

Purity of Oxygen versus Concentration of Oxygen

Is there a clinical difference?

By John R. Goodman BS RRT

From time to time patients who are on oxygen 24 hours per day, 7 days per week find themselves confused between the “purity” of oxygen and the “concentration” of oxygen. Many times the terms are used interchangeably adding even further to the confusion. One thing we know for sure...there is no such thing as “one size fits all” when it comes to oxygen therapy at home. Of course, it took many, many years of trial and error before this important observation came to be accepted by the pulmonary community at large.

If we use the decade of the 60's as the very beginning of our timeline for bringing oxygen into the home, we have somewhere around 50 years of home oxygen experience. Most patients of that era were most certainly on cylinder oxygen as the oxygen concentrator and liquid oxygen were still a decade or more away from widespread acceptance. Although oxygen cylinders for home use were big, heavy, and difficult to store...they did provide oxygen that was rated at 99.99% pure. Even the earliest liquid oxygen systems provided at least 99.0% pure oxygen at the outlet. This was determined to be “medical grade” oxygen. Early oxygen prescriptions were almost certainly written for 2 L/minute with little variation. A rare pulmonary pioneer (like Dr. Tom Petty) might have instructed their patient to increase their flow rate by 1 L/min. with activity, but generally you were on 2 L/min. under all conditions for as long as you were on oxygen.

This, no doubt, was due in large part to the very heavy belief in the “knocking out hypoxic drive” theory that was very deeply believed by just about every pulmonologist prescribing oxygen at that time. We have since debunked much of this theory, at least in how prevalent or dangerous it really is. Another thing that is easy to overlook is there was simply no affordable finger pulse oximeter available at that time. Today (January 2014) we take for granted that a quick Google search will yield a wide variety of very clinically solid oximeters at a reasonable price. All oxygen patients can now carefully titrate their oxygen flow rates to keep them well saturated under conditions of both rest and activity. A routine order from your pulmonologist will have your oxygen company do an overnight oximetry study to monitor your oxygen saturation while you sleep. In many cases a patient is surprised to learn that they actually need more oxygen at night while they are doing absolutely nothing, than they do when they are up and around during the day!



Check your sats periodically



A good home care respiratory therapist checking a saturation

Let's take a minute to review liter flow of oxygen and the actual percentage of oxygen that is delivered to the lungs. For a very long time now, pulmonary clinicians have been following this guideline regarding this topic...for every one liter of oxygen per minute the patient is receiving via nasal cannula, there is about a 4% increase in the amount of oxygen (%) getting down to the lungs.

Remembering that the room air we breathe in and out every day has right at 21% oxygen, it is simple math to continue up the scale as follows:

- 1 L/minute equals 25% oxygen.
- 2 L/minute equals 29% oxygen.
- 3 L/minute equals 33% oxygen.
- 4 L/minute equals 37% oxygen.
- 5 L/minute equals 41% oxygen.
- 6 L/minute equals 45% oxygen.

(None of these numbers is exact, but they are close enough for this illustration)

Flows above 6 L/minute via standard nasal cannula with just a bubble humidifier are pretty difficult for most patients to tolerate 24 hours per day. At this point either an expensive heated humidification system needs to be considered, or perhaps the patient is advised to wear a simple oxygen mask. As underlying lung disease progresses and higher flow rates become necessary, many patients consider transtracheal oxygen for its improved comfort and efficiency.

Since these percentages are actually fractions, the medical abbreviation is FIO_2 , where the (F) stands for fraction the (I) stands for inspired and of course the O_2 is for oxygen. So, altogether we get the *fraction of inspired oxygen*. The numbers listed above assume that the source oxygen was of medical grade or 99+% pure.

So why does the FIO_2 which starts out at near 100% at the (for example) the cylinder outflow connection, drop all the way down to around 30% at 2L/min. by nasal cannula? Well, there are a number of pretty sophisticated equations that do actually explain what happens, but there is no reason to add to the confusion here.

It is just as simple (for a minute) to picture yourself with your nasal cannula set at 2 L/min. taking in a simple breath and exhaling normally. This is called your Tidal Volume and although it differs widely based on sex, age, and height, we can give a range of say 350-500cc per breath. So even though you may have 99+% oxygen flowing out of the prongs of your nasal cannula...you are diluting it with several hundred cc's of room air that contains just 21% oxygen with every breath.

There are other factors such as your respiratory rate, and the difference in the time it takes to inhale and exhale, and the amount of dead space taken up by your mouth, nose and throat. But when we take all the variables into effect, the net result is a very substantial decrease in your FIO₂. As long as that 2 L/min keeps your saturation in the normal range...you are good to go. The same holds true for whatever flow rate is needed to keep your saturations normal.

When the very first concentrators were introduced to the market, they were very big, very noisy, used a great deal of electricity, usually couldn't generate any more oxygen than 3 L/min, and last but not least could not generate the 99.9% "pure" oxygen like oxygen cylinders and liquid oxygen systems produced. About this time the term "purity" began to be used to describe the amount of oxygen that could be manufactured or generated by this new revolutionary technology. This purity figure was usually somewhere between 90 and 95%. I think we all would agree that "purity" of oxygen is a heck of a lot easier to remember than Fraction of Inspired Oxygen!



First generation concentrator



Typical concentrator



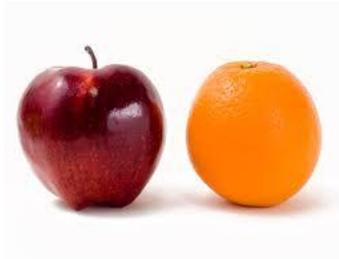
Pt. flying with POC

Once the term stuck and came into common usage, it was here to stay.

Purity has always been inversely related to liter flow. That is, as liter flow went up...oxygen purity (or the FIO₂) dropped. It was true back in the 70's and it is still true today. The question is...what is the clinically acceptable lower limit to purity? The answer is...WE DON'T KNOW! Some of the very latest models of portable oxygen concentrators (POC's) have been extensively studied and the results published in respected peer reviewed journals. Depending on the variables, the purity of at least one current POC was down around 87% with the range being 87-96%. The general opinion seems to be that it is not clinically significant. I say...it only has to be clinically significant to *you*. Clearly we need to study this scenario in detail and that takes time and money.



Lots of POC's
to choose from



They may look similar
but they perform differently



Good for the Goose



Not so good for the
Gander

What does this all mean? This means that what might work acceptably for one patient, might not even be close for another patient. And to bring this full circle you can see where pulmonologists and respiratory therapists like myself put so much emphasis on using your pulse oximeters so that you are not just adequately oxygenated to a saturation of somewhere a little north of 90%, but saturated to whatever saturation is normal for where you live, work, and hopefully play. This will be in the 96-98% range at or near sea level to between 94-97% here in Denver or other cities at altitude. No one knows your body better than you. This is especially true regarding your oxygen therapy. Ask questions, get on the treadmill whenever you can, pay attention to nutrition, check into local pulmonary rehab programs. Take control of the things you CAN control, but don't ever let your lung disease control you!