DECOMPRESSION SICKNESS AFTER AIR BREAK IN PREBREATHE DESCRIBED WITH A SURVIVAL MODEL

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BACKGROUND: Data from Brooks City-Base show the decompression sickness (DCS) and venous gas emboli (VGE) consequences of air breaks in a resting 100% O₂ prebreathe (PB) prior to a hypobaric exposure. METHODS: DCS and VGE survival times from 95 controls for a 60 min PB prior to 2-hr or 4-hr exposures to 4.37 psia are statistically compared to 3 break in PB conditions: a 10 min (n=40), 20 min (n=40), or 60 min break (n=32) 30 min into the PB followed by 30 min of PB. Ascent rate was 1,524 meters / min and all exposures included light exercise and 4 min of VGE monitoring of heart chambers at 16 min intervals. DCS survival time for combined control and air breaks were described with an accelerated log logistic model where exponential N₂ washin during air break was described with a 10 min half-time and washout during PB with a 60 min half-time. RESULTS: There was no difference in VGE or DCS survival times among 3 different air breaks, or when air breaks were compared to control VGE times. However, 10, 20, and 60 min air breaks had significantly earlier survival times compared to control DCS times, certainly early in the exposures. CONCLUSION: Air breaks of 10, 20, and 60 min after 30 min of a 60 min PB reduced DCS survival time. The survival model combined discrete comparisons into a global description mechanistically linked to asymmetrical N₂ washin and washout kinetics based on inspired pN₂. Our unvalidated regression is used to compute additional PB time needed to compensate for an air break in PB within the range of tested conditions.
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ABSTRACT

BACKGROUND: Data from Brooks City-Base show the decompression sickness (DCS) and venous gas embolism (VGE) consequences of an air break in an otherwise normal resting 100% O₂ PB, and none are available after PB includes. Definitive ([1]) states, ‘Air-breathing interruptions of only a few min greatly decrease the efficacy of denitrogenation in the prevention of decompression sickness;’ but provides no reference.

Estimates for O₂ PB payback time have ranged from one (2) to 35 times (3) the length of the break in PB within the range of tested conditions.

METHODS

We used an accelerated log logistic survival model for accounting N₂ washout and wash in to describe DCS survival times in data where <9 min, 9 min, 20 min, or 60 min air breaks occurred at 30 min into a 60 min PB, including a six min accept O₂ PB. Details about survival models and maximum likelihood optimization are available elsewhere (4-7).

Subjects ascended to 4.37 psia at 1,524 MPM to perform repetitive light exercise plus ambulation for 2 hrs (n = 40), or 60 min break (n = 32) 30 min into the PB followed by 30 min of PB. Ascent rate was 1,524 MPM. Time in PB within the range of tested conditions.

Computing Theoretical Tissue N₂ Pressure for Decompression Dose Model

Computing P(DCS) for Altitude Exposure of 4.37 psia

P(DCS) = 1 – exp( – 1.615 (P₁N₂ – 4.37)⁰.⁶⁵²), where P₁N₂ is the initial tissue N₂ pressure; t is the time interval in hr.

SYSSTAT (ver 6.0) used to compute α, β, and χ coefficients in the accelerated log logistic survival model based on recorded survival times influenced by the PB and exposure conditions of the tests.

Legend for curves to follow:

A - 10 min air break at 30 min into a 60 min 100% O₂ PB
B - 20 min air break at 30 min into a 60 min 100% O₂ PB
C - 60 min air break at 30 min into a 60 min 100% O₂ PB
D - 60 min 100% O₂ PB, control data

RESULTS

Fig. 1 shows no difference in the pattern of cumulative VGE incidence for the three curves for air breaks, so we conclude that a 10, 20, and 60 min break 30 min into a 60 min PB reduces DCS failure times that are statistically indistinguishable. This conclusion extends to any comparison with the PB not interrupted by an air break in the VGE failure times that are statistically indistinguishable. This conclusion extends to any comparison with the PB not interrupted by an air break in the VGE incidence and survival data, and accounting for interval censoring as the data from a 10 min PB and a 20 min PB is from a log-logistic survival model. The survival model combined discrete comparisons into a global description mechanistically linked to asymmetrical N₂ washin and washout kinetics based on inspired pN₂.

DeHart (1) states, “Air-breathing interruptions of only a few min greatly decrease the efficacy of denitrogenation in the prevention of decompression sickness;” but provides no reference.

DCS outcome

Our approach to compute O₂ PB payback time is not appropriate outside the range of tested conditions.

The control data are from an “effective PB” of 60 min, and our model computes an effective PB of 50 min for the 10-min air break, 43 min for the 20-min air break, and 63 min for the 60-min air break.

CONCLUSIONS / DISCUSSION

A log-logistic model that maximized the likelihood of the data required very short times. This is perplexing: conclusion since very high DCS incidence is associated with very low computed tissue N₂ pressure, so the model is incomplete, but useful under a narrow range of test conditions.

If returning to the control condition is an acceptable compensation for an air break in a 60 min PB, then our regression model is a quantitative way to define O₂ PB payback time.

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Our regression model has not been prospectively validated, so our conclusions are hypotheses rather than operational recommendations.

REFERENCES