

# Acute Respiratory Distress Syndrome

CPT Megan Mahowald, MD



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# Learning Objectives

1. Conduct a differential diagnosis of ARDS in symptomatic patients.
2. Diagnose ARDS, utilizing current evidence-based criteria.
3. Describe evidence base treatments for ARDS to include lung-protective measures.
4. Develop collaborative care plans for ARDS survivors that offer supportive care, promoting optimal health and function.

FMX

# Audience Engagement System



FMX

## Outline:

- Epidemiology and history
- Definition and diagnostic criteria
- Clinical presentation and work-up
- Management
- Prevention
- Post-ARDS Survivors

“Edema of the lungs, with general asphyxia. Livid cyanosis with great dyspnea is the outstanding feature....A yellow serous fluid fills the air passages in such quantities that it may drip from the mouth of the living patient when the stretcher is tilted head downwards.”

c. 1915

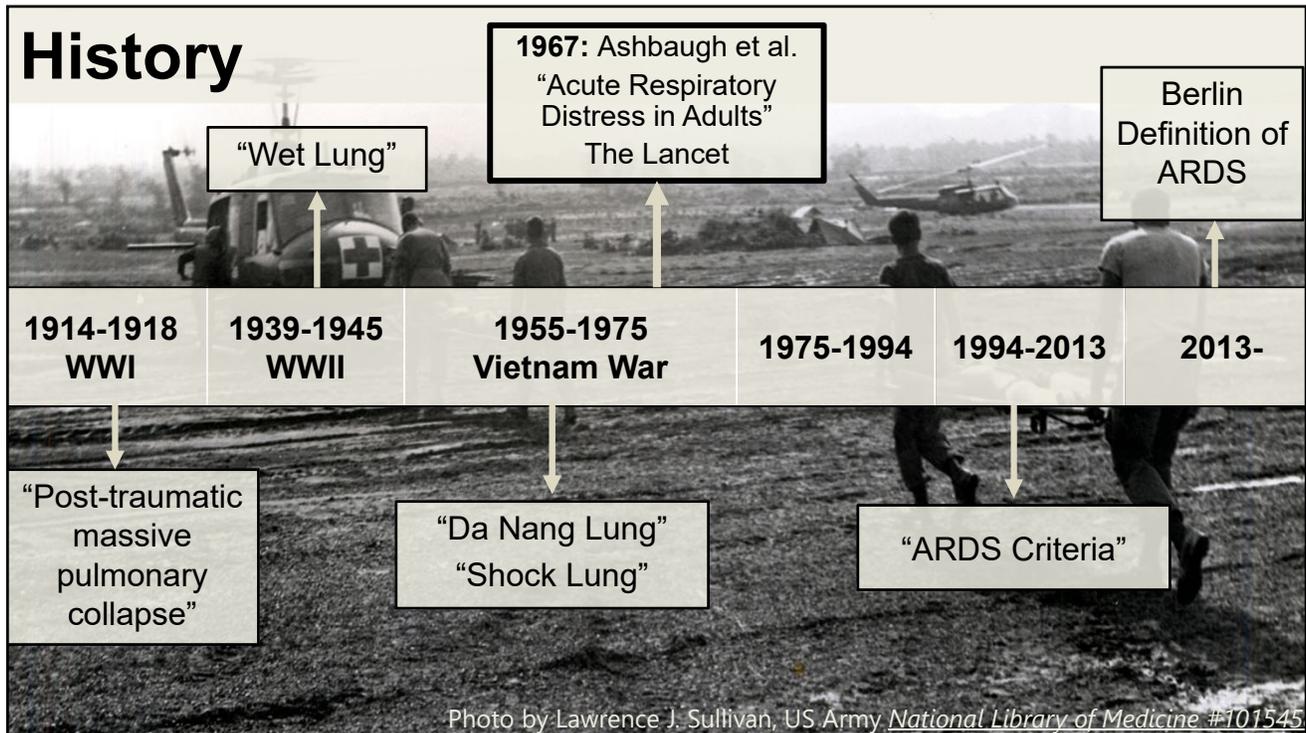
## AES Question 1:

Which of the following is true about acute respiratory distress syndrome (ARDS)?

- A. Estimated 40% in-hospital mortality
- B. Under-recognized condition with up to 40% of cases undiagnosed
- C. Most common cause of death during the 2009 H1N1 pandemic
- D. <50% of survivors return to work 12 months after discharge
- E. All of the above

## Epidemiology and Disease Burden:

- Represents about 10% of total ICU admissions
- Significant geographical variation
- **Under-recognized and under-treated**
- 40% in-hospital mortality
- High rates of cognitive dysfunction, prolonged psychiatric morbidity, and critical illness polyneuropathy in survivors



## Case One:

45 year-old male presenting to the ER complaining of fever, sore throat, and dry cough for the three days and progressive shortness of breath for 1 day.

His medical history is only notable for allergic rhinitis.

In triage, he is in obvious respiratory distress with peripheral cyanosis.

### Triage Vitals:

T 38°C, HR 120, BP 90/60 (M 70), RR 36, SpO2 54% on RA

## Case One:

His respiratory distress and hypoxia persists despite supplemental oxygen with 15L non-rebreather mask. He is intubated in the ER.

### His ventilator settings are:

PRVC Tv: 450 Rate: 24 PEEP 5 FiO<sub>2</sub> 80%

### ABG (30 minutes after intubation):

pH 7.30 PaCO<sub>2</sub> 55 PaO<sub>2</sub> 80

**POCUS:** hyperdynamic left ventricle



Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 35985

## AES Question 2:

**Vent:** PRVC Tv: 450 Rate: 24  
PEEP 5 FiO<sub>2</sub> 80%

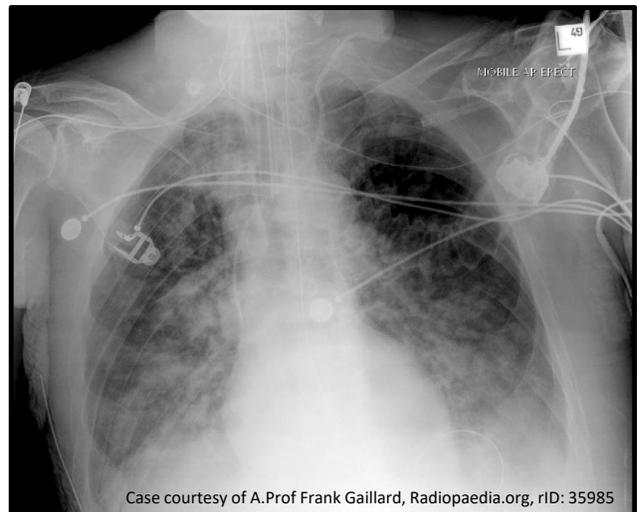
### ABG (30 minutes after intubation):

pH 7.30 PaCO<sub>2</sub> 55 PaO<sub>2</sub> 80

**POCUS:** hyperdynamic LV

### Does he have ARDS?

- A. Yes
- B. No
- C. Not enough information



Case courtesy of A.Prof Frank Gaillard, Radiopaedia.org, rID: 35985

# Acute Respiratory Distress Syndrome (ARDS)

*“The clinical pattern...includes severe dyspnoea, tachypnoea, cyanosis that is refractory to oxygen therapy, loss of lung compliance, and a diffuse alveolar infiltrate seen on chest X-ray.”*

Acute Respiratory Distress in Adults  
Ashbaugh et al. 1967

## Berlin Definition

- Onset within 7 days of a known clinical insult or new or worsening respiratory symptoms
- Respiratory failure cannot *fully* be explained by cardiac failure or fluid overload
- Bilateral opacities consistent with pulmonary edema on chest x-ray or chest CT
- Minimum PEEP setting or CPAP, 5 cm of water

## Berlin Definition

Categorization of severity:

Mild	$\text{PaO}_2:\text{FiO}_2$ 201-300 mm Hg
Moderate	$\text{PaO}_2:\text{FiO}_2$ 101-200 mm Hg
Severe	$\text{PaO}_2:\text{FiO}_2 \leq 100$ mm Hg

## Risk Factors:

Direct Lung Injury:

- Pneumonia\*
- Aspiration\*
- Pulmonary contusion
- Inhalation injury
- Near-drowning

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### Direct Lung Injury:

- Pneumonia\*
- Aspiration\*
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### Indirect Lung Injury:

- Sepsis (non-pulmonary)\*
- Non-thoracic trauma/Hemorrhagic shock
- Pancreatitis
- Major burn injury
- Drug overdose
- Transfusion of blood products

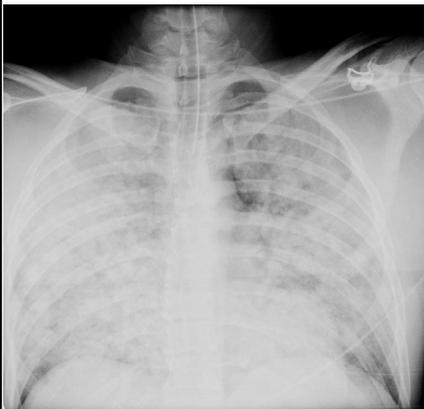
## Clinical Presentation: *History and Physical*

- Usually occurs within 6-72 hours of inciting event
- Complaint: Dyspnea
- Acute distress, tachypneic with diffuse crackles on lung exam, use of accessory muscles

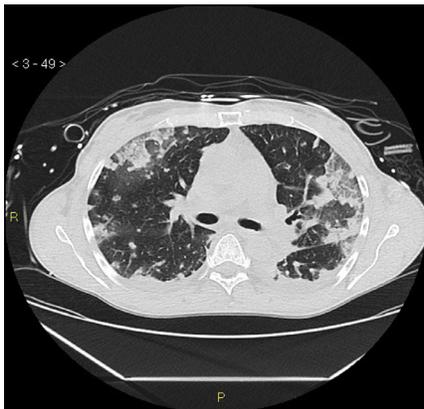
## Clinical Presentation: *Labs*

- ABG – hypoxemia with acute respiratory alkalosis

## Clinical Presentation: *Imaging*



Case courtesy of Dr Alexandra Stanislavsky,  
Radiopaedia.org, rID: 16868



Case courtesy of Dr Sajoscha Sorrentino,  
Radiopaedia.org, rID: 16290

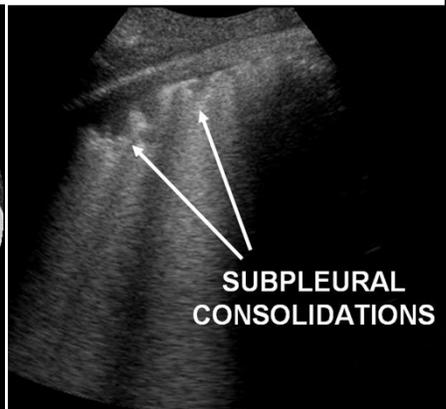


Image courtesy of Copetti et al.  
<https://doi.org/10.1186/1476-7120-6-16>

## Differential:

- Congestive heart failure
- Interstitial lung diseases
- Connective-tissue diseases
- Diffuse alveolar hemorrhage
- Sympathetic crashing acute pulmonary edema (SCAPE)
- Drug-induced lung disease
- Cancer
- Endobronchial tuberculosis
- Hemophagocytic lymphohistiocytosis

## AES Question 3:

The patient is brought up to the ICU. His rapid viral panel is positive for H1N1. His labs are otherwise unremarkable.

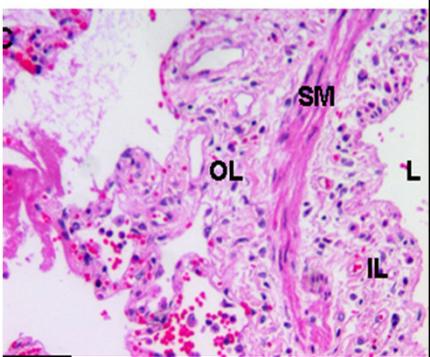
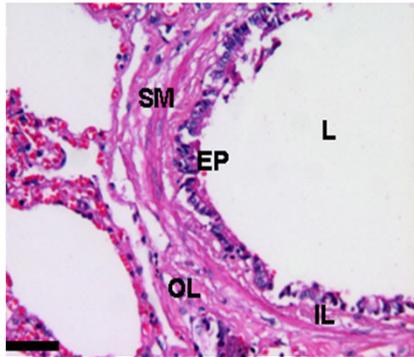
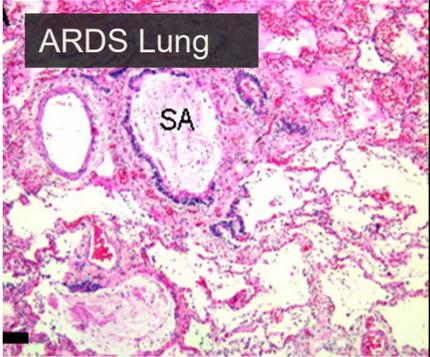
Which of the following is an appropriate ventilatory management strategy for this patient?

- Limit tidal volumes to 4-8 cc/kg of ideal body weight
- Limit tidal volumes to 4-8 cc/kg of actual body weight
- Allow patient to pull whatever tidal volumes he needs with a pressure support mode of ventilation
- Start with low tidal volumes (4-8 cc/kg), but allow volumes up to 15 cc/kg if required to prevent double-triggering

# Management of ARDS

## Pathophysiology

Image courtesy of Morales et al. *Critical Care* 2011;15:R4 <https://doi.org/10.1186/cc9401>



## *Pathophysiology*

### **Exudative Phase**

7-10 days

Lung's initial  
response to injury

### **Proliferative Phase**

2-3 weeks?

Repair process with  
resolution of  
pulmonary edema

### **Fibrotic Phase\***

Chronic

Obliteration of  
normal lung  
architecture

## **Management of ARDS:**

- Treat the underlying cause
- **Supportive care**
  - Manage hypoxia
  - Prevent further tissue damage
- Evaluate need for higher level of care

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  - Prevent further tissue damage
- Evaluate need for higher level of care

No pharmacologic therapy exists for treatment of ARDS

## Fundamentals of Management:

### Oxygenation Goals:

- Target  $P_{aO_2}$  55-80 or  $SpO_2$  88-95%
- Use the *lowest*  $FiO_2$  possible to maintain adequate oxygenation

### Carbon Dioxide Goals:

- Allow for permissive hypercapnia and permissive respiratory acidosis
  - $P_{aCO_2} < 50$  mmHg and/or  $pH \geq 7.20$  if tolerated

## Management of ARDS:

### Strategies that improve outcomes

## Low Tidal Volume

### Recommendation:

- Adult patients with ARDS should receive mechanical ventilation with strategies that *limit* tidal volumes (4-8 cc/kg IBW) and inspiratory pressures ( $P_{\text{plat}} < 30 \text{ cm H}_2\text{O}$ ). [SOR A/LOE 1]

### Patient-Oriented Outcome:

- Reduction in mortality

Evidence: ARDSNet Group

## Low Tidal Volume

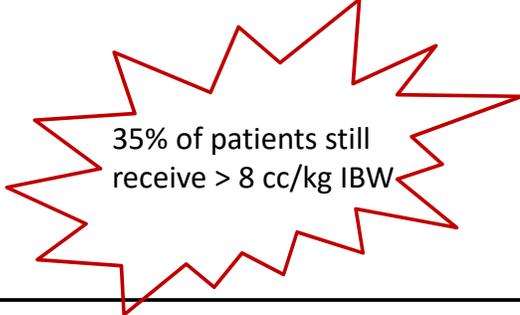
### Recommendation:

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### Patient-Oriented Outcome:

- Reduction in mortality

Evidence: ARDSNet Group



35% of patients still  
receive > 8 cc/kg IBW

## High PEEP

### Recommendation:

- Adults with moderate-to-severe ARDS receive higher rather than lower levels of PEEP. [SOR C/LOE 2]

### Patient-Oriented Outcome:

- Shortened duration of mechanical ventilation

Evidence: ALVEOLI trial, LOV trial, ExPRESS trial

## Prone Positioning

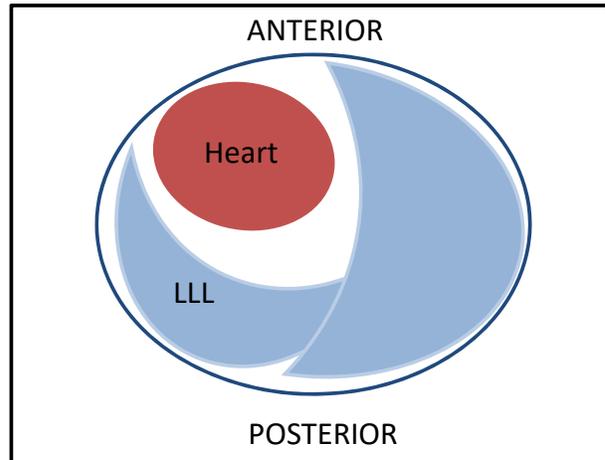
### Recommendation:

- Adult patients with severe ARDS should receive prone positioning for  $\geq 12$  hours per day. [SOR A/LOE 2]

### Patient-Oriented Outcome:

- Reduction in mortality

Evidence: PROSEVA trial



## Prone Positioning

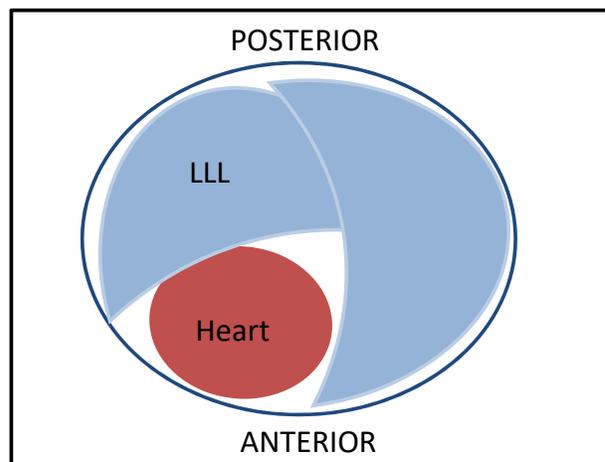
### Recommendation:

- Adult patients with severe ARDS should receive prone positioning for  $\geq 12$  hours per day. [SOR A/LOE 2]

### Patient-Oriented Outcome:

- Reduction in mortality

Evidence: PROSEVA trial



## Conservative Fluid Management

### Recommendation:

- A conservative fluid-management strategy is recommended [SOR C/LOE 2]

### Patient-Oriented Outcome:

- Shortened duration of mechanical ventilation

Evidence: FACTT trial

### **AES Question 4:**

The patient has been in the ICU for 12 hours. He continues to have severe hypoxia ( $\text{PaO}_2:\text{FiO}_2 < 100$ ) despite prone positioning and high PEEP. He is frequently dyssynchronous with the ventilator.

Which of the following is an appropriate next step in management?

- Call regional ECMO center for evaluation for ECMO cannulation
- Consider neuromuscular blockade to improve ventilator synchrony
- Change to APRV/BiLevel/Bi-Vent ventilation mode
- Try regular recruitment maneuvers followed by decremental PEEP trial
- Any of the above

## Management of ARDS:

### Strategies that *might* improve outcomes

### Strategies that *might* improve outcomes

- Neuromuscular blockage
- BiVent/APRV/Bi-Level
- Open Lung Ventilation
- Extracorporeal Membrane Oxygenation (ECMO)

## Neuromuscular Blockade:

### Concept:

Lung-protective ventilation is paramount in management of ARDS. Patient-ventilator dyssynchrony can lead to breath stacking which increases the risk for ventilator-induced lung injury and barotrauma. Muscle paralysis eliminates ventilator dyssynchrony and minimizes muscle oxygen consumption.

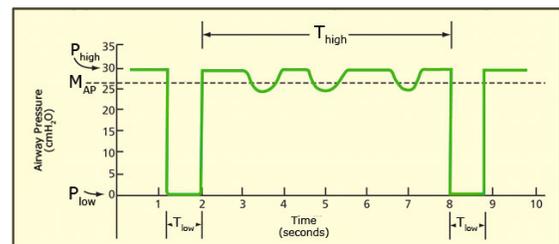
### Evidence:

ACURASYS Trial (2010): improved 90-day mortality in cisatracurium arm  
ROSE Trial (2019): Stopped early for futility. No difference in mortality.

## BiLevel/APRV/Bi-Vent:

### Concept:

Continuous positive airway pressure with brief expiratory intervals. Increased airway pressure contributes to lung recruitment. This *spontaneous* mode of ventilation improves ventilator synchrony and decreases need for sedation/paralysis.



By Je.rtt (Own) [via <https://www.thebottomline.org.uk/summaries/icm/bilevel-aprv/>]

### Evidence:

Bi-Level-APRV Trial (2017): better oxygenation, less sedation, fewer days of mechanical ventilation, shorter ICU stay

## Open Lung Ventilation:

### Concept:

Recruitment maneuvers (RM) transiently increase transpulmonary pressure in an attempt to open previously collapsed alveoli.

### Evidence:

Open Lung Approach for ARDS (2016):

-Improved oxygenation with no adverse effects

ART trial (2017):

-Increased mortality with RM and high PEEP

## Extracorporeal Membrane Oxygenation (ECMO):

### Concept:

- Venovenous ECMO provides oxygenation and carbon dioxide removal, allowing for lung rest and reduction in ventilator-induced lung injury
- Murray Score for ECMO referral

### Evidence:

CESAR Trial (2009): Absolute mortality reduction in ECMO arm

EOLIA (2018): Stopped early for futility. No change in mortality.

## Management of ARDS:

### What does NOT work

### What does NOT work

- High frequency oscillatory ventilation
- Surfactant replacement
- Neutrophil elastase inhibition
- Systemic anticoagulation
- Ketoconazole
- Lisofylline
- Activated protein C
- Statins
- B<sub>2</sub>-agonists
- Antioxidants
- Aspirin
- Steroids (controversial)
- Inhaled vasodilators
- *N*-acetyl-cysteine

## Management of ARDS for the Family Physician

Recognize ARDS in a patient with acute respiratory distress/failure (Berlin Criteria)

Treat underlying cause (if possible)

Utilize lung protective ventilation with low Tv/High PEEP (Tv 4-8 cc/kg IBW)

Restrictive fluid approach  
Dry lungs = happy lungs

## Management of ARDS for the Family Physician

Recognize ARDS in a patient with acute respiratory distress/failure (Berlin Criteria)

Treat underlying cause (if possible)

Utilize lung protective ventilation with low Tv/High PEEP (Tv 4-8 cc/kg IBW)

Restrictive fluid approach  
Dry lungs = happy lungs

Early referral to higher level of care

Consider neuromuscular blockade prior to transport if severe ventilator dyssynchrony and persistent hypoxia

## Prevention of ARDS

### **AES Question 5:**

**Which of the following is likely an effective strategy for primary prevention of ARDS?**

- A. Administration of pneumococcal and seasonal influenza vaccines
- B. Administration of aspirin to all hospitalized patients
- C. Encouraging hospitalized patients to lay flat while sleeping
- D. Institution of daily lung injury prevention checklist for all mechanically ventilated patients

## **Prevention:**

### 1° Prevention

- Vaccinations for prevention of influenza and pneumococcal pneumonia
- Aspiration precautions in hospitalized patients

### 2° Prevention – Identifying At-Risk Patients

- Lung Injury Prevention Score (LIPS)
- Early Acute Lung Injury score (EALI)
- Surgical Lung Injury Prediction (SLIP)
- Biomarkers (theoretical)

## **Prevention:**

### 2° Prevention – Limiting Iatrogenic Injury in At-Risk Patients

- Goal to mitigate “second hit”
- Restrictive transfusion practice, timely treatment of sepsis, lung-protective mechanical ventilation, fluid-conservative resuscitation, prevention of new aspiration events
- Creation of institutional “Best Practices Bundles”

## ARDS Survivors

### Post-hospitalization:

#### Pulmonary Function:

- Most return to normal or near-normal physiology and function
- Pulmonary function testing may have a persistent, mild diffusion defect

#### Physical Impairments:

- Critical illness polyneuropathy, critical illness myopathy, entrapment neuropathy, contractures, tracheal stenosis, heterotopic ossification, tooth loss, scars from invasive procedures

## Post-hospitalization:

### Cognitive Impairments:

- Affects a wide variety of of cognitive domains including attention, visual-spatial abilities, declarative memory, and executive function
- Impairments persist > 5 years in 20% of patients

### Mood disturbances:

- 2/3 of patients will have substantial symptoms
- Over half of survivors have prolonged psychiatric morbidity (>12 months)

## Caregiver and Family Burden:

57% of ICU survivors who receive long-term mechanical ventilation still require assistance of a family caregiver *one year* after their critical illness

- Many caregivers suffer from anxiety, depression, and/or PTSD
- Caregiver burnout may compromise rehabilitation of survivors
- Preliminary programs to train and educate family members are currently being developed

## **PRACTICE RECOMMENDATIONS**

*ARDS is common condition, but is under-diagnosed and under-treated*

- Consider ARDS in any patient with hypoxic respiratory failure and bilateral pulmonary infiltrates
- Patients with ARDS should receive mechanical ventilation with strategies that *limit* tidal volumes (4-8 cc/kg IBW) and inspiratory pressures (SOR A/LOE 1)
- Consider using high PEEP strategies for patients with moderate or severe ARDS (SOR B/LOE 3)

## **PRACTICE RECOMMENDATIONS**

*ARDS is common condition, but is under-diagnosed and under-treated*

- Adult patients with severe ARDS should receive prone positioning for  $\geq 12$  hours per day. [SOR A/LOE 2]
- Pneumococcal and seasonal influenza vaccinations are the primary form of primary prevention for ARDS (SOR C/LOE 3)
- Patients who survive ARDS are at high risk for physical, cognitive, and psychologic disturbances that may persist for years after discharge. Recognition, evaluation, and appropriate management may improve long-term outcomes and quality of life (SOR C/LOE 3)

# Questions



**FMX**

## Resources:

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# Resources:

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17. Alveolar Recruitment for Acute Respiratory Distress Syndrome Trial (ART) Investigators, Effect of Lung Recruitment and Titrated Positive End-Expiratory Pressure (PEEP) vs Low PEEP on Mortality in Patients With Acute Respiratory Distress Syndrome, *JAMA*. 2017;318(14):1335-1345

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