

VIEWPOINT |

## Heliox, nitrox, and trimix diving; hyperbaric oxygen treatment; and a flaw in Henry's law

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The Viewpoint by Ran Arieli published below addresses the topic of the physiology of "mixed-gas diving." You are invited to submit a brief commentary on this Viewpoint, which will be reviewed by Journal editors for possible publication in the *Journal of Applied Physiology*. Please limit your comment to 250 words and 5 peer-reviewed published references.

NON-AIR OR MIXED-GAS DIVING was developed to avoid nitrogen narcosis, improve decompression, decrease gas density, lower thermal capacity, and to prevent oxygen toxicity and the high-pressure nervous syndrome. In the main, there are three mixtures of oxygen, nitrogen, and helium that are used today for deep and saturation diving: nitrox (nitrogen + oxygen), heliox (helium + oxygen), and trimix (helium + nitrogen + oxygen). Nitrox is used for relatively shallow recreational dives, heliox is used for deep diving, and trimix is used for dives to depths at which the high-pressure nervous syndrome may be expected and for short, deep dives. In relative terms, there are less accidents in nitrox than in air dives (2). Although nitrox dives are deeper than those performed using air and could represent a greater risk to the diver, the increased professionalism of the technical diver may explain the smaller number of injuries and fatalities. However, this reduced risk may also be related to an inert gas load that is lower than the calculated level.

It has been shown that the solubility of a gas in water equilibrated with a mixture of gases is not, as postulated by Henry's law, a linear function of the gas pressure (3, 4). This phenomenon was explained by the effect of one dissolved gas on stabilization or destabilization of the water structure, which in turn affects the saturation solubility of another gas (1). The theory suggests that reduced stability will decrease the saturation solubility. Maharajh and Walkley (3) showed that in water equilibrated with a mixture of 50% oxygen and 50% nitrogen, the saturation solubility of oxygen decreased to 73% of the value expected according to Henry's law, whereas that of

nitrogen decreased to 84% of the predicted level. When the other gas was helium, the saturation solubility of oxygen declined more, to 66% of the predicted level. On the other hand, when a mixture of H<sub>2</sub> and N<sub>2</sub> was used at high pressure, there was a mutual increase in solubility (3, 4). The main effect of one gas on the solubility of the other occurs when the concentrations of both gases are equal; the effect is diminished when one gas predominates.

The total amount of dissolved inert gas in mixed-gas diving should, therefore, be less than that expected according to Henry's law, thus lowering the risk of decompression sickness. Air diving decompression tables have been extended to nitrox by calculating the equivalent air depth and to other gas mixtures used in diving by calculating the equivalent mixture depth. However, these new tables are unnecessarily conservative, because there is less dissolved gas in the tissues when breathing gas mixtures in which no one gas predominates, compared with a binary mixture consisting of a low level of oxygen and a high concentration of inert gas. In some hyperbaric oxygen treatments, the oxygen is transported in a dissolved phase, such that in both the arterial and venous blood the hemoglobin is fully saturated with oxygen. Less dissolved oxygen than expected will be transported when a balanced gas mixture (such as 50% He + 50% O<sub>2</sub>) is breathed. The effect of one gas on the solubility of another appears not to have been taken into account in compression-decompression calculations.

### REFERENCES

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