

Breathing lessons

Basics of oxygen therapy

Find out how to choose the right oxygen delivery device for your patient's condition.

ALTHOUGH COMMON as the air we breathe, oxygen is also a drug that can be dangerous if used improperly. In this article, we'll describe when oxygen therapy is indicated and how to administer supplemental oxygen safely and appropriately. First, let's review some basic oxygen facts.

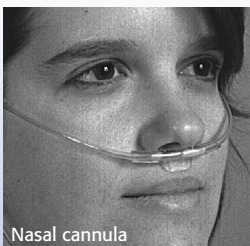
Air transit

Room air consists of about 21% oxygen, 78% nitrogen, and 1% other gases, so the fractional concentration of oxygen in inspired air ($F_{I}O_2$) is 21%. By giving supplemental oxygen, you can raise the patient's $F_{I}O_2$ to as much as 100% oxygen.

Oxygen is transported to the tissues in two ways: About 97% of oxygen is bound to hemoglobin, and the other 3% is dissolved in plasma. The arterial blood gas (ABG) analysis measures PaO_2 —the pressure of oxygen dissolved in plasma. A value of 80 to 100 mm Hg is considered normal, but will increase if the patient receives a higher oxygen concentration.

The saturation of hemoglobin with oxygen can be measured via pulse oximetry (SpO_2) or ABG analysis (SaO_2). A normal SpO_2 or SaO_2 value is above 94%. An SaO_2 or SpO_2 value below 90% means the PaO_2 is below 60 mm Hg, indicating that the patient isn't adequately oxygenated.

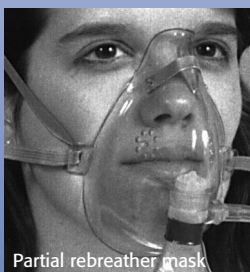
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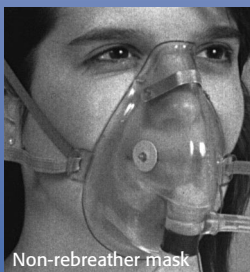
Nasal cannula



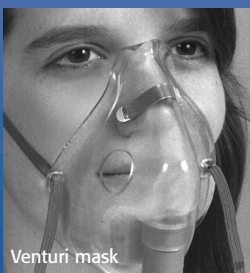
Simple face mask



Partial rebreather mask



Non-rebreather mask



Venturi mask

By William C. Pruitt, RRT, CPFT, MBA, and Michael Jacobs, RN, CCRN, CEN, MSN

When to give supplemental oxygen

Your patient needs supplemental oxygen if she has:

- *documented or suspected hypoxemia*, or deficient oxygenation of the blood, defined as a PaO_2 below 60 mm Hg, an SaO_2 or SpO_2 below 90%, or either value below the desirable range for her clinical situation
- *severe trauma*
- *acute myocardial infarction*
- *procedural sedation or general anesthesia.*

Assess your patient's need for oxygen therapy by monitoring ABG and SpO_2 values and assessing her clinical condition regularly. Signs of increasing hypoxia (reduced tissue oxygenation despite adequate perfusion) include increasing tachypnea and dyspnea, skin color changes (pale at first, then cyanotic), increasing tachycardia, hypertension, restlessness, and disorientation.

A patient in severe hypoxia will go from tachycardia to bradycardia and from hypertension to hypotension. She'll become increasingly somnolent, confused, lethargic, and, without treatment, comatose.

In most cases, you'll administer higher concentrations of oxygen as her oxygen need increases. (Do this carefully in patients with chronic obstructive pulmonary disease [COPD].) Monitor your patient closely and wean her from therapy as soon as possible to avoid oxygen toxicity and absorption atelectasis. Watch for blunting of the respiratory drive, especially in

patients with COPD. Maintaining an $F_{I}O_2$ of 40% or less usually will prevent these problems.

Getting the air there

Devices to deliver oxygen to the patient fall into four groups: low flow, conserving, high flow, and enclosures. For details about low flow and high flow devices, see *A Closer Look at Some Oxygen Delivery Devices*.

Low flow devices such as nasal cannulas, simple face masks, and reservoir masks deliver oxygen at rates below the normal patient inspiratory flow rate of about 30 liters/minute. The patient draws in room air along with the supplemental oxygen, so the true $F_{I}O_2$ can't be determined and can vary greatly. For example, imagine a patient receiving oxygen at 3 liters/minute via nasal cannula. If she's breathing hard and fast, the supplemental oxygen flow will be diluted by the large amount of room air being drawn in, and a relatively low $F_{I}O_2$ will result. On the other hand, if she's taking very slow, deep breaths, very little room air will be mixed with the supplemental oxygen and her $F_{I}O_2$ will be high.

Use a nasal cannula for a patient who has adequate ventilation and tidal volume but needs more oxygen. The nasal cannula gives her more freedom than a mask, which may make her feel claustrophobic. It can

also be used for patients who are mouth breathers.

Another low flow device, the simple face mask, is indicated for a patient who needs a little higher concentration. The higher flow rate keeps her from rebreathing exhaled carbon dioxide (CO_2).

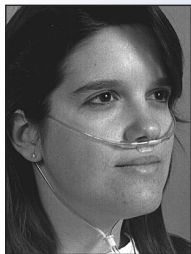
Reservoir masks come in two types: a partial rebreather mask and a non-rebreather mask. Similar in appearance, both masks have a reservoir bag that fills with oxygen, and the bag must be kept inflated. These are considered low flow devices, but can deliver higher oxygen concentrations than a simple face mask. However, a partial rebreather mask has no one-way valves; a non-rebreather mask has a small one-way valve on the outside of the mask and another inside the mask at the top of the bag where it connects to the mask. These valves allow expired CO_2 to leave the mask.

Conserving devices are designed to decrease the oxygen flow needed to provide adequate oxygenation. Patients using home oxygen systems that require periodic refilling (for example, cylinders or liquid oxygen systems) can reduce costs related to the number of home visits needed to replenish their supply. (For information about home oxygen without a mask, see *Another Option for Home Oxygen Delivery*.)

All of these devices can cut oxygen requirements by at least 50%; for example, a patient who needs a flow of 3 liters/minute can reduce the flow to 1.5 liters/minute

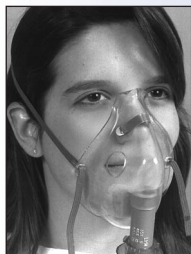
A closer look at some oxygen delivery devices

Device	Oxygen flow (liters/min)	$F_{I}O_2$	Nursing considerations
Low flow			
Nasal cannula	1-6	0.24-0.44	<ul style="list-style-type: none"> • Most commonly used oxygen delivery device in hospital, extended care, and home health care settings • More comfortable than a mask • Can irritate nares and skin around ears
Simple face mask	5-10	0.30-0.60	<ul style="list-style-type: none"> • Patient may find mask uncomfortable and refuse to wear it. • Useful when transporting patients
Partial rebreather mask	8-12	0.40-0.70	<ul style="list-style-type: none"> • Patient may find mask uncomfortable and refuse to wear it. • Adjust the flow so the reservoir bag doesn't collapse when the patient breathes in. • Good for short-term (24-hr) therapy for patients needing higher oxygen concentrations
Non-rebreather mask	10-15	0.60-0.80	<ul style="list-style-type: none"> • Patient may find mask uncomfortable and refuse to wear it. • Adjust the flow so the reservoir bag doesn't collapse when the patient breathes in. • Good for short-term (24-hr) therapy for patients needing higher oxygen concentrations • Provides highest oxygen concentration without intubation
High flow			
Venturi mask	4-12	0.24-0.50	<ul style="list-style-type: none"> • Patient may find mask uncomfortable and refuse to wear it. • Useful for patients with chronic carbon dioxide retention, such as those with chronic obstructive pulmonary disease



A nose-to-nose comparison of flow rates

Device	Oxygen flow (liters/min)	F _I O ₂
Nasal cannula	1	0.24
	2	0.28
	3	0.32
	4	0.36
	5	0.40
	6	0.44
Venturi mask	4	0.24
	4	0.28
	6	0.31
	8	0.35
	8	0.40
	12	0.50



with a conserving device. Newer devices use demand flow or pulsed flow to match the patient's inspiratory effort. As the patient starts to inhale, the oxygen flow begins; as the patient begins to exhale, the flow stops.

High flow devices deliver oxygen at rates above the normal inspiratory flow rate and maintain a fixed F_IO₂ regardless of the patient's inspiratory flow and breathing pattern. One of the most commonly used systems is the venturi mask (also called an air-entrainment mask), which uses a nozzle to accelerate the oxygen flow and mix it with air in a precise ratio. The venturi mask can easily deliver from 24% to 50% oxygen by using different adapters with different-sized nozzle openings, varying the size of the openings where room air enters the system (called entrainment ports), or both. (See *A Nose-to-Nose Comparison of Flow Rates.*)

Aerosol devices produce a fine mist by using a simi-

Another option for home oxygen delivery

A transtracheal oxygen catheter is a small catheter inserted surgically into the trachea between the second and third tracheal cartilage rings. Small-bore oxygen tubing is connected to the catheter. Oxygen fills the trachea and upper airways during exhalation and during the pause before the next inspiration, reducing the inspiratory flow needed to achieve a desired blood oxygen level. Cosmetically, this system is easier to conceal and is less obvious than a traditional nasal cannula. Drawbacks to this system include the surgery and the potential for related complications, the need to replace the catheter every 90 days, and the need for careful cleaning to keep the catheter from clogging with mucus. Also, some insurers don't cover this option.

lar oxygen nozzle to entrain air and fluid. The oxygen-enriched mist can be delivered with a face tent, tracheostomy collar, or T-piece. These devices can deliver 24% to 100% oxygen and, like the air-entrainment mask, can exceed the patient's inspiratory flow at the lower F_IO₂ settings (below 50%). At higher F_IO₂ settings, these devices may need to be run in tandem with another aerosol device, using a large-bore Y adapter in the aerosol tubing to join their outputs, to meet the patient's inspiratory flow.

Enclosures, typically used for neonates and infants, enclose the patient's head or his whole body in an oxygen-enriched atmosphere to treat hypox-

emia. A rigid, clear plastic hood is filled with oxygen by the same aerosol device used with the adult aerosol mask, face tent, or T-piece. A cool-mist tent (also called a croup tent) is a large, clear plastic tent that covers a hospital crib and provides 22% to 40% oxygen and a cool mist to reduce upper-airway edema.

Choosing the right device

When your patient is hypoxic and in respiratory distress, supplemental oxygen is your first priority. Select a device appropriate to her condition and size. Knowing the characteristics of each oxygen delivery device will help you make the right choice. **1**

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