Are Tissue Halftimes Real?

Often at a gathering of divers discussing decompression, you'll hear statements like, "There's no such thing physiologically as a tissue halftime, it's just a mathematical concept." That's not really so. Halftimes occur in processes as real as assessing the age of dinosaur bones to knowing how fast you clear drugs from your system. One of the many substances that has been experimentally measured to leave your body in halftime fashion is nitrogen gas after your dives.

Some Real Halftimes

Radioactivity. In a fixed period of time, a radioactive substance will lose one-half its mass or radioactivity. After another equal period, half the remaining 50 percent also exits. A useful way of expressing the unit of time related to half a substance's life is a "half-life." This is the same as a halftime, just a different name. The time when any one particular nucleus will decay is impossible to predict, but the rate of decay, or half-life, of a mass quantity is precise and real. Decay rates of different radioisotopes vary considerably. Artificially made radioisotopes often have half-lives as short as microseconds. Natural radioisotopes have half-lives up to billions of years. Halflives of natural radioisotopes are useful to determine age of archaeological remains and the geological age of fossils, rocks and the earth itself. The process is called Radiometric Age Dating.

Drugs. Drug metabolism also behaves according to half-lives. Your body takes predictable units of time to get rid of one-half of a standard dose. In pharmacology it's common to call this unit of time a halftime. It is also sometimes called a half-life. The halftime varies a bit among individual people. However, a general range is determinable.Valium, for example, has a halftime of about 44 hours in younger people (higher in older people, lower in some others). Forty-four hours after taking a five-milligram dose (5 mg) for example, about 2.5 mg are still in your body. Someone taking Valium daily will build up levels until the daily intake is the same as the body's ability to clear (get rid of) the drug. This is called a steady state. The level falls if the person then stops taking the drug, bringing on withdrawal symptoms. Different parts of your body have different affinities for the drug, and have different times to reach steady state (get more until it can't hold any more) and to clear (get rid of) half the dose. As a generality, blood and plasma levels usually rise and fall more rapidly than levels in fat. Similarly, divers often say that fat is a problem in decompression because it holds more nitrogen. But it also is slower to get any than other body areas. After the same amount of time of a dive, fat will have acquired less. It has a slower half-life. It is also common to hear that scar tissue will make trouble because it is hard for gas to get back out. It is also hard for gas to get in there in the first place because of the slow halftime. Whether this makes or prevents trouble is not fully sorted out yet.

What About Nitrogen Halftimes?

If you wanted to visualize the transit of radioactivity or Valium, you could make a dot on graph paper after each time interval in which the radioactivity count or Valium concentration dropped by half. This time interval is the halftime. If you connected the dots, you would have a curved line that is characteristic of halftimes.The equation describing that line is called exponential. What would happen if you tried the same dot test with nitrogen leaving a diver?

A Real Nitrogen Halftime. You could catch a diver's exhaled air in a bag, or pipe it directly to an analyzer and measure how much nitrogen comes out over time. That, more or less, is how a measurement called total body nitrogen washout is estimated. If you charted the time for a total body washout of nitrogen, it would look like a curve. That curve is described by the sum of many exponential equations.

Individual Tissue Halftimes. Total body washout curves, like most composite descriptions, lose detail from individual contributors. They tell nothing about how much or little nitrogen makes its way in and out of each of the different parts of you. Different structures of your body gain and lose nitrogen at varying rates. Different nitrogen pressures resulting in those different parts appear to matter. Some parts of you may have relatively little nitrogen. Too much nitrogen pressure in any of your other parts from diving too deep, too long, or surfacing too fast, may begin the process of decompression trouble. Experimental and Theoretical Evidence. Short submarine escape tower work and longer experimental decompression from regular compressed air dives show certain tissue washouts really do proceed faster than others, thereby identifying faster and slower nitrogen halftimes for areas of the body. Diffusion distances are small in most tissues. When diffusion distances between capillaries are small, tissue is effectively "well-stirred" and gas exchange in tissue can be described reasonably well by halftimes. It was also found that adding more halftimes representing those different body areas brings predictions for decompression table safety closer to the actual outcomes. Most decompression models today don't use one halftime to represent the entire body.

Not Just Numbers

The U.S. Navy tables conveniently lower the high number of possible halftimes by grouping them into multiples of minutes, for example, 5, 10, 20, 40, 60, 80, 90, 100 and 120 minutes. Other models use other groupings of minutes.Yes, halftimes are numbers. However, the numbers are descriptive of what is happening in your body, not just concepts. Numbers are an economical way of describing mathematically something that is biologically complicated. And they are much more convenient than running after divers putting dots on paper.

Offgassing in Parallel. Tissue nitrogen transport may look and behave like it follows a simple mathematical pattern, but does it really? Not all systems gain or lose their components exponentially. And even if nitrogen does come and go exponentially under controlled conditions, practical factors and things you do during dives change the calculations. Blood flow is thought to be the main factor that determines tissue halftime. Tissue and blood solubilities are also important. Exercise and temperature changes during the dive have large effects on blood flow. Temperature also affects solubility. The idea of each of your body compartments offgassing separately but at the same time is called offgassing "in parallel." It's highly probable that not all gas diffuses in parallel from each body compartment separately back into your bloodstream for offgassing by exhalation. If a higher nitrogen pressure area is next to a lower pressure area, nitrogen will flow from the higher to the lower, producing serial offgassing of one tissue to another. Serial transfer has already been observed in pharmaceuticals.There is also a difference in the time it takes things to get into your body compared to back out again. A more important monkey wrench in the works is that, in practical application, divers are often creative with dive rules and guidelines, producing conditions that affect orderly and explainable nitrogen transport. That means they screw up. That has practical significance.

Practical Significance

Halftimes describe calculations for dive time limits based on, among other things, eliminating nitrogen that is dissolved in your body, not nitrogen that has become a gas again before you can breathe it out. When bubbles form, nitrogen exchange is no longer governed by halftimes. This is where most decompression models fall apart. Sometimes bubbles can help remove nitrogen, but other times, once bubbles form in your body, they can sometimes obstruct further nitrogen exit by several mechanical and chemical means. What can you do to reduce or prevent bubble-causing trouble?

1. Slow ascent rates
2. Safety stops

3. Keep your cardiovascular system healthy
4. Limit your total nitrogen exposure

Done together, these can make the difference between having time to offgas nitrogen before it evolves into bubbles or allowing your body to fill with inert gas "grenades."

Halftimes Are Real

So do you really have a 60-minute compartment, or a 5- or 120-minute compartment? It's likely you do have body structures that gain or lose half their nitrogen burden in 5, 60 and 120 minutes. Of course, those parts are not an entire organ like your heart or your stomach, but would be similar structures scattered all over you. We may not yet have the complete system to describe nitrogen leaving your body and thereby completely prevent decompression sickness, but halftimes are real.