O_2 Trials and Tribulations

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Many caregivers are regularly challenged with questions regarding portable oxygen. There are more options available than ever and one would assume that would simplify things. However, there is more mainstream marketing directed at patients, and some systems are simply not sufficient for patients' needs.

LOOKING BACK

Forty years ago the only existing "home oxygen" option available was when an industrial supplier of medical gases would deliver a series of "H" cylinders (with brass regulators) to a patient's home. Times have changed. Today's choices include home oxygen concentrators, portable oxygen concentrators (POCs), aluminum portable (lighter and smaller) tanks, oxygen conserver (demand) devices, portable liquid oxygen (LOX), and "self-fill" home systems. In this article, we will briefly discuss some of the newer systems and how they work.

DEMAND AND PULSE OXYGEN CONSERVER

While conservers were initially introduced as a way for portable oxygen tanks to last longer, manufacturers have added this technology to some liquid delivery systems and portable concentrators, as well. The basic operating systems of these conservers are either electric or pneumatic.

Electric conservers can operate on an intermittent-breath or every-breath basis. The "smart" technology senses the negative pressure generated at the beginning of inhalation. With an "every-breath" conserver, the solenoid of the conserver opens every time the sensor signals. The length of time it remains open depends on the pulse setting. The higher the pulse setting, the longer the solenoid remains open, thereby increasing the flow. The volume of the pulse is based on the number on the dial, which manufacturers *compare* to liters per minute (lpm), but it is actually not delivering lpm when in pulse mode. Instead, it is delivering milliliters per breath.

The intermittent-breath conserver senses the breath initiation and fires based on its setting. If the device is set at number 1, it will deliver 1 pulse of a fixed volume of oxygen for every 4 breaths sensed; number 2 will deliver a pulse of oxygen every other breath; number 3 would deliver a pulse of oxygen on 3 out of 4 sensed breaths; and number 4 would deliver it every breath.

A pneumatic conserver senses the initial negative pressure then delivers a fixed pulse of oxygen followed by continuous flow until it senses the beginning of exhalation. For that reason, some pneumatic conservers have a dual cannula (one is attached to the "sensing" port and the other to the "oxygen" port).

Oxygen suppliers stock a variety of systems and it would be very difficult to keep up with the newest developments. When a patient inquires about the eligibility of a conserving device (or a smaller tank), one option is to write a prescription to "titrate and evaluate a patient for a conserver device." The oxygen company would then assess the patient with the conserver that they supply. After documentation is received identifying the patient's precise oxygen saturations on that device, the conserver prescription can be approved or denied.

A recurrent challenge with "pulse" dosing is that a patient (when short of breath) will sometimes breathe through their mouth to "catch up." While "mouth breathing," the sensor does not always recognize the inspiration and therefore will not fire. Lack of oxygen flow further decreases a patient's oxygen level and increases shortness of breath (thereby perpetuating the problem). The same may be true at night when a patient does not generate sufficient pressure to trigger the demand device.[8] Each conserver has specific pros and cons. Instructing the home oxygen company to test the patient on the actual conserver provided is the safest option.

CONSERVER TECHNOLOGY HAS BEEN INTEGRATED WITH VARIOUS CURRENT OXYGEN OPTIONS

Liquid Oxygen

Liquid oxygen (LOX) is one of the only viable home oxygen options for patients on liter flows greater than 10 lpm. There are several variations of setups for high-flow patients. Some patients utilize a concentrator for their home and LOX for portability. If a patient requires a flow between 10 and 15 lpm, patients can receive their home flow from a flowmeter attached to a liquid reservoir. The major drawback to LOX is cost and storage of the refill reservoirs. Each standard home reservoir holds about 20 liters of LOX and weighs between 100 and 160 pounds. Smaller reservoirs hold 10 liters and are usually less than 60 pounds (full). The smaller units are the perfect size for travel and can easily

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Table. Personal Oxygen Concentrators

	DeVilbiss iGo	Invacare SOLO2	OxLife Independence	Respironics SimplyGo	SeQual Eclipse 2	Sequal SAROS	Airsep Freestyle	Airsep Freestyle 5	Airsep Focus	Airsep Lifestyle
Continuous settings	1.0 to 3.0 LPM	.5 to 3.0 LPM	1 to 3 LPM	0.5, 1, 1.5, 2 LPM	.5 to 3.0 LPM	1, 2 & 3 lpm				
Minimum delivery	1.0 LPM	.5 LPM			.5 LPM	1 lmp				
Battery life	4 hours	4.5 hours			4.4 hours	1.1 hrs				
Average delivery	2 LPM	2.0 LPM			2 LPM	2 lpm				
Battery life	2.4 hours	2.5 hours			1.8 hours	45 min				
Maximum delivery	3 LPM	3.0 LPM	3 LPM	2 lpm	3 LPM	3 lpm				
Battery life	1.6 hours	1.5 hours	1 Hour	.9 hours	1.3 hours	30 minutes				
Pulse settings	1.0 to 6.0	1 to 5	1 to 6	1 to 6	.5 to 6.0 (0.5 increments)	16, 32, 48, 64, 80, 96 ml	1 to 3	1 to 5	A single pulse setting (equiv of 2LPM)	1 to 5
Minimum delivery at	setting 1	setting 1	setting 1	setting 1	setting 1	16 ml	setting 1	setting 1		
Oxygen output	16 ml	16 ml	16 ml	12 ml	16 ml	16 ml		8.75ml +/ 15%		
Battery life	6 hours	4.5 hours	4.5 hours		5 hours	1.2 hrs	3.5 hours	3 hours-up to 7 hours with optional Air Belt	3 hours (1.5 hours per battery-2 included)	50 minutes (3.25 hours with 3 batteries in powerpack)
Average delivery at	setting 2	setting 2	setting 2	setting 2	setting 2	48 ml	setting 2	setting 3		setting 2
Oxygen output	32 ml	32 ml	32 ml	24 ml	32 ml	48 ml		26.5ml +/ 10%		
Battery life	4.8 hours	3.5 hours	3 hours	3 hrs	3.5 hours	53 min	2.5 hours	1.5 hours-up to 3.3 hours with optional Air Belt		
Maximum delivery at	setting 6	setting 6	setting 6	setting 6	setting 6	96 ml	setting 3	setting 5		
Oxygen output	96 ml	80 ml	96 ml	72 ml	96 ml	96 ml		43.75ml +/ 10%		
Battery life	3 hours	2.5 hours	1.8 hours		1.8 hours	37 min	2 hours	1 hour-up to 2.3 hours with optional Air Belt		
Weight	15.5 pounds	17 pounds	11.85 pound	10 lbs w/battery	14.5 lbs	10.0 lbs	4.4 pounds	5.8 lbs		9.75 poumds
1 battery	19 pounds	19.9 pounds	14.85 pounds		18 pounds	12.25 lbs /w battery	5.8 pounds	add .53 lb/ battery	1.75lb + .53lb per battery	
1 battery & shoulder bag								1.8 lb AirBelt (opt)	1.8 lb AirBelt (opt)	
1 battery & cart	20 pounds	22 pounds	17 pounds		19 pounds					
2 battery & shoulder bag										
Size (Height X Width X Depth)	15H-11W-8D	16.55H-11W-8D	12H-8W-8D	11.5H-10W-6D	18H-12.3W-7.1D	26.80H-4.375 dia	8.6H-6.1W-3.6D	10.5H-6.4W-4.4D	6.4H-4.8W-2.5D	5.5H-7.25W-6.31D
Sound level	38-40 dBa	35-42 dBa	41-44 dBa	43 dB @ setting 2	40 dB @ 3.0 pulse-48dB @ 3.0 LP continuous	<59 dB	38-44 dBa	41 dBA at setting 2		50 dBa
FAA Approval	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maximum altitude (see note #1)	13,123 ft	10,000ft	10,000 ft	10,000 ft	13,123 ft	18,000 ft	12,000 ft	12,000 ft	10,000 ft	12,000 ft
Oxygen concentration	91% ± 3%	87-95.6%	90% + 3%	86% to 97%	90% ± 3%	93% +/ 3%	90% ± 3%	90% +5.5%-3%	90%-+5.5/-3%	
Oxygen output pressure		12.0 psig	4 psi	3 psi	5.0 psig	4.0 psig				
Max. Hose length (see note #3)	35P 50 C	7 P 25C		30 ft	7 P 50C				7 ft	
Maximum oxygen capacity	3,000 ml / min	3,000 ml/minute		2000 ml/min	3,000 ml / minute					
Maximum Breaths/minute		35	30		40	31 to 40 (96-16 p)				

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Table. Personal Oxygen Concentrators (Continued)

	Inogen One	Inogen One G2	Inogen One G3	International Biophysics Corporation LifeChoice	Invacare XPO2	Inova Labs LifeChoice Activox	Oxus RS00400 / Delphi RS00400	Respironics EverGo	Precision Medical Easy Pulse
Continuous settings									
Minimum delivery				pulse only-has sleep mode technology for 24/7 use					
Battery life									
Average delivery									
Battery life									
Maximum delivery									
Battery life									
Pulse settings	1 to 5 plus a "satellite" setting	1 to 5 plus a "satellite" setting	1 to 4	1 to 3	1 to 5	1 to 3	1 to 5	1 to 6	1 to 5
Minimum delivery at	setting 1	setting 1	setting 1 @ 20 bpm	setting 1	setting 1	setting 1		setting 1	setting 1
Oxygen output	7.5 ml	7.5 ml	9.0ml +/ 10%	1 LPM	13 ml	10 ml		12 ml	13 ml ± 15%
Battery life	3 hours	4 hours on single battery-8 hrs on double battery	up to 4.5 hrs single battery up to 9 hrs double battery	2+ hours on Internal battery on all settings (add 3 hrs with battery)	3 hours	12 hrs /w internal battery add 3 hrs for external battery		5 hours-per battery	4.5 hrs
Average delivery at	setting 2	setting 2	setting 2 @ 20 bpm	setting 2	setting 2	setting 2	setting 2	setting 2	setting 3
Oxygen output	15 ml	15 ml	18.0ml +/ 10%	2 LPM	23 ml	20 ml		23 ml	
Battery life	2.5 hours			additional 3 hours with external battery	2.5 hours	6 hrs (internal battery) +3 hrs for external battery	3 hours at 15 BPM	4 hours-per battery	2.5 hrs
Maximum delivery at	setting 6	setting 6	setting 4 @ 20 bpm	setting 3	setting 5	setting 3		setting 6	setting 5
Oxygen output	37 ml	37 ml	36.0ml +/ 10%	3LPM	58 ml	30 ml		52 ml	42 ml ± 15%
Battery life	1 hours	1 hours			1 hours	5 hrs (internal battery) +2 hrs for external battery		2 hours-per battery	1.5 hrs
Weight			4.8 lbs with 1 battery	4.9 lbs		4.83 lbs			6.8 lbs
1 battery		7 lbs.		add 1 lb for external battery			9.8 pounds		
1 battery & shoulder bag	12 pounds	12 pounds			6 pounds			8.5 pounds	
1 battery & cart	13 pounds	13 pounds			10 pounds			12 pounds	
2 battery & shoulder bag					7.5 pounds			9.9 pounds	
Size (Height X Width X Depth)	12.4H-11.6W-6D	9.5H-10.7W-3.9D	7.25H-8.75W-3.0D	9H-7W-4D	10H-7W-4D	7.875H-9.05W-4.38D	7.4W-4.6-11.6H	8.5H-12W-6D	10.1H-6.5W-4.5D
Sound level	37-40 dBa	38 dBa	42 dBA at setting 2	< 50 dBa	44-46 dBa	41 db at setting 1 46 dB at setting 3		42-44 dBa	44 dBA
FAA Approval	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Maximum altitude (note #1)	10,000 ft	10,000 ft	10,000 ft	10000 ft	10,000 ft	10,000 ft		8,000 ft	9.000 ft
Oxygen concentration	90% ± 3%	90%-3%, +6%	90%-3% /+ 6%	90% ± 3%	90% ± 3%	90% (+/ 3%)	90% ± 3%	90% ± 3%	87% to 95%
Oxygen output pressure								3 psi	
Max. Hose length (note #3)			25 ft (w/ high flow)	9 ft					7 ft
Maximum oxygen capacity	750 ml/minute	900 ml/minute			900 ml/min		925 ml/minute sustained- 1200ml for short periods	1050 ml/ minute	
Maximum Breaths /minute							30		35

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be transported in mid- to large-sized automobiles (as long as the home oxygen company will allow it). How often the oxygen company refills the patient's reservoir depends on liter flow and the rate of evaporation. Consider LOX if your patient requires high flows.

Self-Fill Systems

In recent years reimbursement for home oxygen has decreased, and it has become more fiscally challenging for oxygen companies. With home oxygen companies trying to find more ways to deliver care with fewer deliveries and less upkeep, a new product was developed in 2000, enabling home oxygen patients to fill their own portable gas cylinders *from their oxygen concentrator*. The key with this system is that a cylinder filled with a concentrator will not contain 100% oxygen. A properly functioning concentrator can produce an oxygen concentration as low as 88%; therefore, that would be the percentage of oxygen filling the patient's portable tank. While there have been studies citing this as clinically inconsequential, it should be noted, particularly if your patient needs liter flows >4 lpm.

Portable Oxygen Concentrator

The newest addition to the oxygen world is the POC. There are several factors to consider with each option, keeping in mind all of the particulars discussed previously. Since the 2005 landmark decision by the Federal Aviation Administration to allow POCs on commercial aircraft,[1] there have been a host of new POCs introduced. While 5 portable concentrators have the ability to provide continuous flow and they are limited to a maximum of 3 lpm, the majority of POCs deliver oxygen by pulse flow only. Considerations for selection of a POC include: weight, size, battery life, maximum oxygen capacity, sound level, and oxygen hose length. POC weights with a single battery range from 2.3 to 19.9 pounds. In general, lighter units have shorter battery life and lower maximum oxygen capacities. Battery life varies by POC unit and flow rate used, ranging from <1 hour to 6 hours. Utilizing extra batteries can extend the time between charges.[5] The more details we learn about how portable concentrators work, the more we can appropriately gauge which patients may benefit most from this technology. Different options are constantly emerging.

When initiating oxygen therapy, it is wise to discuss the patient's expectations and lifestyle. Some patients have frequent travel plans and should select a company that can and will accommodate those needs. The world of oxygen systems is ever changing and new developments must be addressed. The focus should center on developing individualized patient oxygen therapy plans as new options emerge.

An important tool in the arena of patient self-monitoring is the portable pulse oximeter. In recent years, the portable pulse oximeter has become increasingly affordable. While it is not a perfect tool, a home pulse oximeter can be very helpful for a patient to report their oxygenation while in the home setting. This is especially true in monitoring patients with exercise-related dyspnea and for titrating oxygen flow for patients on long-term oxygen therapy, provided their disease is stable and they have good circulation. In general, the goal should be to maintain oxygen saturation >90% during all activities.

Pulse oximeters can overestimate oxygen saturation, particularly in those with darkly pigmented skin. Additional cautions should be noted if the patient has:

- Poor perfusion due to systemic hypotension, Raynaud's, hypovolemic shock, cold environment, or cardiac failure—it may result in the machine not providing a reading (or an inaccurate reading)
- Anemia—oxygen delivery to tissues is inadequate due to lack of hemoglobin for oxygen to bind to, but oxygen saturation is normal
- Carbon monoxide poisoning—carbon monoxide binds to hemoglobin, resulting in inadequate oxygen transport despite normal pulse oximeter readings. The pulse oximeter cannot distinguish what gas is binding to the hemoglobin (only that *a gas* is attached).
- Movement, shivering patient, heart arrhythmias—oximeter may not be able to identify an adequate pulse signal due to movement intolerance
- Nail polish, dirt, artificial nails—can cause false low readings or prevent readings altogether

It is difficult to predict whether a patient will be appropriately oxygenated with a particular system, but by working closely with patients and home oxygen providers, patients can truly live life to its fullest.

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