Difficult Weaning: Is it the Diaphragm?

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Disclosures

• Conflicts of Interest
  – None to report
Diaphragm Dysfunction: Key Points

1. Important cause of difficult weaning
2. Results from critical illness and mechanical ventilation (? preventable)
3. Clinical assessment is highly feasible
4. Inspiratory muscle training may help
Weaning: Supply and Demand

Mechanical Ventilation Needed (intolerable load)

Spontaneous Ventilation Possible (tolerable load)

Partial Support

Total Support

Increasing Reserve

Normal Reserve

Demands
- Pressure loads
  - $C_L$
  - $R_{aw}$
- Ventilation loads
  - $V_A$ ($V_{CO_2}$, $V_{O_2}$)
  - $V_D$
- Imposed loads

Capabilities
- Neural drive
- Muscle function
  - Strength
  - Endurance
Action of the Diaphragm

De Troyer and Loring, Handbook of Physiology
Impact on Weaning

Kim et al *Crit Care Med* 2011
Many Ventilated Patients Exhibit Poor Diaphragm Function
Etiologies of Diaphragm Dysfunction

- Sepsis/SIRS
- Shock
- Medications
- Critical illness neuromyopathy
- Electrolyte imbalances
- Sepsis/SIRS
- Fatigue
- Mechanical Ventilation

Diaphragm Injury

Contractile Dysfunction
Evolution of Diaphragm Thickness During MV

Group: Diaphragm Thickness Change
- >10% loss on or before day 8
- <10% change on or before day 8
- >10% gain on or before day 8

Goligher et al AJRCCM 2015
Clinical Issues

- Prevention
- Diagnosis
- Treatment
Prevention: Inspiratory Effort Matters

Goligher et al AJRCCM 2015
Diagnosis: Bedside Ultrasound

12 MHz probe

Zone of apposition

Pleura

Chest Wall

Diaphragm

Peritoneum

B-mode!
Diagnosis: Bedside Ultrasound
Diagnosis: Bedside Ultrasound

Ferrari et al. *Crit Ultrasound J* 2014

DiNino et al. *Thorax* 2014
Diagnosis: Diaphragm Excursion

Reference Values:
- Resting breathing = 1 cm
- Sniff = 1.5 cm
- Deep inspiration = 4 cm
  (Boussuges et al. Chest 2009)
Clinical Significance

Kim et al *Crit Care Med* 2011

Diaphragm Function
Normal (> 1 cm)
Impaired (< 1 cm)
USEFUL Study

Ultrasound to Evaluate Failure of Liberation from Mechanical Ventilation

E. Goligher, G. Douflé, A. Goffi, L. Del Sorbo, L. Brochard, N. Ferguson

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Treatment: Inspiratory Muscle Training

Brace et al., presented at ISICEM 2015
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