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Does a Ventilation-Induced Lung injury threshold exist? An experimental study

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Introduction: mechanical Power (MP) is the amount of energy transferred from the ventilator to the respiratory system and high values of MP were associated with Ventilator-Induced Lung Injury (VILI). We investigated whether a specific value of MP is associated with a safer mechanical ventilation.

Methods: three groups of 6 healthy pigs were ventilated during 48 hours at MP of 3, 7 and 12 J/min. The initial ventilator setting (30 minutes: Tv 8 ml/kg, RR 18 bpm, PEEP 4 cmH_2O, MP 7 J/min) was subsequently modified to achieve the target MP. Respiratory mechanics and gas-exchanges were assessed every 6h. End-experiment pathology findings were compared with a control group of eight healthy pigs, which were never ventilated. MP was calculated with the following formula:

$$MP = 0.098 \cdot TV \cdot RR \cdot \left[Paw_{peak} - \frac{1}{2}\left(Paw_{plat} - Paw_{ee}\right)\right]$$

Results: tidal volume, respiratory rate and PEEP were the following: 3J group 6.9 [0.3] ml/kg, RR 15.7 [1.0] bpm and 3.9 [0.2] cmH_2O; 7J group 9.7 [0.7], 20.7 [1.4] and 4.0 [0.2], and 12J group 11.5 [1.1], 23.3 [1.5] and 4.3 [0.3], resulting in the following applied MP: 2.91 [0.18] J/min, 7.38 [0.67] and 11.70 [0.76], ($p<0.01$).
Increasing MP was significantly associated with higher PaO2 ($p<0.01$) and lower PaCO2 ($p<0.01$) (Figure 1A) and venous admixture ($p<0.01$). Despite a comparable fluid balance between groups, the lung weight, the wet-to-dry and the gas-to-tissue ratio were not significantly different between the three groups, but they significantly differed from the controls (weight $p<0.01$, wet-to-dry p 0.03), (Figure 1B).

Figure 1B: Lung weight and wet-to-dry ratio in controls vs. 3J, 7J and 12J

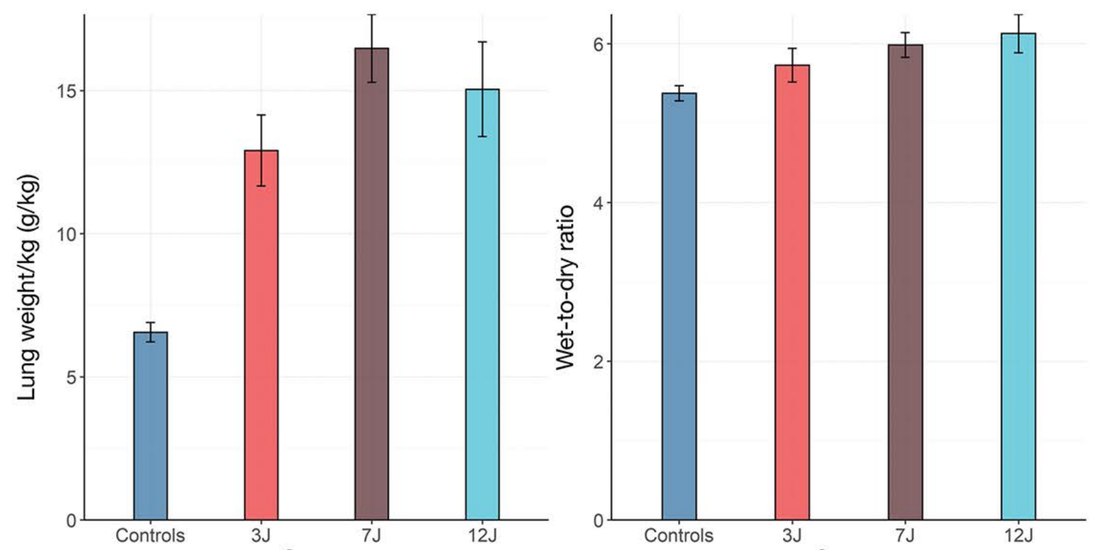
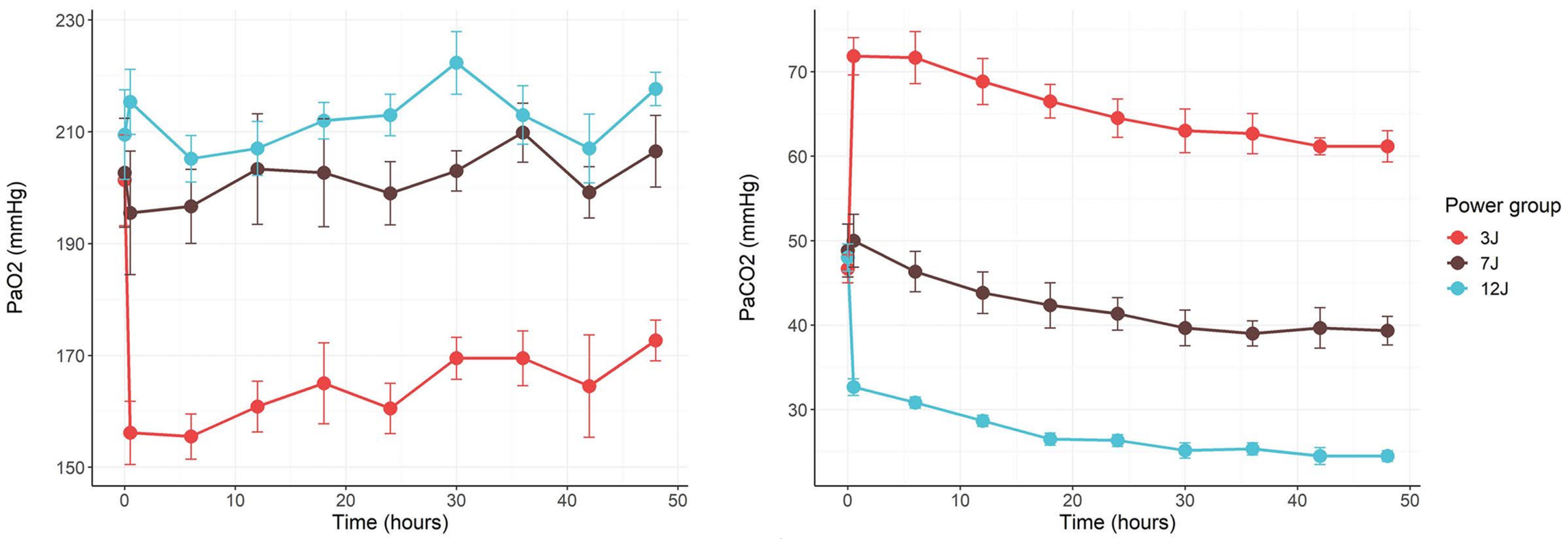


Figure 1A: PaO2 and PaCO2 as a function of time in groups 3J, 7J and 12J



Conclusions: the 3J group was associated with better pathology but worse gas-exchange outcomes when compared with the 7J and 12J groups. Of note, even 3J group was associated with increased lung weight compared to the never ventilated controls. Our results suggest that the best compromise was a MP between 3 and 7 J/min.
Data suggest unfavorable risk/benefit balance when using very low MP as in "ultraprotective approach".