TOWARDS A PROBABILISTIC ASSESSMENT OF HYPOBARIC DECOMPRESSION SICKNESS TREATMENT

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INTRODUCTION: The NASA Decompression Sickness (DCS) Treatment Model links a decrease in computed bubble volume from increased pressure (ΔP), increased oxygen (O_2) partial pressure, and passage of time during treatment to the probability of symptom resolution [P(symptom resolution)]. The decrease in volume is realized in two stages: 1) during compression due to Boyle's Law and 2) during subsequent dissolution of the gas phase by the O_2 window. **METHODS**: The P(symptom resolution) during repressurization was modeled as a log-logistic function of pressure difference (ΔP as psid) and two other explanatory variables while accounting for multiple symptoms within subjects. We used data on 154 symptoms originating from 119 subjects with DCS in 47 different altitude tests (969 exposures) to fit the model. **RESULTS**: The fitted model was P(symptom resolution) = $1 / (1+\exp(-(\ln(\Delta P) - 1.682 + 1.089\times AMB - 0.00395\times T_s) / 0.633))$, where AMB = 1 if ambulation took place during part of the altitude exposure, otherwise AMB = 0; and where T_s is elapsed time in minutes from start of the altitude exposure to recognition of a DCS symptom. To apply this model in future scenarios, values of ΔP as inputs to the model would be calculated from the Tissue Bubble Dynamics Model[1] based on the "effective" Boyle's Law change: $P_2 - P_1$ (ΔP, psid) = $P_1\times V_1/V_2 - P_1$, where V_1 is the computed volume of a spherical bubble in a unit volume of tissue at low pressure P_1 and V_2 is computed volume after a change to a higher pressure P_2. If 100% ground-level O_2 (GLO) were breathed in place of air, then V_2 would continue to decrease through time at P_2 at a faster rate. The computed ΔP would be the effective treatment pressure at any point in time. **DISCUSSION**: Simulation of a "pain-only" symptom at 203 minutes into an ambulatory extravehicular activity (EVA) at 4.3 psia on Mars resulted in a P(symptom resolution) of 0.47 on immediate return to 8.2 psia in the Multi-Mission Space Exploration Vehicle. The P(symptom resolution) increased to near certainty (0.99) after 2 hours of GLO at 8.2 psia or with less certainty at 0.83 on immediate pressurization to 14.7 psia. Given the low probability of DCS during EVA and the prompt treatment of a symptom with guidance from the model it is likely that the symptom and gas phase will resolve with minimum resources and minimal impact on astronaut health, safety, and productivity. Future work includes model validation with data being collected at Duke University.

[1] Gernhardt M.L. (1991) *Development and Evaluation of a Decompression Stress Index Based on Tissue Bubble Dynamics* [dissertation]. Philadelphia: University of Pennsylvania.