

## ELSEVIER Clinical Skills

# Oxygen Therapy and Oxygen Delivery (Pediatric) - CE


### ALERT

**Fire is a significant hazard where oxygen is used. Do not permit flames, sparks, or smoking.**

### OVERVIEW

The administration of oxygen to children requires the selection of an oxygen delivery system that suits the child's age, size, needs, clinical condition, and therapeutic goals. Oxygen delivery systems are categorized as low-flow (variable performance) systems or high-flow (fixed performance) systems. With low-flow systems, 100% oxygen mixes with room air during inspiration, and room air is entrained, making the percentage of delivered oxygen variable. High-flow devices provide such a high flow of premixed gas that the child is not required to inhale room air. Supplemental oxygen therapy is often recommended for children when peripheral oxygen saturation is consistently below 94%.<sup>1</sup>

A nasal cannula, oxygen mask (e.g., simple face mask, partial rebreathing mask with reservoir, a nonrebreathing mask with reservoir, Venturi mask), face tent, and oxygen hood deliver supplemental oxygen to children to treat hypoxia, respiratory distress, and respiratory failure. Because oxygen can dry the respiratory system, many oxygen delivery systems allow for humidification.


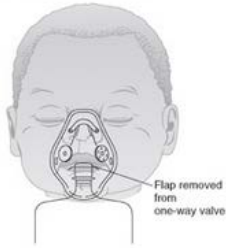
Table 1 Nasal Cannula			
Device	Description	Indications	Considerations
Nasal cannula 			
Low-flow nasal cannula	Nasal cannulas are lightweight and have two soft prongs that fit in the nares and attach on each side to tubing. Different sizes are available.	Children who need oxygen concentrations 22% to 60%. Allows child to eat, talk, and cough without interrupting oxygen delivery.	FIO <sub>2</sub> inconsistent. Most commonly used oxygen delivery device. Child's size and tidal volume alter the oxygen concentration child receives despite same flow rate. Maximum oxygen flow should not exceed 4 L/min. Blenders may be used to wean oxygen in the neonate to allow more precise titration of flow rates. May cause drying of nasal mucous membranes, especially at high flow rates. May be more comfortable than mask.

## Oxygen Therapy and Oxygen Delivery (Pediatric) - CE

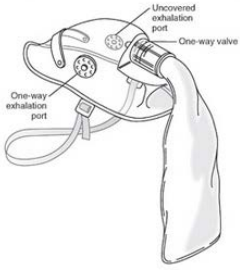
			Mouth breathing reduces $FI_{O_2}$ .
High-flow nasal cannula	Delivers $FI_{O_2}$ with oxygen titrated from a flow rate of 4 L/min in infants up to 40 L/min or more in adolescents.	Used when a higher $FI_{O_2}$ with some end-expiratory pressure is required and ventilation is adequate.	Flow rate can be adjusted based on the child's respiratory effort. Provides some positive end-expiratory pressure.

$FI_{O_2}$ , fraction of inspired oxygen

(Adapted from American Heart Association. [2017]. *Pediatric advanced life support provider manual*. Dallas: AHA.)

Device	Description	Indications	Considerations
 <p>Simple mask</p>	<p>Mask sits on face and over mouth and nose and has elastic strap. Available in variety of sizes.</p>	<p>Low-flow device for children who need approximately 0.35 to 0.6 <math>FI_{O_2}</math>.<sup>a</sup></p>	<p>Inconsistent <math>FI_{O_2}</math> delivery. Monitor child for signs of hypercarbia. Appropriate flow rate is 6 to 10 L/min.<sup>a</sup> Elastic strap may cause irritation. Minimum of 6 L/min<sup>a</sup> must be maintained to ensure enough oxygen is delivered and to prevent rebreathing of carbon dioxide. Mask must be removed for eating.</p>
 <p>Partial rebreathing mask with a reservoir bag</p>	<p>Mask sits on face and over mouth and nose and has elastic strap. Similar to simple mask but with reservoir bag that fills with 100% oxygen and child's exhaled gas.</p>	<p>Can deliver 0.4 to 0.795 <math>FI_{O_2}</math>.<sup>b</sup> Good for short-term therapy in children who need high concentrations of oxygen.</p>	<p>Inconsistent <math>FI_{O_2}</math> delivery. Monitor child for signs of hypercarbia. Exhaled gas in reservoir bag is oxygen rich because it comes from upper airway. Rebreathing of carbon dioxide is prevented if flow is maintained at higher than child's minute ventilation. Oxygen flow rate of 10 L/min is typically necessary.<sup>b</sup> May be uncomfortable for some children. Elastic strap may cause irritation. Adjust flow to prevent reservoir from collapsing on inhalation.</p>

## Oxygen Therapy and Oxygen Delivery (Pediatric) - CE

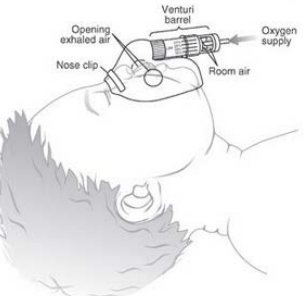
<p>Nonrebreathing mask with reservoir</p> 	<p>Mask sits on face and over mouth and nose and has elastic strap. Attached reservoir bag has two valves, one or two valves in the exhalation ports to prevent room air from entraining during inspiration and a one-way valve to prevent mixing of exhaled gases into the reservoir.<sup>a</sup></p>	<p>High-flow system for children who need highest amount of oxygen (usually for short periods) without intubation.</p>	<p>Can deliver an <math>FI_{O_2}</math> of 0.95.<sup>a</sup> Monitor child for signs of hypercarbia. Elastic strap may cause irritation.</p>
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$FI_{O_2}$ , fraction of inspired oxygen

a. American Heart Association (AHA). (2016). Resources for management of respiratory emergencies. *Pediatric advanced life support provider manual* (pp. 147-170). Dallas: AHA.

b. Heuer, A.J. (2017). Chapter 41: Medical gas therapy. In R.M. Kacmarek, J.K. Stoller, A.J. Heuer (Eds.), *Egan's fundamentals of respiratory care* [pp. 905-936]. St. Louis: Elsevier.

(Adapted from American Heart Association [AHA]. [2017]. *Pediatric advanced life support provider manual*. Dallas: AHA.)

Device	Description	Indications	Considerations
<p>Venturi mask, fixed performance mask</p> 	<p>Mask sits on face and over mouth and nose and has air-entrainment port with elastic strap.</p>	<p>Children who need precise delivery of <math>FI_{O_2}</math> concentrations, not affected by air flow, particularly between 24% and 40%.<sup>a</sup></p>	<p>Inconsistent <math>FI_{O_2}</math> delivery at higher concentrations. Monitor the child for signs of hypercarbia. Air-entrainment mask allows constant flow at low to moderate <math>FI_{O_2}</math> level. Elastic strap may cause irritation. Humidification can alter oxygen concentration with this device.</p>

## Oxygen Therapy and Oxygen Delivery (Pediatric) - CE

Oxygen hood	Clear plastic box covers infant's head. Oxygen can be delivered via either blender or nebulizer.	For neonates or infants who need oxygen. Provides high concentration of oxygen, $FI_{O_2}$ up to 100%. <sup>a</sup>	Monitor the child for signs of hypercarbia. High flow is needed to achieve appropriate oxygen concentrations and decrease hypercarbia. Nasal cannula may be needed when infant is removed from the hood for feeding or other nursing care. Temperature needs to be monitored in tent. Creates moist environment.
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$FI_{O_2}$ , fraction of inspired oxygen

a. Heuer, A.J. [2017]. Chapter 41: Medical gas therapy. In R.M. Kacmarek, J.K. Stoller, A.J. Heuer [Eds.], *Egan's fundamentals of respiratory care* [pp. 905-936]. St. Louis: Elsevier.

(Adapted from American Heart Association [AHA]. [2017]. *Pediatric advanced life support provider manual*. Dallas: AHA.)

- A *nasal cannula* is a low-flow oxygen device. For infants and toddlers who may poorly tolerate a mask, nasal prongs may be a good alternative. The nasal cannula allows breathing through the mouth or nose. The child inspires room air in addition to the supplemental oxygen, and a variable concentration of oxygen is delivered.<sup>2</sup> A nasal cannula can deliver 22% to 60% oxygen with appropriate oxygen flow rates of 0.5 to 2 L/minute.<sup>2</sup>
- A *simple face mask* is a low-flow oxygen device. A simple face mask can deliver 35% to 60% oxygen with an appropriate flow rate of 6 to 10 L/minute. A minimum of 6 L/minute of oxygen flow is needed to prevent rebreathing of exhaled carbon dioxide.<sup>2</sup>
- A *partial rebreathing mask with a reservoir bag* is a face mask that delivers moderate to high concentrations of oxygen. Frequent inspection of the reservoir bag is required to ensure that it remains inflated; if it is deflated, exhaled air collects in it, which results in the child rebreathing large amounts of exhaled carbon dioxide. Side port openings on the mask vent exhaled air on expiration and allow room air to enter on inspiration. The delivered oxygen percentage varies, depending on the rate and depth of the child's breathing.
- A *nonrebreathing mask with reservoir* is a high-flow oxygen delivery device used for children requiring a higher concentration of oxygen. A nonrebreathing mask can deliver a concentration of up to 95% oxygen with an oxygen flow rate of 10 to 15 L/minute.<sup>2</sup>
- A *Venturi mask* is a cone-shaped device with entrainment ports of various sizes at its base. The entrainment ports adjust to deliver various oxygen concentrations. The mask is useful because it delivers a more precise concentration of oxygen to the child.
- A *face tent* is a shieldlike device that fits under the child's chin and encircles his or her face. It is used primarily for humidification and for oxygen only when the child cannot or will not tolerate a tight-fitting mask. Because the tent is so close to the child's face, the amount of oxygen delivered to the child cannot be estimated.

## Oxygen Therapy and Oxygen Delivery (Pediatric) - CE

- *Oxygen tents and hoods* can provide high concentrations of humidified oxygen, which is useful in a child with airway inflammation, epiglottitis (croup), or other respiratory tract infections.

### EDUCATION

- Provide individualized, developmentally appropriate education to the family and child based on the desire for knowledge, readiness to learn, and overall neurologic and psychosocial state.
- Explain the oxygen delivery device, including the rationale for its use and the risks.
- Explain the expected duration and outcome of supplemental oxygen delivery.
- Explain hypoxemia and the signs and symptoms of respiratory distress.
- Explain the necessary assessments during supplemental oxygen delivery.
- Discuss safety precautions for oxygen use.
- Encourage questions and answer them as they arise.

### ASSESSMENT AND PREPARATION

#### Child and Family Assessment

1. Perform hand hygiene before patient contact.
2. Introduce yourself to the child and family.
3. Verify the correct child using two identifiers.
4. Assess the child's developmental level and ability to interact.
5. Assess the child for signs and symptoms of inadequate oxygenation and ventilation.
  - a. Increased work of breathing (e.g., tachypnea, nasal flaring, grunting, intercostal retractions, subcostal retractions)
  - b. Decreased oxygen saturation levels
  - c. Cyanosis
  - d. Anxiety
  - e. Altered level of consciousness
6. Determine if a condition in the medical history predisposes the child to baseline lower-than-normal oxygen saturation levels (e.g., cyanotic heart disease).
7. Assess the child's and family's understanding of the reasons for and the risks and benefits of the procedure.

#### Preparation

1. Select the appropriate oxygen delivery device per the practitioner's order.

### PROCEDURE

1. Perform hand hygiene and don gloves and, if the child's health status requires, a gown, mask, and eye protection or face shield.
2. Verify the correct child using two identifiers.
3. Explain the procedure to the child and family and ensure that they agree to treatment.

## Oxygen Therapy and Oxygen Delivery (Pediatric) - CE

4. Place the selected oxygen device on the infant or child. If one method of oxygen delivery upsets the child, consider changing to another method.
5. Adjust the flowmeter to deliver the desired amount of oxygen. Ensure that the liter flow is appropriate for the device.
6. Apply and secure the noninvasive oxygen delivery device, ensuring that it is the correct size.

Rationale: The correct size device ensures optimal delivery of the prescribed amount of oxygen and reduces the risk of skin breakdown.

- a. If using a mask, ensure that it covers the mouth and nose but not the eyes.
  - b. Use adhesives to secure a nasal cannula or an elastic strap for a face mask.
7. Evaluate the child's oxygen delivery device for proper fit.
    - a. Ensure that nasal cannula prongs remain in the nares.
    - b. Ensure that the infant's head remains in the oxygen hood.
  8. Discard supplies, remove personal protective equipment (PPE), and perform hand hygiene.
  9. Document the procedure in the child's record.

### MONITORING AND CARE

1. Monitor cardiopulmonary status, including vital signs, oxygen saturation, and indicators of oxygenation and ventilation.

**Reportable conditions: Tachypnea, bradypnea, apnea, increased work of breathing, nasal flaring, retractions, diminished or abnormal breath sounds, agitation, anxiety, altered mental status, changes in oxygen saturation, changes in blood gas values, arrhythmias (including tachycardia and bradycardia), hypertension, hypotension, changes in skin color such as pallor or cyanosis, changes in peripheral perfusion**

2. Monitor the child's respiratory status and need for increased or decreased oxygen therapy.

Rationale: Changes in oxygen delivery to avoid oxygen-related complications are based on the child's condition.

3. Monitor the child for signs of hypercarbia.

Rationale: If gas flow is too low, hypercarbia may develop.

**Reportable conditions: Increasing agitation, rapid and deep respiration, dyspnea, progressive lethargy**

4. Monitor a child in an oxygen hood carefully.

## Oxygen Therapy and Oxygen Delivery (Pediatric) - CE

Rationale: Suffocation may occur if the child puts his or her mouth or nose against the plastic walls.

5. Assess the skin frequently for breakdown.

Rationale: The bridge of the nose and the cheeks are prone to skin breakdown.

**Reportable condition: Skin breakdown associated with the device**

6. Monitor the child for signs of dry mucous membranes.

Rationale: Dry and sore mucous membranes can develop with the delivery of oxygen.

**Reportable conditions: Dry or cracked mucous membranes**

7. Provide humidification when the supplemental oxygen delivery device permits. If humidified oxygen is used, check the linens frequently and change them as needed.

Rationale: Oxygen can dry the respiratory system, resulting in thick secretions that are more difficult to mobilize. Dry air can lead to breakdown of the nasal mucosa, resulting in nosebleeds.

8. Assess, treat, and reassess pain.

Rationale: Pain in children can decrease the ability to breathe deeply, thereby affecting gas exchange.

### EXPECTED OUTCOMES

- Signs of improved oxygenation and ventilation
- Decrease in hypoxemia-related adverse effects, including anxiety
- Respiratory, cardiovascular, and neurologic stability
- No skin breakdown
- Adequate pain control during the procedure

### UNEXPECTED OUTCOMES

- Signs of inadequate oxygenation and ventilation
- Increased work of breathing
- Complications of supplemental oxygen
- Increasing cardiovascular, respiratory, or neurologic compromise
- Skin breakdown
- Inadequately managed pain and anxiety

### DOCUMENTATION

- Delivery device and amount of oxygen delivered



## Oxygen Therapy and Oxygen Delivery (Pediatric) - CE

- Respiratory status, including work of breathing and breath sounds
- Vital signs
- Pulse oximeter reading as indicated
- Child's response to supplemental oxygen
- Pain assessment and related interventions
- Unexpected outcomes and related nursing interventions
- Child and family education

### REFERENCES

1. American Heart Association (AHA). (2017a). Part 3: Systematic approach to the seriously ill or injured child. *Pediatric advanced life support provider manual* (pp. 29-67). Dallas: AHA. ([Level D](#))
2. American Heart Association (AHA). (2017b). Resources for management of respiratory emergencies. *Pediatric advanced life support provider manual* (pp. 147-170). Dallas: AHA. ([Level D](#))

### Elsevier Skills Levels of Evidence

- Level I - Systematic review of all relevant randomized controlled trials
- Level II - At least one well-designed randomized controlled trial
- Level III - Well-designed controlled trials without randomization
- Level IV - Well-designed case-controlled or cohort studies
- Level V - Descriptive or qualitative studies
- Level VI - Single descriptive or qualitative study
- Level VII - Authority opinion or expert committee reports

### SUPPLIES

- PPE (gloves, plus gown, mask, and eye protection or face shield if worn)
- Oxygen source (wall supply or portable oxygen cylinder)
- Appropriate prescribed delivery device
- Oxygen analyzer (sometimes used with oxygen hood or tent)
- Flowmeter
- Water for humidified oxygen delivery, if ordered
- Appropriate tubing
- Pulse oximeter
- Supplies to secure the tubing to the child's face as needed (e.g., tape, transparent semipermeable membrane dressing)

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