Arterial Blood Gases, Digital Pulse Oximetry, and Routine Blood Work

By John R. Goodman BS RRT

Patients with chronic lung disease frequently are tested to determine their lung function. The lungs basically have just two primary functions. That is to transfer oxygen from the air we breathe into the blood, and to eliminate carbon dioxide from the body. Tests which measure how well your lungs are performing these functions include pulse oximetry, arterial blood gases, specific blood tests, chest x-rays, and pulmonary function studies. They may be done on a scheduled basis during routine visits to your doctor, or whenever you have symptoms your doctor is concerned about. Let's take a moment to explain why each test is so important.

Pulse Oximetry:

When your doctor, respiratory therapist, or nurse puts a finger pulse oximeter or perhaps a probe from a different type of oximeter on your finger, they are checking how well "saturated" your blood is with oxygen. More specifically, the oximeter reflects how well saturated your Hemoglobin is with oxygen. Hemoglobin is the protein in the red blood cell that actually carries and delivers the oxygen to all the tissue cells of the body. The average adult has over one trillion (1,000,000,000,000) cells that together make up the body. Each and every one of them needs just the right amount of oxygen to perform their assigned role in the body. If you want to think of your oxygen as an *amount*…we all consume about 250 ml's of oxygen per minute. That's about one shot glass less than a ½ a pint of oxygen…every minute, or 15,000 ml per hour (over 4 gallons of oxygen), or 360,000 ml per day (over 95 gallons)!

In people *without* heart or lung disease, arterial blood is over 90% saturated with oxygen while breathing room air. It is somewhat higher at sea level, and slightly lower at higher altitudes, but always over 90%. Your doctor gets concerned when your saturation drops below 90%. For this reason you may be walked while wearing an oximeter to determine what flow rate is required to keep you over 90% with increased activity or exercise. If you have your own oximeter, use it to guide your oxygen therapy. It is ***far more important*** to be adequately oxygenated than it is to conserve oxygen. Increase your flow rate with activity to keep your saturations above 90%.

Remember, the human body is very smart. It will only use the amount of oxygen it

needs from minute to minute. Therefore, there is no real physiologic benefit to keeping your saturations above 97%. In fact, you are probably just wasting oxygen. Some patients like a little "oxygen cushion" and there is nothing wrong with that. Other patients want to use the lowest liter flow possible to make their portable oxygen source last longer. There is nothing wrong with this approach either, as long as your saturations stay above 90% under conditions of rest and activity. Keeping your saturations in the mid 90's is probably the best target for all patients. Don't *focus* on your oxygen flow rate…*focus* on your oxygen saturation!

The first commercially available oximeter for hospital use (around 1979) cost over $21,000.00, only worked with the old style ear-clip, and was so big it required its own cart to wheel from patient room to patient room. Today's digital pulse oximeters are commonly purchased for less than $50.00 on the Internet, yet they utilize the same principle of operation, are much easier to use, and are just as accurate. Technology has indeed come a long way!


Over $63,000.00 in 2011 dollars


Less than $50.00 on the Internet

A Few Personal Comments

The following comments are my own personal observations and recommendations:

While the 90% saturation figure is universally recognized as "acceptable", that doesn't mean you should shoot for JUST 90%. I have been asked literally thousands of times over my career what saturations should a particular patient shoot for. I always answer the same. Well, what is a NORMAL oxygen saturation based on the altitude where you live? Here in Denver where the altitude is virtually exactly 5,280 feet, we use the normal range of 94-97% as quite normal and very acceptable. If you live along or near any of our coastlines (sea level) your "normals" are higher because you are almost literally at sea level. Perhaps a range of 95%-98% would be your normal range. The reason for the difference is due to two values. The first is the percentage of oxygen in the air we all breathe. This one

is easy. The percentage of oxygen in "room air" is just a tick under 21%. We virtually always round up and consider 21% to be that number. Pulmonologists and respiratory therapists know this as the $FI0_2$ or Fraction of Inspired Oxygen.

The second value we need to know is the barometric pressure. Barometric pressure (Pb) can be measured in several different ways. In pulmonary medicine we use the millimeter (mm) of mercury (Hg) as our reference. At sea level the Pb is normally reported as 760 mm/Hg. For reference, here in Denver, our Pb is normally around 620mm/Hg. Since the $FI0_2$ stays exactly the same at 21% up to an altitude of 60 miles, we simply have to multiply the Pb by the $FI0_2$ to see the how much oxygen is available for us to breath at any altitude. This is reported as the $PI0_2$ or the Pressure of Inspired Oxygen. So 760 x .21= a pressure of just about 160mm/Hg, and here in Denver 620 x .21= about 130mm/Hg.

That 30 mm difference can mean a great deal physiologically to patients who require supplemental oxygen. A patient doing well on 2 L/min in Denver, may not need oxygen at all if they travel to Miami. Remember, this is the amount of oxygen in our atmosphere that is available to all of us….it is **not** the final amount of oxygen that makes it to the lungs. More on these values later, when I talk about arterial blood gases. And just for the record, no one can ever have an oxygen saturation of 100% breathing room air anywhere most people live in the United States. I'm not sure if oxygen saturation studies have ever been done in Death Valley or the Dead Sea!

So the take home lesson is….don't just "accept" the lowest oxygen saturation commonly used as the 90% point. Try your best to target a normal saturation….period! This is especially true under conditions of increased activity, when the cells of your body typically are crying out for more oxygen to do more work. Would you "accept" one puff of your inhaler when you know it takes two? Oxygen is the most important drug you are taking. Take exactly what you need, exactly when you need it. You will only not feel better; you will function better, and live longer.

The beauty of pulse oximetry is that it is completely non-invasive. Over the past 30+ years, pulse oximetry has become known as the 5^{th} vital sign. However, even pulse oximetry is limited in that it only gives information primarily regarding oxygenation status. In order to evaluate your lungs ability to both oxygenate properly and eliminate carbon dioxide, an arterial blood gas must be done.

Arterial Blood Gases:

A little additional physiology might be helpful when considering arterial blood gases (ABG's). Although the vast majority of oxygen we breathe in very quickly attaches to the Hemoglobin molecule in our red blood cell, a tiny fraction of that oxygen actually dissolves in the watery part of the blood known as the Plasma. Once dissolved in the Plasma, oxygen exerts a pressure of its own known as the "partial pressure" of oxygen. (Carbon Dioxide, the other gas reported in an ABG, will be covered in another article of the month.) It is reported as your $Pa0_2$. On its way from the air we breathe down to the working units of the lung, the $PI0_2$ we discussed above is reduced (for reasons beyond this discussion.) For example, at sea level, the $Pa0_2$ is considered normal if in the range of about 80-100mmHg. In Denver, we will take a $Pa0_2$ of about 65-75 as within normal limits.

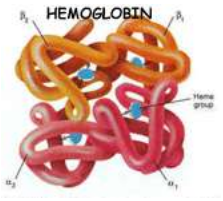
Here is where oxygen saturation which is your $Sa0_2$, meets your $Pa0_2$. A $Pa0_2$ of 60 mm/Hg is roughly equivalent to an oxygen saturation of 90%. Can you see now how and why the 90% saturation figure has come to be accepted as the gold standard? Oxygen saturation is non-invasive, and costs pennies compared to the drawing, running, and reporting of an ABG. Here's how I look at it, oximetry gets you into the ballpark, and the ABG get's you across home plate.

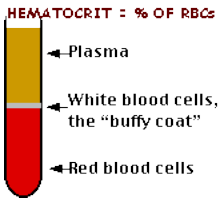
The blood gas gives your doctor, respiratory therapist, or nurse a great deal of information. Along with measuring the overall acidity or alkalinity (Ph) of your blood, the arterial blood gas measures the pressure of both oxygen and carbon dioxide, and how well your body may be compensating for any changes in your breathing. If your $Pa0_2$ is less than 55 mm/Hg breathing room air, you meet the criteria for continuous oxygen therapy. Remember, since oxygen is a drug, your

oxygen prescription needs to be written with just as much care and concern as your inhalers, antibiotics, or any other medication prescribed by your doctor. That is why your doctor is so careful to test you to make **absolutely** sure you will require continuous oxygen therapy. Your doctor looks at all the values on the blood gas report to determine how well your lungs are functioning, and based upon the findings, may adjust your oxygen flow rate and/or medications to maximize your oxygen therapy. No patient enjoys having a blood gas drawn, but the information derived from a single blood gas is well worth any discomfort. (I do know, I have had dozens of ABG's drawn on me by first year respiratory therapy students!)

Pulse oximetry and arterial blood gases provide your doctor, respiratory therapist, or nurse with two very different ways of evaluating your lung's ability to adequately oxygenate your blood. Many times your oxygen flow rate will be "titrated" (adjusted) to a satisfactory reading on the oximeter (greater than 90%) and then an arterial blood gas will be drawn to confirm the results. You should be aware that the benefits of oxygen are directly related to hours of use per day. Patients are therefore encouraged to wear their oxygen 24 hours per day as prescribed by their physician.

Hemoglobin and Hematocrit:





As explained above, Hemoglobin is the protein found in red blood cells that actually carries oxygen molecules to all the tissue cells of our body. It is the combination of Hemoglobin and oxygen that gives arterial blood its normal bright red color. The normal Hemoglobin (Hgb) value for men is 14-18 gm/dl, and for women 12-16 gm/dl. Remember, oxygen combined with Hemoglobin is necessary to produce the energy you need to get up and do the things you want to do. Hematocrit is simply the ratio of the cellular part of your blood (red blood cells, white blood cells etc.) to the liquid part (plasma).

The normal range for Hematocrit (Hct.) in men is 40-54%, while the normal range for women is 36-48%. These are commonly reported together on your lab report as your "H and H." Now here is how it all comes together. When your blood oxygen level is low, your body responds by stimulating your bone marrow to put more red

blood cells into your circulation. It's sort of like adding more box cars to the train that delivers the oxygen. If your Hemoglobin and therefore Hematocrit is elevated, your blood gets thicker. Your heart will have to work harder to pump the thicker blood through your (now constricted) blood vessels. You may even go on to develop Pulmonary Hypertension. (Please refer to the previous article of the month on Pulmonary Hypertension for a much more detailed explanation.)

This can lead to the development of other health problems and may prompt your doctor to alter your medical therapy. Being appropriately oxygenated 24 hours per day is one of the most important ways your body keeps your Hemoglobin and Hematocrit within normal limits.