CARBON MONOXIDE ACCUMULATION IN THE EXTRAVEHICULAR MOBILITY UNIT

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INTRODUCTION: Life support technology in large closed systems like submarines and space stations catalyzes carbon monoxide (CO) to carbon dioxide, which is easily removed. However, in a small system like the Extravehicular Mobility Unit (EMU), spacesuit, CO from exogenous (contaminated oxygen (O_2) supply) and endogenous (human metabolism) sources will accumulate in the free suit volume. The free volume becomes a sink for CO that is rebreathed by the astronaut. The accumulation through time depends on many variables: the amount absorbed by the astronaut, the amount produced by the astronaut (between 0.28 – 0.34 μmoles/hr/kg)[1], the amount that enters the suit from contaminated O_2, the amount removed through suit leak, the free volume of the suit, and the O_2 partial pressure[2], just to list a few. Contamination of the EMU O_2 supply with no greater than 1 ppm CO was the motivation for empirical measurements from CO pulse oximetry (SpCO) as well as mathematical modeling of the EMU as a rebreather for CO. **METHODS**: We developed a first-order differential mixing equation as well as an iterative method to compute CO accumulation in the EMU. Pre-post measurements of SpCO (Rad-57, Masimo Corporation) from EMU ground training and on-orbit extravehicular activities (EVAs) were collected. **RESULTS**: Initial modeling *without consideration* of the astronaut as a sink but only the source of CO showed that after 8 hours breathing 100% O_2 with a 10 mL×min^{-1} (760 mmHg at 21°C standard) suit leak, an endogenous production rate of 0.23 μmoles/hr/kg for a 70 kg person with 42 liters (1.5 ft^3) free suit volume resulted in a peak CO partial pressure (pCO) of 0.047 mmHg at 4.3 psia (222 mmHg). Preliminary results based on a 2008 model[3] *with consideration* of the astronaut as a sink and source of CO suggests that most of the rebreathed CO stays bound to hemoglobin and myoglobin and; therefore, pCO only increased to 0.002 mmHg in the EMU. Hemoglobin saturation after 8 hours was an insignificant 0.4% compared to about 4% for cigarette smokers in the general population. This preliminary modeling result supplements 11 pre-post index finger SpCO measurements from EMU ground training (mean 0.5% versus 1%, *P*=0.41 from paired t-test) and 10 on-orbit pre-post EVAs (mean 1.5% versus 1.1%, *P*=0.17 from paired t-test) that showed no consistent increase, at least no increase outside the accuracy of the oximeter (1% display resolution with ± 3% SD). **DISCUSSION**: Simulations continue, but a preliminary conclusion is that rebreathing endogenous CO accumulating in the EMU is not a serious medical issue during EVA. The absence of CO poisoning signs or symptoms following hundreds of EVAs is also good empirical evidence that corroborates the limited SpCO measurements and preliminary modeling results.

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