EFFECT OF INCREASING AMPLITUDE USING AN ELECTRONIC LUNG SIMULATOR ON TIDAL VOLUME AND PEAK INSPIRATORY PRESSURE DURING ADAPTIVE PRESSURE CONTROL.


BACKGROUND: Many current ICU ventilators offer Adaptive Pressure Control, automatically adjusting peak inspiratory pressure levels between breaths while targeting a desired tidal volume. The purpose of this study was to test the effects of increased amplitude using an electronic lung simulator, simulating an increased patient inspiratory effort, on both tidal volume and peak inspiratory pressure. METHODS: Four ICU ventilators were evaluated: Covidien PB 840, CareFusion Avea, Maquet Servo-i, and Drager Evita XL. The Hans Rudolph HR 1101 Electronic Lung Simulator, used to mimic changes in patient effort, was set at the following values: Resistance 18 cm H2O/L/sec; Compliance 30 mL/cm H2O; Respiratory Rate 15 breaths/minute; Tidal Volume 3000 mL; Ventilator Settings: Mode PB 840 VCV, Avea PRVC, Servo-i PRVC, Drager XL CMV with AutoFlow On. Each ventilator was set at the following parameters: VT 500 mL, Respiratory Rate 15 breaths/minute, Inspiratory Time 0.7 seconds, PEEP 5 cm H2O. Each ventilator was set for a default pressure slope and set to allow triggering with minimal effort, ensuring that there were no missed triggers and no auto-triggering. Data were gathered after the ventilators were calibrated and tested for any leaks prior to the laboratory experiments. Each ventilator was set for a default pressure slope and set to allow triggering with minimal effort. No supervised respiration was used; there were no missed triggers and no auto-triggering. Data were gathered after the ventilators were allowed to stabilize at an Amplitude of 0 cm H2O. Next, Amplitude was increased in increments of 5 cm H2O up to 40 cm H2O. Tidal volume (VT) and peak inspiratory pressure (PIP) were measured using the HR1101, as well as the ventilators. Results: Amplitude was increased, the PIP decreased; however, the lowest PIP varied, as shown in the following: PB 840 10 cm H2O; Avea 8 cm H2O; Servo-i 6 cm H2O; Drager XL 10 cm H2O. The tidal volume increased or decreased with the set tidal volume, as displayed in the graph below. CONCLUSION: Each of the ventilators showed dramatic increases in VT as Amplitude increased. The PB 840 showed the largest increase in VT while the Servo-i displayed the least variation in VT. Also of interest was the variation among the ventilators in the least peak inspiratory pressure.

METHOD: Four ICU ventilators were evaluated: Covidien PB 840, CareFusion Avea, Maquet Servo-i, and Drager Evita XL. Each ventilator uses a specific name to refer to APC: Avea = PRVC; Drager XL = AutoFlow; PB 840 = VC+; Servo-i = PRVC. The Hans Rudolph HR 1101 Electronic Lung Simulator, used to mimic changes in patient effort, was set at the following values: Resistance 18 cm H2O/L/sec; Compliance 30 mL/cm H2O; Respiratory Rate 15 breaths/minute; Tidal Volume 3000 mL; Ventilator Settings: Mode PB 840 VCV, Avea PRVC, Servo-i PRVC, Drager XL CMV with AutoFlow On. Each ventilator was set at the following: VT 500 mL, Respiratory Rate 15 breaths/minute, Inspiratory Time 0.7 seconds, PEEP 5 cm H2O. The ventilators were calibrated and tested for any leaks prior to the laboratory experiments. Each ventilator was set for a default pressure slope and set to allow triggering with minimal effort. No supervised respiration was used; there were no missed triggers and no auto-triggering. Data were gathered after the ventilators were allowed to stabilize at an Amplitude of 0 cm H2O. Next, Amplitude was increased in increments of 5 cm H2O up to 40 cm H2O. Tidal volume (VT) and peak inspiratory pressure (PIP) were measured using the HR1101, as well as the ventilators. Results: Amplitude was increased, the PIP decreased; however, the lowest PIP varied, as shown in the following: PB 840 10 cm H2O; Avea 8 cm H2O; Servo-i 6 cm H2O; Drager XL 10 cm H2O. The tidal volume increased well above the set tidal volume, as displayed in the tables and graphs. Most of the ventilators tested limit the maximum pressure change from breath to breath to 3 cm H2O. The maximum PIP was 5 cm H2O less than the high-pressure alarm setting. The Servo-i required the fewest number of breaths to readjust to the set tidal volume once Amplitude was increased from 0 – 5 cm H2O than the others. The pressure change between breaths in this ventilator may exceed 3 cm H2O, but this may result in large pressure changes in order to deliver the target tidal volume. This resulted in very large changes in tidal volume, particularly during the incremental step from 25 – 30 cm H2O of Amplitude. CONCLUSION: Each of the ventilators showed dramatic increases in VT as Amplitude increased. The PB 840 showed the largest increase in VT while the Servo-i displayed the least variation in VT. Also of interest was the variation among the ventilators in the lowest peak inspiratory pressure among the ventilators. Although this is a bench study and cannot be directly applied to patients, clinicians must be aware of the PIP and VT changes when ventilating patients in APC as patient effort changes.

A decreasing PIP may indicate a reduced airway resistance or increased compliance; however, a decreasing PIP may also indicate an increased work of breathing of the patient, especially if the PIP is less than 20 cm H2O. Clinicians should remain vigilant in applying adaptive pressure control in mechanically ventilated patients while targeting a tidal volume, as this mode of ventilation attempts to apply the lowest possible peak airway pressure to maintain the set target tidal volume. However, it is not feasible for the ventilator to tell the difference between an increase in compliance or a decrease in airway resistance versus an increase in patient effort (amplitude).