Adaptive mechanical ventilation with automated minimization of mechanical power—a pilot randomized cross-over study

Authors: Tobias Becher, Anna Adelmeier, Inéz Frerichs, Norbert Weiler and Dirk Schädler

1. Department of Anesthesiology and Intensive Care Medicine, University Medical Center Schleswig-Holstein, Campus Kiel, Kiel, Germany

What is AVM with minimized inspiratory power?

Adaptive mechanical ventilation modes with optimal targeting automatically adjust respiratory rate (RR) and tidal volume (VT) to deliver the clinically desired minute ventilation, selecting RR and VT based on Otis' equation. The Otis' equation was originally derived to better understand the energetics of unassisted spontaneous breathing, assuming inspiratory muscle pressure to follow a sinusoidal waveform during inspiration. However, all optimal targeting adaptive ventilation modes which are currently on the market are based on pressure-controlled mechanical ventilation, which delivers a "square-wave" inspiratory pressure during mandatory breaths. Therefore, Vyaire proposed the concept of "inspiratory power" and derived an equation to select a combination of RR and VT that minimizes inspiratory power during pressure-controlled adaptive mechanical ventilation.

For calculation of inspiratory power, the work per breath is multiplied with RR to yield a result in J/min. The RR that is associated with minimal inspiratory power can then be calculated by the algorithm using a fixed-point iteration. For a given minute volume, this should lead to lower V_T, reduced driving pressure (ΔP) and reduced total mechanical power (MPtotal) when compared to adaptive ventilation based on Otis' equation. This concept is now implemented in a new adaptive ventilation mode (AVM2) which was specifically developed to minimize inspiratory power and deliver more "lung-protective" combinations of V_T and RR when compared to adaptive mechanical ventilation based on Otis' equation.

Objectives

The aim of this study was to investigate whether AVM2 reduces V_T, mechanical power (MP) and airway driving pressure (ΔP) and maintains similar gas exchange when compared to traditional adaptive mechanical ventilation based on Otis' equation.

	AVM	AVM	p
V_T (mL/kg)	8.2	7.2	<0.0001
V_T ARDS (mL/kg)	7.9	6.6	<0.0001
ΔP	12.6	11.5	<0.0001
ΔP ARDS	13.3	11.8	<0.0044
MP_{total}	18.6	16.8	<0.0024
MP_{total} ARDS	17.5	15.6	<0.0023
PaO_2/FiO_2	291	270	<0.03
PaO_2/FiO_2 ARDS	218	194	<0.008

Table 1 Comparison of AVM and AVM 2

Study methods

A prospective randomized cross-over study was performed in 20 critically ill patients on controlled mechanical ventilation, including 10 patients with acute respiratory distress syndrome (ARDS). Each patient underwent 1 h of mechanical ventilation with AVM2 and 1 h of adaptive mechanical ventilation according to Otis' equation (Adaptive Ventilation Mode, AVM). At the end of each phase, we collected data on V_T, mechanical power, ΔP, PaO_2/FiO_2 ratio, $PaCO_2$, pH, and hemodynamics. ΔP was measured during an inspiratory hold maneuver.

Results

Comparing adaptive mechanical ventilation with AVM2 to the approach based on Otis' equation (AVM), we found a significant reduction in V_T both in the whole study population and in the subgroup of patients with ARDS (Table 1). Similar reductions were observed for ΔP and total mechanical power with AVM2. There was a small decrease in PaO_2/FiO_2 with AVM2 but no differences in $PaCO_2$, pH, and hemodynamics.

Figure 1 First patient ventilated with new AVM algorithm

Literature

Becher, T., Adelmeier, A., Frerichs, I., Weiler, N., & Schädler, D. (2019). Adaptive mechanical ventilation with automated minimization of mechanical power-a pilot randomized cross-over study. Critical Care (London, England), 23(1), 338

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Take home message

Adaptive mechanical ventilation with automated minimization of inspiratory power may lead to more lung-protective ventilator settings when compared with adaptive mechanical ventilation according to Otis' equation.

GLOBAL HEADQUARTERS

Vyaire Medical, Inc. | 26125 North Riverwoods Blvd | Mettawa, IL 60045, USA