DESIGNING AN EXPLORATION ATMOSPHERE PREBREATHE PROTOCOL

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INTRODUCTION: Extravehicular activities (EVAs) at remote locations must maximize limited resources such as oxygen (O_2) and also minimize the risk of decompression sickness (DCS). A proposed remote denitrogenation (prebreathe) protocol requires astronauts to live in a mildly hypoxic atmosphere at 8.2 psia while periodically performing EVAs at 4.3 psia. Empirical data are required to confirm that the protocol meets the current accept requirements: ≤ 15% incidence of Type I DCS, ≤ 20% incidence of Grade IV venous gas emboli (VGE), both at 95% statistical confidence, with no Type II DCS symptom during the validation trial. **METHODS**: A repeated measures statistical design is proposed in which groups of 6 subjects with physical characteristics similar to active-duty astronauts would first become equilibrated to an 8.2 psia atmosphere in a hypobaric chamber containing 34% O_2 and 66% N_2, over 48 h, and then perform 4 simulated EVAs at 4.3 psia over the next 9 days. In the equilibration phase, subjects undergo a 3-h 100% O_2 mask prebreathe prior to and during a 5-min ascent to 8.2 psia to prevent significant tissue N_2 supersaturation on reaching 8.2 psia. Masks would be removed once 34% O_2 is established at 8.2 psia, and subjects would then equilibrate to this atmosphere for 48 h. The hypoxia is equivalent to breathing air at 1,220 meters (4,000 ft) altitude, just as was experienced in the shuttle 10.2 psia – 26.5% O_2 staged denitrogenation protocol and the current ISS campout denitrogenation protocol. For simulated EVAs, each subject dons a mask and breathes 85% O_2 and 15% N_2 during a 3-min depressurization to 6.0 psia, holds for 15 min, and then completes a 3-min depressurization to 4.3 psia. The simulated EVA period starts when 6.0 psia is reached and continues for a total of 240 min (222 min at 4.3 psia). During this time, subjects will follow a prescribed repetitive activity against loads in the upper and lower body with mean metabolic rate approaching 1500 BTU/hr [378 kcal/hr (O_2 consumption about 1.3 $l_{(STPD)}$/min)] in ambulatory subjects. Noninvasive Doppler ultrasound bubble monitoring for VGE in the pulmonary artery will be performed on subjects by 2 Doppler Technicians at about 15 min intervals while at 4.3 psia. At the end of this period, a 15-min repressurization returns all subjects back to 8.2 psia and the cycle is repeated 3 additional times with a day of rest between simulated EVAs. **RESULTS**: With an assumed 1.5% probability of DCS [P(DCS)] and accounting for within-subject correlation, running the proposed study with 20 subjects has a 95% probability of meeting the accept criterion for DCS. But if the true probability of DCS is 3.0%, then 30 subjects would be needed to achieve about the same probability to meet our accept criterion. These results assume a standard deviation of 1.4 for the between-subjects random component of P(DCS) on a logit scale, which was estimated from a previous study. **DISCUSSION**: Our current DCS survival model calculates a low probability of DCS of 1.5% (0.8 to 2.8%, 95% CL) for each EVA for physically active ambulatory subjects based on a computed tissue ratio of 1.22, a bubble growth index[1] of 17, a body mass index of 24, and age of 32 years, and increases to 2.3% (1.2 to 4.4%) for age 45.

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