Portable Oxygen Concentrators
Capabilities and Applications

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Portable oxygen concentrators first entered the home care market several years ago after an early oxygen consensus conference recommended that manufacturers produce a 10-pound concentrator. Oxygen consensus conferences are held to give providers, patients and manufacturers the information they need to respond to market changes, address issues related to patient care, and better-understand the economics associated with long term oxygen therapy (LTOT). Patient's lifestyles have always challenged clinicians to meet their therapeutic needs with an oxygen system that is both effective and aesthetically acceptable. The availability of home oxygen systems, the cost of home oxygen equipment, and the reduction of reimbursement from payers have all had a negative effect on clinical decisions and patient access to more costly modalities such as liquid systems. Portable oxygen concentrators (POCs) can address many of these issues.

Traditional home oxygen therapy provides both a stationary system and a portable system. Several decades ago, LTOT was prescribed at the end of a patient's disease process when there was little capability of being ambulatory.[1] The focus was on the stationary system with the portable being available for emergency backup and short infrequent trips. Today most patients are ambulatory and the focus has shifted to portable oxygen systems. Unfortunately, the reimbursement for LTOT still focuses on stationary systems which receive 80% of the payment, while portable systems receive only 20%. Most of the cost of providing LTOT in the home is related to the delivery cost incurred by the home care provider for replenishing the portable oxygen system or refilling the liquid oxygen dewer that trans fills to a small portable. With the cost of home delivery increasing and reimbursement for home oxygen decreasing, an alternative was necessary.

[1] The original reason for LTOT was ambulation with a liquid system and portable oxygen was the centerpiece of pulmonary rehabilitation program (1966-1968).

The LTOT Consensus Conference request for a portable oxygen concentrator was focused on the patient's need for freedom and the limitations of consumable (refill necessary) portable oxygen systems. While the smaller and lighter liquid oxygen systems have obvious advantages for a highly ambulatory patient, when the patient wanted to be away from their home for an extended period of time, a system that could replenish itself offered a viable alternative. Home care providers needed a method of reducing the cost of providing LTOT, and when liquid was not available, clinicians wanted a system that would encourage patients to be as ambulatory as possible; enter the portable oxygen concentrator (POC).

POCs use the same technology as larger concentrators, but with a focus on efficiency. Sophisticated molecular sieve, motor speed control, high tech batteries and oxygen conserving delivery systems allow for efficient oxygen therapy in a small package.

POCs produce, rather than store oxygen. Thus the challenge is to produce a sufficient volume of oxygen to meet patient needs. POCs produce oxygen that is approximately 93% pure. The compounding of maximum oxygen production, dose setting, patient's respiratory rate, oxygen purity, patient activity type and the environment the device will be used in require patient assessment and titration for individual POCs.

PERFORMANCE DIFFERENCES

Portable oxygen concentrators operate somewhat differently than stationary concentrators. There are also operating differences between individual POCs. Oxygen production capabilities, oxygen dose and the response to an increased respiratory rate are the main differences related to clinical impact. The three products described in this paper are:

SeQual Eclipse®
17.9 pounds
3000 ml oxygen production per minute

Inogen One
10 pounds
750 ml oxygen production per minute

AirSep LifeStyle
10 pounds
750 ml oxygen production per minute

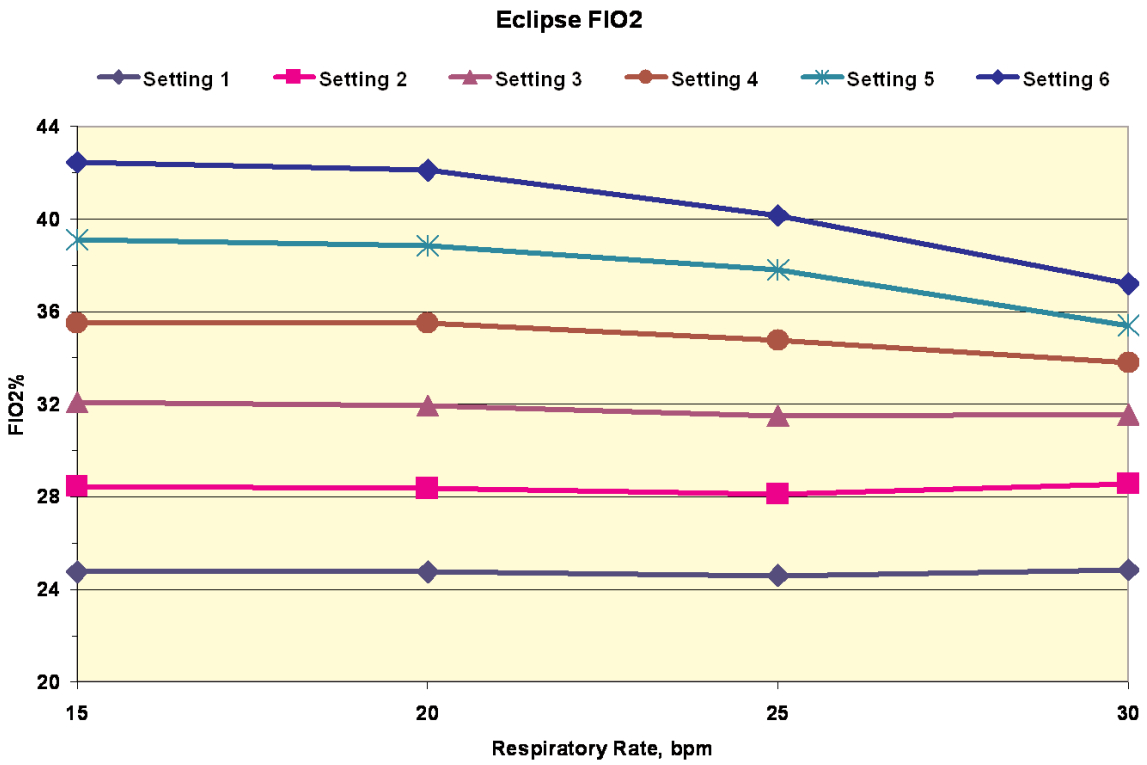
Bench testing of the POC provides an opportunity to consistently deliver a breathing pattern and respiratory rate to determine the capabilities of the equipment and how the equipment responds to consistent changes in respiratory rates.

This information helps the clinician understand how the product will perform under varying patient conditions and make informed decisions related to how and when the product should be used.

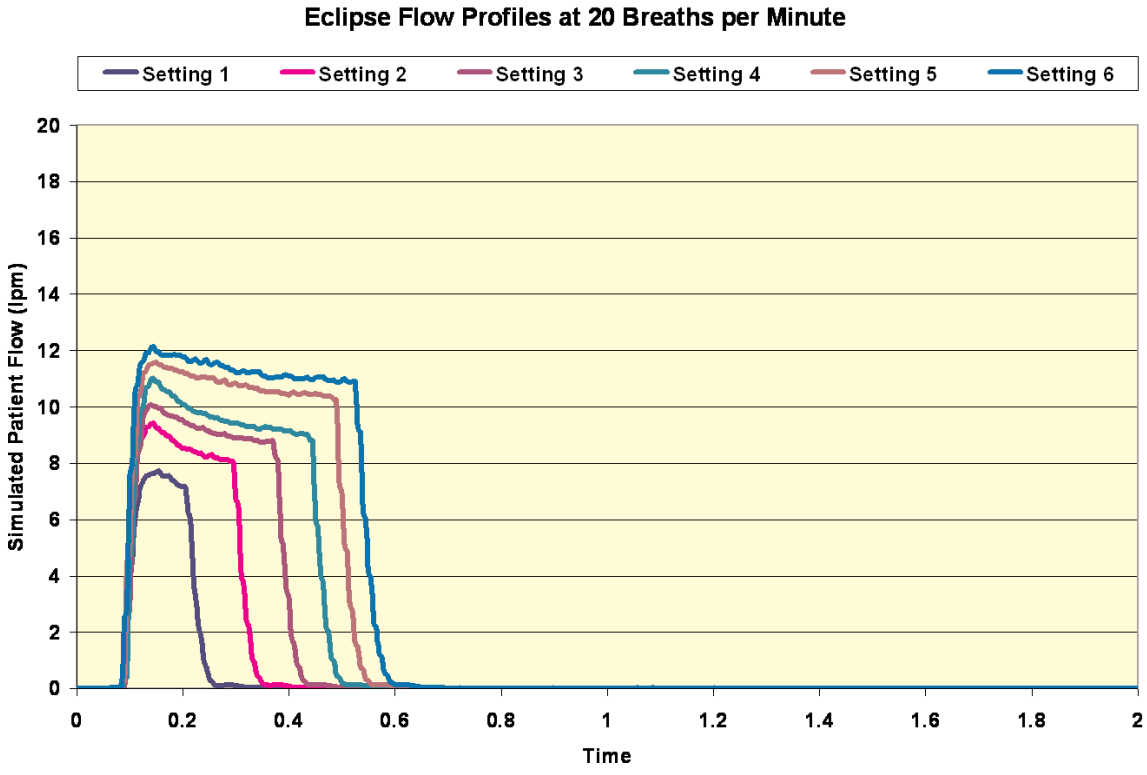
One of the main points from the data below is the impact increased respiratory rate, which occurs with exercise or travel to higher altitudes, has on FIO2 delivery.

BENCH TEST DATA FOR THREE PORTABLE OXYGEN CONCENTRATORS

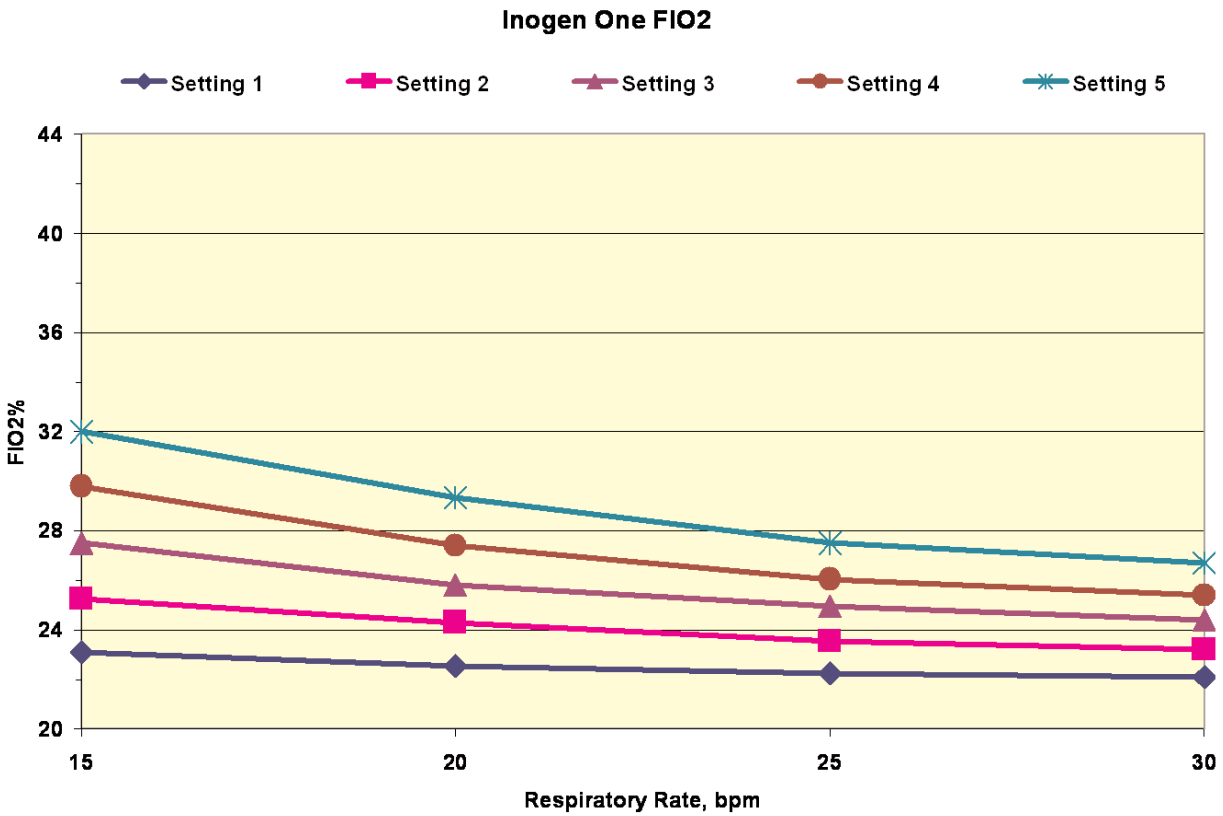
FIO2 Output for the SeQual Eclipse



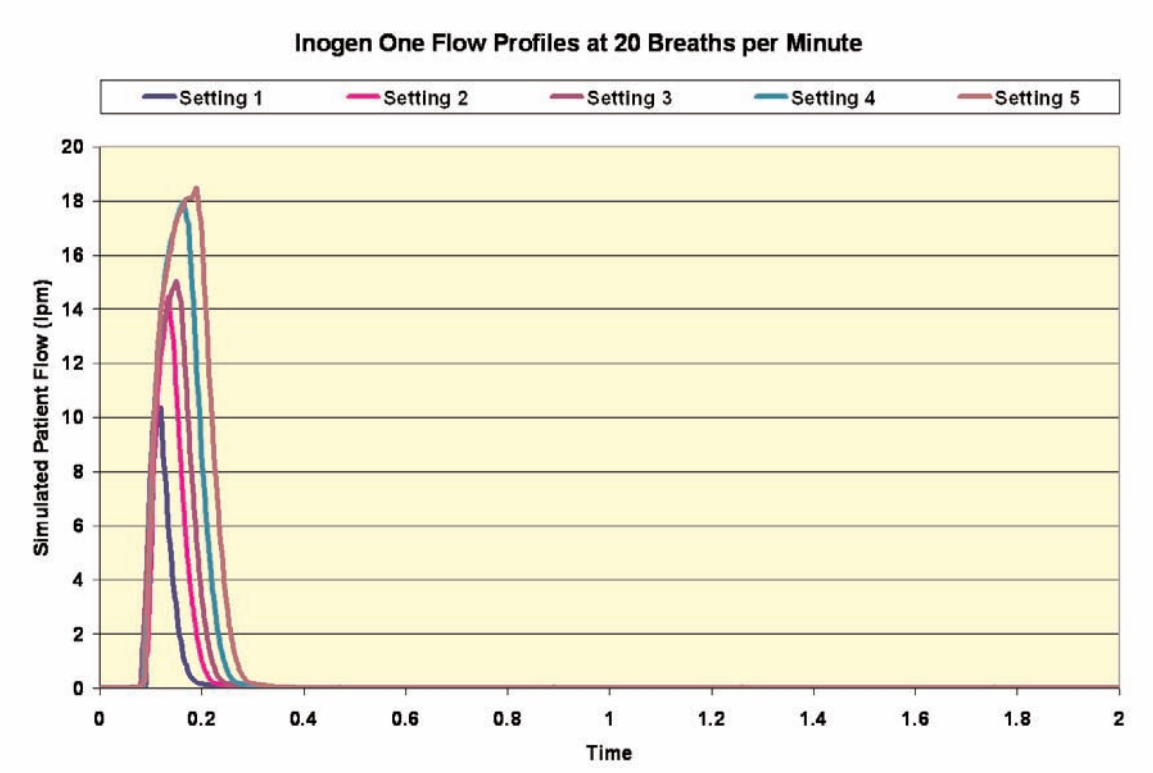
As respiratory rate increased, the Eclipse device maintained relatively consistent FIO2 values at the lower settings of 1, 2 and 3. At the 4, 5 and 6 settings, FIO2 values decreased as respiratory rate increased past 20 bpm.



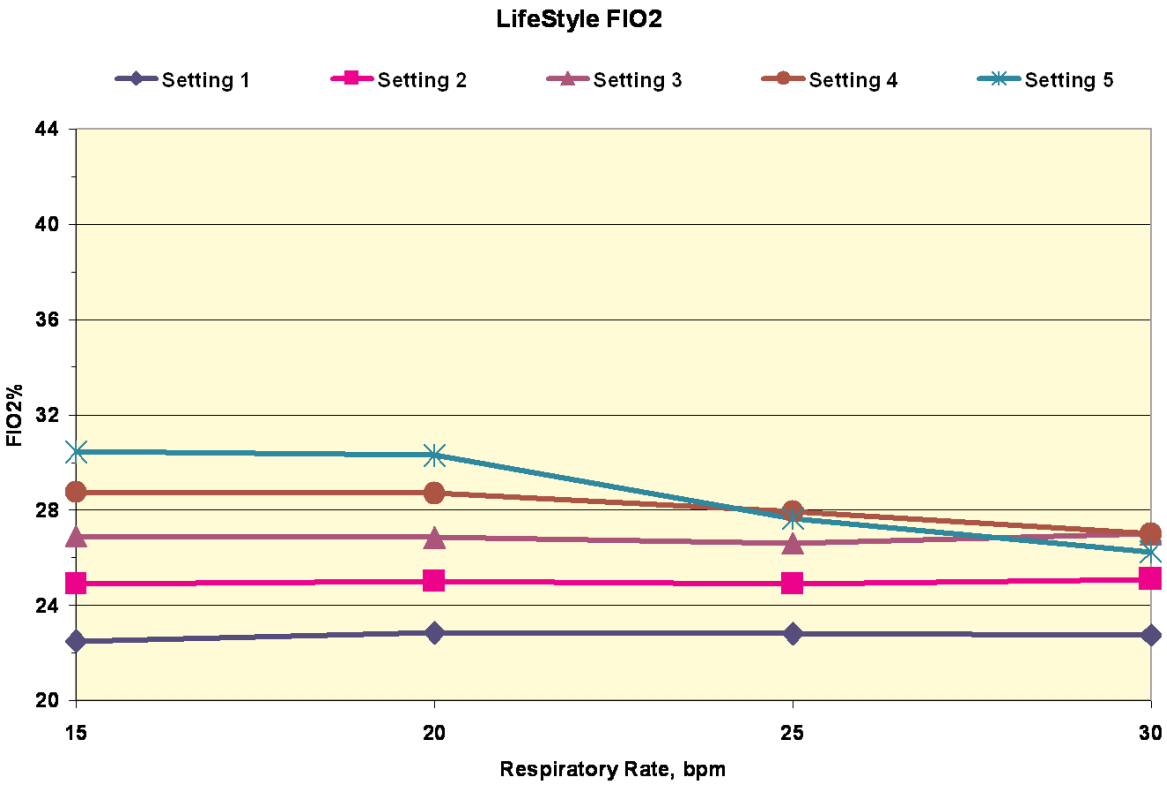
FIO2 Output for the Inogen One



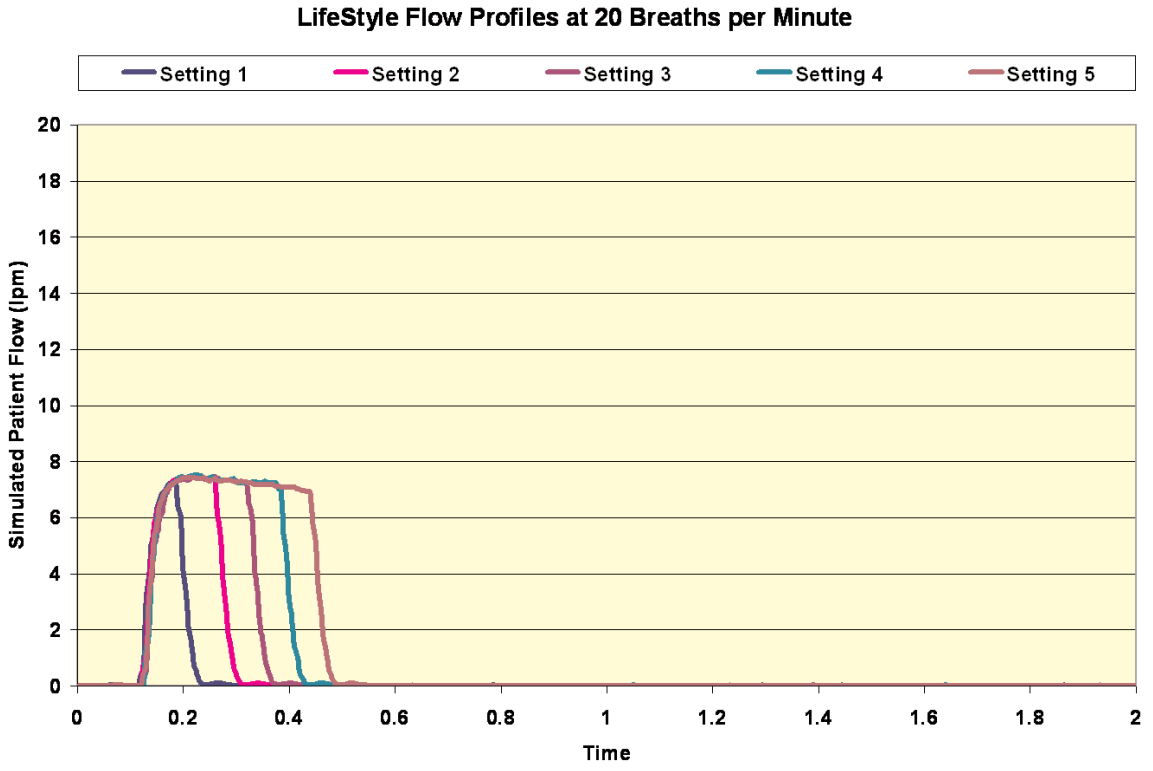
At each setting, FIO2 values decreased as the respiratory rate increased. The largest drop in FIO2 percentage at each setting occurred when the breath rate increased from 15 to 20 bpm.



FIO2 Output for the AirSep LifeStyle



As respiratory rate increased, the LifeStyle maintained relatively consistent FIO2 values at the lower settings of 1, 2 and 3. At the 4 and 5 settings, FIO2 values decreased as respiratory rate increased past 20 bpm.

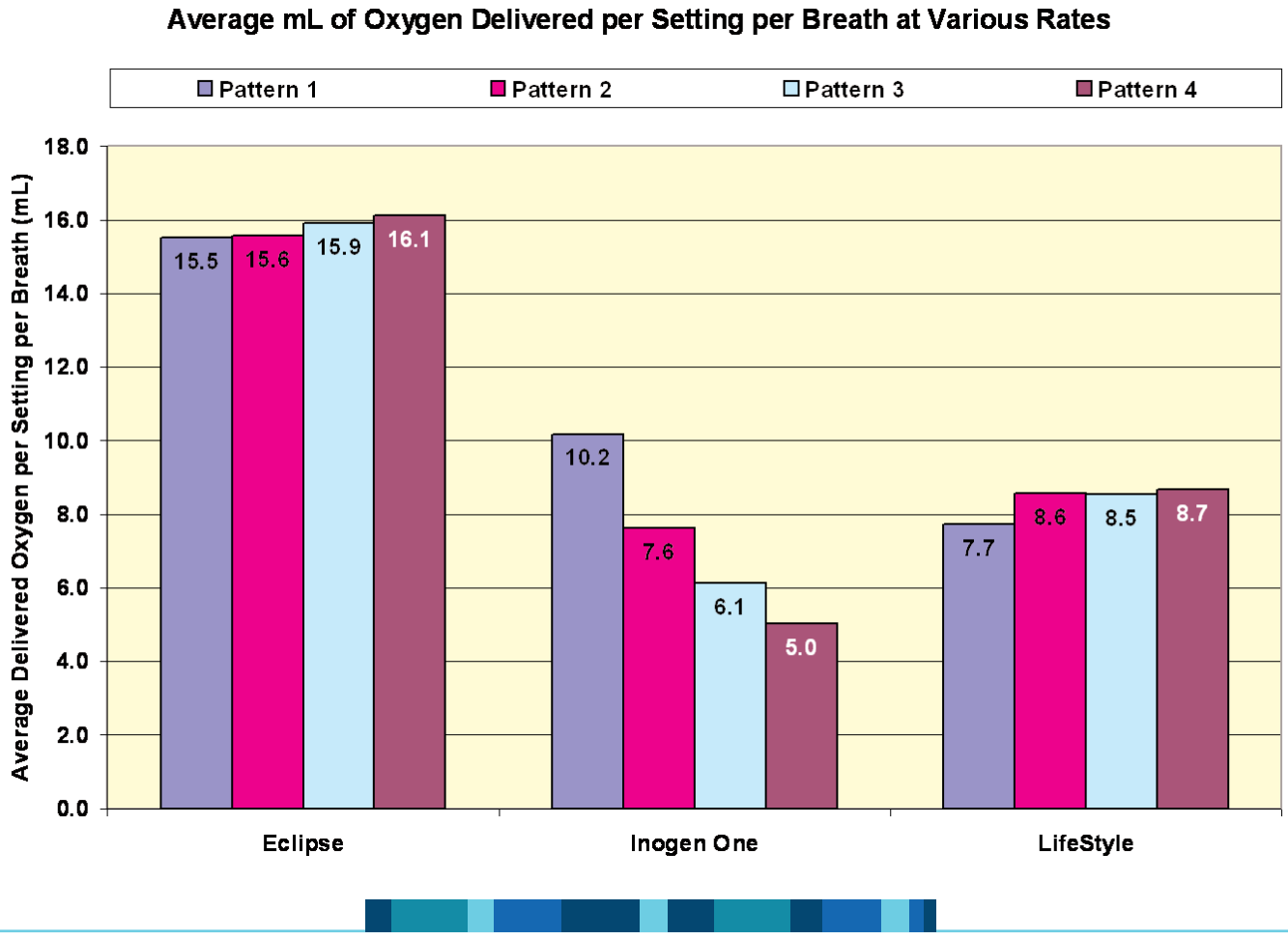


Volume Delivery

Below is a table comparing each concentrator's volume delivery at each pattern and setting. Pattern 1 was 15 bpm, Pattern 2 was 20 bpm, Pattern 3 was 25 bpm, and Pattern 4 was 30 bpm.

	Delivered Volumes (mL) by Setting						
Pattern	**1**	**2**	**3**	**4**	**5**	**6**	**Device**
1	16.6	31.2	46.9	61.1	74.8	90.0	**Eclipse**
	10.2	20.7	30.5	40.5	50.4		**Inogen One**
	7.6	14.8	23.1	31.7	40.1		**LifeStyle**
2	16.4	31.9	47.3	60.7	76.8	88.5	**Eclipse**
	7.6	15.2	22.8	30.7	38.2		**Inogen One**
	8.9	18.1	25.6	33.4	40.1		**LifeStyle**
3	16.5	31.0	46.8	64.8	80.5	93.6	**Eclipse**
	6.1	12.4	18.4	24.5	30.6		**Inogen One**
	8.9	17.8	25.7	33.1	40.3		**LifeStyle**
4	16.9	32.8	47.8	63.4	79.3	95.1	**Eclipse**
	4.9	9.9	14.7	20.4	26.1		**Inogen One**
	9.1	18.2	26.2	33.6	40.1		**LifeStyle**

Below is a bar graph comparing each concentrator's average delivered ml of oxygen per setting.



SLEEPING WITH A POC

There has been little research on the use of oxygen conserving devices (OCD) with sleep. Several articles have been written that indicate that if the unit can sense an inspiratory effort, the patient can maintain adequate oxygen saturation. Triggering sensitivity has not been an issue with ambulatory use of an OCD, yet with sleep, the breathing patterns change and shallow breathing is a strong possibility. It has been recommended at numerous oxygen consensus conferences that the patient be titrated on an OCD at activity level. If a patient is going to use an OCD while sleeping, an overnight oximetry study is recommended. If the patient has obstructive sleep apnea (OSA) and is using a CPAP device, an OCD is counter-indicated as the unit would not trigger or provide sufficient oxygen to meet the patient's needs. If continuous flow is available from a POC, it can be used at the same setting as the stationary concentrator for sleep, yet titration is still recommended.

EXERCISING WITH A POC

The benefit of a POC is that it gives a patient the ability to take the unit on trips – either locally around town or on vacation around the world. If the patient is going to use the unit with activity, there are several factors to consider. The weight of the unit can be a factor, yet all POCs now on the market come with a wheeled cart. With a cart, the weight of the unit is not as much a factor except when the POC needs to be lifted up steps, into the car or over an obstacle. When extending the length of the tubing to allow for the POC to stay more stationary (on a golf cart, for example), the manufacturer's recommendations for tubing length should be reviewed. Length of tubing can impact the operation of the OCD; the unit may not sense an inspiration or the delivery of the dose volume could be diminished due to the resistance to flow of the longer tubing.

A significant factor in exercising with a POC is the effect an increased respiratory rate has on oxygen delivery (see graphs above). If the respiratory rate increases to 25 bpm, the FIO2 delivery drops on two of the units. With increased respiratory rate, oxygen demands increase and a decrease in FIO2 could have a negative impact on the exercising patient. Oxygen dose should be titrated for the activity level. If the maximum dose is set on a POC and the patient is not oxygenating, another POC or portable oxygen system should be considered.

AIR TRAVEL WITH A POC

Most POCs have been approved by the FAA for air travel. Each individual airline needs to approve a specific POC for use on their aircraft. Each POC undergoes rigorous tests to determine if it will work correctly and safely at altitude and not interfere with the aircraft navigation system. None of the systems have been tested with patients to determine the capabilities and limitations of providing clinically effective doses of oxygen at altitude. This would require extensive research to determine the needs of most patients with air travel.

Patients should be assessed on the POC they will be using on an aircraft. An option for the dose setting would be to use a dose at which the patient is able to maintain oxygenation while exercising. This is only a rule of thumb and does not guarantee the patient will maintain oxygen saturation at altitude.

ALTITUDE ADVENTURE

In August 2006, 13 LTOT patients traveled by bus to over 10,000 feet altitude to determine if they would be able to maintain proper oxygenation using the Eclipse POC. Most patients were able to increase the dose of the

Eclipse at altitude. One patient required a higher dose of oxygen and was switched to a continuous flow liquid oxygen system. This was an informal study, yet indicated that the oxygen production range of the SeQual Eclipse was sufficient to meet most of the patients' needs. The Eclipse produces three times the amount of oxygen per minute of the other POCs. It is unknown if the lower production units would have been able to maintain adequate oxygenation at that altitude.

DR. PETTY

Dr. Petty has researched oxygen therapy for over four decades and authored numerous articles on LTOT. He is now an oxygen user and has experienced the personal side of LTOT. The following are his comments:

Experience with the Eclipse

From the beginnings of the development of oxygen technologies, I have personally tested or used virtually all of the oxygen delivery devices that have been introduced during the past 40 years. This began with the original Linde Oxygen Walker in 1965. Recently I have used three of the portable oxygen concentrators and have found them all to be functional and valuable. Most recently I have used SeQual's Eclipse for travels to Tulsa, Aspen (at 8500 feet) and Minneapolis. I found the Eclipse easy to load into the car and to wheel into a motel. It was quiet at night, and even at altitude maintained my oxygen saturation above 90% at all times tested on my relatively low flow of 1 to 1.5 lpm. I have only used the continuous flow setting because I am a mouth breather. I use the Helios filled from a 10 liter canister for ambulation at all altitudes of Denver or higher. I do not use oxygen for ambulation at lower altitudes. I believe the Eclipse is an important new device for traveling and active oxygen patients to consider.

THE ENTRY OF POCS TO THE LTOT MARKET

The entry of POCs to the home care market and the changing trends in patients, therapy, and economics will likely impact some of the methods of LTOT. Greater mobility and freedom from stationary systems will allow patients to live a more normal lifestyle – and to travel without fear of running out of supplemental oxygen. More POCs are anticipated to enter the market in the near future and it will be important for the clinician and the patient to understand the capabilities, limitations, and applications of the portable concentrators and how each may affect their lifestyle. Both bench and field testing will be needed to place and titrate the appropriate product on the patient according to the way in which each patient will use the product.

CONCLUSIONS

Portable oxygen concentrators operate differently than stationary concentrators. There are also operating differences between individual POCs. It is therefore important for the clinician to stay informed of new respiratory products and make informed decisions when prescribing and applying technology to meet their patients' needs.

THOMAS L. PETTY, M.D.

Thomas L. Petty, M.D., a pulmonologist, is a Professor of Medicine at the University of Colorado Health Sciences Center in Denver and Rush-Presbyterian-St. Luke's Medical Center in Chicago. He was previously head of the Division of Pulmonary Sciences at the University and Director of the Fellowship Training Program from 1964-1989.

Dr. Petty, an international authority on respiratory disease, has published over 800 articles in journals, including the *Journal of the American Medical Association, Chest, Annals of Internal Medicine, American Journal of Medicine, Archives of Internal Medicine, and American Journal of Respiratory & Critical Care Medicine*. He is author or editor of 41 books or editions. The Aspen Lung Conference was named after Dr. Petty in 1991.

Dr. Petty was organizer and founding President of the Association of Pulmonary Program Directors (APD) and has served as President of the American College of Chest Physicians. He is a former member of the Board of Governors of the American Board of Internal Medicine. Dr. Petty was the founding Chairman of the National Lung Health Education Program (NLHEP).

Among many awards, Dr. Petty has received the Distinguished Service Award of the American Thoracic Society (1995), was elected to the Colorado Pulmonary Physicians Hall of Fame (1995), and received the annual award for excellence by the American Association for Respiratory and Cardiovascular Rehabilitation (1995). He was elected to Master Fellow of the American College of Chest Physicians (1995), the fifth such award given by the ACCP in its 61-year history. He also received the Master Award of the American College of Physicians in 1996. He was awarded Master fellowship in the American Association of Respiratory Care in 1999.

Today, Dr. Petty remains active in teaching, patient care, and research. He is editor of a quarterly newsletter, *Lung Cancer Frontiers*. He is a consultant for many developmental efforts in the treatment of lung diseases.

ROBERT MCCOY, BS RRT FAARC

Bob is the Managing Director of Valley Inspired Products, Inc. (VIP) a research, testing and consulting company located in Apple Valley MN.

Bob has held many positions in respiratory care starting out as a staff therapist and moving to director of respiratory care for the first 12 years of his career. He then moved to the manufacturing side of respiratory care holding positions ranging from product manger to director of marketing for the next 11 years. He has been managing VIP for the past 10 years.

VIP focuses on how products work and how they make a difference in respiratory care. Comparative bench testing identifies what the capabilities and limitations are for product groups. Field testing helps to add a "real world" perspective to a products use and benefits. Focus groups add the subjective information needed to understand why and how products are utilized.

VIP fills a unique niche in respiratory care and is always looking for better ways to understand practical issues therapist face in providing a service to the patients.

NOTES

Altitude Adventure, August 26th 2006, photo courtesy of John Goodman, RRT

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