# Comparison of Airway Pressure Release Ventilation to Convention Ventilation in a Porcine Model of Severe Inhalation Injury

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## Introduction

Inhalation injury is common in burned combat casualties from war in Iraq and Afghanistan, and greatly increases both morbidity and mortality. The ideal mode of mechanical ventilation for these patients is unknown.

Airway pressure release ventilation (APRV) is a relatively new mode of mechanical ventilation, which delivers continuous positive airway pressure with a time-cycled pressure-release phase. APRV may have advantages to include optimization of mean airway pressures, peak-inspiratory-pressure limitation, and spontaneous breathing throughout the ventilatory cycle. Although APRV has been adopted as the standard mode of ventilation at a few trauma centers, and has been used at deployed Combat Support Hospitals, there are no data on efficacy in patients with inhalation injury. The purpose of this study was to evaluate APRV in a model of severe lung injury secondary to smoke inhalation.

## Objectives

The main objective was to evaluate airway-pressure-release ventilation (APRV) in comparison with conventional volume-cycled ventilation (CMV) for treatment of ALI caused by inhalation of wood bark smoke in a porcine model. The primary endpoint was the $PaO_2$-to-$FiO_2$ ratio (PFR).

## Materials and Methods

- 17 non-pregnant female pigs (weight 35-45 kg)
- 6 pigs comprised the inhalation injury plus conventional ventilation group (Conventional Group). This group was placed on the Controlled Mandatory Ventilation (CMV) mode.
- 7 pigs comprised the inhalation injury plus APRV group (APRV Group).
- 3 additional uninjured animals were used as time controls (Time Control Group) and to provide reference values for assays; these were conventionally ventilated.
- All animals underwent insertion of lines for blood sampling, vitals monitoring, and drug delivery.
- Total Intravenous Anesthesia (TIVA) included an initial starting dose of 150mcg/kg/min of both propofol and ketamine and 5mL/hr of midazolam. These were titrated the duration of the experiment to maintain sedation.
- Following the procedures and baseline studies, animals in the Conventional and APRV Groups sustained lung injury by inhalation of wood smoke. The average smoke volume for the CMV group was 27.4 ±3.0 L; for APRV, 29.6 ±2.6 L (p=0.58, Student's T-test).
- Animals were continuously monitored and data were recorded q6h, including: cardiovascular and ventilator status, PFR, $PaO_2$, $PaCO_2$, pH.

## Results

| | BL | | 1HR | | 24HR | | 48HR | |
|---|---|---|---|---|---|---|---|---|
| | CMV | APRV | CMV | APRV | CMV | APRV | CMV | APRV |
| HR (BPM) | 90±7 | 92±11 | 151±10 | 127±16 | 104±12 | 106±5 | 97±7 | 112±8 |
| MAP (mmHg) | 109±15 | 109±8 | 91±12 | 98±9 | 75±11 | 78±7 | 91±8 | 80±4 |
| CO (L/min) | 5.22±0.21 | 4.67±0.32 | 5.58±0.38 | 5.17±0.21 | 3.37±0.30 | 3.53±0.32 | 4.33±0.62 | 4.49±0.53 |
| TV | 438±24 | 424±21 | 426±21 | 483±73 | 342±29 | 414±33 | 253±13 | 518±65* |
| RR | 11±1 | 12±0 | 11±1 | 13±0 | 18±3 | 14±1 | 27±1 | 16±3 |
| MV | 4.74±0.29 | 4.65±0.22 | 5.60±0.74 | 6.55±1.27 | 5.62±0.48 | 4.99± 0.28 | 6.85±0.50 | 6.32±0.51 |
| PIP | 16±0.5 | 16±0.5 | 19±1 | 22±2 | 29±2 | 33±3 | 42±4 | 35±2 |
| PPlat | 15±0.6 | 16±1 | 20±2 | 16±0 | 31±3 | 18±0 | 31±2 | 16±1 |

**Table 1. Changes in conventional vital signs ( heart rate –HR, mean arterial pressure-MAP, cardiac output-CO and ventilation measurements (tidal volume-TV, respiratory rate–RR, minute ventilation-MV, peak inspiratory pressure–PIP, plateau pressure-PPlat. Significance levels: *, p<0.05 Student's T-test or Wilcoxon when appropriate**

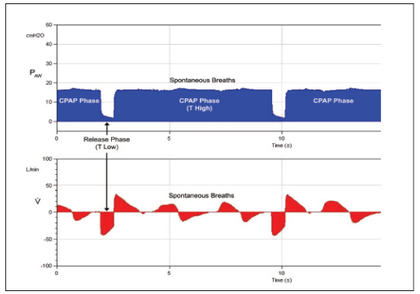
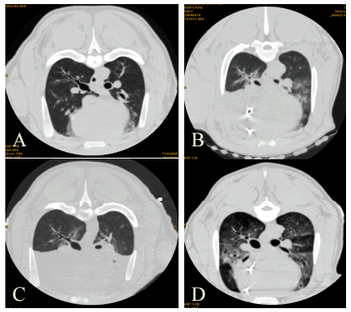
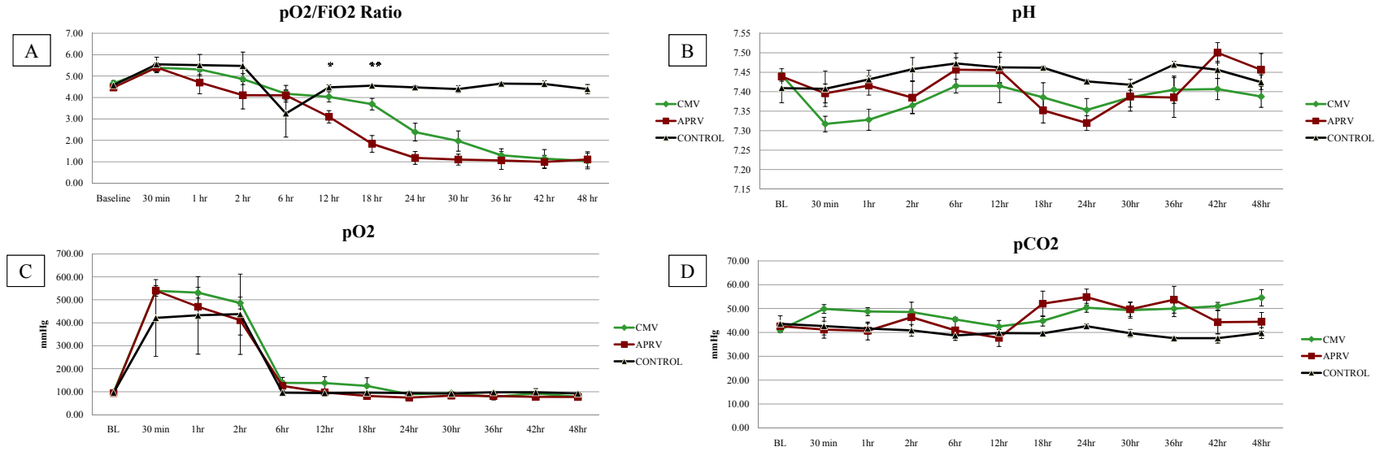



**Fig E. Depiction of continuous positive airway pressure delivery in APRV**




**Figures A-D: A is baseline, B-D demonstrates progression of inhalation injury at 1hr, 24hrs, and 48hrs respectively**




**Graph A-D denoting metabolic changes over 48hts after smoke inhalation injury. A. P/F ratio; B. pH; C. pO2; D. pCO2**
**Significance levels: *, p<0.05; **, p<0.01 Student's T-test or Wilcoxon when appropriate**

## Results

- PFR was not different among groups except at hours 12 and 18 when it was higher in the CMV group
- Cardiovascular status was similar between the CMV and APRV groups.
- TV was lower in the CMV group at the end of the protocol.
- There was no significant difference for RR, MV, PIP, or plateau pressure between the 2 groups.
- Subjects in the CMV arm took a longer time to develop ARDS in this model.

## Discussion and Conclusions

- This study does not support a difference in efficacy between APRV and conventional mechanical ventilation in a model of severe smoke inhalation injury.
- Because smoke inhalation injury involves both small airways injury and alveolar-capillary membrane injury, therapies that address these unique features—in particular, which focus on maintaining small airway patency—may be needed to improve outcome.
- Limitations of this study include the relatively short duration, which does not fully reproduce the weeks of mechanical ventilation which may be needed for humans with injuries this severe; and the absence of pneumonia or cutaneous burns as comorbid factors.
- APRV may have additional benefits not evaluated in this study, such as improved diaphragmatic function leading to faster weaning and extubation.