

2 is Not 2 is Not 2

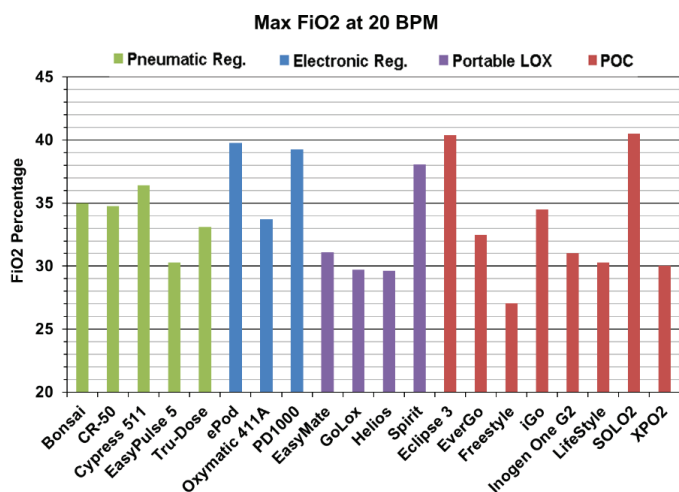
The fundamental flaw in perception when providing long-term oxygen therapy (LTOT) to a patient

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The Reality – 2 liters per minute continuous flow is not equal to a 2 setting on an intermittent flow (IF) device. A 2 setting on one intermittent flow device is not equal to a 2 setting on a different intermittent flow device. Therefore, for oxygen delivery devices: **2 is not 2 is not 2**¹.

Fundamentals of oxygen therapy

Oxygen is the fuel that drives life. Every cell requires the proper amount of oxygen to function properly and without proper oxygen levels, complications occur.²



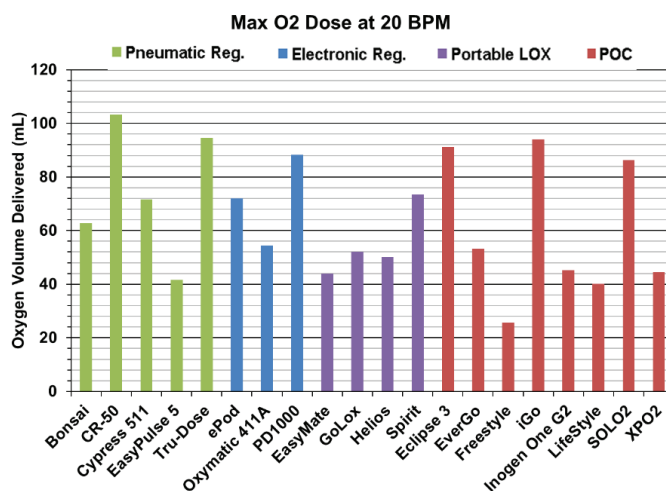
The maximum FiO2 of a variety of portable oxygen systems, utilizing intermittent flow at 20 breaths/min varies greatly.*

The maximum oxygen dose of portable oxygen systems, utilizing intermittent flow at 20 breaths/min varies greatly.*

*Although research exists, more research is needed to explore recent product improvements and new additions to the market.

Normal oxygenation occurs naturally in a healthy body with healthy lungs, yet when lung disease compromises lung function, hypoxemia occurs. Supplemental oxygen therapy is provided to maintain normal oxygen level, yet can only be effective if given in adequate doses to sustain effective oxygenation. When

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providing supplemental oxygen, it cannot be assumed that the oxygen device will provide adequate oxygenation due in part the variability of the devices, oxygenation must be measured at all patient activity levels due to the variability in performance of different oxygen therapy equipment.³

Oxygen is a drug that needs to be prescribed, delivered and monitored like any other drug.

Oxygen is the only drug that has been shown to maintain and prolong life of patients with chronic lung impairment.

Reference: Continuous or nocturnal oxygen therapy in hypoxemic chronic obstructive pulmonary disease: a clinical trial. Nocturnal Oxygen Therapy Trial Group. Ann Intern Med 1980;93(3):391-398.

Hypoxemia and comorbidities

Cor pulmonale

When oxygen is not provided at therapeutic levels, the body will compensate. The pulmonary vasculature will divert blood flow to areas of the lung that have effective oxygen levels. If this is not possible, pulmonary blood vessels will constrict causing blood to back up into the heart and peripheries of the body.

Polycythemia

The blood will compensate by producing more hemoglobin to increase the oxygen carrying capacity of the blood. This thickening of the blood impacts circulation.

General cellular dysfunction

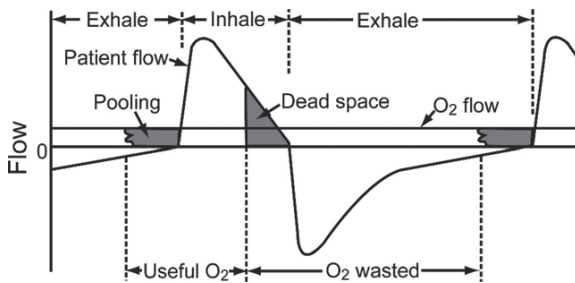
All other organs in the body will slow their function in the response to low oxygen levels.⁴

Basically, the body does not function well without therapeutic oxygen levels, which begins a downward progression of body mechanics to the point where patients will reduce activity, retain secretions and eventually develop chest infections requiring medical intervention. These occurrences are the exacerbations that occur with oxygen-deprived patient and cause them to become the frequent flyers that cost healthcare systems penalties under the ACA.

History of the evolution of continuous flow oxygen therapy to intermittent flow oxygen delivery

Continuous flow (CF) oxygen was the original method of oxygen therapy due to the simplicity of delivery and limitation of technology. The limitation is CF wastes oxygen by delivery flow when the patient is exhaling and pausing between breaths. The fixed flow also allows for FiO₂ to drop when respiratory rate increases shortening inspiratory time.

VIP graph of flow delivery reference 2013 article



Above: Diagram of a respiratory flow cycle in relationship to continuous-flow supplemental oxygen, indicating the sections of the breathing pattern that useful oxygen is delivered.

Continuous flow, oxygen conserving options:

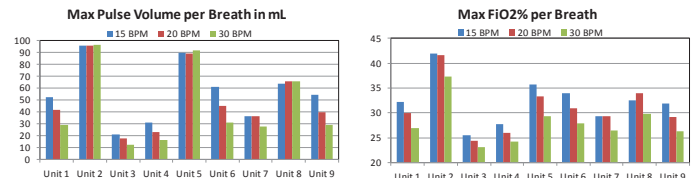
- Transtracheal oxygen – a method of bypassing the upper airway and reduces dead space which allows improved use of oxygen and improves patient compliance due to elimination of cannula irritation.
- Reservoir oxygen systems – utilizes a 20 mL reservoir to store oxygen between breaths improving efficiency of oxygen delivery and conserves oxygen.

Intermittent oxygen delivery options (provides oxygen when the patient is inhaling and turns off with exhalation):

- Demand flow allows for oxygen delivery at the same flow rate as prescribed oxygen which is usually 2 LPM.
- Hybrid flow allows for a higher peak flow of oxygen at the beginning of a breath then returns to the flow rate prescribed.
- Pulse dose provides a higher peak flow at the beginning of a breath and cycles off when the volume of oxygen is delivered. This keeps the volume of oxygen consistent throughout a range of breath rates.
- Minute volume delivery is a fixed delivery of oxygen for one minute. If respiratory rate increases, the volume of gas delivered will decrease to maintain the fixed minute volume.

Why different intermittent flow devices are not the same at the same setting, the first step in explaining 2 is not 2 Pulse volume

Pulse volume at an appropriate dose is the key to effective oxygenation. The volume of oxygen delivered to gas exchange units in the lung (alveoli) is how effective oxygenation occurs. Intermittent flow (IF) oxygen delivery devices are highly variable in delivering consistent volumes of oxygen. Dose settings are not consistent in delivering known volumes of gas. Gas volume, gas delivery peak flow, gas delivery in the first half of inspiration and the purity of the gas all contribute to effective oxygenation. With any change in these parameters, the FiO₂ will change and impact effective oxygenation.



Above: Maximum pulse volumes and FiO₂ of different Pulse systems at different respiratory rates.

Inspiratory time

Inspiratory time is the window of opportunity for therapeutic gas to be delivered to gas exchange units in the lung. As a patient breathes faster, the window of opportunity becomes shorter and the gas must be delivered quickly to be therapeutic. Demand units were not effective in delivering oxygen therapeutically due to fixed/low peak flow delivery. Minute volume devices typically have a higher peak flow, which will allow gas to be delivered quickly, yet with an increased breath rate, oxygen volumes decrease with an impact on FiO₂.

Pulse Delivery Flow Profiles



Above: Flow profiles of 3 pulse dose systems showing oxygen delivery in one second. The first 60% of an inspiratory cycle is considered delivered to gas exchange units in the lung, the rest occupies dead space.

Triggering sensitivity

Triggering sensitivity is important to allow gas delivery in the early part of inspiration. The first segment of a patient's breath goes to gas exchange units in the lung; the remainder of the gas will occupy dead space and not participate in gas exchange, therefore, is wasted. If an intermittent flow device is slow to sense a patient's breath, the volume of gas that is delivered when the device does sense a breath will be delivered later in the breathing cycle and may have some of the gas occupying dead space. IF devices attempt to be as sensitive as possible, yet a nasal cannula is an open system, which causes variability in the devices ability to sense a breath. Cannula placement, tidal

volumes, inspiratory flow rates and mouth breathing are also causes for a device to be slow to trigger or miss an inspiration.

Device Variability

All intermittent flow oxygen delivery devices are different in design and function. The ability to control and deliver oxygen therapeutically depends on the capabilities of the device and the patients breathing patterns. IF system designs attempt to provide therapeutic oxygen in a device that is convenient for the patient to use.

Considerations for therapeutic oxygen delivery

- Amount of source gas available to deliver to the patient.
 - Compressed gas and liquid oxygen systems have the most available source gas on demand.
 - Portable oxygen concentrators are limited by their oxygen product capabilities in one minute (limited oxygen availability on demand).
- Dose settings with a range of oxygen volumes. The greater the dose volume, the greater the FiO₂ potential.
- Triggering sensitivity.
- Peak flow capabilities that allow for oxygen to be delivered quickly, the higher the peak flow capability the faster the oxygen can delivered in therapeutic range.
- Consistent oxygen delivery with variable breathe rates; minute volume delivery of IF devices reduces pulse volume with faster breath rates.

Considerations for patient convenience/compliance

- Device weight – the heavier the device the less likely the patient will use the device consistently.
- Device operating time – if a device does not operate as long as a patient will be away from home, travel outside the home will be limited or the patient may not use the device consistently while away.
Issues:
 - Gas contents for a liquid oxygen or compressed oxygen cylinder.
 - Oxygen production (concentrator) battery weight, battery exchange.
- Ease of use – complicated user interface will limit a patient's use of the device.
- Esthetics – a portable oxygen system that looks like an industrial product will prevent a patient from using the device consistently in public places. Also, oxygen is perceived as a last resort option by patients which prevents some patients from using an oxygen system in public.
- Carrying options, straps carts, etc. – if a device is difficult to incorporate into a normal use similar to purses, backpacks or other standard devices that are carried, the portable oxygen may not be utilized.

Summary

Therapeutic oxygen delivery is necessary to prevent complications, hospitalizations and increased overall healthcare cost. Oxygen is a drug that needs to be assessed correctly, prescribed effectively, delivered therapeutically and monitored consistent to insure patient benefits. Delivery options for oxygen therapy are different and need to be evaluated on a patient at all activity levels to insure effective oxygenation. A 2 setting on one oxygen delivery devices is not the same as the 2 setting on another oxygen delivery device. Patient compliance with LTOT requires the combination of therapeutic oxygen delivery with a system that will allow a patient the ability to do normal activities of

daily living. To prevent to complications of hypoxemia described in this paper, therapeutic oxygen delivery is the most essential component of LTOT.

Conclusion

New oxygen delivery systems are available to address the needs of LTOT patients who desire to maintain a normal lifestyle while using portable oxygen equipment. Newer home oxygen systems have become available that address the patient's lifestyle needs, yet may not provide therapeutic oxygen with all activities, therefore: Clinicians must recognize that when prescribing oxygen therapy, they must either completely understand the capabilities and limitations of the devices they will be prescribing or have a skilled clinician titrate the oxygen dose at all activity levels on the device the patient will be using.

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