YOU ENTER YOUR PATIENT’S room at the beginning of the shift and find her in severe respiratory distress. She’s pale, diaphoretic, tachypneic, and dyspneic, and her $\text{SpO}_2$ is 86%. You activate the rapid response team. While waiting for help to arrive, you obtain her vital signs and prepare to administer supplemental oxygen. Which oxygen delivery device would be the most appropriate for this patient?

In this article, we’ll help you make the best choice by presenting an overview of oxygen therapy for adults in an acute care facility, looking at various types of supplemental oxygen delivery devices, and discussing the strengths and limitations of each.

**Oxygen therapy: What and who?**

As you know, oxygen therapy treats or prevents hypoxia by administering oxygen at concentrations greater than the level found in ambient air. Room air consists of 21% oxygen, 79% nitrogen, and trace amounts of carbon dioxide and other gases. Oxygen therapy is indicated for patients with:

- documented hypoxemia, or a subnormal $\text{PaO}_2$, defined as less than 60 mm Hg (or an $\text{SaO}_2$ of less than 90%) in a patient breathing room air, or a $\text{PaO}_2$ or $\text{SaO}_2$ below the desirable range for the patient’s clinical situation.
- an acute care situation in which hypoxemia is likely, such as severe trauma, acute myocardial infarction, or surgery.

Oxygen therapy has no specific contraindications, but like most other drugs, it can cause adverse reactions and complications. Administer it cautiously to patients with chronic obstructive pulmonary disease who have a hypoxic respiratory drive, and be aware of the risk of oxygen toxicity.

Potential adverse reactions to oxygen therapy include:

- ventilatory depression in spontaneously breathing patients with elevated $\text{PaCO}_2$ and $\text{PaO}_2$ greater than 60 mm Hg
- absorption atelectasis, oxygen toxicity, and depression of ciliary and leukocyte function at $\text{FiO}_2$ values above 0.5.

High oxygen concentrations also pose a fire hazard, and certain nebulization and humidification systems can become contaminated with bacteria, raising infection risks.

**Types of oxygen delivery devices**

Oxygen delivery devices are used to administer, regulate, and supplement oxygen to increase the patient’s arterial oxygenation. The device entrains (mixes) oxygen and air, creating a fixed concentration of oxygen for delivery to the patient.

Typically in nonemergency situations, the healthcare provider will specify which oxygen delivery device to use. Devices can be low-flow or high-flow.

If you’re choosing an oxygen delivery device in an emergency, ask yourself which oxygen concentration the device can deliver when connected to an oxygen supply source, and consider if and how the inspired oxygen concentration varies with the oxygen flow rate. The inspired oxygen concentration typically is expressed as a percentage for supplemental oxygen, but can also be expressed as a decimal ($\text{FiO}_2$), with values between 0.21 (room air) and 1.0 (equivalent to 100% oxygen).

A patient who can protect her own airway and is breathing spontaneously may be able to use various common oxygen delivery devices. Let’s look at the options.

**Low-flow devices**

Low-flow devices deliver oxygen directly into the patient’s airway at flow rates of 8 L/minute or less. Because this flow rate is below the normal adult inspiratory requirements, and because
low-flow devices aren’t sealed to the patient’s face or nares, the patient takes in a variable mix of room air and delivered oxygen with each breath. As a result, the inspired oxygen concentration can vary greatly. For example, if the patient is tachypneic, the supplemental oxygen will be diluted by room air, producing a lower inspired oxygen concentration. If the patient takes slow, deep breaths, he’ll inhale more supplemental oxygen and less room air, increasing the inspired oxygen concentration.

Low-flow reservoir devices generally provide a higher inspired oxygen concentration than nonreservoir low-flow systems, but the concentration remains variable. While the patient exhales, the delivered oxygen is stored in the reservoir and is available for the next inspiration; as a result, the patient inspires the stored oxygen and less room air.

Low-flow devices include the nasal cannula, simple face masks (simple oxygen masks), and rebreather masks (simple masks with a reservoir bag). Let’s look at each device.

**Nasal cannula**

Nasal cannulas are commonly used for stable patients who can tolerate a low, nonfixed oxygen concentration. These devices deliver 100% oxygen, but because the patient also breathes room air, the oxygen concentration ultimately delivered to the alveoli ranges from 24% to 44%. Other factors affecting the inspired oxygen concentration are the oxygen flow rate through the cannula, mouth breathing, respiratory rate and pattern, minute ventilation, and altitude. The acceptable oxygen flow rate for this device ranges from 1 to 6 L/minute. For more on flow rates, see Concentrating on nasal cannulas.

Oxygen supplied via nasal cannula at flow rates of 4 L/minute or less doesn’t need to be humidified. However, oxygen flow rates above 4 L/minute should be humidified to prevent discomfort and prevent nasal mucosa from drying.

**Reservoir nasal cannula**

The reservoir nasal cannula, originally designed for outpatient use, is relatively new for hospitalized patients. These devices store oxygen in a reservoir while the patient is exhaling and deliver a bolus of 100% oxygen on the next inhalation. Because these devices are oxygen-conserving, they can deliver higher oxygen concentrations than a simple nasal cannula despite delivering oxygen at lower flow rates. For example, a flow rate of 2 L/minute with a reservoir cannula produces an FIO$_2$ equivalent to that delivered by a traditional nasal cannula set to deliver 4 L/minute. Sizes vary by manufacturer, but a 20-mL reservoir is typical.

Reservoir nasal cannulas come in two styles: mustache and pendant. The mustache style, which positions the reservoir under the nose, may be more comfortable for some patients. The more discreet pendant style is less noticeable but weighs down the ear loops. Because reservoir nasal cannulas capture water vapor when patients exhale and return the vapor during inhalation, humidification isn’t required.

The reservoir nasal cannula can provide FIO$_2$ rates of 0.5 or greater while letting the patient eat, talk, ambulate, and use incentive spirometry. Because the device is more comfortable and less anxiety-provoking than other devices, the patient may also be more willing to adhere to therapy.

**Concentrating on nasal cannulas**

Starting at 1 L/min, increasing the oxygen flow by 1 L/min will increase the inspired oxygen concentration about four percentage points:

- 1 L/min = 24%
- 2 L/min = 28%
- 3 L/min = 32%
- 4 L/min = 36%
- 5 L/min = 40%
- 6 L/min = 44%
Simple face mask
Like the nasal cannula, the simple face mask (also known as the simple oxygen mask) mixes oxygen with room air. But because the mask itself acts as a reservoir, it can deliver an $F_{\text{IO}_2}$ of 0.35 to 0.50, using oxygen flow rates from 5 to 10 L/minute. A minimum flow rate of 5 L/minute is needed to flush the expired carbon dioxide out of the mask so that the patient doesn’t rebreathe it.

Patients who are mouth breathers may also benefit from a face mask over a simple nasal cannula, but to flush out carbon dioxide, the flow rate must remain above 5 L/minute even if the patient doesn’t require a flow rate that high to maintain his $SpO_2$.

Some patients may find any type of face mask, including the simple face mask, uncomfortable and claustrophobic. Also, the higher flow rates needed for a simple face mask may dry oral and nasal mucous membranes, making the patient uncomfortable and discouraging him from continuing therapy. In addition, prolonged use of a face mask can irritate the skin, potentially leading to skin breakdown and even pressure ulcers.

Partial rebreather mask
A partial rebreather mask, another type of reservoir device, consists of a simple face mask with a reservoir bag. It’s a step up from a simple face mask and a step down from a non-rebreather mask. A low-flow device, the partial rebreather mask can deliver 40% to 70% oxygen at flow rates of 6 to 10 L/minute. The oxygen flow should keep the reservoir bag at least one-third to one-half full on inspiration.

Because this mask’s range of oxygen delivery can be accommodated by either the simple face mask or non-rebreather mask, many hospitals no longer use them.

Non-rebreather mask
Similar to the partial rebreather mask, the non-rebreather mask also has a series of one-way valves. The valve between the reservoir bag and the mask prevents exhaled air from returning to the bag.

The non-rebreather mask is ideal for emergency situations when the patient needs a high inspired-oxygen concentration (60% to 80%) for a short time. The mask can be placed quickly and provide a flow rate of up to 10 L/minute in an emergency.

Theoretically, an inspired oxygen concentration of close to 100% could be achieved if the patient breathed in only the stored oxygen from the reservoir and inspired no room air. But in practice, a concentration over 75% is rare because the mask doesn’t create a perfect seal on the patient’s face and inspiration of some room air is inevitable. (For more, see Non-rebreather masks: Pumping up the volume).

To maximize function of a non-rebreather mask, make sure that the mask fits snugly with no visible gaps between it and the patient’s face. The oxygen flow rate should always maintain the reservoir bag at least one-third to one-half full on inspiration, just like the partial rebreathing mask.

High-flow devices
High-flow devices deliver a prescribed low or high oxygen concentration at rates that exceed patient demand, thereby providing more than enough oxygen for each inspiration. These devices include Venturi masks (also known as Venti masks) and aerosol masks. Unlike low-flow and reservoir devices, these devices control the mixture of room air so the inspired oxygen concentration is consistent.

Venturi mask
Venturi masks typically come in a kit that includes five to seven interchangeable air...
Entrainment devices used to achieve an inspired oxygen concentration between 24% and 50%, depending on the manufacturer. The concentration is controlled using interchangeable color-coded valves, not the oxygen flow rate, so increasing the flow rate without using the appropriate valve won’t increase the concentration.

Because they deliver a consistent inspired oxygen concentration, Venturi masks are good for patients with chronic hypercarbia and moderate-to-severe hypoxemia, such as patients with chronic obstructive pulmonary disease. Humidification usually isn’t needed—because the mask entrains a much greater flow of room air, the mixture of gas delivered to the patient approaches room air humidity. If the patient experiences upper airway mucosal dryness, he may be more comfortable using an aerosol device with the appropriate mask.

**Aerosol masks**

Aerosol face masks, tracheostomy collars, T-tube adapters, and face tents work in the same fashion but attach to the patient differently. The aerosol mask uses a mixture of oxygen, entrained room air, and water to achieve the desired humidified oxygen concentration. A jet flow nozzle produces aerosol water particles; the aerosol mask provides a specific oxygen concentration (ranging up to 100%).

**Assessing oxygenation**

When your patient is receiving supplemental oxygen, monitor her response to therapy using pulse oximetry, arterial blood gas analysis, and physical assessment findings, such as respiratory rate and pattern and breath sounds. Oxygen is a drug, and as with all drugs, you’ll want to administer the smallest amount necessary to achieve the desired effect.

If the patient’s SpO2 is 90% to 94%, she has mild to moderate hypoxia and should receive supplemental oxygen via nasal cannula or simple face mask as needed to achieve the desired SpO2. (A reading of 93% to 100% is considered normal, although your facility may set a lower threshold.) An SpO2 of 85% to 89% indicates moderate to severe hypoxia; provide supplemental oxygen via a face mask with a reservoir. An SpO2 below 85% indicates severe to life-threatening hypoxemia requiring endotracheal intubation and mechanical ventilation.

**Helping your patient**

Now let’s return to the patient we met at the beginning of this article. She’s in severe respiratory distress, on the verge of respiratory arrest, and her deteriorating SpO2 indicates moderate to severe hypoxia. In this emergency situation, administer 100% oxygen via non-rebreather mask and continue to reassess the patient until help arrives.

The rapid response team arrives and intubates the patient to control the airway and correct the hypoxia. She’s taken to the ICU for ventilatory support and further treatment.

By understanding oxygen delivery devices and how to assess your patient’s response to supplemental oxygen therapy, you can help her breathe easy.

**REFERENCES**


**RESOURCES**