Title : REVERSE I:E RATIO, CPAP AND CPPV: IS THERE A DIFFERENCE?

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Introduction. Mechanical ventilation and positive end-expiratory pressure (PEEP) are useful for the treatment of a variety of respiratory disorders. Mechanical ventilation with an inspiratory time (I) exceeding the expiratory time (E) (reversed I:E ratio) has been used to treat infants with idiopathic respiratory distress syndrome (IRDS) and may be preferred to either conventional mechanical ventilation with PEEP (CPPV) or spontaneous ventilation with continuous positive airway pressure (CPAP). It has been suggested that improvement in oxygenation is secondary to the mean airway pressure rather than to the ventilatory pattern itself. We sought to determine if airway pressure pattern is significant when mean airway pressure is held constant.

Methods. Nine, supine mongrel dogs weighing 18.6 ± 3.1 kg were anesthetized with intravenous sodium pentobarbital (25 mg/kg). Their tracheas were intubated and appropriate lines were placed to measure systemic arterial, central venous, pulmonary artery, pulmonary artery occlusion, intrapleural and airway pressures, and cardiac output (CO). Arterial and mixed venous blood was sampled to measure pH, PO_2, PCO_2, and hemoglobin and physiologic intrapulmonary shunt fraction ($\dot{Q}sp/\dot{Q}t$) was calculated. Measurements and calculations were obtained after induction of anesthesia and again 15 minutes after aspiration with 22 ml/kg distilled water during spontaneous respiration. Animals then breathed spontaneously with 13 torr CPAP (Group 1) and measurements were repeated. Animals were paralyzed with succinylcholine and mechanically ventilated with a time-cycled, constant flow ventilator at a rate necessary to maintain $PaCO_2$ consistent with the control period. A constant flow, time-cycled ventilator will generate a square wave. The following ventilatory patterns were then applied in random order:

Group	I:E Ratio	Plateau Airway Pressure	PEEP (torr)
2	2:1	20 torr	0
3	2:1	17 torr	5
4	1:2	30 torr	5

Animals breathed room air at all times.

Results. With the four modes of ventilatory assistance we attempted to produce a mean airway pressure of approximately 13 torr regardless of ventilator rate (12.4 ± 1.53) (mean ± SD). Control values before aspiration were CO 4.8 ± 0.4, PaO_2 77 ± 3 and $\dot{Q}sp/\dot{Q}t$ 16 ± 3 (mean ± SEM). The results follow:

Group	CO (L/min)	PaO_2 (torr)	$\dot{Q}sp/\dot{Q}t$ (%)
Post-Aspiration	4.4 ± 0.4††	27 ± 2††	74 ± 3††
1	3.2 ± 0.4*,**	39 ± 4	53 ± 5
2	2.4 ± 0.4**	40 ± 3	43 ± 5
3	1.9 ± 0.2	42 ± 2	44 ± 3
4	1.9 ± 0.2	57 ± 4*	25 ± 4*

mean ± 1 SEM
*p < 0.05 compared to other treatment groups
**p < 0.05 compared to Group 3
†p < 0.05 compared to pre-aspiration
††p < 0.05 compared to all treatment groups

Fresh water aspiration caused a significant increase in physiologic intrapulmonary shunt but did not alter cardiac output. Treatment with CPAP significantly decreased CO and $\dot{Q}sp/\dot{Q}t$ and improved oxygenation. Mechanical ventilation further decreased cardiac output regardless of I:E ratio. Shunt fraction was lower during mechanical ventilation with a 1:2 I:E ratio plus PEEP (CPPV) than with CPAP or mechanical ventilation with a reversed I:E ratio, even when PEEP was added to the latter.

Discussion. A decrease in pulmonary surfactant activity is the principal abnormality in newborn IRDS. Arterial oxygenation has been shown to improve in newborns with IRDS with increasing mean airway pressure, either by increasing CPAP or by altering ventilatory pattern. Aspiration of fresh water similarly alters surfactant activity causing alveolar collapse and atelectasis with a resultant increase in intrapulmonary shunt fraction and arterial hypoxemia. Large-volume mechanical ventilation with PEEP has been shown to improve oxygenation when the animals were treated with 100% oxygen. This has been explained as being due to an increased lung volume, increased stability of the alveoli, and decreased intrapulmonary shunting of blood. We chose to study this model with decreased surfactant activity and maintained constant mean airway pressure while altering ventilatory pattern. We found different ventilatory patterns to have significantly different effects on cardiac output, $\dot{Q}sp/\dot{Q}t$, and PaO_2 in spite of identical mean airway pressures. Reverse I:E ratio did not improve ventilation in this model and we recommend ventilation with PEEP to treat pulmonary insufficiency induced by near-drowning. This must be accompanied by cardiovascular monitoring and support if necessary. We found no evidence to suggest use of reverse I:E ratio.