# Acute respiratory distress syndrome in adults

## TERMINOLOGY

### CLINICAL CLARIFICATION
- Acute respiratory distress syndrome is severe and often fatal acute respiratory failure; characterized by diffuse inflammatory lung injury rapidly progressing to increased pulmonary vascular permeability, increased lung weight, and hypoxemia [1]
- Preceded by a clinical insult—usually pneumonia, nonpulmonary sepsis, or trauma
- Berlin definition of acute respiratory distress syndrome includes presence of all following criteria: [2]
  - Timing of acute onset of symptoms (or worsening of nonacute symptoms) within 1 week of a known clinical insult [2]
  - Hypoxemia as shown by the $PaO_2$ to $FIO_2$ ratio of 300 mm Hg or less with PEEP or CPAP of 5 cm $H_2O$ or greater [2]
  - Chest imaging showing bilateral opacities that are not explained by effusions, atelectasis, or nodules, and are not cardiogenic in nature [2]
  - Respiratory failure or pulmonary edema not fully explained by cardiac failure or fluid overload [2]

### CLASSIFICATION
- Under conventional mechanical ventilation, the following apply: [2]
  - The 3 categories of acute respiratory distress syndrome are based on degree of hypoxemia, as follows:
    - Mild: 200 mm Hg < $PaO_2/FIO_2$ ≤ 300 mm Hg [2]
    - Moderate: 100 mm Hg < $PaO_2/FIO_2$ ≤ 200 mm Hg [2]
    - Severe: $PaO_2/FIO_2$ ≤ 100 mm Hg [2]
  - A minimum PEEP of 5 cm $H_2O$ is required to make the severity classification; it may be delivered noninvasively with CPAP to classify mild cases [2]

## DIAGNOSIS

### CLINICAL PRESENTATION
- History
  - Recent known clinical insult (usually within 3 days and nearly always within 7 days) or new or worsening respiratory symptoms [2]
  - Symptoms may vary in severity, with some being mild initially; all worsen over a period of several hours
    - Dyspnea
    - Cough
    - Chest discomfort
    - Anxiety
  - With vaping-related lung injury, some patients report nonspecific gastrointestinal symptoms [3]
    - Nausea, vomiting, diarrhea, and abdominal pain
- Physical examination
  - Cyanosis may be evident
  - Tachypnea at rest
  - Tachycardia at rest
  - Hypotension is often present
  - Fever may or may not be present, depending on the presence of infection as an underlying cause
  - Use of accessory muscles of respiration (usually indicates moderate to severe disease)
  - Coarse crepitations of both lungs at presentation
  - Cold, mottled extremities with prolonged capillary refill time (longer than 2 seconds) indicates ineffective circulation [4]

### CAUSES AND RISK FACTORS
- Causes
  - Direct alveolar injury
    - Pneumonia
    - Aspiration of gastric contents
    - Noxious inhalation (eg, chlorine, high oxygen)
  - Indirect alveolar injury
    - Sepsis (nonpulmonary origin)
    - Trauma
    - Multiple blood transfusions
    - Drug reaction (eg, nitrofurantoin) or overdose (eg, opiates)
    - Cardiopulmonary bypass
    - Burns
    - Acute pancreatitis

- Vaping-related injury[3]
    - Cause is unknown; association with vaping is evident
- Risk factors and/or associations
    - Age
        - May occur at any age
        - In trauma patients, progressive increase in risk up to ages 60 through 69, with declining risk thereafter[5]
        - In vaping-related pulmonary disease, most patients are aged 18 to 34 years[6]
    - Sex
        - In trauma patients, females are at increased risk[7]
    - Genetics
    - Ethnicity/race
        - Mortality rates are higher for black people than for white people in broad epidemiologic studies[8]
        - When limited to national trauma data:[9]
            - Black race is protective (ie, lower incidence of acute respiratory distress syndrome)
            - Hispanic ethnicity is associated with increased acute respiratory distress syndrome–associated mortality
    - Other risk factors/associations
        - Chronic alcohol abuse

## DIAGNOSTIC PROCEDURES
- Primary diagnostic tools
    - Use history, physical examination findings, arterial blood gas measurements, and imaging studies to diagnose according to Berlin definition[2]
        - Imaging includes chest radiography and, in some patients, other modes, such as echocardiography (to exclude cardiogenic pulmonary edema) or CT[2]
    - Early stages can be difficult to differentiate from cardiogenic pulmonary edema, possibly resulting in delay of critical interventions[10]
    - Vaping-related lung injury criteria per CDC[3, 6]
- Laboratory
    - Arterial blood gas measurement[2]
        - Indicated for diagnosis and ongoing monitoring of all patients in whom the syndrome is suspected
        - Findings include:
            - Varying degrees of hypoxemia
            - Respiratory acidosis with hypercapnia (common finding)
            - Widened alveolar-arterial gradient
        - $PaO_2$ to $FIO_2$ ratio is used to assess severity, as follows:[2]
            - Mild: 200 mm Hg < $PaO_2/FIO_2$ ≤ 300 mm Hg[2]
            - Moderate: 100 mm Hg < $PaO_2/FIO_2$ ≤ 200 mm Hg[2]
            - Severe: $PaO_2/FIO_2$ ≤ 100 mm Hg[2]
    - Additional laboratory tests are indicated to identify the underlying cause, if unknown
- Imaging
    - Chest radiography
        - Indicated for diagnosis and ongoing monitoring of all patients in whom acute respiratory distress syndrome is suspected[2]
            - Within first few hours of precipitating event, lungs may appear normal[2]
            - Within 24 hours, bilateral airspace opacities are usually evident[2]
            - In severe acute respiratory distress syndrome, airspace opacities are commonly present in 3 or 4 lung quadrants[2]
    - CT
        - Useful for determining root cause of respiratory symptoms in some cases (eg, cancer, chronic interstitial lung diseases, edema)[2]
            - Widespread patchy or coalescent airspace opacities are consistent with acute respiratory distress syndrome
            - Consider risk versus benefit of moving a critically ill patient for CT scan
    - Echocardiography[2]
        - Objective aid to clinical judgment for excluding cardiogenic pulmonary edema; however, cardiogenic and noncardiogenic pulmonary edema can coexist

## DIFFERENTIAL DIAGNOSIS

- Most common
  - Cardiogenic pulmonary edema
    - Clinical indicators
      - Abnormal findings on cardiac examination
        - Third heart sound ($S_3$ gallop)
        - Heart murmurs
        - Irregular heart rate
        - Displaced point of maximum impulse of heart
        - Elevated jugular venous pressure
      - Radiographic abnormalities may overlap with the findings of acute respiratory distress syndrome; abnormalities include:
        - Pulmonary venous congestion
        - Kerley B lines
        - Cardiomegaly
        - Pleural effusions
    - Differentiating features
      - Echocardiography with findings of cardiac dysfunction favors cardiogenic pulmonary edema
      - Plasma brain natriuretic peptide level less than 100 pg/mL favors acute respiratory distress syndrome [11, 12]
  - Viral or bacterial pneumonitis
    - Clinical indicators
      - Upper respiratory symptoms may precede illness
      - Fever is likely
    - Differentiating features
      - History, physical examination, and diagnostic test findings will not meet the Berlin definition [2]
      - Sputum microscopy, culture, and/or rapid antigen detection suggest infection
      - Bronchoalveolar lavage with suggestive cytologic changes favors viral pneumonitis
    - In addition to being a possible differential diagnosis, pneumonia is also the most frequent lung condition leading to acute respiratory distress syndrome
- Less common
  - Chronic interstitial lung diseases (eg, idiopathic pulmonary fibrosis, occupational lung diseases, autoimmune diseases)
    - Clinical indicators
      - Dyspnea and cough slowly progressing over months or years, caused by diffuse alveolar damage
        - However, chronic interstitial lung diseases may sometimes worsen rapidly, mimicking acute respiratory distress syndrome
      - Associated signs/symptoms of the underlying disease (eg, arthralgias or arthritis in autoimmune disease)
      - Early radiographs may reveal subpleural reticular changes mixed with alveolar opacities
    - Differentiating features
      - Slower, progressive onset
      - Will not meet the Berlin definition [2]
      - CT scan may suggest the diagnosis
      - Lung tissue biopsy confirms diagnosis
  - Acute interstitial pneumonitis
    - Clinical indicators
      - Rapid onset of respiratory failure, which clinically mimics acute respiratory distress syndrome symptomatically and radiologically, but for which no precipitating factor is identified
    - Differentiating features
      - Difficult to differentiate; can be thought of as idiopathic acute respiratory distress syndrome
  - Malignancy
    - Clinical indicators
      - Rapid, progressive cancer disseminating throughout the lungs may have a presentation similar to that of acute respiratory distress syndrome
      - Usually lymphoma or acute leukemia
    - Differentiating features
      - Will not meet the Berlin definition [2]
      - Bronchoalveolar lavage may reveal malignant cells

- Diffuse alveolar hemorrhage
  - Clinical indicators
    - Syndrome presenting with hemoptysis (two-thirds of patients) evolving over days to weeks with progressive anemia, diffuse alveolar infiltrates, and hypoxemic respiratory failure
    - Most commonly associated with underlying connective tissue disorder and less commonly with toxin inhalation or drug reaction
  - Differentiating features
    - Often requires serial bronchoalveolar lavage for diagnosis because symptoms and imaging findings are nonspecific
      - Hemoptysis is absent in one-third of patients and those patients may be indistinguishable from patients with acute respiratory distress syndrome
      - Intra-alveolar RBCs appear in lavage fluid in increasing numbers, with hemosiderin-laden macrophages appearing within 48 to 72 hours
      - CBC shows progressive anemia

## TREATMENT

### GOALS
- Maintain oxygenation via mechanical ventilation with adjustments of $FiO_2$ and PEEP; ARDS Network goal is $PaO_2$ of 55 to 80 mm Hg or $SpO_2$ of 88% to 95%[13]
- Avoid ventilator-induced lung damage by using protective (ie, volume-limited and/or pressure-limited) ventilator settings
- Maintain a neutral or net-negative fluid balance in hemodynamically stable patients
  - Central venous pressure goal of 4 to 8 mm Hg[14]
  - Urine output of more than 0.5 mL/kg[14]
  - Adequate cardiac output[14]
- Identify and treat or reverse the underlying cause

### DISPOSITION
- Admission criteria
  - Criteria for ICU admission
    - All patients in whom acute respiratory distress syndrome is either confirmed or suspected
- Recommendations for specialist referral
  - Refer to pulmonologist or critical care specialist for ventilator management
  - Consult infectious disease specialist if infection is suspected

### TREATMENT OPTIONS
- Mainstay of treatment is supportive care in an ICU setting
  - Mechanical ventilation using PEEP and a lung-protective strategy of either low-tidal-volume ventilation or low-pressure ventilation[15, 16]
    - Minority of patients may be managed with noninvasive delivery high $FiO_2$ (ie, humidified high-flow nasal cannula)[14, 17]
  - Prone positioning improves mortality in severe cases and should be used as an up-front management strategy rather than as a rescue effort[18, 19, 20]
  - For refractory hypoxemia, extracorporeal membrane oxygenation is a reasonable adjunctive therapy when used as a bridge therapy to lung recovery, but a survival advantage has not yet been determined[21, 22]
  - Deep sedation to decrease oxygen consumption[23]
    - Addition of neuromuscular blockade during mechanical ventilation requires more study, but could be considered for moderate to severe acute respiratory distress syndrome (resulted in a mortality benefit in a clinical trial)
  - Conservative fluid management results in more ventilator-free days and fewer days in the ICU compared with liberal fluid management[24, 25]
    - Fluid management strategies include use of IV crystalloids, vasopressors (eg, norepinephrine), inotropes (eg, dobutamine), and diuretics (eg, furosemide) to maintain effective tissue perfusion
    - In some cases it may be reasonable to combine a liberal strategy (ie, for resuscitation early in course of disease) with a conservative strategy (ie, later in course of disease)[24]
    - Pulmonary artery catheter–guided fluid management is associated with more complications than central venous catheter–guided management and does not improve outcomes; a pulmonary artery catheter should not be routinely used[26]
  - Other supportive care, including nutrition and prophylaxis of expected medical complications (eg, deep venous thrombosis, stress ulcers)
  - Corticosteroid therapy has been reported in many cases to be useful in vaping-related lung injury, but no standardized recommendations exist for treatment[6, 3]

- Drug therapy
  - There are no effective pharmaceutical treatments specifically for acute respiratory distress syndrome [27, 16]
  - Pharmaceutical interventions should be aimed at: [28, 29]
    - Treating root causes (eg, antibiotics for sepsis or bacterial pneumonia)
    - If indicated, maintaining blood pressure and effective tissue perfusion and oxygenation (eg, pressors, inotropes, diuretics)
- Nondrug and supportive care
  - Prone positioning
    - General explanation
      - Prone position for severe cases during conventional mechanical ventilation provides significant survival benefit in meta-analyses, although pressure ulcers and airway problems are increased [20, 19, 30]
      - May be especially helpful in subpopulation of patients who are already receiving low-tidal-volume ventilation without improvement
      - Outcomes are best when used in combination with low-tidal-volume ventilation (6 mL/kg) and neuromuscular blockade [20]
      - Prone position is maintained for at least 16 hours per day [20]
      - 2017 American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine clinical practice guideline recommends prone positioning for more than 12 hours per day in severe acute respiratory distress syndrome [31]
      - Contraindications include facial/neck trauma, spinal instability, recent sternotomy, large ventral surface burn, elevated intracranial pressure, large volume hemoptysis, and high risk for requiring cardiopulmonary resuscitation or defibrillation [20]
    - Indication
      - Patients with severe acute respiratory distress syndrome who do not improve with lung-protective ventilator strategies
  - Careful fluid management
    - Includes optimal use of IV crystalloids (ie, fluid boluses and maintenance IV fluid infusions), use of vasopressors (eg, dobutamine), and use of diuretics (eg, furosemide) to maintain effective central and peripheral tissue perfusion and oxygenation
    - Various strategies have been studied and are loosely categorized as *conservative* (aiming for a lower intravascular pressure and resulting in lower positive cumulative fluid balance) or *liberal* (aiming for a higher intravascular pressure and resulting in higher positive cumulative fluid balance) [25, 24]
    - Research-based fluid management protocols for each of these strategies are complex and take into account the goal intravascular pressure (eg, low versus high as measured by central venous pressure or pulmonary artery wedge pressure), mean arterial pressure, urine output, and evidence of adequate peripheral tissue perfusion [32]
      - Details of management used in research studies (including a protocol algorithm) [4] are available from the NIH/National Heart Lung and Blood Institute Acute Respiratory Distress Syndrome Network [32]
      - Conservative fluid management results in more ventilator-free days and fewer days in the ICU, compared to liberal fluid management [25]
        - Recent study included 3 levels of fluid management: [25]
          - Conservative (cumulative fluid balance – 136 mL) [25]
          - Simplified/conservative (cumulative fluid balance + 1913 mL) [25]
          - Liberal (cumulative fluid balance + 6992 mL) [25]
      - Simplified/conservative strategy was considered a safe and effective alternative to a conservative strategy, and both appeared preferable to a liberal fluid strategy [25]
  - Other supportive care
    - Nutritional support [33]
      - Initiate nutritional support within 24 to 48 hours after intubation
      - Enteral feeding (either gastric or small-bowel) is preferred over total parenteral nutrition when the gastrointestinal tract is functional, owing to fewer complications (eg, infection)
      - No difference in 6- to 12-month outcomes (eg, physical function, survival, multiple secondary outcomes) with initial trophic (small-volume) versus full enteral feeding [34]
      - Polymeric formula is preferred; fluid-restricted formulas are available
      - Withhold enteral feedings if patients are hypotensive
    - Deep vein thrombosis prophylaxis using pharmacologic agents according to established clinical practice guidelines [35]
    - Gastrointestinal bleeding prophylaxis for all patients receiving mechanical ventilation has traditionally been advised, but a recent meta-analysis suggested a possible increased risk of pneumonia when given to patients receiving enteral nutrition [36, 37]

- Procedures
  - Conventional mechanical ventilation using lung-protective strategy
    - General explanation
    - Lung-protective strategies include low-tidal-volume ventilation and/or low-pressure ventilation
      - Decreased mortality at 28 days, but evidence is insufficient regarding long-term morbidity and quality of life after protective strategy versus conventional strategy [15]
      - 2017 American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine clinical practice guideline recommends mechanical ventilation using lower tidal volumes (4-8 mL/kg predicted body weight) and lower inspiratory pressures (plateau pressure less than 30 cm $H_2O$) [31]
      - Scandinavian guidelines on mechanical ventilation for acute respiratory distress syndrome recommend use of either low-volume or low-pressure strategy [38]
      - Cochrane review found insufficient evidence to confirm or refute any advantage with low-tidal-volume ventilation as compared with low-pressure ventilation [39]
      - Low-tidal-volume ventilation
        - Tidal volume of about 6 mL/kg (predicted body weight) is considered low volume, in comparison to usual 8 to 15 mL/kg [40]
        - Predicted body weight is about 20% lower than measured body weight and is calculated as:
          - Males (in kg): 50 + 0.91 (height, 152.4 cm) [41]
          - Females (in kg): 45.5 + 0.91 (height, 152.4 cm) [41]
        - 6 mL/kg volume is recommended by international guidelines for management of patients who develop acute respiratory distress syndrome due to sepsis [40]
        - Permissive hypercapnia (which usually accompanies lower tidal volumes) is considered safe and is associated with improved outcomes; ARDS Network goal is pH of 7.3 to 7.45, but many authors advocate allowing pH as low as 7.2 [13, 42]

## Mechanical ventilation goals in acute respiratory distress syndrome.

| Tidal volume | 4-6 mL/kg of ideal body weight |
| --- | --- |
| Plateau pressure | Ideally less than 30 cm $H_2O$ but lower may be better |
| pH, respiratory rate, minute ventilation | Depends on patient comorbidities but pH of 7.2 is widely accepted as acceptable permissive hypercapnia; lower may also be acceptable |
| PEEP | Unknown; higher may be better for severe ARDS |
| FiO2 | Unknown; titration based on PEEP to $FiO_2$ table is appropriate |

From Przybysz TM et al: Early treatment of severe acute respiratory distress syndrome. Emerg Med Clin North Am. 34(1):1-14, 2016, Table 7.

- Low-pressure ventilation [15]
  - Plateau pressure 30 cm $H_2O$ or less [15]
- Other evidence-based ventilation strategies
  - Use PEEP to improve oxygenation and prevent atelectasis [38]
    - Set PEEP for at least 5 cm $H_2O$; higher may be better [38]
      - Improves oxygenation; mortality benefit of higher PEEP is limited to patients with more severe acute respiratory distress syndrome [43]
      - 2017 American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine clinical practice guideline recommends higher PEEP in patients with moderate or severe acute respiratory distress syndrome [31]
      - No significant increase in the risk of barotrauma with higher PEEP [43]
  - Consider using recruitment maneuvers to keep all alveoli open (or to open previously collapsed alveoli) in refractory hypoxemia [38]
    - 2017 American Thoracic Society/European Society of Intensive Care Medicine/Society of Critical Care Medicine clinical practice guideline recommends recruitment maneuvers in patients with moderate or severe acute respiratory distress syndrome [31]
    - Brief intervals (eg, 40 seconds) of increased airway pressure (eg, 40 cm $H_2O$) may increase oxygenation; however, there is risk for overdistention and consequent shunting [41]
  - Sedation to improve mechanical ventilation tolerance and decrease oxygen requirements [41]
  - Neuromuscular blockade for 48 hours early in the course of severe cases improves 90-day mortality and increases the time off the ventilator without increasing muscle weakness [23]
- NIH ARDS Network ventilator protocol [13]
  - Calculate predicted body weight
    - Males (in kg) = 50 + 2.3 (height, 60 in) [13]

□ Females (in kg) = 45.5 + 2.3 (height, 60 in) [13]
  □ Select any ventilator mode
  □ Set ventilator settings to achieve initial tidal volume of 8 mL/kg predicted body weight [13]
    □ Reduce by 1 mL/kg at intervals of 2 hours or less until tidal volume equals 6 mL/kg predicted body weight [13]
  □ Set initial rate to approximate baseline minute ventilation (not greater than 35 breaths per minute) [13]
  □ Adjust tidal volume and respiratory rate to achieve pH and plateau pressure goals
  □ Plateau pressure goal is 30 cm $H_2O$ or less [13]
    □ Check plateau pressure (0.5 second inspiratory pause) at least every 4 hours and after each change in PEEP or tidal volume
    □ If plateau pressure is greater than 30 cm $H_2O$, decrease tidal volume in increments of 1 mL/kg (maintain minimum of 4 mL/kg) [13]
    □ If plateau pressure is less than 25 cm $H_2O$ and tidal volume is less than 6 mL/kg, increase tidal volume by 1 mL/kg until plateau pressure is greater than 25 cm $H_2O$ or tidal volume equals 6 mL/kg [13]
    □ If plateau pressure is less than 30 cm $H_2O$ and breath stacking or dyssynchrony occurs, increase tidal volume in 1 mL/kg increments to 7 or 8 mL/kg (if plateau pressure remains less than 30 cm $H_2O$) [13]
  □ Oxygenation goal is $PaO_2$ of 55 to 80 mm Hg or $SpO_2$ of 88% to 95% [13]
    □ Use a minimum PEEP of 5 cm $H_2O$ [13]
    □ Consider use of incremental $FiO_2$/PEEP combinations to achieve goal using ARDS Network table of combinations [13]
  □ Indication
    □ Acute respiratory distress syndrome of any severity classification
  □ Complications
    □ Hypercapnic respiratory acidosis may develop in some patients
- Comorbidities
  ○ Usually related to underlying etiology (eg, sepsis, pancreatitis, trauma)

### MONITORING
- Continuously monitor blood pressure, pulse oximetry, temperature, and respiratory rate (from ventilator)
- Frequently monitor arterial blood gas
- Central venous pressure monitoring is not mandatory but can assist with fluid management; pulmonary artery catheter is not indicated

## COMPLICATIONS AND PROGNOSIS

### COMPLICATIONS
- Common complications that occur in an ICU setting include the following:
  ○ Ventilator-induced lung injury, especially pulmonary edema
  ○ Ventilator-associated barotrauma (eg, pneumothorax, subcutaneous edema)
  ○ Ventilator-associated pneumonia [44]
  ○ Catheter-related infections
  ○ Poor nutrition and loss of muscle mass
  ○ Deep vein thrombosis
  ○ Gastrointestinal bleeding
  ○ Delirium [23]
- Pulmonary fibrosis develops in roughly two-thirds of patients with acute respiratory distress syndrome; patient may become increasingly reliant on persistent mechanical ventilation [45]
- Cognitive impairment is common (70%-100% at hospital discharge, 46%-80% at 1 year, and 20% at 5 years) [46]
- Depression and posttraumatic stress disorder are common [46]

### PROGNOSIS
- No specific biomarker is considered predictive of outcome [40]
- Mortality outside of a clinical trial setting remains high and relatively unchanged since the original consensus definition was developed in 1994 [47]
  ○ Mild acute respiratory distress syndrome is associated with 34.9% mortality [48]
  ○ Moderate disease is associated with 40.3% mortality [48]
  ○ Severe disease is associated with 46.1% mortality [48]
  ○ Highest risk of death is when sepsis is the underlying cause; trauma-related cases have a lower mortality rate than those unrelated to trauma [41]

## SCREENING AND PREVENTION

### SCREENING

### PREVENTION

- No evidence exists for effective preventive measures specific to this syndrome; however, some good practices likely to decrease risk include:[49]
  - Primary prevention of nosocomial pneumonia
  - Primary prevention of aspiration
  - Appropriate antibiotic use
  - Restrictive use of blood transfusions
- Vaping-related lung injury[6]
  - Vaping and smoking cessation
  - If continuing e-cigarette use or vaping
    - Do not use devices purchased from sources other than authorized retailers
    - Do not modify devices or use devices modified in any manner not intended by the manufacturer
    - Only use substances sold by an authorized manufacturer
    - Do not use products that contain THC (tetrahydrocannabinol)

## SYNOPSIS

### KEY POINTS

- *An outbreak of lung injury associated with vaping was identified by CDC in September 2019; severe lung disease and death can occur*[6,3]
- Acute respiratory distress syndrome is severe and often fatal acute respiratory failure; characterized by diffuse inflammatory lung injury rapidly progressing to increased pulmonary vascular permeability, increased lung weight, and hypoxemia
- Most commonly secondary to pneumonia, nonpulmonary sepsis, and trauma. Worsening respiratory status most commonly develops within 1 week of clinical insult[2]
- Primary diagnostic tools are arterial blood gas levels showing hypoxemia with a $PaO_2$ to $FIO_2$ ratio of 300 mm Hg or less and radiograph showing bilateral opacities; echocardiogram may be required to ascertain that these opacities are not attributable to cardiogenic pulmonary edema[2]
- Treatment is primarily conventional mechanical ventilation using lung-protective strategies (ie, low-tidal-volume and/or low-pressure ventilation) and a high concentration of inspired oxygen and PEEP
- Other supportive care measures include prone positioning during mechanical ventilation, conservative fluid management strategies, and provision of enteral nutrition to prevent respiratory muscle weakness
- Additional treatments should focus on addressing the underlying cause
- High mortality rate of up to 46%; survivors commonly have residual lung damage[48,2]

### URGENT ACTION

- Conventional mechanical ventilation with low tidal volumes, PEEP, and moderate to high oxygen, with the goal of maximizing oxygenation[39,30]
- Prone positioning decreases mortality[30]

### PITFALLS

- Early stages can be difficult to differentiate from cardiogenic pulmonary edema, possibly resulting in delay of critical interventions[10]

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