The Physical Exam of the Critically Ill Mechanically Ventilated Patient

Rolf D Hubmayr
Mayo Clinic College of Medicine

Has responded with nothing to disclose.

Message Objectives

1) Forget the stethoscope! It is rare for lung sounds to guide efficacious therapy.

2) Pay attention to body habitus and chest wall motion

3) Mechanical ventilators are heart and lung function testing machines…use them as such!

4) It is unlikely that you will find comparable information in the Vital Sign Section of the EMR

Look

Listen

Feel

….have different meanings in the ICU
Tools and Variables

**Usually Available at the Bedside**
- Ventilator Waveforms
- Vascular Pressures
- Indices of Oxygenation
- EKG
- Lung Sounds

**Sometimes Available at the Bedside**
- Thoracic Gas Volume
- Esophageal Pressure
- Respiratory Muscle EMG
- Thoracic Impedance
- Portable Ultrasound

Ventilator Waveform Analysis

- Is the ventilator setting patient/lung protective
- Does the patient have airflow obstruction
- Are patient and ventilator “in sync”
Mechanics

One-Compartment Model


Ventilator Management of Injured Lungs

Ranieri et al. Anesthesiology 2000; 93(5):1320-8

Chest Wall Mechanics in ARDS

Arterial Oxygen Tension is NOT the only Biomarker of "Best PEEP"

Mattingley et al. Crit. Care; 2011
The Chest Wall Curve of ARDS Patients is shifted to the right

Esophageal Manometry in ARDS

Predicted Body Weight does NOT scale with the size of the injured lung


Mattingley et al. Crit. Care; 2011
Ventilator Waveform Analysis

- Is the ventilator setting lung protective
- Does the patient have airflow obstruction
- Are patient and ventilator “in sync”

Dynamic Hyperinflation
Airflow Limitation, PEEP and the Effort required to trigger a Machine Breath

Pcrit = Pel

Best PEEP

Low PEEP

"Best PEEP" in COPD

What about increasing expiratory time by increasing inspiratory Flow?
Effect of Flow Settings on Respiratory Rate

Ventilator Waveform Analysis
- Is the ventilator setting lung protective
- Does the patient have airflow obstruction
- Are patient and ventilator "in sync"

Wasted Efforts
Breaths Stacking

Tidal Volume Lower than 6 ml/kg Enhances Lung Protection
Role of Extracorporeal Carbon Dioxide Removal

Patient-Ventilator Asynchrony
Loss of Entrainment in a sick Patient

Neurally Adjusted Ventilation Assist

Heart-Lung Interactions

Arterial Pressure Monitoring

Probability of Stroke Volume Increase following a Fluid Bolus

Pulse Pressure Monitoring

Baseline

After Volume Loading

Rivers et al
Early Goal Directed Therapy
In the Treatment of Sepsis and severe septic
Shock
NEJM Vol 345, pg 1368, Nov 2001
The ARDS Network FACTT Trial

More respect for the CVP?

Venous Pressure Monitoring
Is there a single venous $O_2$ saturation threshold indicative of tissue hypoxia?

Cain. JAP 42:228; 1977

Metabolic Hyperbola

$$PCO_2 = \frac{VCO_2}{VE \times (1 - Vd/Vt)}$$
Validation of a poor man’s VD/VT

The Times are a Changin’

Patient on Ventilator