Venous gas embolism after an open-water air dive and identical repetitive dive

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ABSTRACT

Decompression tables indicate that a repetitive dive to the same depth as a first dive should be shortened to obtain the same probability of occurrence of decompression sickness (pDCS). Repetition protocols are based on small numbers, a reason for re-examination. Since venous gas embolism (VGE) and pDCS are related, one would expect a higher bubble grade (BG) of VGE after the repetitive dive without reducing bottom time. BGs were determined in 28 divers after a first and an identical repetitive air dive of 40 minutes to 20 meters of sea water. Doppler BG scores were transformed to log number of bubbles/cm^2 (logB) to allow numerical analysis. With a previously published model (Model2), pDCS was calculated for the first dive and for both dives together. From pDCS, theoretical logBs were estimated with a pDCS-to-logB model constructed from literature data. However, pDCS the second dive was provided using conditional probability. This was achieved in Model2 and indirectly via tissue saturations. The combination of both models shows a significant increase of logB after the second dive, whereas the measurements showed an unexpected lower logB. These differences between measurements and model expectations are significant (p-values <0.01). A reason for this discrepancy is uncertain. The most likely speculation would be that the divers, who were relatively old, did not perform physical activity for some days before the first dive. Our data suggest that, wisely, the first dive after a period of no exercise should be performed conservatively, particularly for older divers.

INTRODUCTION

In recreational diving, a repetitive dive performed on the same day as the initial dive is a common practice. Multiday repetitive diving has become especially popular during dive holidays or long weekends. Despite this, studies of the risk of decompression sickness (pDCS) and the occurrence of venous gas embolism (VGE) following repetitive dives are scarce.

Decompression tables and algorithms as used in dive computers provide strategies for repetitive diving. However, the underlying research of pDCS (and VGE) is generally based on small numbers, mostly three or four subjects [1,2], due to the many possible combinations of profiles for the first (dive1) and second dive (dive2).

Decompression tables such as those of DCIEM or the U.S. Navy consistently show that a repetitive dive (with a short surface interval) to the same depth as the previous dive should have a shorter bottom time, because of the residual nitrogen load, to present the same risk for decompression sickness. The reduction of bottom time is needed, as there is a residual nitrogen load in the tissues at the start of dive2.

This research investigates whether a moderately deep repetitive dive near the no-stop limit and identical to the initial dive, produces more VGE bubbles as would be expected from decompression theory.

To be able to conclude whether the difference between the measured bubble grades (BGs) of dive1 and dive2 is in accordance with decompression theory, it is necessary to estimate the theoretically expected BGs from the dive profile. Unfortunately, a direct and practical procedure to predict BGs from a dive profile does not exist (but see [3]). In the literature, several models, mostly based on a probabilistic approach, have been published to predict pDCS from the dive profile (see [4] and [5] for references). An easily applicable model to calculate pDCSs has been described as Model2 by Weathersby *et al.* [6], based on 920 air dives. In the same study Model1 has been described, but this model is inappropriate for our purposes. In Model2, a momentary risk

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