Dispelling Misunderstandings

As divers we all know there's a small but real risk in the sport we love: namely, pressure injuries like decompression illness (DCI). We know also that the incidence of decompression sickness (DCS, or the bends) and embolism (AGE), is very low*, we want to be sure we're getting the best treatment if these unlikely injuries happen.
In the diving community, some persistent misconceptions exist about hyperbaric treatment. Here are some examples:

- A diver with possible DCS symptoms was referred to a local hyperbaric facility for evaluation and possible treatment. He told the DAN medic beforehand that the referral facility could not treat him because its chamber "goes only to 60 feet (18 meters)."
- An emergency medical services (EMS) crew transported a potentially injured diver and needed DAN to provide an alternate chamber facility. The closest facility had a chamber that "only went to 60 feet," according to the injured diver.

A military facility on a remote Pacific island could no longer treat civilian divers. Seeking advice, local divers contacted DAN. They were concerned because the only other chamber on the island could "only go to 60 feet."
With each of these misconceptions, a DAN medic was able to quickly dispel the divers' accompanying fears. What has perpetuated this misunderstanding?

* DCS incidence within the USN no-stop limits is 1-8.4 DCS/10,000 dives. From: Vann RD. "Mechanisms and risks of decompression," Bove AA, ed. Bove and Davis' Diving Medicine, 4th ed. (Philadelphia: Saunders; 2004:127-164.)

Treatment is more than pressure
Effective hyperbaric treatment is not just a function of pressure. The high partial pressure of oxygen is probably as important. To better understand the suitability of a chamber that can "go only to 60 feet," we need to make a quick review of hyperbaric treatment history.
The treatment for nitrogen bubble disorders began in the 19th century with caisson workers – construction workers employed in underwater chambers building bridges and other structures with underwater bases. They could work at depth, breathing air from the newly developed (1837) air pressure pump. But they soon discovered that with increased times and depths, they experienced what they called "rheumatism and cold."

Nearly four decades passed before this phenomenon was identified as decompression sickness. The treatment that eventually evolved was to return the caisson workers to the pressure at which they had been working until their symptoms improved. They would then begin a slow ascent to the surface.
That procedure remained through the beginning of the 20th century. During treatment, the breathing gas was air. Similar procedures were initially used for the treatment of DCS in divers. Eventually, fixed treatment depths were implemented through the efforts of the Royal Navy, British physiologist J.S. Haldane and the U.S. Navy.

Since air was the only widely available breathing gas, severe cases were often compressed to greater depths, especially if the treating medical personnel saw no immediate improvement. Thus, the capability of a maximum chamber treatment depth of 165 feet (50 meters) was considered essential. In the late

1930s, Dr. Albert Behnke and associates attempted to incorporate oxygen therapy into the treatment to shorten the number of hours needed to treat decompression illness. Although physiologically sound, this idea met with resistance. In the 1960s, researchers Dr. Michael W. Goodman and Dr. Robert D. Workman developed the oxygen treatment tables that eventually became the U.S. Navy Treatment Tables 5 and 6. Since their adoption in 1965, these tables have yielded consistently good results.

Table 6 is the treatment used most often for diving injuries. (See Figure 1) For several years, the U.S. Navy Diving Manual has recommended initial DCS and arterial gas embolism (AGE) treatment at 60 feet (18 m) but maintained 165 feet (50 m) as an option for instances in which the diver does not improve or worsens at a 60-foot treatment depth. Such instances are extremely rare.
One reason for the proven effectiveness of Treatment Tables 5 and 6 is the difference between the partial pressures of nitrogen in the tissues and the alveoli of the lungs1 or the arterial blood. This pressure difference, usually measured in millimeters of mercury (mm Hg), represents the driving force for nitrogen to diffuse out of bubbles.

Figure 2 shows that if the diver has nitrogen bubbles, the nitrogen partial pressure difference between bubble and tissue at the surface is 142 mm Hg (upper left). The graph in the lower right corner indicates that at 2.8 atmospheres absolute (ATA; 60 fsw, 18 msw) when breathing 100 percent oxygen the partial pressure difference increases to 2,086 mm Hg. The greater the pressure gradient, the faster nitrogen will diffuse out of the bubble into surrounding tissue. The same principle can be used to explain one reason for the effectiveness of surface oxygen.
The upper right graph represents a diver being treated at 2.8 ATA (60 fsw/18 msw) without additional oxygen (nitrogen partial pressure difference 482 mm Hg). The graph in the lower left corner illustrates the partial pressure difference with surface oxygen alone (nitrogen partial pressure 718 mm Hg). Surface oxygen alone creates a greater nitrogen partial pressure difference than pressure at 60 fsw breathing air.When using oxygen, the vast majority of decompression illness cases, can be treated at 60 feet (18 m). The U.S. Navy Diving Manual recommends initial treatment of all cases with Table 6 (See Figure 3). The effectiveness of 60-foot tables is such that even serious cases generally have a good outcome.

A treatment table developed by the staff at the University of Southern California's Catalina Hyperbaric Chamber is a modification of USN TT6, with up to eight oxygen cycles at 60 feet/18 m. This table has been used effectively to treat divers with serious symptoms (See Figure 4).
Other treatment tables have been specifically designed for monoplace chambers that are incapable of delivering air breaks; they appear to be effective for most cases.

In a professional text, DAN Senior Medical Consultant Dr. Richard E. Moon states, "Experience with treatment of decompression illness in practice has shown that it is rarely necessary to recompress a diver deeper than 2.8 ATA (60 fsw/18 msw) . . ." (2) When dealing with a potentially injured diver, the priority is to provide oxygen if available and transport to the nearest emergency facility. Contact DAN at the earliest opportunity: We can coordinate with the receiving facility in determining which chamber is available at that time. Chambers that can treat divers with a U.S. Navy Table 6 (or equivalent) and have knowledgeable staff that can evaluate and treat divers are considered appropriate. Treatments to greater depths rarely provide better outcomes. Therefore, the appropriateness of transferring a diver to a chamber should not be judged solely on its depth capability.