be attributable to metabolic rather than to respiratory acidosis. On the basis of our measurements, however, we offer an alternative explanation to that provided by the authors. We speculate that an intracellular acidosis reduction within the respiratory muscle may also contribute to the reduction in metabolic acidosis [5].

Compliance with ethical standards

Conflicts of interest Jean-Luc Diehl has acted as a consultant for Alung Technologies and Xenios-Novalung. Funding for research purposes: Alung Technologies (EPHEBE study, NCT02586948). Jean-Christophe Richard is currently an employee from Air Liquide Medical Systems. The other authors have no conflict of interest in relation to the subject of the letter to declare.

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