Mechanical power and ventilatory efficiency during flow-controlled ventilation in severe COVID-19 ARDS

Grassetto[1], T. Pettenuzzo[2], F. Badii[1], R. Carlon[1], N. Sella[2], P. Navalesi[2]
[1] Ospedale di Vittorio Veneto, Dept of Anaesthesiology & Intensive Care, Treviso, Italy
[2] Padua University Hospital, Dept of Anaesthesiology & Intensive Care, Padova, Italy

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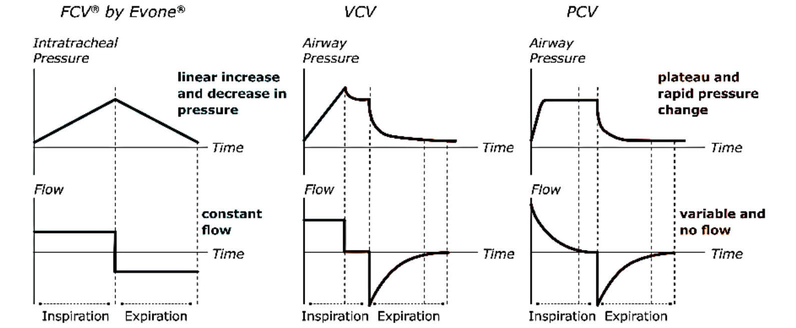
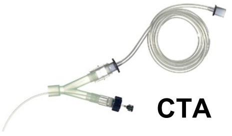
Background

The prevention of ventilator-induced lung injury (VILI) is the mainstay of the management of mechanical ventilation in patients with ARDS. Mechanical power, which represents the total inflation energy transferred from the mechanical ventilator to the lungs, including flow and respiratory rate, is associated with VILI and mortality in patients with ARDS.

Flow controlled Ventilation (FCV)

FCV is a ventilation mode that provides low, constant flow throughout both inspiration and expiration without pauses implemented by the Evone® ventilator (Ventinova Medical, Eindhoven, The Netherlands). By avoiding high peak flows and reduced respiratory rate, FCV may lead to the minimization of applied and dissipated energy in order to attenuate VILI in ARDS patients[1].





CTA

Ventilator Evone

References
[1]Barnes et al. TACC 2018.
[2]Chiumello et al. Critical Care 2022

Goal

To evaluate the ventilatory efficiency and applied mechanical power during FCV in ARDS patients.

Methods

Design: Prospective observational study

Inclusion criteria:

- Patients (n=10) with COVID-19 related ARDS
- Conventional volume-controlled mechanical ventilation (CMV)
- Prone positioning > 12 hours
- Receiving neuromuscular blockade
- P/F ratio <150 mmHg

We registered the changes in ventilatory settings, respiratory mechanics and gas exchanges during the transition from CMV to FCV and back.

Calculations

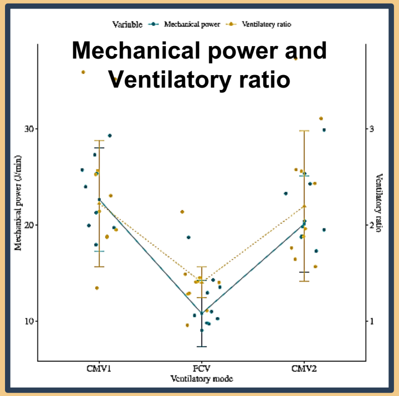
During CMV, plateau pressure (Pplat) and total PEEP were measured during an end-inspiratory and end-expiratory pause.
FCV is a fully dynamic ventilation mode with Pplat displayed every 10 cycles, but without an end expiratory pause.

Static driving pressure CMV: Pplat - total PEEP
Static driving pressure FCV: Pplat - EEP
Static Crs CMV and FCV: Tidal volume / static driving pressure
Inspiratory flow CMV: Tidal volume / inspiratory time
Inspiratory flow FCV: set value
Mechanical power (see Chiumello et al.[2]):
0.098 × respiratory rate × tidal volume × [Ppeak - ½ × (Pplat - PEEP)]
The ventilatory ratio:
(minute ventilation × PaCO2) / (predicted bw × 100 × 37.5)

Results

As compared to CMV, FCV resulted in:

- Lower inspiratory flow, with a decreased respiratory rate and minute ventilation.
- Lower applied mechanical power, despite similar driving pressure and compliance
- Lower ventilatory ratio.



Variable	CMV1	FCV	CMV2	*p-value*
Respiratory rate (breaths/min)	26 (24-28)	17 (16-18)$^{\wedge\S}$	25 (22-26)	*<0.001*
Tidal volume (mL)	430 (422-475)	440 (404-500)	435 (422-470)	*0.968*
Minute ventilation (L/min)	11.80 (10.20-12.80)	7.66 (7.10-8.24)$^{*\#}$	10.80 (9.62-12.10)	*<0.001*
Peak pressure (cmH2O)	27 (25-28)	23 (20-25)$^{\wedge\S}$	26 (25-28)	*<0.001*
Plateau pressure (cmH2O)	21 (20-23)	21 (19-23)	22 (21-23)	*0.015*
PEEP (cmH2O)	9 (8-10)	9 (7-10)	10 (8-10)	*0.772*
Inspiratory flow (L/min)	26 (23-26)	15 (14-15)$^{*\#}$	22 (22-26)	*<0.001*
Static Crs (mL/cmH2O)	36 (34-38)	35 (34-40)	36 (33-39)	*0.704*
Driving pressure (cmH2O)	13 (12-13)	12 (11-13)	13 (12-14)	*0.331*
Mechanical power (J/min)	22.7 (20.3-25.6)	10.8 (9.9-13.4)$^{*\#}$	20.1 (19.0-24.0)	*<0.001*
pH	7.37 (7.30-7.42)	7.39 (7.36-7.42)	7.34 (7.27-7.42)	*0.28*
PaCO2 (mmHg)	49 (43-51)	45 (42-48)	51 (45-56)	*0.275*
PaO2/FiO2 (mmHg)	128 (116-134)	136 (115-147)	134 (106-152)	*0.275*
Ventilatory ratio	2.22 (1.90-2.56)	1.40 (1.28-1.44)$^{*\#}$	2.20 (1.79-2.57)	*<0.001*

Conclusions

Our findings suggest that FCV may reduce mechanical power and increase ventilatory efficiency in patients who remain severely hypoxemic despite the optimization of CMV.