Effect of PEEP and I:E ratio on cerebral oxygenation in ARDS: an experimental study in anesthetized rabbits

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Study Background

Although PEEP and inversed I:E ratio ventilation (IRV) have been shown to improve gas exchange in ARDS, both can adversely affect systemic haemodynamics and cerebral perfusion and thus, affect neurological outcome.

Goal of the Study

Assess how changes in PEEP and I:E ratio affect cerebral perfusion and oxygenation in normal and injured lung.

Methods

- 6 Anesthetised Chinchilla-Bastard rabbits (3.5±0.3 kg) ventilated in pressure regulated volume control mode (PRVC) with settings at baseline VT 6 ml/kg, PEEP 6 cmH₂O, FIO₂ 0.4, RR for PaCO₂ = 40 mmHg.
- Random I:E order of 1:2, 1:1 or 2:1.
- ARDS was induced by a multiple hit model: IV lipopolysaccharide (300 mcg/kg), whole lung normal saline lavage (100 ml/kg) and 10 min injurious ventilation (VT 10 ml/kg, PEEP 0 cmH₂O FIO₂ 1).
- Ventilation PRVC mode (VT 6 ml/kg, FIO₂ 0.4, RR for PaCO₂ = 40 mmHg) with PEEP 9 (group INJ-PEEP9) and then 6 cmH₂O (group INJ-PEEP6) in random I:E order.
- Data were tested by repeated-measures ANOVA with a Student-Neuman-Keuls multiple comparisons procedure. P<0.05 was considered significant.
- Cerebral and peripheral oxy & deoxy haemoglobin concentration changes (ΔHbO₂ & ΔHHb) were measured continuously by NIRS NIRO-200NX®.
- Mean arterial pressure (MAP) was measured continuously by a femoral arterial catheter, while arterial and venous blood gas were taken at each step to measure respectively arterial (PaO₂) and jugular saturation (SjO₂).
- Carotid flow (CF) was measured by a doppler ring located around the right carotid artery.

Results I : NIRS

- Cerebral ΔHbO₂ showed a significant decrease at BL with increasing I:E ratio.
- Cerebral ΔHbO₂ decreased significantly during INJ-PEEP6 when compared to both BL and INJ-PEEP9 (Figure 1).
- Peripheral ΔHbO₂ decreased significantly during INJ-PEEP6 when compared either to BL or INJ-PEEP9 (Figure 2).
- Peripheral ΔHHb increased significantly during INJ-PEEP9 and INJ-PEEP6 conditions when compared to baseline (Figure 2).

Results II : Hemodynamics

- In injured lungs, PaO₂ and SjO₂ decreased significantly during both PEEP conditions, reflecting ARDS severity (p<0.05); PEEP effect was evidenced on PaO₂ increase in INJ-PEEP9 condition.
- CF showed a significant decrease with IRV during INJ-PEEP9 (Figure 3).

Conclusions

- In rabbits with normal lungs, IRV reduced CF and MAP without changing blood oxygenation, hence a decrease in cerebral oxygenation.
- In injured lungs, a small increase in PEEP decreased CF but significantly improved PaO₂, resulting in an improved cerebral oxygenation.
- The further improvement in PaO₂ with increasing I:E ratio was PEEP dependant, but led to reduction in CF, without effect on ΔHbO₂.
- The effect of ventilation strategies on changes in cerebral oxygenation depend on their combined effects on cerebral perfusion and systemic gas exchange parameters.

References

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