SUPPLEMENTAL OXYGEN & GASES UNDER PRESSURE

by Kenneth Capek RRT, CHT, MPA

Supplemental Oxygen is commonly used to treat various types of hypoxic diseases. Normal delivery of oxygen percentages above 21% are achieved by means nasal cannulas, masks and other devices. Hyperbaric oxygen therapy not only treats patients to an oxygen percentage of 100% but at levels higher than atmospheric pressure. This increases the available oxygen to the body's cells, which can help heal hypoxic wounds. As helpful and healing as this can be, it can result in detrimental effects such as oxygen toxicity.

What is important to understand is that gases under pressure change their characteristics and affect us very differently, even good old room air 21% oxygen. This phenomenon is best explained by examining Dalton's Law. Dalton's Law of Partial Pressure states that the pressure of a gas mixture is the sum of the partial pressures of the individual components of the gas mixture. Partial pressure can be expressed in PSI, feet of seawater, or in atmospheres. During a hyperbaric treatment or "dive", the patient experiences the same pressure at 15 PSI or one added atmosphere (ATM) as a diver when he descends 33 feet underwater. Supplemental oxygen, of the hyperbaric type, is actually what a diver experiences every time they dive and the effects of pressure on gas mixtures is the same in both environments.

We use PO2 or ppO2 as an expression for the partial pressure of oxygen. Room air on the surface has a value of .21 (Nitrogen is expressed as PN2 with a value of .79). When the patient is pressurized in the chamber or when a diver descends, the partial pressure of the gases he is breathing increases, not the percentage. As an example, the PO2 of 21% oxygen at 33 feet or 2 ATM pressure is .42. The PO2 can be calculated for each depth or level of pressure and also for different oxygen mixtures. A breathing mixture of 32% oxygen at 33 feet or 1 ATM has a PO2 of .64 and at 132 feet or 5 ATM the PO2 is 1.6. This 1.6 PO2 value is significant in diving because this is a level, that for safety reasons, a diver must never exceed. In diving, this level is referred to as an Oxygen Time Limit or Oxygen Tolerance Unit. For this reason a diver will limit breathing a 100% oxygen mixture to a maximum depth of 20 feet. They would only breathe this 100% mixture at the end of deep dive and is required for underwater decompression to prevent decompression sickness. A diver breathing a normal compressed air mixture of 21 % oxygen gets the same effect as if he was breathing 100% oxygen in his cylinder at depths greater than 218 feet. Technical (advanced trained) divers will use various gas mixtures dependant upon the depths they plan to dive but they must be extremely careful in their calculations and depth planning. In the dive community, gas mixtures above 21% oxygen with nitrogen are referred to as Nitrox or Enriched Air Nitrogen (EAN). They use these mixtures to stay in the water longer for longer periods of time at particular depths without increasing the risk of decompression sickness.

You may ask; "If the oxygen toxicity problems increase as the pressure rises why not reduce the oxygen level in a divers cylinder?" Well you can. What if the diver had 4% (yes four) oxygen in his cylinder and rather than using nitrogen gas he replaced it with helium - heliox? Can a diver take supplemental oxygen and breathe various gas mixtures safely underwater? Again the answer to this question is yes. A commercial diver at a depth of 400 feet is typically breathing a gas mixture in his cylinder that contains only 4% oxygen and 96% helium. In order to minimize the risk of oxygen toxicity the percentage is reduced to 4%, but at that depth this is a sufficient amount for normal respiration. Remember it's all about PO2. A diver cannot afford the getting a seizure underwater, the worse symptom of oxygen toxicity. In the hyperbaric chamber when we use 100% oxygen at pressures over 2 ATM we have the patient breathe room air for two 10 minute periods in order to reduce the risk of oxygen toxicity. At least on dry land you can't drown due to a seizure. There are strict rules that determine the oxygen percentage permitted at specific depths. The nitrogen in this mixture is replaced with helium in order to prevent what is called nitrogen narcosis. As the PN2 of nitrogen increases it becomes a narcotic at that depth. This typically starts at 100 feet and the effect has been referred to as the martini effect or rule - each atmosphere deeper is like drinking another martini. When helium is added to a gas mixture of oxygen and nitrogen, it is called tri-mix, not Heliox. These mixtures are not typically used by new open water certified divers. Special training and certification is required for these various types of mixtures.

continued on page 73

University of Kansas Review... *Continued from page 44*

The child's Storybook is colorful and focuses on "Doc" Monaghan and a young boy newly diagnosed as having asthma. It covers much the same information as the parent's guide but in a more kid-friendly manner. MDIs, holding chambers and peak flow meters are illustrated and are show with an actual human not the claymation character. This, I believe, places the reader into the realm of reality rather than into a fiction or fantasy another smart direction taken by Monaghan in this program. Application of the "Zone Chart" to daily life is clearly explained relating the effects of each zone on the activities of daily living.

The DVD/CD contains two 20 minute videos; one in Spanish and one in English. The video consist of a mix of animation featuring the "Doc" Monaghan character and a real live young boy of perhaps 6 or 7 years old. The boy has just been diagnosed with asthma and is sure that his life is "ruined. The interaction between the boy and "Doc" is educational with respect to asthma, asthma triggers, peak flow monitoring and tracking and social impacts of asthma. Additionally it is very entertaining as "Doc" is somewhat of a comical character, but one with a message. His overriding message is that "Knowledge is power".

The video integrates the "live" performance with the cartoon action extremely well. The discussion of asthma in the video closely parallels the text of the Storybook. In fact, much of the Storybook art is from the video (both of which have high quality graphics).

Summary

This is a well integrated multi-media asthma education packet. It has activities for all ages and provides clear and accurate information on asthma, its diagnosis, treatment and monitoring. Additionally, a great deal of attention is given to identification and control of asthma triggers. The reference list Monaghan provides is an excellent sampling of additional information and education sources such as websites and various association phone numbers.

There have been educational materials available for children patients, adolescent patients, young adult patients and their families for years, but it is obvious that a great deal of professional attention and development was invested into this program by the Monaghan corporation not to mention top-notch and probably costly production. I would say that of all the materials currently out there addressing asthma education, this program ranks as the most complete in this reviewers opinion. I would suggest this for all parents and I recommend that all offices/clinics where asthmatic children are treated and evaluated consider it for integration into their programs.

Monaghan Corporation can be contacted by calling them at 1-800-833-9653. They also have an extensive website with more information on the Doc Monaghan program. It is located at www.monaghanmed.com.

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"I've done nothing for years, surely that must count for something"

Hyperbaric Medicine... *Continued from page 54*

I am frequently amazing at how many similarities there are between diving, respiratory care and hyperbaric medicine. So lets add another field; anesthesiology. There are devices called a "rebreather" that allows a diver to carry a small oxygen cylinder and oxygen analyzer and mix the level of oxygen necessary as the dive progresses. The breathing circuit is like that of an anesthesia machine in that scrubbers remove carbon dioxide from your exhaled air.

Navy seals initially used these devices to eliminate the release of exhaled air bubbles to the surface. Surface bubbles are not good if you're trying to be undetected in a battle zone. Again special training and certification is required for using these devices. The advantage in using these is longer dive times yet as we add complexity, we add risk. These will become more popular in diving once the price tag decreases.

In summary, our normal everyday gases can display amazingly different properties under pressure. They can move from very safe to very dangerous with changes in pressure.

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