Physiology and mechanical ventilation: using esophageal pressure

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Why esophageal pressure?

Esophageal balloon is inflated to directly transmit the pressure within the esophagus, which is a collapsible virtual cavity between the lungs and the chest wall.

Pes value should reflect **pleural pressure** (Ppl) at that level.
Airway vs. transpulmonary pressure

ARDS, 75 kg PBW
Crs 30
Cw 200
C_L 37.5
Vt 6 ml/kg

\[ P_L = \text{Paw} - \text{Ppl} \]

END-EXP
PEEPtot 15
Ppl 8

\[ P_{L,ei} = 20 \]
\[ P_{L,E-L/tot} = 26 \]
\[ \Delta P_L = 13 \]
\[ P_{L,ee} = 7 \]

END-INSPI
Pplat 30
Ppl 10

Mauri T and the Plug Intensive Care Med 2016
Transpulmonary pressure at the bedside

1. Vt
2. Pplat
3. PEEP
4. $P_{L,ei}$
5. $P_{L,ee}$

$\Delta P_{aw}$

$\Delta P_L$
Is Pes-based transpulmonary pressure validated?

Yoshida T ATS abstract 2017
<table>
<thead>
<tr>
<th>Flow (L/s)</th>
<th>Pes (cmH₂O)</th>
<th>Pg (cmH₂O)</th>
<th>Paw (cmH₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room air</td>
<td>Stomach</td>
<td>Esophagus</td>
<td>Catheter positioning</td>
</tr>
</tbody>
</table>

50-55 cm and retract. In passive pts, around 35-40 cm.
Filling volume at the bedside
Filling volume at the bedside

We usually choose the volume in the middle of the “stable” Pes end exp pressure range.
Correct positioning: no change in $P_L$

Active patient: Baydur test

*Baydur A et al. Am Rev Respir Dis 1982*
Correct positioning: no change in $P_L$
Do we need esophageal pressure?

Esophageal pressure is a monitoring technique

It doesn’t save lives

But it might yield useful information to guide personalised protective ventilation settings

Does it?
End exp $P_L (P_{L, ee})$ to set PEEP

$$P_{L, ee} = PEEP_{tot} - P_{es_{ee}}$$
End-insp $P_L$ to assess “safe” $P_{plat}$?

\[
P_{L, ei} = P_{plat} - P_{es, ei} \\
P_{L, E-L/tot} = P_{plat} \times \frac{E_L}{Ers}
\]

$P_{L, ei}$ kept below 25 cmH$_2$O (rarely reached)

$P_{L, E-L/tot}$ increased to 25 cmH$_2$O by PEEP made ECMO criteria disappear.

Driving $P_L$ to set $V_t$?

$$\Delta P_{L, ee} = (P_{plat} - P_{es_e}) - (PEE_{Ptot} - P_{se_e})$$
Driving $P_L$ in active pts

1. End-insp (zero flow) $\Delta P_L$
2. Dynamic $\Delta P_L$
3. Peak $P_L$
Increased $\Delta P_L$ in spont. breathing ARDS
Determinants of $\Delta P_L$ in active pts

PSV 16
$\Delta$Pes 5
Dynamic $\Delta P_L$ 21

PSV 12
$\Delta$pes 10
Dynamic $\Delta P_L$ 22

Mauri T Int Care Med 2016
Decreasing $\Delta P_L$ in active patients

Mauri et al. Anesthesiology 2016
Sometimes even ECMO fails

Severe ARDS patient on ECMO day 7

ECMO GF 11 L/min

VCO₂ML/tot 77%

Dynamic $\Delta P_L > 40$ cmH₂O!!!
Assessing patient’s effort

COPD - Biselli P J Appl Phys 2017

AHRF - Mauri T AJRCCM 2017
Patient’s effort during SBT

Decreased EELV, increased PaCO₂
Failure

Stable mechanics and gas exchange
SUCCESS

RR/Vt to assess readiness to undergo an SBT, stable Pes swings over time to predict successful weaning from MV.
Asynchronies

Reverse triggering: change sedation strategy?

Mauri T, and the PLUG. ICM 2016

Ineffective efforts: minimize PEEPi? Decrease support? Change sedation?

Akoumianaki et al. Chest 2013
Asynchronies

A. Delayed cycling
- Decrease inspiratory time?
- Decrease PSV?

B. Double triggering
- Increase inspiratory time?
- Increase PSV?

Blanch et al. Intensive Care Med 2015
Mauri T, and the PLUG. ICM 2016
Asynchronies

Pt on NAVA: 4 asynchronies in 14 seconds.

Switch to controlled ventilation?
**Esophageal pressure**

- Esophageal pressure monitoring is physiologically sound, (almost) validated, (very) simple and minimally invasive.

- Pes yields accurate bedside assessment of lung stress, strain, patient effort and asynchronies during both controlled and assisted ventilation.

- Pes might guide personalised settings to fully exploit lung protection and early weaning during mechanical ventilation.
Thanks!