Monitoring of Mechanical Ventilation

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CONFLICTS OF INTEREST

- Air Liquide Medical Systems (part time)

Financial support for research (Genève /Annecy/Angers)

-VYGON (personal fee for lectures)
- SHILLER
- MAQUET (NAVA)
- COVIDIEN (PAV+) (personal fee for lectures)
- DRAGER (SmartCare)
- GE (FRC)
Monitoring of ventilation based on flow and Paw time curves

Volume assist control
Equation of motion of the respiratory system during controlled ventilation

\[ P_{aw} = (\text{flow} \cdot R) + (\text{Volume} \cdot E) + P_0 \]
Monitoring of MV based on flow and airway pressure curves

Pressure-targeted

Flow-targeted
Volume Control (flow regulated)

Ventilator

Valve

Flow
60 l/min

Pressure measured

Pressure

Flow

Oc

Tins
end-exp Alv. Pressure
end-insp Alv. Pressure

PRESSURE

FLOW
- \( R = \text{Pres} / \text{Flow} \)
- \( R = \frac{\text{Ppeak} - \text{Pplat}}{\text{Flow}} \text{ cmH}_2\text{O.L}^{-1}.\text{s} \)
- \( C = \frac{\text{Vol}}{\text{Pel}} \)
- \( C = \frac{\text{Vol}}{\text{Pplat} - \text{PEEPtot}} \text{ mL. cmH}_2\text{O}^{-1} \)
- \( C = \frac{\text{Vol}}{\text{Driving Pressure}} \)
Effect of end-inspiratory pause duration on plateau pressure in mechanically ventilated patients

Fig. 2 Individual values of tracheal plateau pressures recorded on PEEP in 11 ARDS patients at 0.5 s, 1 s, 2 s, 3 s, and 5 s after end-inspiratory occlusion
Driving pressure = Pplat - PEEPtot
How to set inspiratory flow?

- \( R = \text{Pres} / \text{Flow} \)
- \( R = \frac{\text{Ppeak} - \text{Pplat}}{\text{Flow}} \) cmH\(_2\)O.L\(^{-1}\).s
- \( R = \frac{\text{Ppeak} - \text{Pplat}}{1 \text{ L/sec}} \)

60L/min (1L/sec)
Volume Controlled

$P_{peak}$

Pressure

Flow

Volume
Volume Controlled

\( P_{\text{peak}} \)

Pressure

Flow

Volume
Pressure regulated mode

Ventilator

Airway pressure

Pressure setting
20 cmH2O
Pressure Controlled

- **Pressure**
  - Graph showing pressure change over time.
- **Flow**
  - Graph showing flow rate over time.
- **Volume**
  - Graph showing volume change over time.
Monitoring of Vt during Pressure Controlled
Time constant for expiration

\[ V = V_0 e^{-t/t} \]

\[ t = R \times C \]

\[ 3t = 96\% \, V_0 \]
Intrinsic PEEP: 3 causes

- Dynamic hyperinflation
- Flow limitation
- Expiratory muscle recruitment
Flow (L/s)

Paw (cm H₂O)

Volume (L)

COPD
Evaluation of Alveolar Derecruitment

\[ \Delta P_{\text{EEP}} = 10 \]

1. Reduce RR
2. Reduce PEEP
3. Record expired Vt
4. Record Pplat

\[ \Delta EELV = [\text{PEEP 1} - \text{PEEP 2}] \times C \]

\[ V_{\text{rec}} = \Delta EELV - Vt\ exp \]

\[ V_{\text{rec}} = 300\text{ml} - 450\text{ml} = 150\text{ ml} \]

Compliance = 30 ml/cmH$_2$O

Chen L et al. Crit Care 2017
Conclusions

- During volume targeted mode of ventilation Paw (Ppeak & Plat) permit to simply monitor occurrence of clinical events.
- During pressure targeted mode flow & volume carry similar information but much more tricky to monitor.
- Routine use of end expiratory and end inspiratory occlusion is possible in both volume control and pressure control.
- Occlusion pressure permit to reliably assess pressure inside the respiratory system which is of high clinical value.