

## Portable Oxygen Concentrators' Performance Variables that Affect Therapy

**L**ong-term oxygen therapy (LTOT) patients have evolved over the past decades by becoming more knowledgeable of their disease, more involved in their therapy, and more aware of their options for care. In the past, oxygen therapy was initiated as a last resort for patients with severe lung disease. This created a home oxygen program that was more focused on stationary equipment with portable oxygen as emergency backup. In the early days of LTOT, patients did not receive oxygen until they could no longer do any activities. The lack of oxygen created many consequences so, when oxygen was finally prescribed, the patient was not able to ambulate. We have come a long way in understanding the consequences of chronic hypoxemia<sup>1</sup> and now prescribe oxygen as soon as necessary and are beginning to counter the debilitating effects of starving the patient of life-giving and preserving oxygen.

With this knowledge, manufacturers have developed new oxygen systems that can meet the patient's needs at a variety of activity levels. Portable oxygen systems are the most challenging products to develop, as patients' needs for activities of daily living require systems that are able to oxygenate the patients yet have a weight and range capability that allow for the best mobility. Lightweight oxygen cylinders, **oxygen conserving devices** (OCDs), small liquid oxygen systems, and now **portable oxygen concentrators** (POCs) have all found a place in the growing list of LTOT equipment options.

Unfortunately, the payers for home oxygen therapy, respiratory clinicians, and patients have often focused on product aesthetics rather than oxygenation as the key to improved outcomes with LTOT. The appropriate focus of oxygen therapy is to prevent hypoxemia at all ac-

tivity levels; LTOT products are tools in the hands of knowledgeable clinicians to be used to accomplish that objective. An oxygen system that lasts a long time, is lighter than other systems, or has better packaging than another system is only appropriate if it produces acceptable patient oxygenation at all activity levels.

POCs have been a valuable addition to the options available to home oxygen patients for improved mobility and travel. The need for POCs was known prior to the technology becoming available. Early long-term oxygen therapy consensus conferences challenged industry to produce such a product,<sup>2</sup> and, in the early 1990s, the first POC was introduced in the United States.

In the past few years, there have been five new POCs introduced to the market. Each has different features, capabilities, and options that the patients and clinicians should be aware of before using the POC. Performance variables may affect therapy and require adjustment to the product; if the product cannot meet the patient's clinical needs at all activity levels, another POC or LTOT product should be utilized to ensure proper oxygenation.

Portable oxygen concentrators manufacture oxygen; they do not store oxygen. This requires the POC to produce enough oxygen per minute that allows for an acceptable dose of oxygen to the patient with each breath (Table 1). A POC's oxygen production is similar to the larger stationary systems that have been used in the home since the mid-1970s, which use pressure swing absorption technology to generate oxygen. The POC manufacturers have been able to reduce the size of the sieve bed, improve compressor performance, utilize oxygen-conserving



### About the Author

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**Table 1. Oxygen Production Capabilities**

Product Name	Oxygen Production Capabilities per Minute (mL)
Eclipse (SeQual Technologies Inc.)	3000 mL
EverGo (Respironics, Inc.)	1050 mL
LifeStyle (AirSep Corporation)	750 mL
Inogen One (Inogen, Inc.)	750 mL
FreeStyle (AirSep Corporation)	~500 mL

technology, and integrate sophisticated battery systems to make these systems as small as possible. Each manufacturer has determined how much oxygen they will produce, which determines maximum oxygen delivery, weight, and operating time. These feature differences will have an impact on patient therapy, and the clinician needs to know the capabil-

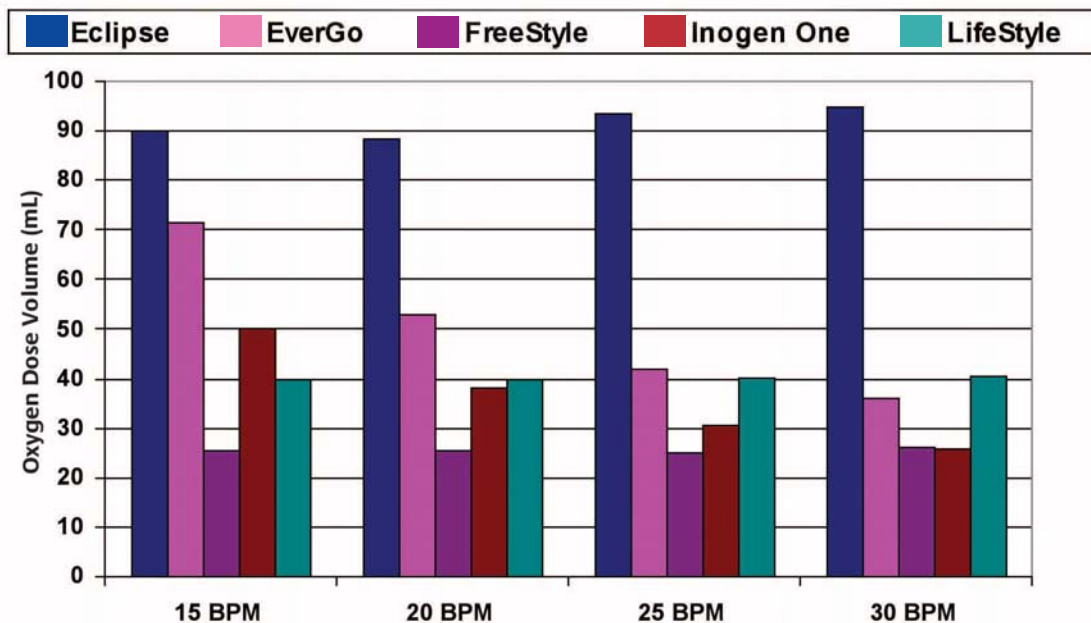
ities of a POC to determine the appropriate device to use for the patient.

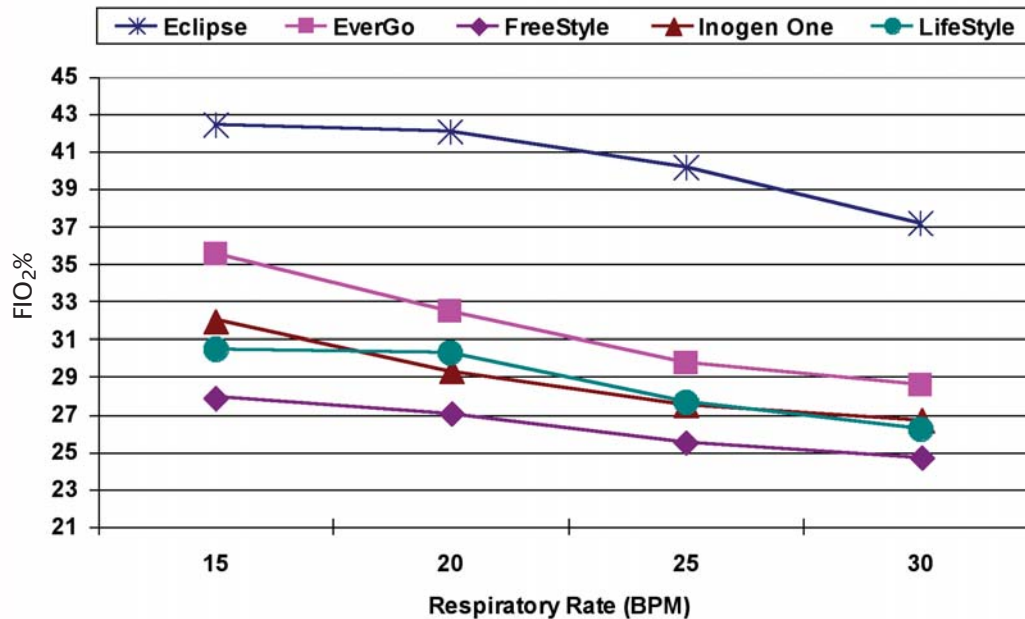
Patient needs vary as much as the POCs, so there is no one right POC for all patients. Knowing the capabilities of the POC, the needs of the patient, and the activities the patient will be doing while using the POC are important points of information for the clinician to consider when working with the patient to determine therapy options. Recommendation 8 from the Second LTOT Consensus Conference (1987) states, "Clinical evaluation should include regular assessments of patients' compliance with prescribed therapy, potential complications, potential hazards, and the need for continued education. Patients receiving LTOT share responsibility with the prescribing physicians for remaining in communication with their physician in order to assure continued appropriate care for their condition."<sup>3</sup> This recommendation emphasizes that a patient be titrated on the oxygen system they will be using and at all activity levels that they will be using the device.

**POC environments**

Portable oxygen concentrators have the potential to be used at rest, exercise, sleep, and altitude. Each

**Figure 1. Maximum Recorded Dose at Various Breath Rates**



**Figure 2. Maximum Recorded FIO<sub>2</sub>% – POCs**

one of these situations needs to be evaluated with the patient and the POC.

**Rest:** This is the least challenging situation for a POC. Many patients need very little oxygen with rest, and a low dose will most likely keep the patient oxygenated.

**Exercise:** This is the most challenging situation for all oxygen delivery systems. With exercise, patients' respiratory rates increase and oxygen demands are at their peak. A patient breathing at an increased respiratory rate while using a POC with a fixed minute production of oxygen (or any other oxygen conserving delivery system) may see the delivered **fraction of inspired oxygen** (FIO<sub>2</sub>) drop when the patient actually needs an increased FIO<sub>2</sub> (Figures 1 and 2). This drop in FIO<sub>2</sub> may have a negative impact on patient oxygenation.<sup>4</sup>

**Sleep:** This situation is similar to rest, with the issue here being the OCD in use with the POC. Patient oxygen demands are not high (in most cases)

with sleep, yet the OCD needs to sense and deliver oxygen with each breath. If the device does not sense a breath, it will not deliver oxygen. Most of the POCs have a very good triggering sensitivity; one clinical study indicated that a current POC could maintain proper oxygen saturation with nine out of 10 patients tested,<sup>5</sup> yet if the cannula placement changes, the POC may miss a breath. Patients who need to connect their oxygen system to a continuous positive airway pressure system at night cannot use a POC that only delivers pulse-dose oxygen and will need to use continuous flow at night.

**Altitude:** This is a challenging situation for a POC. One of the best “features” of POCs is the approval by the Federal Aviation Administration and individual airlines to allow these products to be used on airplanes. The environment in a plane is similar to breathing at 8,000 feet altitude. The reduction in pressure is similar to breathing 14% oxygen. There is no way of testing a patient for oxygen delivery at that pressure, so there is no way of titrating for patient oxygenation with air travel. If the patient’s needs exceed the capabilities of the POC they are using at altitude, it is unknown what impact that might have on the patient.

On Aug. 25, 2006, 13 LTOT patients, their friends and family, and five clinicians undertook what was called an “altitude adventure.”<sup>6</sup> This adventure involved renting a bus and taking a field trip to Echo Lake in Colorado, which is at approximately 10,500 feet above sea level. The objective of this adventure was to monitor the patients at altitude to determine if a new POC was able to oxy-



Eclipse™ (SeQual Technologies Inc., San Diego, CA)



EverGo™ (Respironics, Inc., Murrysville, PA)



FreeStyle™ (AirSep Corporation, Buffalo, NY)



Inogen One™ (Inogen, Inc., Goleta, CA)



LifeStyle™ (AirSep Corporation, Buffalo, NY)



generate the patients. The POC used was able to generate 3,000 mL of 93% oxygen per minute, which makes it one of the higher oxygen producing units. This POC unit can also deliver pulse or continuous flow oxygen, which gave the clinicians an option if the patient needed a different dosing method.

The patients wore a continuously monitoring oximeter, recorded their oxygen setting, subjective feelings of dyspnea, and recorded the altitude that was given to them by one of the clinicians. Twelve of the 13 patients were able to maintain adequate saturations at all altitudes. One patient's arterial oxygen saturation dropped below 88% and was switched to a continuous flow liquid oxygen system for the remainder of the trip.

The objective of this adventure was to simulate the cabin pressure of an airplane without the hassle of working with an airline to accomplish the study. This method of testing may be a valuable option in controlled studies of traveling at altitude with new POCs to determine the patient's response to specific products.

### POC products

There are currently five portable oxygen concentrators (see photos) being marketed in the United States. Each of these products has different oxygen production capabilities and dosing algorithms that are key to patient oxygenation. These products are being marketed with features and benefits that are desirable to the LTOT patients, with weight, battery life, packaging, and noise level being important consumer concerns. Once the patient has been tested, titrated, and ensured that the product they want keeps them properly oxygenated at all activity levels, the clinician should feel comfortable recommending that product. If the product cannot keep the patient oxygenated at the activity levels

at which they will be using the product, the clinician should assist the patient in finding a different product that has the capabilities to meet the patient's needs for proper oxygenation, and help to titrate the patient for a dose setting for each activity. Recommending a POC that has the features the patient wants, yet does not oxygenate the patient, is **not** providing the clinical services the respiratory therapist should be providing and **adds** to the complications and costs that are currently burdening the health care system.

Knowing the capabilities of the POC, the needs of the patient, and the activities the patient will be doing while using the POC are important points for the clinician to consider when determining therapy options.

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The appropriate focus of oxygen therapy is to prevent hypoxemia at all activity levels; LTOT products are tools in the hands of knowledgeable clinicians to be used to accomplish that objective.

### Product differences

Oxygen production capabilities of individual POCs are listed in Table 1. As shown in Figures 1 and 2, the maximum dose volume varies between individual POCs. As respiratory rate increases, oxygen dose and/or purity will drop since POCs have a fixed minute production of oxygen. Each device tested responded differently to an increased respiratory rate.<sup>7-14</sup>

### Clinical research

Clinical research for POCs has been limited due to the recent introduction of these products and the variability of the individual units. Historical studies on OCDs used with exercise or sleep are limited since the products that were used are no longer commercially available and the method of oxygen dosing is variable with each product.<sup>15</sup> Clinical studies on OCDs used for comparison must be with the specific devices due to the large variability of OCD and the oxygen delivery algorithm. There are a few clinical studies on the current POCs commercially available, yet there is very little objective clinical data on the wider use of these products. At this time, patients appear to be doing their own clinical research by purchasing a POC and determining if the product meets their clinical needs. This testing is very subjective; the patient's conclusions could be drawn on insufficient data. These patients are sharing their personal studies over the Internet with other LTOT patients who are looking for answers. This type of research should not be happening; yet with the lack of involvement by the clinician, the patient is left with taking research into his own hands.

### RTs' expertise needed

POCs are a valuable addition to the options available to clinicians and patients who receive LTOT, with fewer restrictions and more options for mobility. These products are early generation products with limitations that may be overcome in the future with development of new technology. At a time when patient needs are increasing, payments for LTOT in the home are decreasing, and new technology is continually entering the market to address

these changes, the respiratory therapist must become actively involved in the education, testing, and monitoring of POCs used in LTOT to ensure patient safety and improved long-term outcomes. ■

### EDITOR'S NOTE

The author, Robert McCoy, is a researcher and has provided research, testing, or educational programs for the manufacturers mentioned in this article.

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