DECOMPRESSION RISK ANALYSIS COMPARING OXYGEN AND 50% NITROX DECOMPRESSION STOPS.

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INTRODUCTION:

US Navy and Technical Divers use oxygen or 50% Nitrox for accelerated decompression. 50% Nitrox as a single decompression gas has been proposed to be iso-risk with pure oxygen profiles where using 50% results in an overall shorter decompression time. We used probabilistic models, validated with thousands of laboratory conducted man-dives with known outcomes, to estimate the risk of DCS for planned decompression dives[1] using oxygen or 50% nitrox as a single decompression gas.

METHODS:

Tables were produced for 32% nitrox dives with either 100% oxygen or 50% nitrox for decompression. Bottom times at 110fsw (pO2=1.38 ATM) were limited to mandatory decompression dives, planned not to exceed the extreme exposure limits established in the US Navy Diving Manual. Within that range, dive times were calculated based on the first 10 minute interval requiring mandatory decompression and extended to the limit of time achievable based on consumption of 2/3rds of twin 130 cubic foot cylinders (173cuftavailable) at a 0.4cuft/min surface consumption rate. DecoPlanner decompression software (High Springs, FL) was used to generate tables using two algorithms: (1) Buhlmann with Gradient Factors (B-GF) and (2) the Variable Permeability Model-B (VPM-B). Overall stop times between the dives were matched with the final stop depth of 20 fsw. Default software settings were used except to adjust the depth of last decompression stop to 20 fsw.

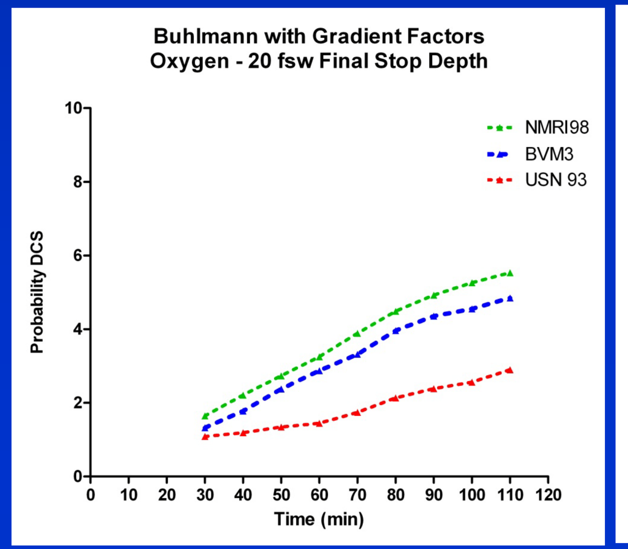
Three probabilistic models validated with US Navy dive outcome data [USNavy-93 (USN93)[2], Bubble Volume Model-3 (BVM3)[3], Navy Medical Research Institute- 98 (NMRI98)[4]] generated probability of DCS (pDCS) based risk profiles for dive tables planned with VPM-B or B-GF. All three models are parameterized to decompression data that includes the time of occurrence of decompression sickness. USN93 and BVM3 are fit to the same dataset, while NMRI98 was fit to an expanded dataset including dives with high fractions of oxygen. USN93 and NMRI98 have risks as a function of theoretical tissue compartment gas content, while BVM3's risks are a function of bubble volume. The pDCS for each decompression gas profile generated by the two algorithms was plotted against the planned dive time while controlling for total dive and ascent time, for each of the three models.

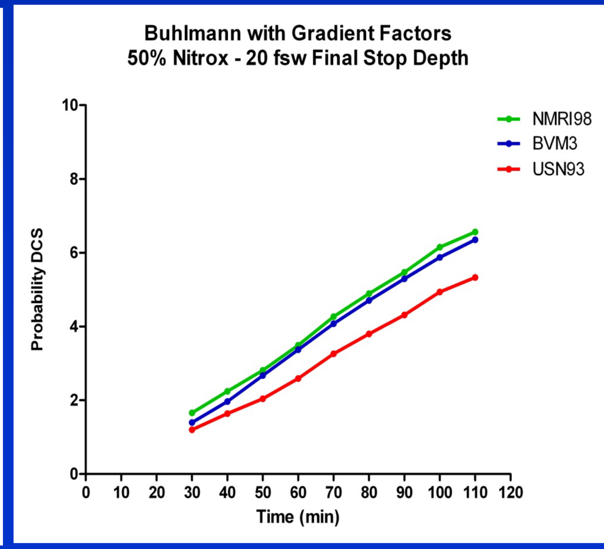
Model Data Sets vs. Risk Calculation	Nominal Dive Dataset	Dive Dataset with High FiO2
Risk as a function of tissue compartment gas load	USN-93	NMRI-98
Risk as a function of bubble volume	BVM-3	Not Tested

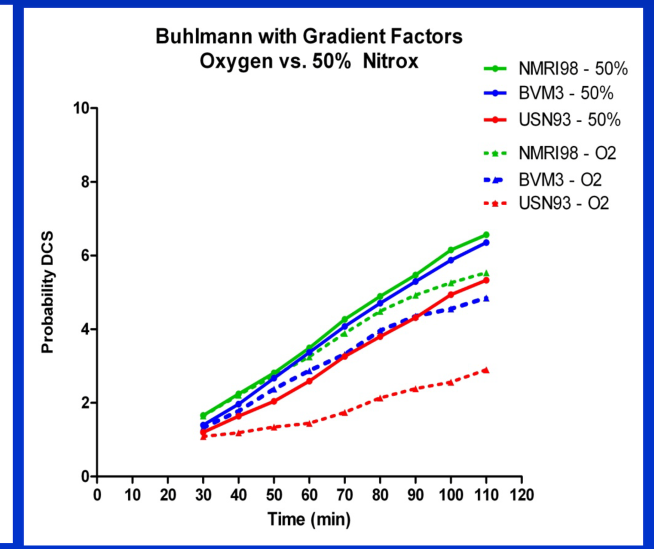
RESULTS:

When time matched to control all variables except decompression gas, risk of DCS increased in all models when decompressing on 50% Nitrox. For VPM-B, the pDCS demonstrated a relative increase of 96.9% using the USN-93 model, 34.3% on BVM-3, and 20.6% on NMRI-98, using 50% Nitrox for decompression. Using Buhlmann-GF, the pDCS also demonstrated a relative increase of 84.1% with USN-93, 31.0% with BVM-3, and 18.7% with NMRI-98.

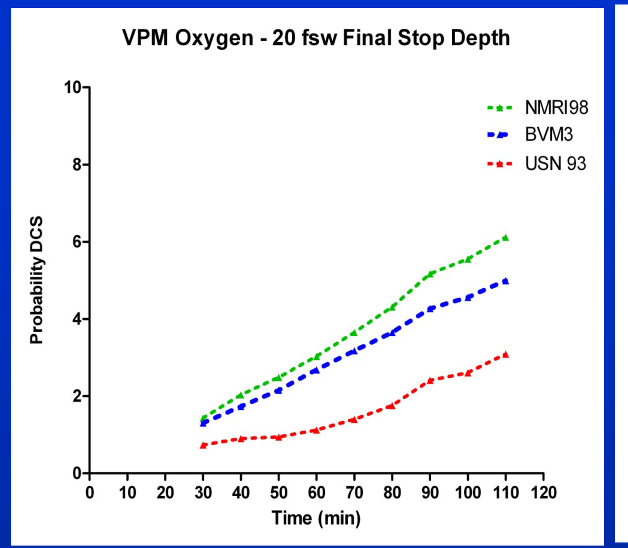
Series 1: The pDCS vs. time for Buhlmann-GF generated decompression profiles using either oxygen or 50% nitrox as a single deco gas.

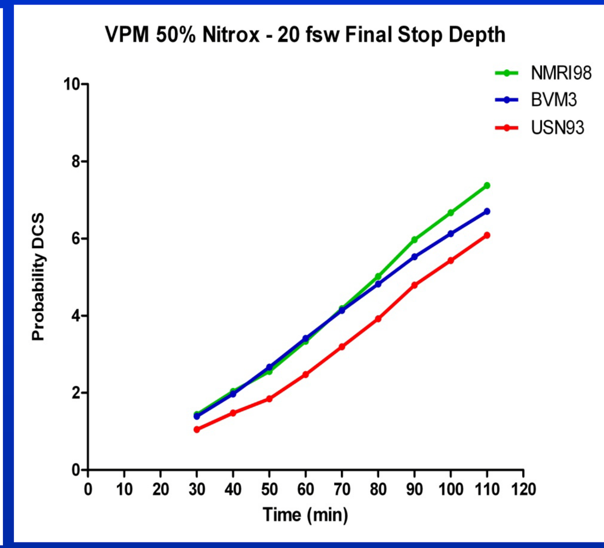


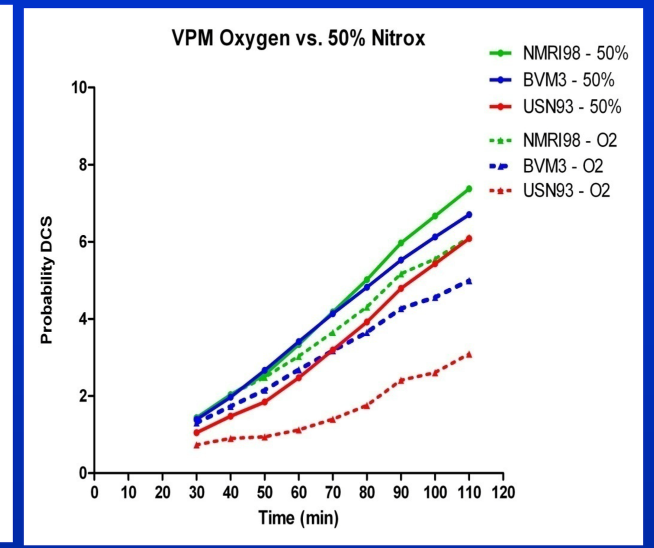




Series 2: The pDCS vs. time for VPM-B generated decompression profiles using either oxygen or 50% nitrox as a single deco gas.







The probability of decompression sickness is plotted against time for each of the three models based on the calculated decompression profile using both the Buhlmann-GF algorithm in the top graphs and the VPM-B algorithm in the lower graphs. In each case, all three models demonstrate a higher pDCS using 50% nitrox for decompression than for oxygen on both the Buhlmann and VPM profiles.

Table 1: A comparison of the pDCS for each model at the 110 minute mark (greatest exposure modeled).

pDCS at 110 fsw/110 min	NMRI 98	BVM 3	USN 93
Buhlmann-GF on O2	5.530%	4.848%	2.897%
Buhlmann-GF on 50%	6.563%	6.353%	5.332 %
VPM-B on Oxygen	6.115%	4.990%	3.090%
VPM-B on 50%	7.373%	6.702%	6.084%

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.

DISCUSSION:

It has been postulated within the diving community that using 50% nitrox is a more efficient (i.e. less risky with respect to DCS) decompression gas choice than oxygen, principally due to the fact that a diver can switch to 50% much deeper (70fsw maximum operating depth or MOD) than pure oxygen (20 fsw MOD) with a similar theoretical oxygen toxicity risk. On certain profiles, 50% does in fact 'clear' a diver to surface sooner than a similar profile using oxygen only. Taken in isolation, this would seem to imply that 50% is a 'safer' choice for a decompression gas, from a DCS standpoint.

This seeming disparity between the two gas profiles is likely the result of a mathematical anomaly where the leading tissue compartment controlling ascent to the surface is different due to the initiation of deeper decompression. The 50% decompression gas is usually initiated at 70 fsw (pO2= 1.56), which is still relatively deep for a diver completing even a 90 minute dive to 110 fsw, as a diver on this profile would still be on-gassing nitrogen at their gas switch. A diver completing decompression on 50% at 20 fsw also has the obvious disadvantage of his/her bloodstream being partially (50%) saturated with inert gas from breathing the decompression gas mix alone. Conversely, a diver breathing oxygen would have a bloodstream devoid of inspired inert gas and capable of handling a larger amount of inert gas tension generated by the tissues. Due to the ability of pure oxygen to largely desaturate the arterial blood of inert gas and thereby provide the largest "physiological sink" for inert gasses, it stands to reason that oxygen would provide a more efficient decompression for the diver. Our studies supported this conclusion by showing that divers decompressing on 100% oxygen would have a reduction in the pDCS as compared to those on 50% nitrox.

CONCLUSIONS:

Decompression using oxygen decreases the probability of DCS compared to divers decompressing with 50% nitrox, irrespective of overall decompression time.

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