Changes in lung physiology during progressive lowering of respiratory rate in healthy pigs undergoing ECMO

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INTRODUCTION

No consensus exists on how to set mechanical ventilation (MV) during ECMO: in usual clinical management the ventilation load is variably decreased in order to achieve protective MV, being respiratory rate (RR) the most variable parameter.

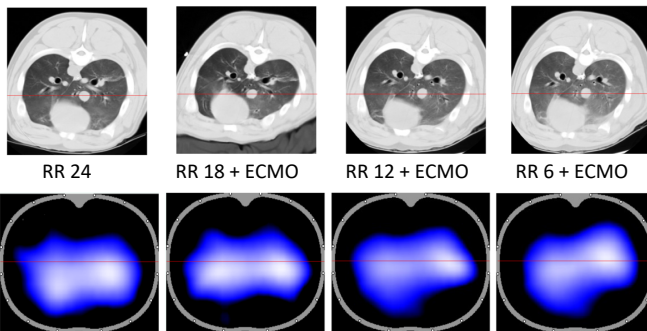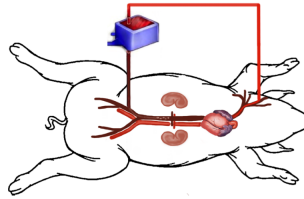In this study we focused on the effects of reducing RR, highlighting its physiological strengths and weaknesses.

PROTOCOL

Data collection (6-h steps):
- Respiratory mechanics
- Gas exchange
- Haemodynamic
- CT scan
- EIT
- ECMO

MATERIALS AND METHODS

Six ♀ pigs (40±4 kg).

MV: Vt 10 ml/kg, PEEP 5, FiO_2 0.5, I:E 1:2, RR 24.

ECMO + three six-hours study steps marked by progressive reduction of RR: RR 18, RR 12, RR 6.

ECMO Gas Flow (GF) was adapted to keep $PaCO_2$ in physiological range, Blood Flow (BF) was kept at 1.5 L/min.

Data collection was performed at Baseline and then at each time point.

RESULTS

1. Development of atelectasis

Reducing RR, we observed an increase in lung atelectasis, measured by CT scan as an increase in non-aerated lung tissue (p=0.002), mirrored by EIT as a decrease of tidal ventilation reaching the gravitationally-dependent lung regions (p=0.018) (*Figure 1*), associated with a drop of regional respiratory system compliance (p=0.012).
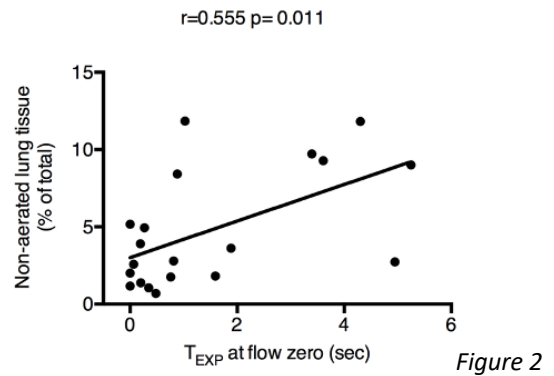

Figure 1

Figure 2

The amount of non-aerated lung tissue was related to expiratory time spent at flow zero (*Figure 2*) and with the respiratory quotient of the membrane lung (r=0.702, p=0.004), and not to changes in plateau or mean airway pressure (r=0.102, p=0.636 and r=-0.333, p=0.111, respectively).

2. Worsening of oxygenation

At lower RR we observed an increase in intrapulmonary shunt and mean pulmonary artery pressure and a decrease in PaO_2 (*figure 3*). Intrapulmonary shunt was correlated with the SvO_2 and with the % of total VO_2 granted by ECMO (r=0.419, p=0.047 and r=0.664, p=0.001, respectively).
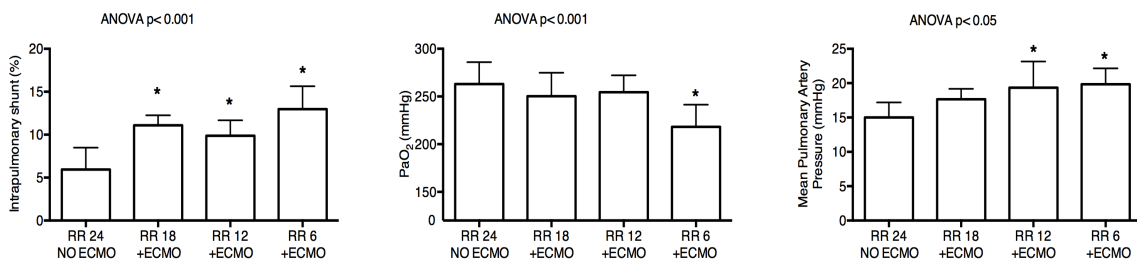

Figure 3

CONCLUSIONS

Progressive decrease of RR and increased CO_2 extraction leads to a lower mechanical power, but, on the other hand, paves the way to development of atelectasis, ventilation heterogeneity, higher intrapulmonary shunt and lower arterial oxygenation.