Decompression Risk Evaluation of Commercially Available Desktop Decompression Algorithms.

Gene W. Hobbs and Keith A. Gault*
Rubicon Foundation, Inc and Duke Center for Hyperbaric Medicine and Environmental Physiology, Durham, NC, USA;
*US Navy Experimental Diving Unit Panama City, FL, USA

Introduction

Probabilistic decompression models are used for decompression sickness risk calculations based upon parameters that best fit the estimated risk to the known decompression outcomes of recorded depth-time profiles. The three probabilistic models chosen for this analysis were calibrated with thousands of laboratory conducted man-dives. We evaluated estimated risks for theoretical profiles using three probabilistic models.

A goal in performing this analysis is to demonstrate for novice technical divers the generally accepted trend that estimated risks of decompression sickness increase with bottom time for common decompression schedules.[1]

Methods

We produced decompression tables for 32% nitrox dives and a single 100% oxygen decompression gas. Bottom times were limited to the time one could safely dive using the "Rule of thirds" on double 130cuft cylinders (173 cuft used) with a surface gas consumption rate of 0.4 cuft/min. The software and models tested include: DecoPlanner (Global Underwater Explorers, High Springs, FL) Buhlmann and Variable Permeability Model (VPM) –B, GAP-Software (Heerhugowaard, Netherlands) Reduced Gradient Bubble Model (RGBM), NAUTILUS Dive Planner (Lake Havasu City, AZ) Decompression Computation and Analysis Program (DCAP) and Hamilton-Kenyon Bubble Model (HKBM), and V-Planner (HHS Software Corp., Kingston ON, Canada) VPM-B/E. Default settings for each software program were used. Profiles were modified to select a last decompression stop at 20 feet sea water (6 meters). Profiles were calculated for all required decompression with a bottom time spacing of 10 minutes (depth fsw/maximum time): 40/200; 50/180; 60/160; 70/140; 80/130; 90/120; 100/110; 110/110; 120/100; 130/90.

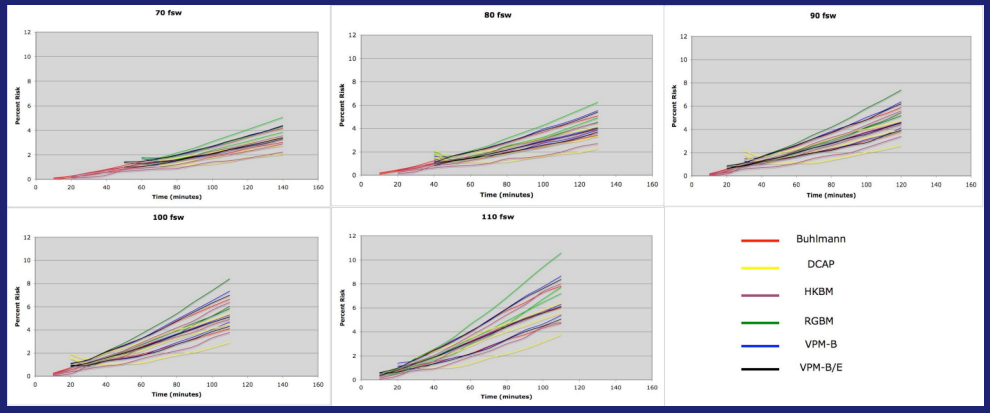
The probabilistic models are three compartment decompression models that are parameterized to decompression data that includes the time of occurrence of decompression sickness. USN93[2] and BVM3[3] are fit to the same dataset, while NMRI98[4] was fit to an expanded data set including dives with high fractions of oxygen. USN93 and NMRI98 have risks as a function of compartment gas content, while BVM3's risks are a function of bubble volume.

Results

The percent risk predicted:

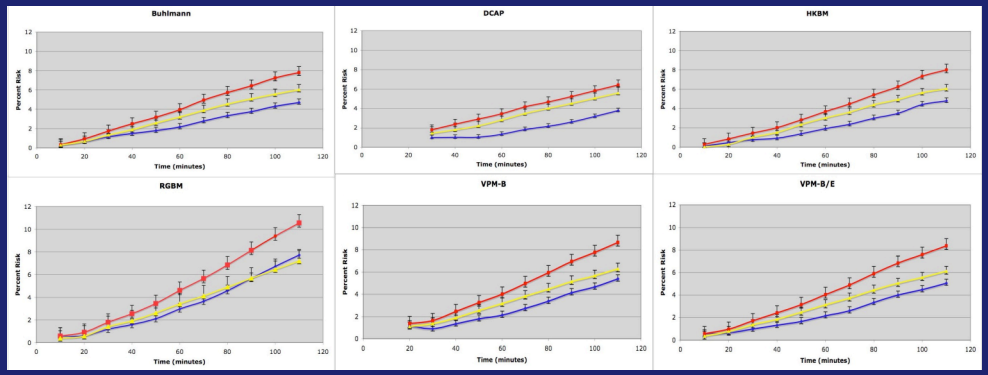
	BVM3	USN93	NMRI98
Buhlmann	0.001-6.867	0.018-5.002	0.005-8.746
DCAP*	0.312-6.438	0.338-4.026	0.484-7.112
HKBM*%	0.023-7.057	0.102-5.638	0.178-9.452
RGBM	0.391-8.01	0.580-8.269	0.591-11.791
VPM-B	0.541-7.067	0.682-5.688	0.729-9.633
VPM-B/E	0.372-6.95	0.569-5.464	0.589-9.401

* Nautilus software called for instant decent, we used 0.01 seconds
% unable to calculate decompressions for shortest dives



In the figures above, estimated risk from all three probabilistic models are plotted for the six commercial software products which can lead to the erroneous observation that there is a three fold risk increase at the max bottom time across the software products. These graphs were chosen to emphasise that the estimated risk for the no-stop limits are similar for all the software products tested, and risks increase as the bottom time lengthens regardless of the probabilistic model used to estimate the risks. The risks of the no stop limits are approximated by the first point in each line of the above figure.

The figures below show there is approximately a 2% estimated risk difference over the algorithms for base risks of 4 to 8 % depending upon the model used to estimate the risks.



Discussion

The lowest risk is not for the shallowest dives because this analysis starts a decade of time prior to the no-stop limit and continues to a bottom time limited by the divers gas supply.

There is a high degree of confidence that the actual risks of the profiles for all the models increase as their bottom times increase because of the agreement of the three probabilistic models from two different classes of models. At most, there is a difference of 50% in the estimated risks for these products which does not present a clear advantage of one product over another for nitrox diving.

Risk modification is necessary when comparing to dives performed by technical divers. The models used are calibrated to data with moderate work during the bottom time (1.5 – 2.0 L/min VO_2), and divers wearing wetsuits in cold water. Work levels are done by technical divers are lower and include swimming and use of Diver Propulsion Vehicles and should therefore reduce the inert gas volume seen with moderate work.[5] Decompression tests show required decompression can be dramatically reduced based on diver thermal status.[6] While the absolute values of estimated risk from the probabilistic models may not apply directly to technical diving, the relative values are of use for comparing schedules.

This risk analysis was performed on square dive profiles with a direct descent to depth, maximum stay at the maximum depth followed by a direct ascent to the first stop depth. These parameters are used to plan adequate decompression for the maximum possible dive within these confines. It should be recognized that for most recreational technical dives, majority of the dive profile will not be spent at the maximum depth. This deviation from a square profile reduces the estimated risk when dove with the planned decompression schedule.

Conclusions

The profiles are not iso-risk. The maximum risk appears with greatest depth/ bottom time. The lowest risk was not necessarily on the shortest/ shallowest combination. We can suggest that with the estimated risk being similar, other product features can be used to select which software to use (although this trial was nitrox only).

Acknowledgements

Although the profiles used in this analysis were created with licensed copies of all software, the companies and individuals that created the software did not condone or review our methods or results. We would like to thank them for their hard work in making these tools available to divers. We would also like to thank Dr. David Doolette for his assistance.

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