

Variability of tidal volume in assisted mechanical ventilation in ARDS: a bench study

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Introduction

Even though limiting tidal volume (TV) in ARDS patients is recommended, this goal may not be achieved once spontaneous breathing comes up and assisted modes are used. Furthermore ICU ventilators offer numerous assisted ventilation modes that work differently across the brands. We underwent present bench study to systematically investigate the effect of assisted mechanical modes on a single ICU ventilator on size and variability of TV at different breathing frequencies (f), patient effort and ARDS severity.

Methods

We performed a bench study in our university laboratory on an ICU ventilator (V500 Infinity, Dräger®, Germany) using ASL 5000 lung model. Compliance was set at value mimicking mild, moderate and severe ARDS as recently reported. Thirteen assisted ventilation modes were tested falling into three categories, namely volume controlled ventilation with mandatory minute ventilation (VCV-MMV), pressure-controlled ventilation (PCV) including airway pressure release ventilation (APRV) and biphasic positive airway pressure (BPAP), and pressure support ventilation (PSV). f and effort were tested each at two levels for each ARDS severity in each mode. TV was expressed as median (first-third quartiles) and compared across modes using non parametric tests. The probability for TV > 6 ml/kg ideal body weight (IBW) was assessed by binomial regression and expressed as odds ratio (OR) with 95% confidence intervals (CI). The variability of TV was measured from the coefficient of variation.

Results

The distribution of TV over all f, effort and ARDS categories significantly differed across modes ($P < 0.001$, Kruskal Wallis test). TV was significantly greater with PSV (420mL (332-527)) than with any other mode except for the three modes accommodating a variable PS level. The risk for TV to be greater than 6ml/kg IBW was significantly increased with spontaneous breaths assisted by PSV modes (for PSV OR 19.36; [12.37-30.65]) and significantly reduced in APRV (OR 0.44; [0.26-0.72]) and PSV with guaranteed volume mode. The risk increased with increasing effort and decreasing f. Coefficients of variation of TV were greater for low f and for VCV-MMV and PCV modes. APRV had the greatest within-mode variability.

Conclusions

The ventilation mode had an important impact on TV in this study. The risk of TV > 6ml/kg IBW was significantly reduced in APRV and PSV with guaranteed volume mode. APRV had the highest variability. PSV with guaranteed volume could be tested in ARDS patients.