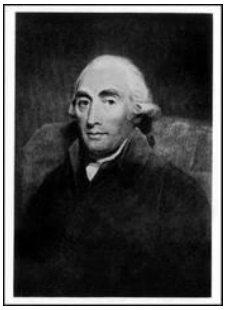
Much ado about CO_2

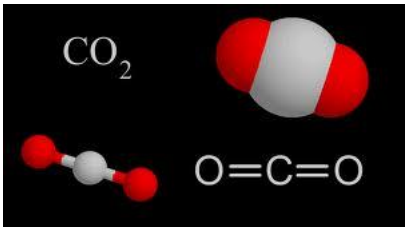
By John R. Goodman BS RRT

With chronic lung disease of any source most, if not all, of the attention goes to the effects of lung disease on oxygenation. Surely this is an important component in both the diagnosis and treatment for any patient who becomes a member of the "Hypoxic Club." Fortunately, it is relatively easy to correct mild to moderate hypoxemia with standard nasal cannula or other oxygen delivery device. As a quick review, remember in the air we breathe the percentage of oxygen is pretty darn constant at just about 21%. Now if your lung disease has involved enough of your functioning lung tissue so that you are unable to maintain a normal oxygen saturation, or even better, a PO_2 from an arterial blood gas….well you need supplemental oxygen to get you back into the normal range. Many studies have been done over the past 50 years regarding supplemental oxygen, including one done earlier this year. For every one (1) liter a minute of nasal oxygen you receive, you are adding about 4% to the room air amount of 21%. This means that by the time you may need 6 L/min, you might be getting somewhere between 40 and 45% oxygen. I bring this up to compare it to carbon dioxide or CO_2. While it is at least doable up to a point to raise your oxygen…it's not so easy to help you reduce or normalize your CO_2 level. So let's talk about carbon dioxide, what it is and how it factors into many lung diseases.

Carbon dioxide is found naturally in our atmosphere as a trace gas making up only 0.039% of our atmosphere. But what an important 0.039% it is. It is composed of 2 atoms of oxygen bonded to a single atom of carbon. CO_2 was discovered way back in the 1750's by a Scottish chemist named Joseph Black. He observed that the gas was heavier than air, was not compatible with life, and would not support a flame. Just two decades later in 1772, Joseph Priestly (who would go on to discover oxygen), bubbled CO_2 though water to produce "soda water." By 1834, CO_2 in the form of dry ice was even well known.



Joseph Black



Carbon dioxide molecule

Although it's nice to have dry ice, carbonated beverages, and a host of other industrial uses, it is the role of carbon dioxide in photosynthesis that we must start with. Photosynthesis is a miracle of biology! Basically, green plants, algae, and many types of bacteria use carbon dioxide and water to form food compounds such as glucose and get this….oxygen. Imagine oxygen as a by-product of photosynthesis, now released to refresh and regenerate the air we breathe. It takes approximately 30,000 years to replenish all the oxygen in the atmosphere. So that's where the 21% oxygen in the air we breathe comes from.

What happens next is basically the reverse of photosynthesis and is called respiration. In our bodies, we breathe in oxygen from the air, combine it with glucose to produce energy, a bit of water, and carbon dioxide. (A much more thorough explanation of energy production was covered in November's article of the month titled "Why does my oxygen saturation drop when I get up and move around.") In terms of lung disease, this is where the rubber hits the road. It is one of the chief roles of the lungs to eliminate CO_2 as it accumulates. Just as we must use or consume about 250cc of oxygen per minute to sustain life, we must eliminate around 200cc of carbon dioxide per minute to keep our blood levels of CO_2 in the normal range. This is especially daunting when you think we normally breathe over 20,000 times per day and something like 600,000,000 breaths by the age of 70! With chronic lung disease this is easier said than done.

Increases in CO_2 are not as easy for your doctors to treat as it is for them to correct your low blood oxygen levels. This is complicated by the fact that there is no easy, painless, inexpensive way to measure your actual blood level of CO_2 without getting a sample of your arterial blood. On the blood gas report this will be shown as your PCO_2. Many of you already know that a reliable digital pulse oximeter can be purchased on the internet for under $30.00. There is no commercial CO_2 equivalent of the digital pulse oximeter. Devices that measure exhaled CO_2 are called capnometers and the science is called capnography.

A variety of examples of capnometers primarily used in a hospital setting

So what is a normal CO_2 level? If we go by the blood gas (the RT's bible) then at sea level the normal range is 35-45 mm. Here in Denver and other cities of altitude it is a little lower…maybe 34-38 mm. So is there another *non-invasive* way to measure CO_2? Actually there is. Not exactly as accurate as a blood gas, but there *is* another way. We can measure the amount of CO_2 in your exhaled breath. This principle has been known for many years. In fact it was first described by John Tyndall in 1864. It is safe to say that the measurement of exhaled CO_2 ($etCO_2$) found its first use in the operating room, and has since gone on to many applications from EMT's and paramedics, to ICU personnel taking care of the most critical patients. An exhaled CO_2 of 4-5 percent is in the same range as the 35-45mm from the blood gas. Capnography has also gone through many technological advances over the past 30-40 years, but basically still works on the same principle…and there is the rub. It is just not that easy to miniaturize capnometers like it was for oximeters. Pricing is still pretty cost prohibitive as well for home use. Also, unlike oximetry, with advancing lung disease, capnometers are not quite as "trustable" as even an inexpensive digital pulse oximeter.

So here we are in 2012 and there is still no easy way to monitor your CO_2 in the home. Unlike noticing your fingers or lips getting a little blue when your oxygen is low…we cannot "see" your CO_2 level. Many patients think that when they get short of breath (SOB) it is time to turn up their oxygen. Smart patients who go by their oximeters know that you can be quite SOB with very normal oxygen levels. That is because SOB is not just caused by low blood oxygen levels. It may also be due to increased CO_2 levels. The human body is amazing in its ability to compensate for chronic conditions it has to deal with. In patients with lung disease compensation occurs over many years. This is especially true concerning your PCO_2. If your CO_2 level begins to climb, you must work a little harder to eliminate the extra carbon dioxide. Working harder requires more muscle involvement, and that requires more oxygen to produce the energy to do the work. Another Catch 44 cycle develops. If you can't supply the oxygen you need to do the "work", your CO_2 continues to rise, this stimulates you to work harder…requiring more oxygen and more work etc. At some point your CO_2 will elevate to a point where you can no longer do the work and you will require not only supplementary oxygen support, but also some assisted ventilatory support. Something has to be done to break this cycle and rest your muscles of ventilation. This most commonly takes the form of BiPap. Some examples are below.




Carbon dioxide also acts as an acid in the blood. If the CO_2 gets too high, it causes the pH of the blood to fall to dangerous levels. The cells of our body are geared to working in the normal pH range of 7.35-7.45. Everything gets messed up if the pH becomes too acidotic. In fact the textbook definition of respiratory failure is a PO_2 of 50mm, with a PCO_2 of 50 mm, and a pH at 7.25 or below.

Not all chronic lung diseases cause increased CO_2 levels in the blood. COPD is the group most often affected due to the actual destruction of functioning lung tissue and premature collapse of the small airways. Many times patients with Interstitial Lung disease (ILD) have normal or even low CO_2 levels because their disease is so very different from COPD.

Is there anything else that can be done to decrease your CO_2 levels? Bipap has now been used for over 25 years to help manage CO_2. There are just now (and I am being very careful here) devices called portable ventilators being introduced to the home market. Time and clinical experience will tell what role they *might* play. Certainly your medication regimen prescribed by your doctor can help manage your CO_2. In the past drugs to stimulate your brain to breathe a bit more rapidly were tried, but have largely been proven ineffective. Pulmonary rehab and breathing retraining exercises can help as well. Mobilizing secretions, watching what you eat (stay away from those carbs!) and learning to manage your disease can all help to keep your CO_2 down to levels that are more easily handled by your amazing wonderful body.