Evaluation of Patient-Ventilator Synchrony in the Respironics ST/D, Vision and V60 when Ventilating a Mannequin Interfaced with an Electronic Breathing Simulator

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Introduction: Chronic Obstructive Pulmonary Disease (COPD), including Chronic Bronchitis and Emphysema, is a lung disease that affects the tissue of the lungs, and impairs a person’s ability to ventilate. Currently in the United States, COPD is the 4th leading cause of death, and is projected to be the third leading cause of death by the year 2025. In the year 2000, 726,000 visits to the Emergency Department occurred with the chief complaint being related to an exacerbation of COPD. COPD (COPD Statistical Information. 2004). When these patients come into the Emergency Department, protocols often recommend initiation of Noninvasive Positive Pressure Ventilation (NPPV) to reduce the work of breathing, increase alveolar ventilation and reduce CO2 levels.

Patient-ventilator synchrony is important in this patient population because dysynchrony can increase the work of breathing. Dysynchrony may be apparent if the patient is expending their muscular efforts during the device’s inspiratory phase due to a prolonged inspiratory time, if there are untriggered efforts or if there is a trigger delay. Trigger delay is identified as a lag from the time the patient begins to generate an inspiratory effort to when the ventilator delivers the breath. It is important that the ventilator’s inspiratory time matches the patient’s inspiratory time and that there is minimal trigger delay. In this project we measured the trigger delay and inspiratory time while ventilating an electronic breathing simulator with the Respironics ST/D, Vision and V60 interfaced with a mannequin.

Methods: The Laerdal Heart-Sim mannequin was modified by connecting the left and right mainstem bronchi to the Hans Rudolph HR 1101 Electronic Lung Simulator via corrugated tubing and 15 mm adaptors to simulate a spontaneously breathing patient. A Respironics ComfortGel full face mask was placed on the mannequin with a measured leak of 45 L/min to complete the circuit. The V60, Vision, and ST/D were connected to the mask via standard BiPAP tubing. Ventilator settings were: Mode Spontaneous/Timed, Rate 15 breaths/minute, IPAP 15 cmH2O, Rise minimum allowed by the ventilator, ST/D setting inspiratory time 0.93 seconds. The V60 and ST/D were set to 0.20 second for the ST/D and 0.14 seconds for the Vision. Compliance 60 mL/cmH2O, Target volume 3000 mL, Load Effort Normal. Each ventilator ran for five minutes; the middle two minutes were used for analysis.

Results: Data was measured by the HR 1101 at intervals of 0.05 seconds. Inspiratory time was measured as the amount of time from the beginning of inspiratory flow to the beginning of expiratory flow. The average inspiratory time was 0.93 seconds for the V60, compared to 1.0 second for the Vision and 1.75 seconds for the ST/D. Trigger delay was measured as the amount of time from when patient effort began (measured by amplitude) to when inspiratory flow began. The average trigger delay was 0.10 seconds for the V60, compared to 0.14 seconds for the Vision and 0.20 seconds for the ST/D.

Conclusion: The findings in this study have determined that the V60 is potentially more effective at reducing patient-ventilator dysynchrony than the ST/D and the Vision, as measured by trigger delay and inspiratory time. This study could impact the clinician’s choice in ventilators for patients with COPD.

Methods: The Laerdal Heart-Sim mannequin was modified by connecting the left and right mainstem bronchi to the Hans Rudolph HR 1101 Electronic Breathing Simulator via 10 mm corrugated tubing and 15 mm adaptors. This allowed the HR 1101 to “inhale” and “exhale” through the mannequin’s airway via the ventilator, as shown in the photo. The lung simulator was set to mimic a spontaneously breathing patient with a COPD exacerbation. HR 1101 settings: Compliance 60 mL/cmH2O, Resistance 25 cmH2O/sec, Rate 15 breaths/minute, Amplitude (patient effort) 8, Effort slope 15.0%, inhale 20, Target Volume 3000 mL, Load Effort Normal. Three ventilators were evaluated: Respironics ST/D, Vision and the V60. The mannequin was interfaced to each ventilator with a Respironics ComfortGel full face mask; the leak was measured at 45 L/minute with each ventilator. The V60, Vision and ST/D were connected to the mask via standard BiPAP tubing. Ventilator settings: Mode Spontaneous/Timed, Rate 4 breaths/minute, IPAP 15 cmH2O, Rise minimum allowed by the ventilator. ST/D setting inspiratory time 1.0 seconds for the V60, compared to 1.0 second for the Vision and 1.75 seconds for the ST/D. Trigger delay was measured as the amount of time from when patient effort began (measured by amplitude) to when inspiratory flow began. The average trigger delay was 0.10 seconds for the V60, compared to 0.14 seconds for the Vision and 0.20 seconds for the ST/D.

Results: The average inspiratory time was 0.93 seconds for the V60, compared to 1.0 second for the Vision and 1.75 seconds for the ST/D. The average trigger delay was 0.10 seconds for the V60, compared to 0.14 seconds for the Vision and 0.20 seconds for the ST/D.

Conclusion: The V60 is more effective at synchronizing with a patient undergoing a COPD exacerbation by minimizing trigger delay and shortening inspiratory time. This allows for a lower WOB as well as a longer expiratory time to allow the patient to fully exhale, and help reduce occurrence of auto-PEEP when compared to the Vision and ST/D. This study could impact the clinician’s choice of ventilator when initiating NPPV in a patient with COPD. The findings in this study need further evaluation in the clinical setting.

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