BMJ Best Practice

Acute respiratory distress syndrome (ARDS)

Straight to the point of care

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Table of Contents

Summary

Acute respiratory distress syndrome (ARDS) typically presents with dyspnea and hypoxemia, which progress to acute respiratory failure.

Common causes are pneumonia, sepsis, aspiration, and severe trauma.

Mortality is between 30% and 50%.

Low tidal volume, plateau-pressure-limited mechanical ventilation is the primary treatment that has been shown to reduce mortality. In severe ARDS, neuromuscular blockade, prone positioning, and extracorporeal membrane oxygenation (ECMO) may improve clinical outcomes.

Complications include pneumothorax, ventilator-associated pneumonia, multiple organ failure, and pulmonary fibrosis with prolonged respiratory failure.

This topic covers ARDS in patients over the age of 12 years.

Definition

Acute respiratory distress syndrome (ARDS) is a noncardiogenic pulmonary edema and diffuse lung inflammation syndrome that often complicates critical illness. The clinical definition of ARDS was updated in 2024 to include both intubated and nonintubated patients and to allow diagnosis of ARDS in resource-limited settings.[1] Diagnosis of ARDS is based on fulfilling three criteria:

- Acute onset (within 1 week)
- Bilateral opacities on chest radiography or computed tomography (CT), or bilateral B lines and/or consolidations on ultrasound not fully explained by effusions, atelectasis, or nodules/masses
- PaO_2/FiO_2 (arterial to inspired oxygen) ratio of ≤300 or SpO2/FiO2 (pulse oximetric saturation to inspired oxygen) ratio of ≤315.[1]

If no risk factors for ARDS are present, then acute pulmonary edema as a result of heart failure should be ruled out.

Epidemiology

Overall, 10% to 15% of patients admitted to the intensive care unit meet the criteria for ARDS, with an increased incidence among mechanically ventilated patients.[2] [3] [4]

The incidence of ARDS is estimated at 64 cases in 100,000 people, or 190,000 cases per year in the US. This incidence rate is 2 to 40 times greater than previous estimates, which probably does not represent a rising incidence but rather a historical underestimation.[5] The incidence of ARDS may be higher in the US than in Europe and other developed countries, although evidence suggests that rates in the US may be declining.[6] [7]

Critical illness, cigarette smoking, and alcohol use are predisposing factors for ARDS.[8] [9] [10] Long-term exposure to ambient air pollutants also increases risk of developing ARDS.[11] [12] [13] Sex, ethnicity, and race have not been definitively associated with the incidence of ARDS.

The mortality of ARDS is approximately 30% to 50%, although mortality in large clinical trials seems to be steadily decreasing.[3] [5] [14] The distinction between mild (PaO_2/FiO_2 200-300), moderate (PaO_2/FiO_2 100-200), and severe (PaO_2/FiO_2 ≤100) ARDS has been associated with clinical outcomes.[1] Ongoing research suggests there are at least two discrete ARDS subphenotypes, although the clinical implications of this are under investigation.[15] [16] [17]

Etiology

Many different conditions can lead to ARDS, although sepsis is the most common cause, usually with a pulmonary origin (e.g., pneumonia).[4][5] Other conditions associated with ARDS include aspiration, inhalation injury (including e-cigarette or vaping product-associated lung injury), acute pancreatitis, trauma, burns, pulmonary contusion, transfusion-related lung injury, cardiopulmonary bypass, fat embolism, disseminated intravascular coagulation, and drug overdose.[18]

ARDS is a common feature of infection with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus responsible for pandemic coronavirus disease 2019 (COVID-19). Older age, neutrophilia, and organ and coagulation dysfunction are risk factors associated with the development of ARDS, and progression from ARDS to death, in patients with COVID-19 pneumonia.[19]

Pathophysiology

The pathophysiology of ARDS is complex and incompletely understood.[18] [20] Early in the development of ARDS, the primary pathologic finding is diffuse alveolar damage, although this is not seen uniformly in all patients. The diffuse alveolar damage leads to injury to the alveolar-capillary membrane, made up of type I and type II alveolar pneumocytes and capillary endothelial cells. The alveolar air spaces are subsequently flooded with proteinaceous edema fluid, inflammatory cells (neutrophils and activated alveolar macrophages), and inflammatory mediators, including pro-inflammatory cytokines, lipid mediators, and oxidants. Epithelial injury may be severe, with necrosis and sloughing of the type I cells exposing the basement membrane. Fibrin deposition occurs along the denuded basement membrane, resulting in the hyaline membranes that are characteristic of diffuse alveolar damage. Injury to type II cells and alveolar flooding contribute to surfactant dysfunction.

Mechanical ventilation with high pressures and high volumes may further injure the lung, contributing to the pro-inflammatory cytokine cascade.

The early phase of ARDS manifests clinically as acute hypoxemic respiratory failure with an increased alveolar-arterial oxygen gradient and poorly compliant lungs. Concomitant multiple organ failure may occur, particularly if the underlying cause of ARDS is sepsis. Right ventricular dysfunction is also common and is associated with worse outcomes.

After the acute onset of alveolar flooding and inflammation, some patients have rapid resolution and return to normal lung histology and function. Pulmonary edema fluid is cleared by active transport of sodium and chloride across the alveolar epithelium. In other patients, this early exudative inflammatory phase progresses to a fibroproliferative phase. During this later phase, the lung develops organized fibrous tissue and collagen deposition, which leads to irreversible and sometimes catastrophic lung fibrosis.[21] This phase is characterized by continued respiratory failure, high minute ventilation, and poorly compliant lungs. Patients with COVID-19 induced ARDS appear to be more prone to progress to fibrotic lung injury.[22]

Case history

Case history #1

A 60-year-old man presents with acute onset of shortness of breath, fever, and cough. A chest x-ray shows a right lower lobe infiltrate, and sputum has gram-positive diplococci. He is given intravenous antibiotics but his respiratory status declines over 24 hours. He becomes hypotensive and is transferred to the intensive care unit. He is intubated for hypoxemia and requires vasopressors for septic shock despite adequate volume resuscitation. He requires high levels of inspired oxygen (FiO_2) and positive end-expiratory pressure on the ventilator to keep his oxygen saturation >90%. Repeat chest x-ray shows bilateral alveolar infiltrates, and his partial pressure of oxygen, arterial (PaO_2)/FiO_2 ratio is 109.

Approach

Because the diagnosis of ARDS is based on clinical criteria rather than a pathologic diagnosis, ARDS should be considered in all critically ill patients regardless of whether invasive mechanical ventilation is required. As many as 40% of patients who meet the criteria for ARDS are never diagnosed with the condition.[4] [42] If patients develop new bilateral infiltrates on chest x-ray (CXR), they may have or may be developing ARDS. The importance of evaluating patients for the development of ARDS stems primarily from the survival benefit gained by ventilating with a low tidal volume, plateau-pressure-limited ventilator strategy.

History

The history should be directed at determining whether there is an underlying condition associated with ARDS, such as sepsis, pneumonia, aspiration of gastric contents, pancreatitis, blood transfusions, severe trauma, or e-cigarette use/vaping. The underlying cause can be an important determinant of outcome; patients with ARDS due to sepsis generally have the highest mortality. Specific treatments directed at the underlying cause are warranted, with particular attention to source identification and treatment in the context of sepsis. Symptoms that suggest ARDS include the acute onset of shortness of breath and hypoxemia leading to acute respiratory failure requiring high flow nasal oxygen or noninvasive or invasive mechanical ventilation, and cough with expectoration of frothy pulmonary edema. The history should also collect information that might suggest an alternate diagnosis of an ARDS mimic, such as pulmonary edema secondary to heart failure, diffuse alveolar hemorrhage due to pulmonary vasculitis, collagen vascular disease, or acute eosinophilic pneumonia.[43]

Examination

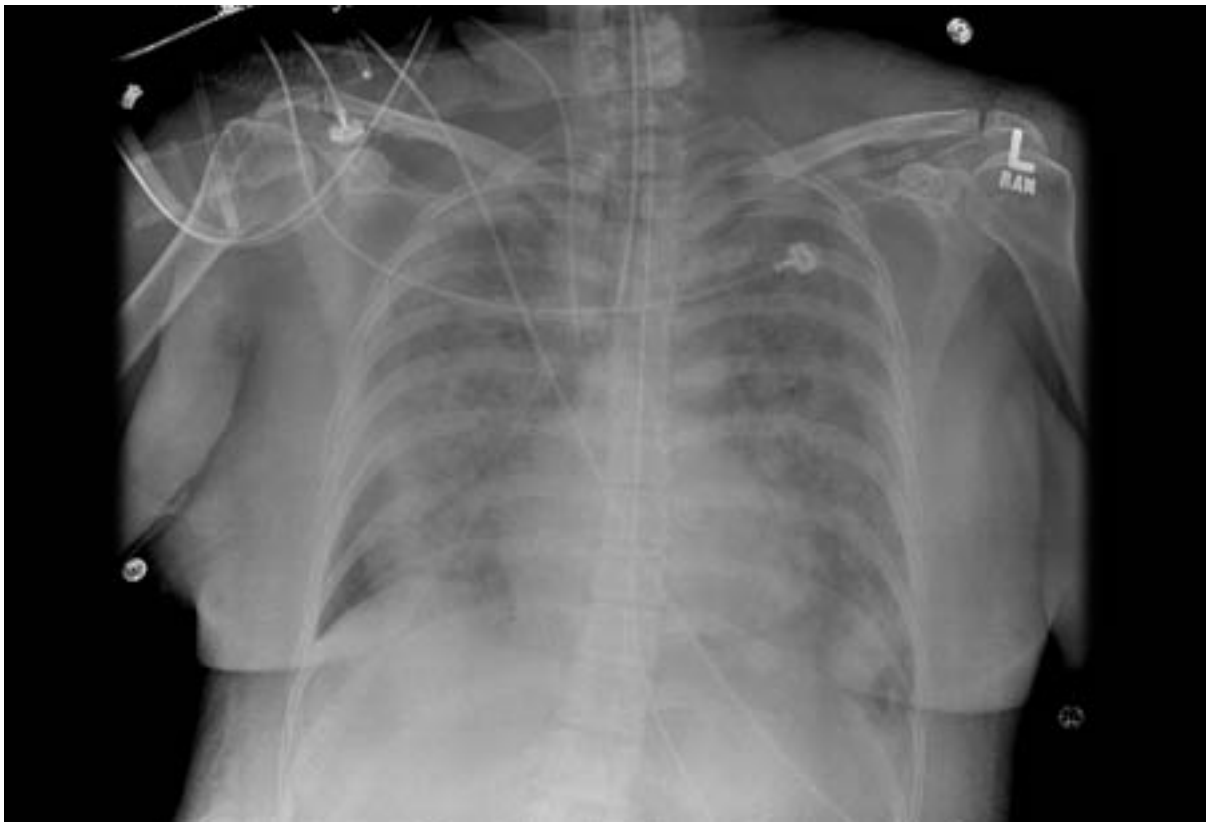
Physical examination findings that support the diagnosis of ARDS are acute hypoxic respiratory failure requiring high levels of oxygen and/or positive end-expiratory pressure to maintain an oxygen saturation >90%. In ventilated patients, both peak inspiratory pressure and end-inspiratory plateau pressure are also increased. Lung examination may reveal basilar or diffuse rales.[44] Particular attention should be put on identifying the source of infection if sepsis is suspected to be the underlying cause of ARDS.

Investigation

Key tests include arterial blood gas analysis for calculation of the partial pressure of oxygen, arterial (PaO_2)/inspired oxygen ratio. In screening for ARDS, the oxygen saturation to inspired oxygen fraction (SpO_2/FiO_2) can also be used as long as the SpO_2 is less than 97% (below the plateau on the oxyhemoglobin dissociation curve). An SpO_2/FiO_2 ratio of 315 has been shown to correlate with PaO_2/FiO_2 of 300.[45] Use of the SpO_2/FiO_2 ratio to diagnose ARDS identifies patients with similar clinical outcomes to patients diagnosed using the PaO_2/FiO_2 ratio and is now included in the new global definition of ARDS.[1] [46]

A CXR should be performed to look for bilateral infiltrates that are consistent with pulmonary edema and not fully explained by atelectasis or pulmonary effusions. In resource-limited settings, lung ultrasound by an experienced operator to look for evidence of bilateral B lines and/or consolidations may be substituted if chest radiography is not available.[1] Brain natriuretic peptide (BNP) levels should be considered if heart failure is a potential cause in patients with bilateral infiltrates on radiography. BNP levels <100 picograms/mL make heart failure unlikely, whereas BNP levels >500 picograms/mL make it likely. An echocardiogram should be ordered if heart failure is still a possible diagnosis after BNP levels are available, particularly if there are no risk factors for ARDS present. If the BNP and echocardiogram are

inconclusive, insertion of a pulmonary artery catheter (to estimate left ventricular end-diastolic pressure) may be helpful to differentiate heart failure from ARDS. However, routine insertion of a pulmonary artery catheter in all patients is not indicated.[47]



Chest x-ray image of bilateral infiltrates in a patient with ARDS

From the personal collection of Dr Lorraine Ware; used with permission

Blood, sputum, and urine cultures should be performed to investigate for the presence of sepsis. Viral testing should be considered in the appropriate clinical setting (e.g., influenza, SARS-CoV-2). Bronchoalveolar lavage (BAL) or endotracheal aspiration for Gram stain and cultures is also recommended in patients with ARDS due to suspected pneumonia and those without a defined predisposing condition.[48] However, bronchoscopy should be avoided in patients with suspected SARS-CoV-2 (COVID-19)-related ARDS due to high risk of provider exposure during aerosolizing procedures.[49] BAL can also be helpful for identifying other causes of acute respiratory failure with bilateral radiographic infiltrates that mimic ARDS, such as diffuse alveolar hemorrhage or acute eosinophilic pneumonia.

Serum lipase and amylase tests should be requested in patients with suspected acute pancreatitis. Both tests have similar sensitivity and specificity, but lipase levels remain elevated for longer (up to 14 days after symptom onset vs. 5 days for amylase).[50]

Computed tomography (CT) scanning of the thorax is not routinely required to diagnose or manage ARDS. It is more sensitive than a plain CXR and may be helpful in some patients for diagnosing pneumonia or underlying lung disease.[51] CT scanning has shown that ARDS affects the lung parenchyma heterogeneously, with dependent portions of the lung being the most affected.[44] However, routine chest CT scanning in ARDS to assess the heterogeneity of infiltrates is not currently indicated.

Open lung biopsy can be helpful in the setting of continued diagnostic uncertainty.[52] [53] However, this is not routinely performed in critically ill patients because of the high risk of morbidity and mortality.

History and exam

Key diagnostic factors

low oxygen saturation (common)

- Low despite supplemental oxygen.

acute respiratory failure (common)

- Progressively worsening respiratory failure in the setting of critical illness.

Other diagnostic factors

critically ill patient (common)

- Patients developing ARDS are critically ill, often with multisystem organ failure.

dyspnea (common)

- Dyspnea is the most common presenting symptom.

increased respiratory rate (common)

- Respiratory rate >20 breaths per minute.

pulmonary crepitations (common)

- Pulmonary crepitations on auscultation are common and typically diffuse.[27]

low lung compliance (common)

- Measured by tidal volume/(plateau pressure minus positive end-expiratory pressure).

fever, cough, pleuritic chest pain (common)

- These symptoms are often present, particularly if the underlying cause of ARDS is pneumonia.

frothy sputum (uncommon)

- Presence of cough productive of frothy sputum, or frank pulmonary edema that may be blood-tinged.

Risk factors

Strong

sepsis

- Sepsis is the most common underlying cause of ARDS, usually having a pulmonary origin.[4] [5] The incidence of ARDS in patients with sepsis is between 6% and 7%, but is significantly higher in patients

with septic shock.[8] [23] [24] Systemic activation of inflammation and coagulation is thought to lead to indirect injury to the alveolar-capillary membrane.

aspiration

- Aspiration of gastric contents is a common cause of ARDS.[5] About one third of hospitalized patients with a witnessed aspiration event develop ARDS.[25] Aspiration is thought to cause direct injury to the alveolar epithelium and alveolar-capillary membrane.

pneumonia

- Pneumonia from any source (bacterial, viral, fungal, parasitic) is a common cause of ARDS.[4] [26] [27] Direct injury by the pathogen and the inflammatory response to the pathogen are thought to be the responsible mechanisms.

severe trauma

- About 7% to 10% of patients with severe trauma develop ARDS.[28] Potential mechanisms include indirect injury from early hemorrhagic shock or later onset of multiple organ failure. Pulmonary contusions increase the risk of ARDS, as do long bone fractures, aspiration, and multiple transfusions of blood products.

blood transfusions

- Multiple transfusions of blood products are associated with ARDS.
- Transfusion-related acute lung injury (TRALI) can also develop with transfusion of as little as 1 unit of any plasma-containing blood product. Proposed mechanisms of TRALI include recipient neutrophil activation by donor-antibody recognition of recipient neutrophil epitopes or by biologically active lipids released from stored red blood cells.

lung transplantation

- ARDS, also known as primary graft dysfunction, occurs in 10% to 25% of patients after lung transplantation.[29] The mechanism is thought to be due to ischemia-reperfusion injury.
- Risk factors for ARDS (primary graft dysfunction) after lung transplantation include donor smoking, higher FiO_2 in the allograft at reperfusion, use of cardiopulmonary bypass, recipient body mass index, and pulmonary arterial hypertension in the donor or recipient.

pancreatitis

- Although not well studied, ARDS probably occurs in 10% to 20% of patients with severe acute pancreatitis.[30] In one study, treatment of patients with acute pancreatitis with octreotide reduced the incidence of ARDS.[31]

history of alcohol misuse

- Alcohol misuse is associated with an increased incidence of ARDS in adults.[8] [9]
- The mechanism is thought to be due to depletion of endogenous antioxidants.

burns and smoke inhalation

- ARDS is common after burns and smoke inhalation, with an incidence of 40% among mechanically ventilated patients with burns in one study.[32]

drowning

- ARDS is common after significant drowning episodes (grades 3 to 6).[27] [33] These patients usually recover much faster than those with other causes of ARDS.[34]

e-cigarette and vaping product use

- Emerging in the US in the summer of 2019, an outbreak of e-cigarette and vaping product-associated lung injury was reported among mostly young adults with a history of vaping, presenting with a clinical syndrome identical to ARDS.[35]
- Many cases seem to occur in patients vaping tetrahydrocannabinol products that contain vitamin E acetate.[36]

Immunotherapy

- A variety of drug exposures have been associated with development of ARDS including various chemotherapies and immunotherapies. Among these, checkpoint inhibitors have emerged as a new cause of ARDS.[37]

Weak

drug overdose

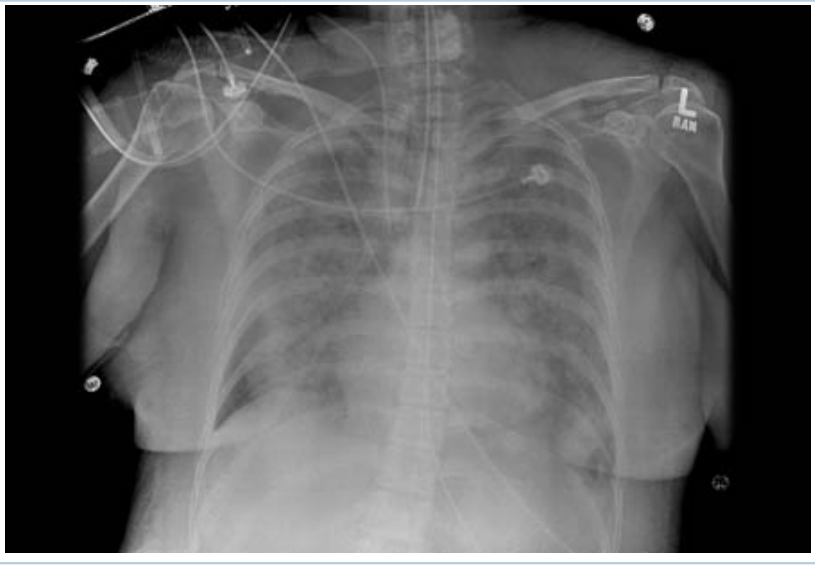
- Overdose of many common drugs (e.g., salicylates, tricyclic antidepressants, opioids, cocaine, phenothiazines) can cause ARDS, although loss of consciousness with aspiration of gastric contents may also contribute in this setting.[38]

cigarette smoking

- Smoking has been associated with an increased risk of ARDS in the setting of severe trauma, sepsis, transfusion, and after lung transplantation.[10][39] [40] [41]

Investigations

1st test to order

Test	Result
chest x-ray • New onset of bilateral opacities that is not fully explained by effusions, lobar/lung collapse, or nodules is part of the clinical diagnostic criteria for ARDS.[1] Therefore, CXR is 100% sensitive. • Specificity is poor because other conditions may cause bilateral pulmonary infiltrates, including cardiogenic pulmonary edema and diffuse alveolar hemorrhage.  *Chest x-ray image of bilateral infiltrates in a patient with ARDS* *From the personal collection of Dr Lorraine Ware; used with permission* • In resource-limited settings, lung ultrasound by an experienced operator to look for evidence of bilateral B lines and/or consolidations may be substituted if chest radiography is not available.[1]	**bilateral infiltrates**
arterial blood gases • A PaO_2/FiO_2 (inspired oxygen) ratio of ≤300 on PEEP or continuous positive airway pressure ≥5 cm H_2O is part of the diagnostic criteria for ARDS.[1] • It is 100% sensitive, but specificity is poor because many other conditions can cause hypoxemia.	**low partial oxygen pressure**
sputum culture • Sputum cultures are recommended to test for any possible underlying infection (as sepsis is the most common cause of ARDS).	**positive if underlying infection**
blood culture • Blood cultures are recommended to test for any possible underlying infection (as sepsis is the most common cause of ARDS).	**positive if underlying infection**
urine culture • A urine culture is recommended to test for any possible underlying infection (as sepsis is the most common cause of ARDS).	**positive if underlying infection**

Test	Result
amylase and lipase • Serum amylase and lipase, in conjunction with clinical assessment, can be used to help establish whether the patient has acute pancreatitis, a common cause of ARDS.[54] Both tests have similar sensitivity and specificity but lipase levels remain elevated for longer (up to 14 days after symptom onset vs. 5 days for amylase).[50] Its prolonged elevation creates a wider diagnostic window than amylase.	**amylase and/or lipase 3 times the upper limit of the normal range in cases of acute pancreatitis**

Other tests to consider

Test	Result
brain natriuretic peptide (BNP) • BNP levels <100 picograms/mL make heart failure unlikely and thus ARDS more likely. • BNP levels >500 picograms/mL make heart failure likely and thus ARDS less likely. • BNP levels between 100 and 500 picograms/mL are indeterminate. • BNP levels may be difficult to interpret in patients with acute or chronic kidney failure. However, BNP levels should be <200 picograms/mL in patients without heart failure with an estimated glomerular filtration rate <60 mL/minute.	**BNP levels <100 picograms/mL**
echocardiogram • Abnormal left ventricular systolic or diastolic function suggests cardiogenic pulmonary edema rather than ARDS. • Some patients may have both ARDS and cardiac dysfunction.	**usually normal**
pulmonary artery catheterization • PAOP ≤18 mmHg suggests ARDS. • Pulmonary artery catheterization should not be used routinely to manage patients with ARDS. • Can be used to determine whether pulmonary edema is cardiogenic if the diagnosis is still in doubt after measuring brain natriuretic peptide levels and carrying out echocardiography. • Some patients can have an increased left ventricular end-diastolic pressure superimposed on ARDS. For this reason, PAOP measurements are no longer included in the definition of ARDS.[1] • In the ARDS Network FACTT trial, approximately 20% of patients had an initial PAOP >18 mmHg, although elevations >24 mmHg were unusual.[47]	**pulmonary artery occlusion pressure (PAOP) ≤18 mmHg**
bronchoalveolar lavage or endotracheal aspirate • Recommended in some patients with suspected pneumonia and patients without a defined predisposing condition, to exclude a noninfectious parenchymal lung disease. • Avoid in patients with suspected COVID-19-related ARDS.[49]	**identification of infectious pathogens; characteristic findings of alternative diagnoses**
CT scan of the thorax • CT scanning of the thorax is not routinely required to diagnose or manage ARDS. A CT scan provides more information than a plain CXR and may be helpful in some cases for diagnosing pneumonia or another underlying lung disease.	**may be helpful in identifying pulmonary causes of ARDS such as pneumonia**
Lung ultrasound • In resource-limited settings, lung ultrasound by an experienced operator may be substituted if chest radiography is not available.[1]	**May be helpful to look for evidence of bilateral B lines and/or consolidations**
viral testing • Reverse transcriptase-polymerase chain reaction or other molecular tests should be considered in the appropriate clinical setting (e.g., influenza, SARS-CoV-2).	**detection of SARS-CoV-2; may be positive for influenza A and B viruses and other respiratory pathogens**

Test	Result
open lung biopsy • Can be helpful in the setting of continued diagnostic uncertainty.[52] [53] However, this is not routinely performed in critically ill patients because of the high risk of morbidity and mortality.	**diffuse alveolar damage, fibroproliferation, infection, or other pathology**

Differentials

Condition	Differentiating signs / symptoms	Differentiating tests
Coronavirus disease 2019 (COVID-19)	• Residence in or travel to an area with local transmission of COVID-19, or close contact with a suspected or confirmed case in the 14 days prior to symptom onset. • May be difficult to distinguish clinically from bacterial pneumonia. In addition to fever, cough, and dyspnea, other common presenting symptoms include sore throat, myalgia, fatigue, and altered sense of taste and/or smell. • Patients with respiratory distress may have tachycardia, tachypnea, or cyanosis accompanying hypoxia. • Many patients with COVID-19 pneumonia meet the criteria for ARDS, but there is uncertainty about whether severe COVID-19 pneumonia is a distinct phenotype of ARDS.[55]	• Real-time reverse transcription polymerase chain reaction: positive for SARS-CoV-2 RNA. • It is not possible to differentiate COVID-19 from other causes of pneumonia on chest imaging.
Acute heart failure	• A history of cardiac disease, acute myocardial ischemia or infarction, or a known low ejection fraction suggests cardiogenic pulmonary edema, as do an S3 and elevated neck veins on physical examination.	• Heart failure is suggested on chest x-ray by an enlarged cardiac silhouette, a vascular pedicle width >70 mm, central infiltrates, and Kerley B lines. • Brain natriuretic peptide levels >500 picograms/mL also suggest cardiogenic edema. • An echocardiogram and measurement of the pulmonary artery occlusion pressure may be needed if the history and physical and lab tests do not rule out cardiogenic pulmonary edema.
Bilateral pneumonia	• A history of fever and cough with or without sputum production. • Patients may have pleuritic chest discomfort.	• Severe pneumonia with bilateral infiltrates on chest x-ray meets the radiographic criteria for ARDS.

Condition	Differentiating signs / symptoms	Differentiating tests
		• If patients do not have severe hypoxemia with their pneumonia (PaO_2/FiO_2 ≤300 or SpO_2/FiO_2 ≤315), they do not have ARDS.
Acute interstitial pneumonia	• Onset is usually subacute, over days to weeks. • Patients are previously healthy, with no related systemic illness. • Some authors have termed this disease idiopathic ARDS.[48]	• Meets all the clinical criteria for ARDS. • Best differentiated by history.
Diffuse alveolar hemorrhage	• Associated with bleeding from the small vessels of the airways (capillaritis) and seen in many conditions, ranging from autoimmune to mitral valve diseases. • Almost always a reversible form of respiratory failure, once the underlying cause is known.	• A syndrome of hypoxia with infiltrates on chest x-ray. • The hallmark is finding sequentially bloodier aliquots of fluid during serial bronchoalveolar lavage. • Serologic tests to look for autoimmune diseases may help differentiate it from ARDS.[48]
Acute eosinophilic pneumonia	• Presents as a mild to severe pneumonia in previously healthy people. • Patients have an excellent response to intravenous corticosteroids.[56]	• The hallmark of this disease is increased numbers of eosinophils (upward of 50%) on bronchoalveolar lavage.
Hypersensitivity pneumonitis	• A pneumonitis after inhalation of an organic antigen. • Patients present with infiltrates and a pneumonia-like syndrome that is clinically indistinguishable from ARDS if severe. • Differentiated from ARDS by clinical history of an inhalational allergen, usually of avian origin. • Corticosteroids may be beneficial.[48]	• No differentiating investigations.
Postobstructive pulmonary edema	• Acute pulmonary edema after removal of an upper airway obstruction, most commonly caused by laryngospasm. • Causes an acute respiratory failure often requiring mechanical ventilation with	• No differentiating investigations.

Condition	Differentiating signs / symptoms	Differentiating tests
	varying levels of positive end-expiratory pressure. • The keys to differentiation are the history of upper airway obstruction, postsurgical development, and the rapid resolution of symptoms.[57]	

Criteria

New Global Definition of ARDS[1]

In 2024, modifications to the Berlin definition of ARDS (termed the "Global Definition") were made. A diagnosis of ARDS can be made if the patient fulfills all of the following criteria:

- Acute onset (within 1 week of known clinical insult)
- Bilateral opacities on chest radiography or computed tomography (CT), or bilateral B lines and/or consolidations on ultrasound not fully explained by effusions, atelectasis, or nodules/masses
- PaO_2/FiO_2 (arterial to inspired oxygen) ratio of ≤300 or SpO_2/FiO_2 (pulse oximetric saturation to inspired oxygen) ratio of ≤315
- Respiratory failure not fully explained by heart failure or fluid overload (objective assessment such as echocardiogram recommended if no risk factor).

Categories of ARDS

- Nonintubated ARDS. PaO_2:FiO_2 ≤300 mmHg or SpO_2:FiO_2 ≤315 (if SpO_2 ≤97%) on high flow nasal oxygen (HFNO) with flow of ≥30 L/min or noninvasive ventilation (NIV)/continuous positive airway pressure (CPAP) with at least 5 cm H_2O end-expiratory pressure
- Intubated ARDS. PaO_2:FiO_2 ≤300 mmHg or SpO_2:FiO_2 ≤315 (if SpO_2 ≤97%) on invasive mechanical ventilation
- ARDS in resource-limited settings. SpO_2:FiO_2 ≤315 (if SpO_2 ≤97%). Neither positive end-expiratory pressure nor a minimum flow rate of oxygen is required for diagnosis in resource-limited settings.

Severity of Intubated ARDS

- Mild: 200 <PaO_2:FiO_2 ≤300 mmHg or 235 <SpO_2:FiO_2 ≤315 (if SpO_2≤97%)
- Moderate: 100 <PaO_2:FiO_2 ≤200 mmHg or 148 <SpO_2:FiO_2 ≤235 (if SpO_2 ≤97%)
- Severe: PaO_2:FiO_2 ≤100 mmHg or SpO_2:FiO_2 ≤148 (if SpO_2 ≤97%).

Approach

The goals of treatment in patients with ARDS are supportive care and a protective strategy of lung ventilation using low tidal volumes to limit end inspiratory plateau pressure.[58] If the suspected underlying cause of ARDS is infection, then the source should be identified and controlled, and antibiotics started immediately. Otherwise the immediate goals are supportive care and the prevention of complications.

The mortality of patients with ARDS is usually not due primarily to respiratory failure. Most patients die from the underlying cause of ARDS, secondary infections, other organ failures, underlying comorbidities, or the complications of prolonged hospitalization.

Oxygenation and ventilation

Although the original low tidal volume trial by the ARDS Network targeted an oxygen saturation between 88% and 95%, two subsequent clinical trials suggest that higher oxygenation targets may be associated with better clinical outcomes. A French randomized trial of oxygenation saturation target of 88% to 92% versus ≥96% in patients with ARDS was stopped early due to safety concerns, with numerically higher mortality in the low oxygen saturation target group compared with the higher saturation group at both day 28 and day 90.[59] However, one Cochrane review of oxygen targets in the intensive care unit (ICU) during mechanical ventilation for ARDS, which included this trial alone, concluded that the evidence for giving more or less oxygen to patients with ARDS remains very uncertain because of the high risk of bias (due to lack of blinding, small numbers of participants, and the trial stopping prematurely).[60] An Australian and New Zealand trial of lower versus higher oxygenation targets in critically ill mechanically ventilated patients showed nonsignificant trends toward worse outcomes in the lower oxygenation target group.[61]

Based on these findings, it seems prudent to target an oxygen saturation of ≥92%.[62]

With the increasing availability of high flow nasal oxygen (HFNO), the number of patients with ARDS who can be managed with either HFNO or noninvasive ventilation has increased. However, the failure rate is high and many patients with ARDS will require endotracheal intubation and mechanical ventilation.[63] The American Thoracic Society (ATS) provides guidance on how to facilitate communication with mechanically ventilated patients as a key component of symptom assessment.[64] Ventilator-associated lung injury may be limited by the use of a low tidal volume, plateau-pressure-limited protective ventilatory strategy. This therapy has been shown to reduce mortality.[65] [66] [67] [68]

A tidal volume of 4-8 mL/kg predicted body weight should be used to maintain an inspiratory plateau pressure <30 cm H_2O.[69] Predicted body weight for men is calculated as 50 + 0.91 × (height [cm] - 152.4), and for women is 45.5 + 0.91 × (height [cm] - 152.4).[65] If the plateau pressure is >30 cm H_2O, then tidal volume should be lowered to 5 mL/kg or as low as 4 mL/kg, if needed.

Use of positive end-expiratory pressure (PEEP) titration tables

PEEP and FiO_2 should be titrated using established PEEP titration tables.[65] [70] The available data suggest that higher levels of PEEP are safe and may improve oxygenation in some patients.[69] [71] [72] In a meta-analysis of available trials, there was no overall reduction in mortality with higher PEEP.[73] An earlier meta-analysis suggested that higher PEEP reduces mortality in patients who respond with improved oxygenation.[74]

Individualized PEEP titration (rather than using a PEEP titration table), lung recruitment maneuvers in conjunction with higher PEEP levels, and PEEP titration based on radiographic classification of ARDS (as diffuse or focal) have all been evaluated in patients with ARDS.[75] [76] [77] [78] However, consistent clinical benefits have not been demonstrated with these approaches.

Managing respiratory acidosis

Respiratory acidosis, a common complication of low tidal volume ventilation, is treated by increasing the respiratory rate. Although it is not known what level of respiratory acidosis is harmful in patients with ARDS, permissive hypercapnia is often tolerated due to low tidal volume ventilation. However, severe hypercapnia is independently associated with higher ICU mortality.[79] Normocapnia often cannot be achieved (and should not be a goal).

Clinical guidelines recommend an arterial pH of 7.30 to 7.45 is maintained, but studies suggest patients who undergo permissive hypercapnia can tolerate a blood pH as low as 7.15. Bicarbonate infusions may be administered when the pH falls below 7.15.

Prone positioning

Prone positioning can improve oxygenation in patients with ARDS and has been shown to reduce mortality in patients with severe ARDS (PaO_2/FiO_2 <150).[69] [83] [84] [85] [86] [87]

One systematic review found that reduced mortality was contingent upon patients remaining prone for at least 12 hours daily.[88] Given the potential complications of prone positioning, including facial edema, pressure sores, and dislodgement of catheters and endotracheal tubes, prone positioning should usually only be considered in patients with severe ARDS (PaO_2/FiO_2 <150).[69]

Conservative intravenous fluid management

The patient's fluid balance should be maintained as slightly negative or neutral (providing the patient is not in shock).[62] A central line is recommended to measure the central venous pressure (CVP), with regular assessments of fluid status. The goal is to keep the CVP <4 cm H_2O. The routine use of a pulmonary artery catheter (to measure pulmonary artery occlusion pressure) is not recommended as insertion is associated with more complications than a central line.[47]

A conservative fluid strategy reduced the duration of mechanical ventilation but had no effect on mortality in a large clinical trial in patients with ARDS who were not in shock.[89] Similar results were reported in one systematic review and meta-analysis of adults and children with ARDS, sepsis, or systemic inflammatory response syndrome.[90]

Antimicrobials

In patients who have an infectious cause for ARDS (e.g., pneumonia or sepsis), the prompt initiation of antimicrobials is important.[101] [102]

Empiric antibiotics targeted at the suspected underlying infection should be used as soon as possible after obtaining appropriate cultures including blood, sputum, and urine cultures. Antivirals or antifungals may be appropriate in patients with suspected or confirmed viral or fungal infections. Once culture results are available, the antimicrobial regimen can be tailored for the identified organism. There is no evidence to support the use of antibiotics in patients who have ARDS without infection.

Supportive care

Standard supportive care of critically ill patients includes prevention of deep vein thrombosis, blood glucose control, prophylaxis against stress-induced gastrointestinal bleeding hemodynamic support to maintain a mean arterial pressure >60 mmHg, and transfusion of packed red blood cells in patients with hemoglobin <7 g/dL.[103] [104] Nutrition should be provided enterally where possible.[105] In one large randomized trial of 1000 patients with ARDS, low-dose enteral feeding for the first 5 days of ARDS had similar clinical outcomes compared with full-calorie feeding.[106] Supplemental nutrition with omega-3 fatty acids and antioxidants is not recommended.[107]

Inhaled or intravenous beta-adrenergic agonists to promote alveolar fluid clearance and resolution of pulmonary edema are not recommended.[108] [109] Neither early nor late administration of corticosteroids has been shown to improve mortality in patients with ARDS who do not have COVID-19, and their routine use is not recommended.[110] [111]

Refractory hypoxemia

In patients with refractory hypoxemia despite an FiO_2 of 1.0 and high levels of PEEP, rescue therapies for oxygenation should be considered.[62]

Neuromuscular paralysis

- Neuromuscular paralysis improves ventilator-patient synchrony and often improves oxygenation.
- Intermittent doses of paralytics can be used as effectively as a continuous intravenous infusion. If a patient is on a continuous intravenous infusion of a paralytic, train-of-four monitoring should be used to monitor the muscle fiber twitch response to the drug.
- Although one randomized clinical trial showed a 28-day mortality benefit with use of neuromuscular paralysis with cisatracurium besylate for the first 48 hours in severe ARDS (PaO_2/FiO_2 <150), a subsequent study with a similar approach to early neuromuscular blockade in ARDS was stopped early for futility.[112] [113]
- Given these findings, neuromuscular blockade should be reserved for patients with ARDS and refractory hypoxemia despite low tidal volume ventilation and adequate sedation, particularly if there is still evidence of ventilator-patient dyssynchrony.[62] The ATS suggests using neuromuscular blockers in patients with early severe ARDS.[69]

Inhaled nitric oxide and inhaled prostacyclin

- Inhaled nitric oxide can improve oxygenation in patients with ARDS, but does not improve mortality and has been associated with acute kidney injury.[114] [115] [116] Thus, it should be used only as a rescue therapy for refractory hypoxemia.[62]
- Inhaled prostacyclin is easier to administer than inhaled nitric oxide, and also has the potential to improve oxygenation in ARDS through better ventilation perfusion matching. However, there are currently no published large randomized controlled trials of inhaled prostacyclin; thus, it should be used cautiously and only as a rescue therapy.[117]

Extracorporeal membrane oxygenation

- Where available, extracorporeal membrane oxygenation (ECMO) should be considered (in conjunction with low tidal volume mechanical ventilation) in select patients with severe ARDS in whom standard therapies are failing (i.e., patients with profound refractory hypoxemia).[69] [118]

- One multicenter trial showed that patients with severe ARDS randomized to transfer to a tertiary care center for consideration of ECMO (75% [n=68] of whom actually received ECMO) were more likely to survive to 6 months without disability than patients randomized to continued conventional management (RR 0.69, 95% CI 0.05 to 0.97, P=0.03).[119] A subsequent randomized multicenter trial (n=249) did not demonstrate significantly lower 60-day mortality in the ECMO treatment group compared with standard care (35% vs. 46%, respectively; P=0.09); however, one meta-analysis pooling data from both trials reported significantly lower 60-day mortality in the venovenous ECMO group compared with the control group (RR 0.73, 95% CI 0.58 to 0.92, P=0.008) despite a moderate risk of major bleeding in the ECMO group.[120] [121] An additional meta-analysis that included trials in critically sick patients with indications other than ARDS found that ECMO was associated with a reduction in day-90 to one-year all-cause mortality, along with a threefold increased risk of bleeding.[122]

High-frequency oscillatory ventilation

- Routine use of high-frequency oscillatory ventilation (HFOV) in moderate-to-severe ARDS is not beneficial, and may be harmful.[123] [124] [125] [126] [127]

Coronavirus 2019 (COVID-19)

ARDS is one of the World Health Organization (WHO) criteria for the diagnosis of critical COVID-19 disease.[128] Patients with COVID-19 and ARDS should be treated in line with standard ARDS management recommendations, with the following further considerations:

- Appropriate isolation and infection prevention and control measures.
- Corticosteroids (low-dose intravenous or oral dexamethasone, or an alternative corticosteroid) are strongly recommended for adults with severe or critical COVID-19 disease, including those with ARDS, based on several large randomized clinical trials. The recommended duration of treatment is 7 to 10 days.[129] [130]
- Consider a trial of high-flow nasal oxygen or noninvasive ventilation in selected patients with COVID-19 and mild ARDS. Endotracheal intubation should not be delayed if there is no improvement after a short trial (1 hour).[128]
- Prone positioning for 12 to 16 hours per day is recommended for patients with COVID-19 and severe ARDS.[128] Awake prone positioning can be considered for patients with COVID-19 receiving high-flow nasal oxygen or noninvasive ventilation.[128] [131] Two small case series found that many people tolerated the prone position while awake, breathing spontaneously, or receiving noninvasive ventilation; these patients experienced an improvement in oxygenation and a decrease in respiratory rate.[132] [133] In a meta-analysis of 17 trials, awake proning reduced the risk of endotracheal intubation.[134]
- There are conflicting recommendations across international guidelines about the use of the antiviral remdesivir in patients with COVID-19. Local guidance and protocols should be consulted. The WHO recommends against the use of remdesivir in hospitalized patients in addition to standard care, regardless of disease severity, based on one systematic review and a network meta-analysis of four randomized trials.[130] However, remdesivir is approved by the Food and Drug Administration for the treatment of COVID-19 in hospitalized adult and pediatric patients (ages ≥12 years and weighing ≥40 kg), based on data from a large randomized clinical trial that showed improvements in time to recovery with remdesivir treatment. Its use in selected patients is supported by several US guidelines.[131] [135] [136] [137] [138]

- There is a strong recommendation that patients with ARDS due to COVID-19 should be treated with Il-6 inhibitors (tocilizumab or sarilumab) and the Janus Kinase (JAK) inhibitor baricitinib.[139] [BMJ: a living WHO guideline on drugs for Covid-19] (https://www.bmj.com/content/370/bmj.m3379.long)

See our topic Coronavirus disease 2019 (COVID-19) for more information on the management of COVID-19.

Treatment algorithm overview

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

Acute		(summary)
all patients		
	1st	oxygen and ventilation
	adjunct	prone positioning
	adjunct	intravenous fluids
	adjunct	antimicrobials + identification and treatment of source of infection
	adjunct	supportive care
	adjunct	rescue therapies

Treatment algorithm

Please note that formulations/routes and doses may differ between drug names and brands, drug formularies, or locations. Treatment recommendations are specific to patient groups: see disclaimer

Acute

all patients

1st **oxygen and ventilation**

» Although the original low tidal volume trial by the ARDS Network targeted an oxygen saturation between 88% and 95%, two subsequent clinical trials suggest that higher oxygenation targets may be associated with better clinical outcomes.[59] [61] Based on the findings of these studies, it seems prudent to target an oxygen saturation of ≥92%.[62]

» With the increasing availability of high flow nasal oxygen (HFNO), the number of patients with ARDS who can be managed with either HFNO or noninvasive ventilation has increased. However, the failure rate is high and many patients with ARDS will require endotracheal intubation and mechanical ventilation.[63] The American Thoracic Society (ATS) provides guidance on how to facilitate communication with mechanically ventilated patients as a key component of symptom assessment.[64]

» Ventilator-associated lung injury may be limited by the use of a low tidal volume, plateau-pressure-limited protective ventilatory strategy. This therapy has been shown to reduce mortality.[65] [66] [67] [68]

» A tidal volume of 4-8 mL/kg predicted body weight should be used to maintain an inspiratory plateau pressure <30 cm H_2O with an initial setting of 6 mL/kg.[69] Predicted body weight for men is calculated as 50 + 0.91 × (height [cm] - 152.4), and for women is 45.5 + 0.91 × (height [cm] - 152.4).[65] If the plateau pressure is >30 cm H_2O, then tidal volume should be lowered to 5 mL/kg or as low as 4 mL/kg, if needed.

» Positive end-expiratory pressure (PEEP) and FiO_2 should be titrated using established PEEP titration tables.[65] [70] The available data suggest that higher levels of PEEP are safe and may improve oxygenation in some patients.[69] [71] [72] In a meta-analysis of available trials, there was no overall reduction in mortality with higher PEEP.[73] An earlier meta-analysis suggested that higher PEEP reduces mortality in patients who respond with improved oxygenation.[74]

Acute

» Respiratory acidosis, a common complication of low tidal volume ventilation, is treated by increasing the respiratory rate. Although it is not known what level of respiratory acidosis is harmful in patients with ARDS, permissive hypercapnia is often tolerated due to low tidal volume ventilation. However, severe hypercapnia is independently associated with higher intensive care unit mortality.[79] Normocapnia often cannot be achieved (and should not be a goal). Clinical guidelines recommend an arterial pH of 7.30 to 7.45 is maintained, but studies suggest patients who undergo permissive hypercapnia can tolerate a blood pH as low as 7.15. Bicarbonate infusions may be administered when the pH falls below 7.15.

»

» Selected patients with COVID-19 and mild ARDS can be considered for a trial of high-flow nasal oxygen or noninvasive ventilation. Endotracheal intubation should be not delayed if there is no improvement after a short trial (1 hour).[128]

» See our topic Coronavirus disease 2019 (COVID-19) for more information on the management of COVID-19.

adjunct **prone positioning**

Treatment recommended for SOME patients in selected patient group

» Prone positioning can improve oxygenation in patients with ARDS and has been shown to reduce mortality in patients with severe ARDS (PaO_2/fraction of inspired oxygen [FiO_2] <150).[69] [83] [84] [85] [86] [87] One systematic review found that reduced mortality was contingent upon patients remaining prone for at least 12 hours daily.[88] Given the potential complications of prone positioning, including facial edema, pressure sores, and dislodgement of catheters and endotracheal tubes, prone positioning should only be considered in patients with severe ARDS (PaO_2/FiO_2 <150).[69]

» Prone positioning is recommended for patients with COVID-19 and severe ARDS (12-16 hours per day). Awake prone positioning can be considered for patients with COVID-19 receiving high-flow nasal oxygen or noninvasive ventilation.[128] [131]

» See our topic Coronavirus disease 2019 (COVID-19) for more information on the management of COVID-19.

Acute

adjunct **intravenous fluids**

Treatment recommended for SOME patients in selected patient group

» The patient's fluid balance should be maintained as slightly negative or neutral (providing the patient is not in shock).[62] A central line is recommended to measure the central venous pressure (CVP), with regular assessments of fluid status. The goal is to keep the CVP <4 cm H_2O. The routine use of a pulmonary artery catheter (to measure pulmonary artery occlusion pressure) is not recommended as insertion is associated with more complications than a central line.[47]

» A conservative fluid strategy reduced the duration of mechanical ventilation but had no effect on mortality in a large clinical trial in patients with ARDS who were not in shock.[89] Similar results were reported in one systematic review and meta-analysis of adults and children with ARDS, sepsis, or systemic inflammatory response syndrome.[90]

adjunct **antimicrobials + identification and treatment of source of infection**

Treatment recommended for SOME patients in selected patient group

» In patients who have an infectious cause for ARDS (e.g., pneumonia or sepsis), the prompt initiation of antimicrobials is important.[101] [102] Empiric antibiotics targeted at the suspected underlying infection should be used as soon as possible after obtaining appropriate cultures including blood, sputum, and urine cultures. Antivirals or antifungals may be appropriate in patients with suspected or confirmed viral or fungal infections. Once culture results are available, the antimicrobial regimen can be tailored for the identified organism. There is no evidence to support the use of antibiotics in patients who have ARDS without infection.

» There are conflicting recommendations across international guidelines about the use of the antiviral remdesivir in patients with COVID-19. Local guidance and protocols should be consulted.

» Patients with COVID-19 should be managed with appropriate isolation and infection prevention and control measures.

» There is a strong recommendation that patients with ARDS due to COVID-19 should

Acute

be treated with Il-6 inhibitors (tocilizumab or sarilumab) and the Janus Kinase (JAK) inhibitor baricitinib.[139] [BMJ: a living WHO guideline on drugs for Covid-19] (https://www.bmj.com/content/370/bmj.m3379.long)

» See our topic Coronavirus disease 2019 (COVID-19) for more information on the management of COVID-19.

adjunct **supportive care**

Treatment recommended for SOME patients in selected patient group

» Standard supportive care of critically ill patients includes prevention of deep vein thrombosis, blood glucose control, prophylaxis against stress-induced gastrointestinal bleeding, hemodynamic support to maintain a mean arterial pressure >60 mmHg, and transfusion of packed red blood cells in patients with hemoglobin <7 g/dL.[103] [104] Nutrition should be provided enterally where possible.[105] In one large randomized trial of 1000 patients with ARDS, low-dose enteral feeding for the first 5 days of ARDS had similar clinical outcomes compared with full-calorie feeding.[106] Supplemental nutrition with omega-3 fatty acids and antioxidants is not recommended.[107]

» Inhaled or intravenous beta-adrenergic agonists to promote alveolar fluid clearance and resolution of pulmonary edema are not recommended.[108] [109] Neither early nor late administration of corticosteroids has been shown to improve mortality in patients with ARDS, and their routine use is not recommended in patients who do not have COVID-19.[110] [111]

» Corticosteroids (low-dose intravenous or oral dexamethasone or an alternative corticosteroid) are strongly recommended for adults with severe or critical COVID-19 disease, including those with ARDS, based on several large randomized clinical trials. The recommended duration of treatment is 7 to 10 days.[129] [130]

» See our topic Coronavirus disease 2019 (COVID-19) for more information on the management of COVID-19.

adjunct **rescue therapies**

Treatment recommended for SOME patients in selected patient group

» In patients with refractory hypoxemia despite a fraction of inspired oxygen (FiO_2) of 1.0 and high levels of positive end-expiratory pressure

Acute

(PEEP), rescue therapies for oxygenation should be considered.[62]

» Neuromuscular paralysis improves ventilator-patient synchrony and often improves oxygenation. Intermittent doses of paralytics can be used as effectively as a continuous intravenous infusion. If a patient is on a continuous intravenous infusion of a paralytic, train-of-four monitoring should be used to monitor the muscle fiber twitch response to the drug. Given findings from randomized controlled trials, neuromuscular blockade should be reserved for patients with severe ARDS and refractory hypoxemia despite low tidal volume ventilation and adequate sedation, particularly if there is still evidence of ventilator-patient dyssynchrony.[62] [112] [113] The ATS suggests using neuromuscular blockers in patients with early severe ARDS.[69]

» Inhaled nitric oxide can improve oxygenation in patients with ARDS, but does not improve mortality and has been associated with acute kidney injury.[114] [115] [116] Thus, it should be used only as a rescue therapy for refractory hypoxemia.[62] Inhaled prostacyclin is easier to administer than inhaled nitric oxide, and also has the potential to improve oxygenation in ARDS through better ventilation perfusion matching. However, there are currently no published large randomized controlled trials of inhaled prostacyclin; thus, it should be used cautiously and only as a rescue therapy.[117]

» Where available, extracorporeal membrane oxygenation (ECMO) should be considered (in conjunction with low tidal volume mechanical ventilation) in select patients with severe ARDS in whom standard therapies are failing (i.e., patients with profound refractory hypoxemia).[69] [118] One multicenter trial showed that patients with severe ARDS randomized to transfer to a tertiary care center for consideration of ECMO (75% [n=68] of whom actually received ECMO) were more likely to survive to 6 months without disability than patients randomized to continued conventional management (RR 0.69, 95% CI 0.05 to 0.97, P=0.03).[119] One subsequent randomized multicenter trial (n=249) did not demonstrate significantly lower 60-day mortality in the ECMO treatment group compared with standard care (35% vs. 46%, respectively; P=0.09); however, one meta-analysis pooling data from both trials reported significantly lower 60-day mortality in the venovenous ECMO group compared with the control group (RR

Acute

0.73, 95% CI 0.58 to 0.92, P=0.008) despite a moderate risk of major bleeding in the ECMO group.[120] [121] An additional meta-analysis that included trials in critically sick patients with indications other than ARDS found that ECMO was associated with a reduction in day-90 to one-year all-cause mortality, along with a threefold increased risk of bleeding.[122]

» Routine use of high-frequency oscillatory ventilation (HFOV) in moderate-to-severe ARDS is not beneficial, and may be harmful.[123] [124] [125] [126] [127]

Emerging

Early corticosteroid administration

Controversy regarding the utility of corticosteroids in non-COVID ARDS persists, as clinical trials have mostly been small, heterogeneous, and some were done prior to the era of low tidal volume ventilation.[140] An open-label randomized controlled study of patients with moderate-to-severe ARDS found that early dexamethasone resulted in a substantial increase in ventilator-free days (4.8 days), and a 15% reduction in mortality, compared with placebo.[141] These findings need to be validated and must be considered cautiously given serious concerns about the safety of glucocorticoids in critically ill patients who do not have COVID-19. Additionally, the optimal corticosteroid regimen remains unknown; further research is needed to determine the appropriate formulation, dose, timing, and course of therapy to better guide clinical care. Longitudinal data are also needed to better understand the adverse consequences of corticosteroids.[69] Several large randomized clinical trials of glucocorticoids in ARDS are ongoing and should provide additional evidence to guide use of corticosteroids in ARDS.

FOLLOW UP

Monitoring

Monitoring

No long-term monitoring is needed in patients who survive ARDS, unless they continue to have shortness of breath. In that instance, yearly pulmonary function tests are used to monitor their course.

Complications

Complications	Timeframe	Likelihood
death	**short term**	**medium**
Mortality for patients with ARDS is estimated at 30% to 50%.[4] [142]		
ventilator-associated pneumonia	**short term**	**medium**
Can develop in any patient who requires mechanical ventilation for more than 48 hours. Signs and symptoms include a new fever, elevated white blood cell count, new infiltrate on chest x-ray, increased or changing pulmonary secretions, and hypotension.		
multiple organ failure	**short term**	**medium**
In addition to respiratory failure, the most common manifestations in patients with ARDS are renal failure, shock, acute delirium, or coma. Less common are hepatic and hematologic failure. Treatment includes supportive therapy as well as specific interventions for each organ: mechanical ventilation for respiratory failure, dialysis for renal failure, and vasopressors for hypotension.		
pneumothorax	**short term**	**low**
Most often a complication due to pulmonary barotrauma. Barotrauma occurred in 13% of patients enrolled in the ARDS Network low tidal volume trial and was associated with higher levels of positive end-expiratory pressure (PEEP).[148] Signs and symptoms include tracheal deviation, sudden worsening hypoxemia, high peak and plateau pressures on the ventilator, hypotension, and cardiovascular collapse. Chest x-ray can confirm the presence of a pneumothorax. Treated with insertion of a chest tube.		
persistent dyspnea	**variable**	**high**
Persistent dyspnea is particularly present during exercise. A majority of patients who survive ARDS have a mild to moderate decrease in carbon monoxide diffusion in the lung, but steady improvement is seen in the first year.[146] [147]		
abnormal lung function	**variable**	**medium**
In one study, 40% of patients had either restriction or obstruction 1 year after ARDS, but similar abnormalities were not observed in another study.[146] [147]		
reduced quality of life	**variable**	**medium**
Studies looking at quality-of-life scores found a reduction in quality of life for at least the first year after surviving ARDS.[146] [147]		

Prognosis

Mortality in patients who develop ARDS is 30% to 50%.[4] [142] Death is most often due to multiple organ failure rather than purely to respiratory failure.[143] Low tidal volume ventilation reduced in-hospital mortality from 40% to 31% in the 2000 ARDS Network trial.[65] Being of a younger age may also increase the chances of survival.[144] Patients who do survive their illness usually have some residual decrease in lung function, although it may not always cause symptoms.[145] [146] Muscle weakness, neuropathies, joint disorders, and chronic pain are also common in survivors of ARDS at 1 year.[147]

Treatment guidelines

International

Symptom assessment for mechanically ventilated patients: principles and priorities (https://www.atsjournals.org/doi/10.1513/AnnalsATS.202301-023ST) [64]

Published by: American Thoracic Society **Last published:** 2023

Mechanical ventilation in adult patients with acute respiratory distress syndrome (https://www.thoracic.org/statements/cc.php) [69]

Published by: American Thoracic Society; European Society of Intensive Care Medicine; Society of Critical Care Medicine **Last published:** 2024

Guidelines on the management of acute respiratory distress syndrome (https://bmjopenrespres.bmj.com/content/6/1/e000420.info) [118]

Published by: The Faculty of Intensive Care Medicine; Intensive Care Society **Last published:** 2019

Online resources

1. BMJ: a living WHO guideline on drugs for Covid-19 (https://www.bmj.com/content/370/bmj.m3379.long) *(external link)*

Key articles

- Matthay MA, Arabi Y, Arroliga AC, et al. A new global definition of acute respiratory distress syndrome. Am J Respir Crit Care Med. 2024 Jan 1;209(1):37-47. Full text (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10870872) Abstract (http://www.ncbi.nlm.nih.gov/pubmed/37487152?tool=bestpractice.bmj.com)
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Images

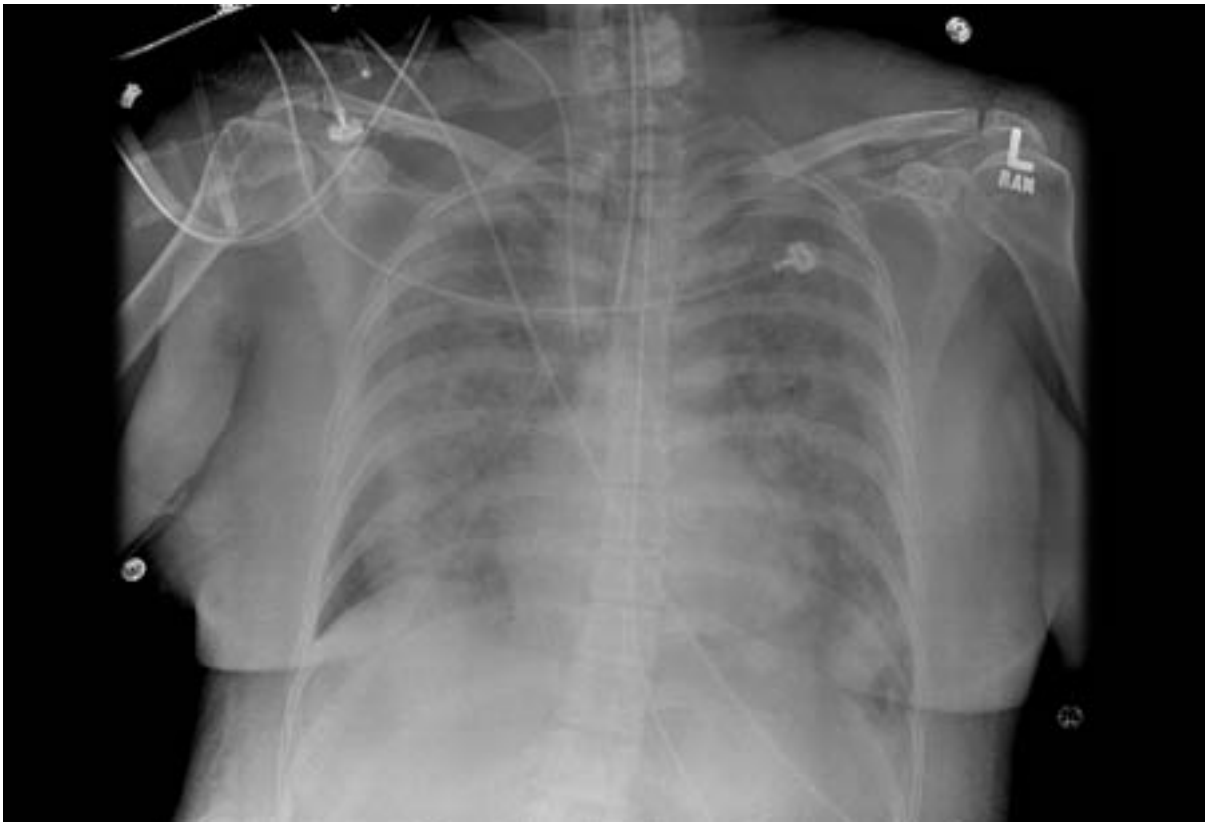

Figure 1: Chest x-ray image of bilateral infiltrates in a patient with ARDS

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Figure 1 – BMJ Best Practice Numeral Style

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