Separate assessment of dependent and non-dependent lung regions by forced oscillation technique in a porcine model

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Background

Mechanical ventilation in supine position enhances the development of

- dependent lung zones dorsally
- non-dependent regions ventrally.

These collectively determine global lung ventilation and mechanics.

Aims

- To develop a model for the simultaneous assessment of respiratory mechanics in both lungs
- To investigate the effect of lateral position and subsequent lung homogenization manoeuvres on respiratory mechanics

Methods

- Anaesthetised pot-bellied pigs (n=7) intubated with a right sided double-lumen endotracheal tube
- Ventilated with 10 ml/kg tidal volume (V_T)
- Respiratory impedance ($Z_{rs} = P/V'$) simultaneously measured in both lungs

Forced oscillation technique

- Airway and tissue parameters extracted from respiratory impedance by model fitting
- Airway resistance (Raw): flow resistance
- Airway inertance (Iaw): $\sim$ gas volume
- Tissue damping (G): $\sim$ tissue resistance
- Tissue elastance (H): $\sim$ tissue stiffness

Protocol

- Baseline measurements (BL) in supine position
- Turned to their left side, and measurements were repeated after 15 (P0-15) and 45 (P0-45) minutes
- Further measurements with the PEEP increased to 4 (P4) and 8 cmH₂O (P8), and after a recruitment manoeuvre

Conclusion

- This experimental model allows the separate assessment of lung ventilation and mechanics for left and right lungs.
- Lateral position results in decreased tidal volume with increased atelectases, ventilation heterogeneity and tissue stiffness in the dependent lung, while opposite changes can be observed in the non-dependent lung.
- Increasing PEEP to 8 cmH₂O alleviates the adverse respiratory alterations in the dependent lung caused by lateral position without deteriorating lung mechanics in the non-dependent lung.

Results

- V_T showed a tendency to decrease in the dependent lung and increase in the non-dependent lung.
- Increasing PEEP to 8 cmH₂O led to drops in Raw in the dependent lung compared to P0-15 (-35 ± 16 [SE]%).
- Iaw increased in the dependent side at P0-15 compared to BL, and remained unchanged to PEEP.
- G and H increased in the dependent (55 ± 13 %) and decreased in the non-dependent lung (-29 ± 12 %).
- Elevated PEEP reduced G and H compared to the P0-45 in both the dependent (-23 ± 11 % and -47 ± 20 %) and the non-dependent lung (-26 ± 12 % and -39 ± 10 % for G and H, respectively, $p < 0.05$ for all)

#: $p < 0.05$ Right vs. Left
 α : $p < 0.05$ vs. BL

β : $p < 0.05$ vs. P0-15
 γ : $p < 0.05$ vs. P0-45
 δ : $p < 0.05$ vs. P4