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# A LESS THAN PERFECT VACATION

**A COUPLE IS ON VACATION IN AN EXOTIC LOCATION AND THEY DECIDE TO TAKE A SCUBA COURSE. THEY GO TO THE LOCAL DIVE OPERATOR, RECEIVE SOME INSTRUCTION AND A QUICK GEAR FAMILIARIZATION. ALL TOO SOON THEY ARE IN THE OCEAN.**

They do two dives, 15m for 45 min, 90 min surface interval, 15m again for 35 min. Approximately 5 hours after the second dive the guy notices shortness of breath and then develops numbness and tingling in his hands and both feet. He gets very concerned, goes to the local hospital, and is placed on oxygen. While on O2 his symptoms improve. Communication is difficult as the medical personnel speak broken English. A diagnosis of decompression sickness is made and he is transported to a second hospital several hours away. He encounters some resistance to being treated until he proves that he can pay. During this time he experiences some muscle spasms. The diver receives an almost 5 hour long treatment in the hyperbaric chamber and during the treatment his symptoms pretty much resolve. The next day he still has some shortness of breath and tingling in his hands and feet, he returns to the hospital and is given a 2.5 hour long hyperbaric treatment. The following day he receives another 2.5 hour long hyperbaric treatment. About this time the diver finally manages get in touch with diving medical specialists in his home country and they have to try and determine what is going on.

The preceding scenario is loosely based on a true story and is an excellent example of just how difficult it can be to sort things out in an exotic location. So let's start at the beginning and try to make sense out of this very challenging problem. Shortness of breath as a result of diving can be due to pulmonary barotrauma, salt water aspiration or decompression sickness. Some key information is required. Exactly what were the dive profiles? Where there any problems during the dives? Specifically, did the regulator work properly or was the diver inhaling water? How long did he take on the ascents? Were there any episodes of rapid ascent? Did he cough or hold his breath for any reason while ascending? Did he have any symptoms after the dives that occurred before the shortness of breath and numbness/tingling that started 5 hours after diving and if so, exactly what were they and when did they occur?

These general questions need to be answered to determine the likelihood that his symptoms are due to the three diagnoses mentioned. It turns out the dives were completely routine.

Maximum depth on both dives was around 15m but he spent very little time at that depth and in fact most of the dive time was spent at less than 10m. Based on this information, decompression sickness becomes extremely unlikely. In addition, pulmonary DCS is due to massive quantities of intravascular bubbles largely obstructing the circulation of the lungs resulting in pulmonary hypertension and accumulation of fluid in the lungs. To generate this massive quantity of intravascular bubbles, the diver has to miss an hour or more of required decompression. The dives this diver conducted are not even close to requiring any decompression and therefore pulmonary DCS is virtually impossible.

Other forms of DCS can occur after less serious dives but in general, the dive profiles have to at least approach the no-decompression limits. In addition, DCS that occurs on dives with little decompression stress usually has pain as the primary symptom. Also, shortness of breath and tingling of the hands and feet would be a highly unusual presentation for any form of DCS.

Very rarely, serious neurological DCS can occur after trivial dives. However, shortness of breath with numbness and tingling of both hands and feet would require multiple highly specific lesions in the brain and the probability of this happening is near zero. Therefore, although in medicine very little is absolute; given this scenario DCS is so unlikely that we must seek other more probable explanations.

Shortness of breath can be due to pulmonary barotrauma. The lungs are damaged during ascent and therefore symptoms have to start almost immediately after surfacing. If you can get a reliable history and if the symptoms start more than ten minutes after surfacing, pulmonary barotrauma becomes extremely unlikely. In this case the symptoms started 5 hours after the dive and there were no events during the dive to suggest pulmonary barotrauma had occurred so it also becomes an extremely unlikely explanation for the diver's symptoms.

Salt water aspiration is relatively common in divers and is usually associated with a malfunctioning regulator such that when the diver takes a breath, a small amount of salt water spray enters the lung. Typically the diver develops severe fatigue, mild cough, and some difficulty breathing an hour or so after the dive. They may also experience hot and cold spells. This usually settles over a few hours. The diver in our scenario does not seem to be having symptoms to support this diagnosis either. In addition, there is no history of lung problems, he is young, fit, does not smoke, and the chest x-ray done at the hospital was perfectly normal.

Now we have a problem. The three relatively common dive related problems that might explain his symptoms are all highly unlikely. Is there something else that could be going on?

Numbness and tingling of both hands and feet is a fairly classic presentation of hyperventilation so let's explore this possibility. Breathing is an activity that we all must do on a continuous basis or we will die! It is controlled by the respiratory center in the brain and is primarily driven by the level of carbon dioxide (CO2) in the blood. The level of oxygen in the blood has a much smaller effect. So why does the body pay so much attention to the level of CO2?

Every cell in the body requires energy to function. Basically, it takes 'food' and O2 from the blood and through a very complex series of chemical reactions 'burns' the food to produce energy. In addition to energy, CO2, water and other waste products are also produced. The CO2 produced in the cells is taken up by the blood and returned to the lungs where we breathe it out. Carbon dioxide is involved in several chemical reactions that allow the blood to carry larger quantities than would be possible if CO2 was just dissolved as a gas (oxygen binds to hemoglobin for the same reason) and these chemical reactions have a large effect on the acid/base balance of the body. The bottom line is that CO2 is produced in direct proportion to the amount of O2 used by the body and controlling the level of CO2 is usually an excellent way to ensure enough O2 is delivered to the cells.

Breathing is work. The stimulus to breathe is a result of the level of CO2. Therefore the amount a person breathes is the result of an endless balance between the level of CO2 and the work of breathing. When you start to exercise, you increase the production of CO2 in the muscles. It dissolves in the blood and is carried to the brain where the respiratory center responds to the increased level of CO2 by ordering the body to breathe more. You start to breathe faster and more deeply. This results in the elimination of more CO2 by the lungs driving the level of CO2 down. Breathing faster and deeper is more work than breathing normally so during exercise a balance is reached at a slightly higher level of CO2 than normal. When you stop exercising both breathing and the level of CO2 in the body return to normal over several minutes.

However, breathing is not always automatic. We can intentionally breathe faster and deeper, and we can intentionally hold our breath. When we hold our breath the level of CO2 rises in the body and the stimulus to breathe from the respiratory center increases. Eventually the stimulus to breathe becomes so strong that we are forced to breathe and can not hold our breath any longer. Occasionally we can hold our breath so long that we use up enough of the O2 in the body to cause us to loss consciousness. Of course we then start to breathe.

We can also force ourselves to breathe more than is required to maintain the level of CO2 in the body and drive the level of CO2 down. This is called 'hyperventilation' as you are ventilating (breathing) more than required (hyper). People often do this to allow them to hold their breath longer (you start with less CO2 in the body). However, hyperventilation does NOT result in more O2 in the body and therefore when you hold your breath longer, it becomes much more likely that you will loss >

SHORTNESS OF BREATH AS A RESULT OF DIVING CAN BE DUE TO PULMONARY BAROTRAUMA, SALT WATER ASPIRATION OR DECOMPRESSION SICKNESS

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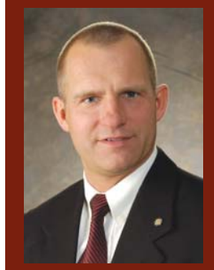

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# diving medicine

consciousness before the drive to breathe is strong enough to force you to take a breath. Exercise while you are holding your breath greatly increases the likelihood of this happening and is the reason that breathhold diving can be so dangerous (drowning due to loss of consciousness underwater).

Hyperventilation causes the level of CO2 in the body to be less than normal and upsets the acid/base balance. These changes result in symptoms including lightheadedness and tingling/numbness of the hands and feet. If a person continues to hyperventilate they can experience muscle spasms and anxiety (try taking deep breaths at a faster than normal pace for a little while and you will experience these symptoms). The person usually feels short of breath and this causes them to try and breathe more! If you recognize what is going on you can simply hold your breath or breathe in and out of a paper bag (this will raise the CO2 in the air you are breathing and return the level of CO2 in the body to normal).

Anything that makes breathing harder will cause the level of CO2 to rise. Breathing O2 usually involves some kind of mask or regulator that makes breathing more difficult. In addition, a higher than normal level of O2 in the body will reduce the drive to breathe slightly. Both effects will tend to reduce the symptoms of hyperventilation.

Being treated in a hyperbaric chamber will also tend to cure the symptoms of hyperventilation. Not only is a mask/regulator usually used, the air/oxygen is 2.8 times denser at 18m depth than on the surface and that also makes breathing more difficult.

So let's return to our diver. His symptoms and response to O2 and hyperbaric treatment are entirely consistent with hyperventilation but how do we 'prove' that was the problem? If the symptoms are cured by breathing from a paper bag and if the symptoms can be caused to return by intentionally hyperventilating, the diagnosis is strongly supported. Unfortunately, there is no absolute proof and there are a very large number of things that can cause shortness of breath.

These include pneumothorax, pulmonary embolism, bronchospasm, foreign body, toxic inhalation, several heart problems, pneumonia, poisoning, and of course anxiety disorders. In confusing cases, specific tests of the heart and the lungs must be done to rule out problems in these areas.

This column illustrates several very important points. Some medical problems can be extremely challenging. Getting appropriate medical care can be difficult at home and much worse when on vacation in a location where the standards of care are different and where it may be difficult to communicate effectively with the local medical personnel due to language and cultural barriers. Not everything that happens after diving is due to the dive. Finally, always make sure you have some way to pay for medical care you might require while on vacation as the costs can rapidly total tens of thousands of dollars! ■