Back to basics with O₂ therapy

For many patients, supplemental oxygen is indeed the breath of life. Your nursing skills can make all the difference in how patients respond to this lifesaving intervention.

Administering supplemental oxygen is an everyday procedure for nurses. But just because it’s familiar doesn’t mean you should take it lightly. In fact, giving supplemental oxygen is a powerful intervention, one that takes as much knowledge and skill as many of the other procedures you perform.

Knowing when to administer oxygen is important, but so is choosing the right delivery system. From nasal cannula to Venturi mask, oxygen delivery systems vary, and what’s appropriate for one patient might not be the best choice for another. Familiarizing yourself with the various systems and how they differ will help you choose the one that best suits your patient’s needs.

When and why patients need supplemental oxygen

When healthy people breathe ambient (or room) air, they take in all the O₂ they need to keep the body functioning properly at the tissue and cellular level. The fraction of inspired oxygen (FiO₂) in room air is 21%, which is quite sufficient to
oxygenate the blood to normal levels.

Two indices are used to assess the oxygenation of arterial blood: SaO2 (or SpO2 by pulse oximetry), a measure of the saturation of arterial hemoglobin with oxygen, and PaO2, a measure of the partial pressure of dissolved oxygen in arterial blood.

Normal values are >94% for SaO2 and >80 mm Hg for PaO2. Normal readings indicate that both the respiratory and cardiovascular systems are in working order: The lungs are taking in adequate amounts of O2, and the heart is transporting oxygen-saturated red blood cells to the tissues in a timely fashion. But when disease or trauma disrupts either of these systems, room air may not provide all the oxygen the patient needs. An SaO2 <90%, which is equivalent to a PaO2 of <60 mm Hg, means the patient is hypoxemic and needs supplemental O2 to raise arterial oxygen to normal levels.

Supplemental oxygen can also be prescribed to prevent hypoxemia. It’s used routinely for this purpose in acute care situations, such as severe trauma, acute myocardial infarction, and post-anesthesia recovery. Regardless of the indication, the primary goal of O2 therapy is to provide an FiO2 that will result in a stable SaO2, thus reversing hypoxemia or keeping it at bay.

Once a patient is adequately oxygenated, clinical signs of hypoxemia—tachycardia, tachypnea, hypertension, dyspnea, anxiety or agitation, the use of accessory muscles to breathe, and cool, pale, dry skin—should abate. Breathing should become easier, and dyspnea and anxiety should decrease. An appropriate method of delivering supplemental O2 will provide the minimal amount necessary to reach these goals.

Choosing the right delivery system

Oxygen delivery systems are differentiated by the amount of supplemental O2 they can deliver. Understanding their design and function will help you anticipate which type is best suited to your patient’s physiologic needs.

For example, a patient admitted with pneumonia and an SpO2 of 88%, but no other indications of distress might do well with a device that delivers a small amount of supplemental O2. However, if this same patient has tachypnea and is using accessory muscles to breathe, she probably requires an oxygen delivery system (ODS) that delivers a higher FiO2.

These systems are divided into low-flow, low-flow reservoir, and high-flow systems. “Flow” refers to the rate at which the supplemental O2 is delivered.

Low-flow systems. This type of system delivers O2 in concentrations greater than room air, but not in a volume sufficient to fill the lungs entirely. That’s because the concentration of oxygen gets diluted with room air as the patient inhales, and varies with the rate and depth of respirations. Because of the mixing of these two sources of O2, the actual FiO2 is inconsistent and cannot be precisely specified. Therefore, low-flow devices are best suited for patients who can take an adequate breath, at a rate and volume that’s near normal.

The most commonly used low-flow ODS is the nasal cannula (NC). This device is relatively comfortable and easy to secure on the patient. It can provide about 24% – 44% O2 at flow rates of up to 6 liters per minute (L/min). An increase in flow rate by 1 L/min generally will increase O2 delivery by 4%. Obviously this device works best for patients who can breathe through the nose, but mouth breathers may also benefit because some of the O2 fills the nasopharynx and can be captured with inspiration.
One drawback of the NC system is that patients may develop dryness of the nares, epistaxis, or even infection, particularly at higher flow rates. To keep the nares and mucous membranes moist, some clinicians recommend the use of humidification with flow rates >4 L/min.

If a flow rate of 6 L/min isn’t providing sufficient oxygen, you can switch from the NC to a simple face mask. Be sure to choose the appropriate size: The mask should fit snugly but not so tightly that it irritates the skin on the face or ears. A simple face mask can deliver higher FiO₂ (30% - 50%) because the mask itself acts as a reservoir. Between breaths, O₂ fills the space inside the mask. Each succeeding breath then draws in O₂ from the supplemental source, the reservoir in the mask, and the room air that leaks into the mask. When using a face mask, maintain a flow rate of at least 5 L/min to prevent rebreathing of exhaled carbon dioxide.²³

**Low-flow reservoir systems.** Masks with attached reservoirs can deliver a higher FiO₂ than a simple face mask. Delivering oxygen via this type of system may be the best way to avoid intubation and mechanical ventilation in a critically ill patient with moderate to severe hypoxemia. Depending upon the flow rate, how well the mask fits, and the patient’s breathing pattern, these devices can deliver an FiO₂ ranging from 60% to close to 100%.³⁴ A reservoir bag attached to the mask fits with O₂ with each inspiration, so that each succeeding breath contains a higher FiO₂.

Low-flow reservoir systems are either “partial rebreathing” or “non-rebreathing.” With a partial rebreathing system, some of the patient’s exhaled CO₂ is inhaled during the next respiratory cycle. In a non-rebreathing system, a series of one-way valves prevents any exhaled gas from entering the reservoir bag, so the patient doesn’t inhale his exhaled CO₂.

With either type of system, the flow rate should be high enough to keep the reservoir bag at least one-third to one-half full on inspiration and the mask should fit snugly to minimize the influx of room air.²⁲ Of all the available low-flow delivery systems, the non-rebreather can deliver the highest FiO₂.

**High-flow systems.** These systems deliver O₂ at rates three to four times higher than the patient’s inspiratory flow rate³⁴ and can deliver a fixed FiO₂ regardless of the patient’s breathing pattern. A high-flow system is desirable if the O₂ concentration must be held constant—in chronic obstructive pulmonary disease (COPD), for example, where small increases in FiO₂ can lead to hypoventilation, respiratory depression, or even arrest.

The most commonly used high-flow system is the Venturi mask (also called the air-entrainment mask), which uses a nozzle to accelerate O₂ flow and mix it with room air in a precise ratio. Depending upon the size of the nozzle, the Venturi mask can deliver an FiO₂ ranging from 24% - 50%,³ as detailed in the table on page 40.

**Monitoring patients on O₂ therapy**

When a patient is receiving supplemental O₂, your priorities are to achieve the desired outcome while keeping your patient safe from preventable
High-flow O\textsubscript{2} delivery system (Venturi mask)

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<tr>
<th>O\textsubscript{2} flow rate</th>
<th>Fixed FiO\textsubscript{2} delivered</th>
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</thead>
<tbody>
<tr>
<td>4 L/min</td>
<td>24%</td>
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<tr>
<td>5</td>
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complications. For optimal results, supplemental O\textsubscript{2} should be administered continuously for as long as it’s indicated.

Patients with hypoxemia need frequent monitoring to assess for evidence of increasing respiratory distress and to evaluate the effectiveness of the oxygen therapy. Assess the patient’s breathing pattern, vital signs, skin color and temperature, and mental and emotional status. You should use pulse oximetry to monitor SpO\textsubscript{2}. For patients who are more critically ill, you may need to send specimens for blood gas analysis so that you can check the pH, PaO\textsubscript{2}, PaCO\textsubscript{2}, and SaO\textsubscript{2} of arterial blood, more reliable indicators of hypoxemia than SpO\textsubscript{2} alone.

Institutional guidelines may differ but, in general, patients receiving supplemental O\textsubscript{2} at an FiO\textsubscript{2} of <40% should have their SpO\textsubscript{2} or arterial blood gases measured within the first 12 hours. Those at a higher FiO\textsubscript{2} should have theirs checked within the first eight hours. Patients with COPD require SpO\textsubscript{2} monitoring within two hours to ensure that they’re not receiving too much supplemental O\textsubscript{2}. Too much of a good thing can have dire consequences for these patients because their central nervous system’s trigger to take a breath is dependent upon a lack of O\textsubscript{2} and not—as it is for most people—a rise in CO\textsubscript{2}.

Patients with COPD are not the only ones who can suffer complications from high levels of supplemental O\textsubscript{2}. Oxygen toxicity, the poisonous effect of supplemental O\textsubscript{2} on the lungs, can develop when a person has breathed 100% O\textsubscript{2} for more than 12 hours. It can also occur at an FiO\textsubscript{2} of >50%, but will take longer to manifest. That’s why it’s important to administer the lowest amount of O\textsubscript{2} your patient needs. Indicators of O\textsubscript{2} toxicity include increasing dyspnea, paresthesia in the extremities, signs of pulmonary edema, and decreased breath sounds from atelectasis. To prevent permanent lung damage, the physician will need to reduce FiO\textsubscript{2} to a safer level.

Patient safety and comfort are key

While your patient is receiving O\textsubscript{2}, make sure the oxygen source is working properly, no one is smoking nearby, there are no electrical hazards, and the tubing isn’t kinked or disconnected. Inspect the patient’s skin to make sure the components of the ODS aren’t causing irritation; check the face, bridge of the nose, back of the neck, and behind the ears. You can place gauze or cushions under the straps of the mask to relieve pressure or prevent irritation, as long as you ensure that too much room air doesn’t leak in.

Although the risk of infection is relatively low, you’ll need to replace face masks and straps if copious amounts of secretions are being expelled. Supplemental O\textsubscript{2} can be discontinued as soon as a “trial” of room air reveals an acceptable SpO\textsubscript{2} or PaO\textsubscript{2}, depending upon which of these indices the physician is following.

Your assessment skills and your knowledge of oxygen delivery systems and how they work should give you confidence in providing supplemental oxygen safely and appropriately. You and your patient will both breathe easier.

REFERENCES
