Monitoring Spontaneous Breathing

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Conflicts of Interest

 INSTITUTIONAL:
  – Research grants from:
    • Draeger
    • Maquet
    • Airway Medix
    • Fisher-Paykel
  – Patent transferal to:
    • Draeger

 PERSONAL
  – Lecturing fees:
    • Draeger
    • Pfizer
What to monitor during assisted spontaneous breathing?

- Tidal Volume
- Respiratory Rate
- RSBI
- P0.1
- Minute ventilation
- PaCO2
- PaO2
- EtCO2
- Negative inspiratory force

- EAdi
- Pressure time product
- Work of breathing
- PEEPi
- Compliance
- Resistance
- Flow/volume loops
- Oxygen consumption
- Asynchrony index
- ....
The bright side of spontaneous breathing

- Less Sedation
- Muscle Atrophy
- Hemodynamics
- Better V/Q match
Topographic Distribution of Tidal Ventilation in Acute Respiratory Distress Syndrome: Effects of Positive End-Expiratory Pressure and Pressure Support

Tommaso Mauri, MD; Giacomo Bellani, MD, PhD; Andrea Confalonieri, MD; Paola Tagliabue, MD; Marta Turella, MD; Andrea Coppadoro, MD; Giuseppe Citerio, MD; Nicolo’ Patroniti, MD; Antonio Pesenti, MD

\[ P_{0.1} = 1 \pm 0.6 \]

\[ P_{0.1} = 4 \pm 0.6 \]
Rapidly Progressive Diaphragmatic Weakness and Injury during Mechanical Ventilation in Humans

Samir Jaber\textsuperscript{1,2,6}, Basil J. Petrof\textsuperscript{3}, Boris Jung\textsuperscript{1,2}, G\textsuperscript{\textregistered}erald Chanques\textsuperscript{1,2}, Jean-Philippe Berthet\textsuperscript{4}, Christophe Rabuel\textsuperscript{5}, Hassan Bouyabrine\textsuperscript{6}, Patricia Courouble\textsuperscript{1,2}, Christelle Koechlin-Ramonatxo\textsuperscript{7}, Mustapha Sebbane\textsuperscript{1,2}, Thomas Similowski\textsuperscript{8}, Val\'erie Scheuermann\textsuperscript{9}, Alexandre Mebazaa\textsuperscript{5}, Xavier Capdevila\textsuperscript{1,2}, Dominique Mornet\textsuperscript{2}, Jacques Mercier\textsuperscript{2,10}, Alain Lacampagne\textsuperscript{9}, Alexandre Philips\textsuperscript{2}, and Stefan Matecki\textsuperscript{2,10}

The dark side of spontaneous breathing

Risk of high Vt
High inspiratory pressure
Asynchronies
O₂ Consumption
Inspiratory Resistive Breathing Induces Acute Lung Injury

Dimitris Toumpanakis¹, George A. Kastis¹, Panagiotis Zacharatos¹, Ioanna Sigala¹, Tatiana Michailidou¹, Maroussa Kouvela¹, Constantinos Glynos¹, Maziar Divangahi¹, Charis Roussos¹, Stamatios E. Theocharis², and Theodoros Vassilakopoulos¹

Am J Respir Crit Care Med Vol 182. pp 1129–1136, 2010
Oxygen consumption

Bellani G el al. Anesthesiology, 2010
The dark side of spontaneous breathing
- Risk of high Vt
- High inspiratory pressure
- Asynchronies
- $O_2$ Consumption

The bright side of spontaneous breathing
- Sedation
- Muscle Atrophy
- Hemodynamics
- Better V/Q match
The Comparison of Spontaneous Breathing and Muscle Paralysis in Two Different Severities of Experimental Lung Injury

Takeshi Yoshida, MD\textsuperscript{1,2}; Akinori Uchiyama, MD, PhD\textsuperscript{2}; Nariaki Matsuura, MD, PhD\textsuperscript{3}; Takashi Mashimo, MD, PhD\textsuperscript{2}; Yuji Fujino, MD, PhD\textsuperscript{3}

(Crit Care Med 2013; 41:536–545)
Assessing effort and work of breathing

Giacomo Bellani$^{a,b}$ and Antonio Pesenti$^{a,b}$

KEY POINTS

- Breathing effort is a double-edged sword with harmful and protective effects during lung injury and weaning failure.

- Monitoring of breathing effort might allow a better titration of ventilatory assistance.

- Esophageal pressure remains the standard technique for measurement of breathing effort, but alternate tools have been proposed and validated.

- Electrical activity of the diaphragm is a reliable tool to monitor and quantitate the patient’s breathing effort.
Do spontaneous and mechanical breathing have similar effects on average transpulmonary and alveolar pressure? A clinical crossover study

Giacomo Bellani, Giacomo Grasselli, Maddalena Teglia-Droghè, Tommaso Mauri, Andrea Coppadoro, Laurent Brochard, and Antonio Pesenti

Critical Care (2016) 20:142

\[ \Delta P_{\text{aw}} \]

\[ \Delta P_{\text{es}} \]

\[ \Delta P_{\text{L}} \]

\[ \Delta P_L \text{ during PSV (cmH}_2\text{O)} \]

\[ \Delta P_L \text{ during CMV (cmH}_2\text{O)} \]

\[ R^2=0.74 \]

\[ P<0.01 \]
Do spontaneous and mechanical breathing have similar effects on average transpulmonary and alveolar pressure? A clinical crossover study

Critical Care (2016) 20:142

Giacomo Bellani$^{1,2*}$, Giacomo Grasselli$^{2,3}$, Maddalena Teglia-Droghi$^{1,2}$, Tommaso Mauri$^{3}$, Andrea Coppadoro$^{4}$, Laurent Brochard$^{5,6}$ and Antonio Pesenti$^{1,2,3}$
As simple as....

Bellani G et al. Anesthesiology, 2010
Respiratory muscles electromyography

➢ To monitor patient’s ventilator synchrony
Reverse trigger
Respiratory muscles electromyography

- To monitor patient’s ventilator synchrony
- To calculate the total pressure applied to the respiratory system (Paw+Pmus)
LINEAR RELATIONSHIP BETWEEN Eadi AND Pmusc

PEI measurement without esophageal pressure

This Pmusc/Eadi index (PEI) has dimensions of cm H$_2$O/µV and is supposed to indicate the amount of pressure (in cm H$_2$O) that the respiratory muscles of the patients are generating for each microvolt of electrical activity. We also have:

$$\frac{P_{musc}}{E_{adi}} = PEI_{occl}$$
Respiratory muscles electromyography

- To monitor patient’s ventilator synchrony
- To calculate the total pressure applied to the respiratory system (Paw+Pmus)
- To follow the patient during weaning
Eadi during T-tube trial
«Intrinsic Eadi» to monitor PEEPi

Bellani G, Anesthesiology, 2014
Respiratory muscles electromyography

- To monitor patient’s ventilator synchrony
- To calculate the total pressure applied to the respiratory system (Paw+Pmus)
- To follow the patient during weaning
- To be less invasive [in the future?]
Correlation between Eadi and surface Eadi

Bellani submitted

Mean $R^2$: 0.88 (Range 0.66 – 0.98)
In all patients who are not paralyzed monitoring spontaneous breathing effort is desirable.

Pes is the standard.

P0. is a useful simplification.

Eadi readily available for clinical use, sEMG in the pipeline.