Letters to the Editor

Commentary on using critical flicker fusion frequency to measure gas narcosis

We read with great interest the paper on using critical flicker fusion frequency (CFFF) for monitoring gas narcosis in divers.[1] We agree with the authors' general conclusion that the CFFF has many limits prohibiting its regular use for monitoring decrease of mental performance in divers exposed to pressure and increased partial pressure of gases, including nitrogen, helium, carbon dioxide and oxygen. However, we do not think that the experiments conducted were planned correctly for reaching such conclusions. We do not agree with some of the explanations of physiological phenomena presented in the text as a part of the literature review.

First, as reported in the text, each measurement was preceded by a five-minute acclimatisation period for the pressure and/or gas mixture. Such a short time is enough to reach the equilibrium for dissolving breathing gases in the lipid layers of the central nervous system, which is the basic assumption for inert gas narcosis based on the Meyer-Overton hypothesis, or for carbon dioxide acting of ion changes in the brain. But it is possibly too short to observe effects of other mechanisms potentially influencing gas narcosis, including oxygen effects on neurological tissues. Therefore, in our past experiments, referred to in the abovementioned paper, we did measurements of CFFF at different partial pressures of oxygen (0.7, 1.4, 2.8 atmospheres absolute [atm abs]) only after at least 25 minutes of breathing oxygen.[2] Also, general hyperbaric practice shows that oxygen seizures rarely occur before passing 20 minutes of breathing oxygen, even at high oxygen partial pressures (2.4–2.5 atm abs). This time-dependency is reflected in the cumulative risk of oxygen toxicity index.[3]

Second, while mentioning the use of CFFF for monitoring oxygen influence on CNS, the authors did not say that some of the 'conflicting' or 'paradoxical' reports from the literature can be easily explained if one considers subjects' experience with oxygen. Jammes et al. have already reported that the threshold for hyperbaric oxygen-induced neuromuscular hyperexcitability is elevated in divers repeatedly exposed to high oxygen pressure during their occupational activities as elite combat divers compared to recreational divers.[4] This can easily explain differences in CFFF readouts between recreational divers reported by Hemelryck et al.[5] and military combat divers reported by us.[2]

Third, Hesser et al. have already quantified the narcotic effect of oxygen to be 3 to 4 times as potent a narcotic as nitrogen.[6] This must be considered while dealing with 'inert' gas narcosis, but it cannot be explained based on the Meyer-Overton hypothesis as the solubility of oxygen in lipids is only 1.7 greater than nitrogen. Moreover, at some point, the oxygen effect converts to toxicity. Interestingly, Lavoute et al. demonstrated biphasic oxygen effect on dopamine release in the nigrostriatal pathway, at least in animal model.[7] Taken together, this may indicate that oxygen-induced brain poisoning and an increase in neuronal excitability measured by CFFF may use the same or intertwined cellular signaling pathways.[2]

To conclude, the CFFF is a recognised method to assess neuronal excitability influencing attention and alertness.[8] Hyperbaric exposure is a mixture of pressure effects per se, inert gas narcosis, additive/synergistic effects of metabolic gases (oxygen and carbon dioxide), physical environmental factors (immersion, temperature, stress) and many others. The limitation of measuring gas narcosis using the only single indicator for attention and alertness is an oversimplistic approach doomed to failure.

References

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