Introduction:
Our objective is to describe and analyze, in a hypothetical patient with severe acute respiratory distress syndrome (ARDS), the following: (1) the energy transfer from the ventilator to the lungs; (2) venous-venous extracorporeal membrane oxygenation (VV-ECMO) oxygen transfer to patient oxygen consumption (VO2) match; (3) ECMO carbon dioxide removal, and (4) the potential effect of systemic venous oxygenation on pulmonary artery pressure.

Methods:
Mathematical modeling approach with hypothetical scenarios, using computer simulation.

Results:
The transition from protective ventilation to ultraprotective ventilation in a severe ARDS patient with static respiratory compliance of 20 mL/cmH2O reduced the energy transfer from the ventilator to the lungs from 35.3 to 2.6 Joules/minute. A hypothetical patient with VO2 = 200 mL/minute, high cardiac output and slightly anemic can reach an arterial oxygen saturation of 80%, while keeping the match between ECMO oxygen transfer and patient VO2 (Figure 1). Carbon dioxide is easily removed and normal PaCO2 is frequently reached. The venous blood oxygenation through ECMO circuit drives the PO2stimulus of pulmonary hypoxic vasoconstriction to normal values (Figure 2).

Conclusion:
Ultraprotective ventilation massively reduces the energy transfer from the ventilator to the lungs. Severe hypoxemia on VV-ECMO support may occur despite matching between ECMO oxygen transfer and patient’s VO2. Normal range of PaCO2 is easy to reach. VV-ECMO support potentially relieves hypoxic pulmonary vasoconstriction.
Oxygen partial pressure responsible for the hypoxic pulmonary vasoconstriction inhibition in four different clinical scenarios. The dotted line at $P_{stim/O2}$ of 19.2 mmHg represents the partial pressure during breathing of a healthy person. The other clinical scenarios reproduce mechanical ventilation in a severe ARDS patient with hypercapnia, pulmonary shunt fraction of 45%, and $PvO2 = 20$ mmHg (closed triangle); the closed squares represent this same patient after ECMO initiation, when the pulmonary shunt increased to 60% (Whitening-up phenomenon) and the $PvO2$ increased to 180 mmHg; at last, the open circles represent this same patient with a pulmonary shunt of 95% and a $PvO2$ of 300 mmHg.