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Pediatric Acute Respiratory Distress Syndrome

About the Guideline

- The guideline panel consisted of 52 international, multidisciplinary experts in pediatric acute respiratory distress syndrome (PARDS) and four methodology experts from 15 countries.
- These guidelines are an update from the 2015 Secondary Pediatric Acute Lung Injury Consensus Conference (PALICC-2), which addressed the diagnosis and management of PARDS.
- The literature search included MEDLINE, EMBASE, and CINAHL Complete (EBSCOhost); and Grading of Recommendations, Assessment, Development, and Evaluating (GRADE) methodology was used to evaluate the quality of the evidence.
- This update includes 146 recommendations and statements.

Key Clinical Considerations

Become familiar with the recommendations and best-practice statements provided in this guideline, especially if you work in a pediatric acute care setting.

Diagnosis of PARDS

- Diagnosis of PARDS includes the following criteria:
    - Age—the patient must be younger than 18 years of age without active perinatal lung disease
    - Timing—symptoms of hypoxemia and radiographic changes must occur within seven days of a known clinical insult
    - Origin of edema—edema not fully explained by cardiac failure or fluid overload must be present
    - Chest imaging—the presence of opacity (or opacities) found by chest imaging and consistent with acute pulmonary parenchymal disease that is not explained by effusion or atelectasis
    - Oxygenation—disease stratification that is determined by severity of hypoxemia
        - For children treated with invasive mechanical ventilation (IMV), oxygenation index (OI) or oxygen saturation index (OSI), rather than arterial partial pressure of oxygen (PaO_2)/fraction of inspired oxygen (FIO_2) or pulse oximeter oxygen saturation (SpO_2)/FIO_2, should be utilized to measure lung disease severity.
        - For children receiving noninvasive ventilation (NIV) or high-flow nasal cannula (HFNC), PaO_2/FIO_2 or SpO_2/FIO_2 should be used to diagnose PARDS or possible PARDS.
    - For children with cyanotic heart disease, PARDS is diagnosed using the above criteria, when acute deterioration in oxygenation is present that is not otherwise explained by cardiac disease.
    - For children with chronic lung disease, PARDS is diagnosed using the above criteria when acute deterioration in oxygenation from baseline is present.
- After a period of 4 hours, children should be stratified into severity categories according to oxygenation levels and method of ventilation.

- To aid in the bedside assessment and risk stratification, measurement of dead space to tidal volume ratio and/or end-tidal alveolar dead-space fraction is suggested for children with arterial access.

Invasive ventilatory support

- No recommendation is made regarding the specific ventilator mode preferred for children with PARDS.
- The use of physiologic tidal volumes between 6 and 8 mL/kg is suggested.
    - Use of tidal volumes below 6 mL/kg is suggested if children need to stay below suggested plateau and driving pressure limits.
    - Tidal volumes less than 4 mL/kg should be used with caution.
- Inspiratory plateau pressure of 28 cmH_20 or less is suggested in the absence of transpulmonary pressure measurements.
    - For children with reduced chest wall compliance, plateau pressure may be higher.
- Limiting driving pressure to 15 cm H_20 is suggested.
- Titrating positive end-expiratory pressure (PEEP) to oxygenation/oxygen delivery, hemodynamics, and compliance measurements under static conditions is suggested.
- Maintaining PEEP levels at or above the lower PEEP/higher FIO_2 table from the ARDS Network protocol is recommended.
    - Avoid exceeding plateau pressure and/or driving pressure limits when adjusting PEEP levels to achieve the proposed oxygen target range.
- When caring for ventilated children with PARDS, using a lung protective ventilation bundle rather than no bundle is suggested.
- No recommendation is made for or against the use of recruitment maneuvers in children with PARDS.
- Insufficient evidence is available regarding the use of mechanical power calculations to guide pediatric mechanical ventilation.
- No recommendation is made regarding the use of high-frequency oscillatory ventilation (HFOV) over conventional ventilation.
- Optimal lung volume should be attained by exploration of the potential for lung recruitment with a stepwise increase and decrease of the mean airway pressure while continuously monitoring oxygen and CO_2 response and hemodynamic parameters when using HFOV.
- For mild/moderate PARDS, maintaining SPO_2 between 92% and 97% is suggested.
- For severe PARDS, after optimizing PEEP and in order to reduce FIO_2, an SPO_2 less than 92% can be accepted.
- While receiving supplemental oxygen, prolonged exposure of an SPO_2 less than 88% or more than 97% should be avoided.
- Central venous saturation and markers of oxygen delivery/utilization should be monitored when SPO_2 is less than 92%.
- Allowing permissive hypercapnia (lower limit pH of 7.20) is suggested to remain within previously recommended tidal volume and pressure ranges.

    - Exceptions include intracranial hypertension, select congenital heart disease lesions, significant ventricular dysfunction, severe pulmonary hypertension, and hemodynamic instability.
- Routine use of bicarbonate supplementation is not suggested.
- When ventilating a child with PARDS, cuffed endotracheal tubes should be utilized.

Ancillary pulmonary treatment

- Routine use of inhaled nitric oxide is not suggested.
- Routine use of surfactant therapy is not suggested.
- Insufficient evidence is available to endorse or oppose the use of prone positioning.
- An unobstructed airway should be maintained in intubated children.
- No recommendation can be made regarding the use of a closed versus an open suctioning system.
- Instillation of isotonic saline prior to endotracheal suctioning should not be performed routinely.
- No recommendation can be made regarding the use of specific methods of airway clearance.
- Routine use of corticosteroids is not suggested.
- No recommendation can be made regarding the following treatments:
    - Inhaled or intravenous (IV) prostaglandins therapy
    - Inhaled β-adrenergic receptor agonists or ipratropium
    - IV N-acetylcysteine for antioxidant effects
    - Helium-oxygen mixture
    - Fibrinolytics or other anticoagulants
    - Plasminogen activators

Nonpulmonary treatments

- Validated assessment scales for pain, sedation, delirium, and withdrawal should be utilized to monitor and adjust therapies and to facilitate communication among the care team.
- Sedation should be titrated to attain the appropriate mechanical ventilation plan that promotes oxygen delivery, oxygen consumption, and work of breathing goals.
- The care team should utilize a validated protocol to establish daily sedation goals when monitoring, titrating, and weaning sedation.
- Providers weaning children from five or more days of sedation should incorporate a plan that facilitates weaning and assessment of the child for iatrogenic withdrawal syndrome using a validated assessment tool.
- Assess children for delirium daily utilizing a validated pediatric delirium screening tool.
- To prevent and treat delirium, incorporate nonpharmacologic interventions as first-line tools.
- No recommendation can be made for the use of melatonin, typical or atypical antipsychotics, or other medications for the routine prevention and treatment of delirium.
- The use of neuromuscular blockade (NMB) in conjunction with sedation is suggested over the use of sedation alone if effective mechanical ventilation cannot be attained.
- The NMB should be monitored and titrated to the goal prescribed by the care team.

- Early initiation of enteral nutrition is suggested over parenteral nutrition or delayed enteral nutrition.
- Nutrition plan goals should include promoting recovery, maintaining growth, and meeting the child's metabolic needs.
- A minimum intake of 1.5 g/kg/day of protein is suggested.
- Maintaining optimal oxygen delivery and preserving end-organ function while preventing fluid overload should be the focus of daily fluid goals and the administration of fluids.
- Except in the case of hemolytic anemia, critically ill children with respiratory failure who have a hemoglobin of less than 5g/dL should receive packed red blood cells (PRBCs).
- For critically ill, hemodynamically stable children with a hemoglobin of 7 g/dL or more (without a chronic cyanotic condition, severe PARDS, or hemolytic anemia), the transfusion of PRBCs is not suggested.
- For critically ill children who have severe hypoxemia or who are hemodynamically unstable, no recommendation can be made regarding the optimal PRBC transfusion threshold.
- Nonpharmacologic approaches should be utilized to enhance day-night activities and rest patterns.
- Activity and mobility goals should be assessed and determined daily.
- Physical therapy and/or occupational therapy evaluation should be performed within the first 72 hours of admission to establish baseline function and rehabilitation goals.

Monitoring

- At a minimum, all children with PARDS should have continuous monitoring of respiratory rate, heart rate, and pulse oximetry, and regular intermittent monitoring of noninvasive blood pressure.
- Lung volume metrics, such as tidal volume, should be interpreted after standardization to body weight.
- Tidal volume should be continuously monitored during invasive ventilation.
    - Adjust as needed, either manually or via ventilator settings, using compensation for circuit compliance.
- Monitor ventilator inspiratory pressures, including driving pressure and plateau pressure.
- Assess the accuracy of respiratory timings by monitoring flow-time, pressure-time curves, and intrinsic PEEP.
- Clinical assessment should include monitoring the child's effort of breathing.
- No recommendation can be made regarding routine monitoring of the following parameters of respiratory system mechanics:
    - Flow-volume loop
    - Pressure-volume loop
    - Dynamic compliance and resistance
    - Strain
    - Stress index
    - Esophageal manometry and transpulmonary pressure
    - Functional residual capacity

    - Ventilation index
    - Mechanical power
    - Mechanical energy
    - Electrical activity of diaphragm
    - Thoraco-abdominal asynchrony quantification by respiratory inductance plethysmography
- Adjust the frequency of blood pH and $PaCO_2$ measurement according to PARDS severity, noninvasive monitoring data, and stage of disease.
- During IMV, continuous monitoring of CO_2 should be used to assess adequacy of ventilation.
- When $PaCO_2$ and either end-tidal CO_2 pressure or mixed-expired CO_2 pressure are available during IMV, dead space should be calculated and monitored.
- Perform daily assessment of predefined clinical and physiologic criteria of extubation readiness to avoid unnecessary prolonged ventilation.
- Chest imaging is imperative for the diagnosis of PARDS, to assess severity, and to detect complications, such as equipment displacement or an air leak.
- No recommendation can be made regarding the routine use of chest computerized tomography (CT) scans, lung ultrasonography, or electrical impedance tomography.
- Hemodynamic monitoring should be performed to evaluate the effect of ventilation and disease on right and left cardiac function and to assess the delivery of oxygen.
- Monitor cumulative fluid balance.
- Perform echocardiography to provide noninvasive evaluation of both left and right ventricular function, preload status, and pulmonary arterial pressures for children with severe PARDS or suspected cardiac dysfunction.
- Consider an arterial catheter for continuous monitoring of arterial blood pressure and arterial blood gases.
- No recommendation can be made regarding the use of the following hemodynamic monitoring devices:
    - Pulse contour with transpulmonary dilution technology
    - Pulmonary artery catheters
    - Alternative devices to monitor cardiac output, such as an ultrasonic cardiac output monitor
    - Central venous pressure monitoring
    - B-type natriuretic peptide measurements

Noninvasive respiratory support

- If no clear indications for intubation are present, a time-limited trial of NIV is suggested for children with possible PARDS or for those who are at risk for PARDS and who are on conventional O_2 therapy or on HFNC and showing signs of worsening respiratory failure.
- For children not showing clinical improvement after the first 6 hours of NIV or for those who have signs of worsening illness, intubation is suggested over continuing NIV (including those children at higher risk for complications related to IMV).
- NIV should be utilized in settings with experienced staff, who can perform close monitoring and perform interventions if necessary.

- Monitor children who are receiving NIV for skin breakdown, gastric distension, conjunctivitis, and barotrauma.
- Utilize heated humidification for NIV and HFNC.
- Sedation can be utilized for children with a poor tolerance for NIV and HFNC.
- Inspiratory pressure augmentation with pressure support should be used to reduce inspiratory muscle effort for children managed with NIV. CPAP alone may be appropriate for those unable to attain child-ventilator synchrony or when using a nasal interface.
- No recommendation can be made regarding the use of HFNC for children with possible PARDS or at risk for PARDS.
- For children at risk for PARDS, the use of HFNC or CPAP is suggested over standard oxygen therapy.
- In resource-limited settings, CPAP is suggested over HFNC for children with possible PARDS.

Extracorporeal support

- When lung protective strategies result in inadequate gas exchange and the child has a potentially reversible cause of severe PARDS, evaluation for extracorporeal membrane oxygenation (ECMO) is suggested.
- Evaluation of case history and clinical status should guide the decision to institute ECMO.
- Decisions regarding ECMO eligibility should be guided by successive evaluations rather than a single assessment.
- For children with adequate cardiac function, venovenous ECMO is suggested over venoarterial ECMO.
- Consider transferring the child to an ECMO center when non-ECMO therapies have failed to stabilize the child.
- Maintaining a normal PAO_2 is suggested for a child supported by ECMO.
- A slow decrease of $PACO_2$ is suggested over a rapid decrease, especially in the setting of hypercapnia.
- To avoid additional lung injury in a child supported by ECMO, mechanical ventilator pressure should comply with the lung protective limits that were previously identified.
- No recommendation can be made regarding when to use extracorporeal carbon dioxide removal technology in the child population.
- For all pediatric ECMO survivors, perform short- and long-term neurodevelopmental and physical functioning evaluations to assess for impairment.

Morbidity and long-term outcomes

- Screening for post-ICU (intensive care unit) morbidities should be performed by the child's primary care provider (PCP) within three months of discharge from the hospital.
- Screening for pulmonary function abnormalities should be performed within the first three months after hospital discharge, and should include a respiratory symptom questionnaire, respiratory examination, pulse oximetry, and if age appropriate, spirometry.
- When pulmonary function deficits are discovered, referral to a specialist is recommended.

Reference:

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