2013 ACS Critical Care Update
ARDS, Ventilators MCQs
August, 2013

(Berlin Definition of ARDS – Question 1)

The Berlin definition of Severe ARDS includes assessment of which of the following?

A. **Oxygenation: $PaO_2/FiO_2 \leq 100$ mmHg**
B. Minute Ventilation: $VE_{CORR} \geq 10$L/min
C. Radiographs: CXR with all 4 quadrants showing pulmonary edema
D. Ventilator pressures: $P_{plat} > 25$ cm H_2O
E. Compliance: $C_{RS} \leq 40$ mL/cm H_2O

Rationale: In 2011, an international task force was convened to update the prior American-European Consensus Conference (AECC) diagnostic criteria[1] for ARDS. The current "Berlin Definition"[2] discards the use of the term acute lung injury (ALI) and instead divides ARDS into Mild, Moderate, and Severe categories based on degree of hypoxemia (PaO_2/FIO_2 ratio ≤300 mm Hg, ≤200 mm Hg, and ≤100 mm Hg, respectively on PEEP or CPAP ≥ 5 cm H_2O). Additional elements incorporated into the final model include 1) timing of onset within 1 week of a known clinical insult or new or worsening respiratory symptoms, 2) chest imaging bilateral, opacities—not fully explained by effusions, lobar/lung collapse or nodules, 3) respiratory failure not fully explained by cardiac failure or fluid overload, with objective evaluation required in the absence of a known ARDS risk factor. The addition of additional higher PEEP, radiographic, compliance or dead space variables did not improve the validity of the construct over use of oxygenation alone.

1. Bernard GR, Artigas A, Brigham KL, et al. The American-European Consensus Conference on ARDS. Definitions, mechanisms, relevant outcomes, and clinical trial coordination. American journal of respiratory and critical care medicine 1994;149:818-24.
2. Ranieri VM, Rubenfeld GD, Thompson BT, et al. Acute respiratory distress syndrome: the Berlin Definition. JAMA : the journal of the American Medical Association 2012;307:2526-33.

(HFOV – Question 2)

Which of the following is not true regarding High Frequency Oscillatory Ventilation (HFOV)?

A. **Early initiation of HFOV in ARDS is associated with increased survival.**
B. Decreasing Hertz (decreasing frequency) will increase minute ventilation.
C. Improvements in oxygenation may be seen within six hours of therapy.
D. Sedation and neuromuscular blockade use are increased with HFOV.

Two recent prospective, randomized multicenter trials of HFOV in ARDS revealed no survival benefit and one demonstrated increased mortality. Vasopressor, sedative and neuromuscular blockade use were increased in the HFOV group. Given these data, at present, the role of HFOV in ARDS should be restricted to rescue situations. Oxygenation and ventilation are decoupled during HFOV. Oxygenation is dependent on mean airway pressure (mPaw) and inhaled oxygen concentration (FiO2). Ventilation is altered with frequency (inversely related to delivered tidal volume) and amplitude (power).

1. Ferguson ND, Cook DJ, Guyatt GH, et. al. for the OSCILLATE Trial investigators and the Canadian Critical Care Trials Group. High-Frequency Oscillation in Early Acute Respiratory Distress Syndrome. NEJM 2013 Feb 28; 368 (9): 795-805
2. Young D, Lamb S, Shah S, et. al. for the OSCAR Study Group. High-Frequency Oscillation for Acute Respiratory Distress Syndrome. NEJM, 2013 Feb 28; 368(9):806-13

(Prone Positioning – Question 3)

Prone Positioning in adult patients with ARDS is associated with:

A. Increased radiographic edema
B. Reduced pressure ulcer rates
C. Increased ventilator associated pneumonia rates
D. Reduced mortality in patients with severe hypoxemia

Prone positioning for ARDS attempts to improve shunt by redistributing blood flow away from areas of dependent atelectasis. Previous metaanalyses suggests that the subset of ARDS patients with severe hypoxemia ($PaO_2/FiO_2 \leq 100$ mmHg) ENREF 3[1,2] may have a mortality benefit with prone positioning, and the recent multicenter, prospective randomized PROSEVA trial demonstrated benefit in patients with early, severe ARDS[3]. Prone positioning has been associated with increased oxygenation, decreased rates of ventilator associated pneumonia, but also increased rates of pressure ulcer and sedation use.

1. Gattinoni L, Carlesso E, Taccone P, Polli F, Guerin C, Mancebo J. Prone positioning improves survival in severe ARDS: a pathophysiologic review and individual patient meta-analysis. Minerva anestesiologica 2010;76:448-54.
2. Sud S, Friedrich JO, Taccone P, et al. Prone ventilation reduces mortality in patients with acute respiratory failure and severe hypoxemia: systematic review and meta-analysis. Intensive care medicine 2010;36:585-99.
3. Guerin C, Reignier J, Richard J-C, et.al for the PROSEVA study group. Prone Positioning in Severe Acute Respiratory Distress Syndrome. NEJM 2013 368(23): 2159-68 June 6, 2013

(Early neuromuscular blockade in ARDS – Question 4)

The early use of cis-atracurium in severe ARDS is

A. Contraindicated in patients with diabetes
B. Associated with lower mortality in severe ARDS
C. May be facilitated by discontinuation of sedation
D. Required with rescue treatment (HFOV, prone positioning, ECMO)

The ACURASYS study reported 90-day mortality advantages (30/8% vs. 44.6%) and increased ventilator-free days following 48 hours of neuromuscular blockade versus placebo in early severe ARDS. The underlying mechanism of action is unknown, but is postulated to be related to increased ventilator synchrony and decreased ventilator induced lung injury early in the ARDS treatment course. Cis-atracurium provides neuromuscular blockade but no sedative properties; concurrent sedation is mandatory. In many cases, rescue therapy may be accomplished without full neuromuscular blockade. The authors reported no increased muscular weakness as assessed at day 28 or at the time of ICU discharge, however concerns for prolonged motor weakness, particularly in patients with elevated serum glucose or on concurrent steroid or aminoglycoside treatment, temper enthusiasm for these results and evaluation of the role of neuromuscular blockade in ARDS is ongoing.

1. Papazian L, Forel J-M, Gacouin A, et. al., for the ACURASYS Study Investigators. NEJM 2010; 363:1107-16

(Esophageal pressure monitoring, transpulmonary-pressure guided ventilator management in ARDS – Question 5)

A 56 year old man is admitted to the ICU with ARDS and sepsis following emergency colectomy for mesenteric ischemia. His height is 65 inches; his weight is 285 pounds. On lung protective ventilator settings, his:

Peak inspiratory pressure (PIP) is 35 cm H_2O
Plateau pressure (Pplat) is 30 cm H_2O
Mean airway pressure (Paw) is 20 cm H_2O
Esophageal balloon pressure (Pes) is 17 cm H_2O.

Transpulmonary pressure (Ptp) is estimated by the formula:

A. Paw-Pplat
B. PEEP-Pes
C. Pplat-Paw
D. Paw-Pes

Transpulmonary pressure reflects the pressure gradient across the lung opposing alveolar collapse is measured as the difference between alveolar pressure and intrapleural pressure. Clinically, alveolar pressure is estimated by airway pressure and intrapleural pressure is estimated by esophageal pressure. Conditions leading to elevated intrapleural pressure (abdominal compartment syndrome, alterations in chest wall compliance, obesity) may thus lead to negative transpulmonary pressure and favor alveolar collapse. A pilot trial of transpulmonary pressure-guided ventilator titration to achieve positive transpulmonary pressure in ARDS[1] demonstrated increased oxygenation and respiratory compliance, with a trend towards a mortality difference. Phase II trials of this individualized strategy are in progress.

1. Talmor D, Sarge T, Malhotra A, O'Donnell CR, Ritz R, Lisbon A, Novack V, Loring SH. "Mechanical Ventilation Guided by Esophageal Pressure in Acute Lung Injury", NEJM 2008; 359:2095-2104
2. EPVent 2- A Phase II Study of Mechanical Ventilation Directed by Transpulmonary Pressures (EPVent2), NCT01681225

(ECMO for adult ARDS – Question 6)

Which of the following is true regarding ECMO in adult patients with ARDS?

A. VA-ECMO is associated with decreased mortality compared to VV-ECMO
B. Anticoagulation is required but is not associated with increased complications
C. **Transfer to a specialized center with ECMO capability is associated with decreased mortality**
D. ECMO is contraindicated after ≥ 5 days of mechanical ventilation

Interest in ECMO support of severe ARDS has increased following reports of successful salvage of H1N1 patients and with advances in pump and oxygenator rechnology. The CESAR trial randomized 180 ARDS patients to best conventional expert treatment versus transfer to a specialized center with ECMO capabilities; significant reduction of six-month mortality was seen in the specialized center group[1]. A European multicenter trial is underway to assess these findings in early severe ARDS[2]. VV-ECMO is the preferred mode for support of acute respiratory failure. Bleeding events are responsible for the most serious complications on ECMO. ECMO support is most commonly considered within seven days of initiating mechanical ventilation, however, successful support is feasible after the initial time window.

1. Peak GJ, Mugfor M, Tiruvoipati R, Wilson A, et. Al, Efficacy and economic assessment of conventional ventilator support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR) a multicentre randomized controlled trial. Lancet 2009; 374:1351-63
2. ECMO to rescue Lung Injury in Severe ARDS (EOLIA) trial, NCT01470703