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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J Conkin, AA Filimoni, Universities Space Research Association1, Air Force Research Laboratory, Brooks City-Base (Retired Consultant)2, Houston, Texas, USA 77058.

ABSTRACT

BACKGROUND: Data from Brooks City-Base show the decompression sickness (DCS) and various gas emboli (GVE) conditions identified in a military 100% O2 prebreathe (PB) prior to a hypoxic exposure. METHODS: DCS and GVE survival times from 95 controls for a 60 min PB prior to 2 hr or 4-hr exposures to 4.37 psia to 8.64 psia were compared. Survival in PB conditions: a 10 min (n=40), 20 min (n=40), or 60 min break (n=32) into the PB followed by 30 min of PB. Ascendant rate was 1.524 minutes/m 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 halftime and washout during PB with a 60 min halftime. RESULTS: There was no difference in VGE or DCS survival times among 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, or 60 min after 30 min of a 60 min PB reduced DCS survival times. The survival model combined describe comparisons into a global description mechanistically linked to asymmetrical N2 washin and washout kinetics based on inspired pN2. Our hypothesis is that N2 washin during an air break is faster than N2 washout during 100% O2 PB due to the pressure difference to a power as decompression sickness progresses.

RESULTS

Table 1: Model Results to Describe DCS Survival Times

<table>
<thead>
<tr>
<th>Duration (hr)</th>
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<tr>
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Table 2: DECOMPRESSION SICKNESS AFTER AIR BREAK IN PREBREATH DESCRIBED WITH A SURVIVAL MODEL

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CONCLUSIONS / DISCUSSION

ACV, a logistic model that maximized the maximum likelihood in these data required very short times. This is a perplexing conclusion since very high DCS incidence is associated with very low computed tissue N2 pressure, so the model is incomplete, but unobtrusive over 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 quadratically or linear fit to define O2 pressure during air breaks. Our approach to compute O2 PB 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 37 min for the 60-min air break.

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

REFERENCES


METHODS

We used an accelerated log logistic survival model for asymmetrical N2 washout and washin to describe DCS survival times in data where (time, 1/2 time, 2time, 3time, 4time, or 6time) air breaks occurred at 30 min into a 60 min PB, including a six min accent on O2 PB. Details about survival models and maximum likelihood optimization are available elsewhere (4-7).

Subjects ascended to 4.37 psia at 1.524 MPH to perform repetitive light exercises plus ambulation for 2 hrs (n = 95) or 4 hrs (n = 28) in the controls, and for the 3 experimental conditions (n = 112).

VGE monitoring was every 15 min for 4 min, using Hewlett Packard SONOS 1000 Echo Imaging System with paraaxial, short-axis view of the heart. Our hypothesis is that N2 washin during an air break is faster than N2 washout during 100% O2 PB due to the release of the vasacostriction of high O2 partial pressure.

Computing Physiological N2 Pressure, Pressure for Decompression Dose Model

P = P0N2 = P0N2i (1 – exp(−k * t)), where P0N2i is initial equilibrium tissue N2 pressure taken as 1.0 psi.

Computing O2 Payback Time for Altitude Exposure of 4.37 psia

P = P0O2 = PO2i * exp(t * kO2), where PO2i is initial O2 pressure taken as 4.37 psia.

Computing VGE Incidence at 4.37 psia

P = P1O2 = PO2i * exp(t * kO2), where PO2i is initial O2 pressure taken as 4.37 psia.

Computing O2 Payback Time for Altitude Exposure of 4.37 psia

P = P0O2 = PO2i * exp(t * kO2), where PO2i is initial O2 pressure taken as 4.37 psia.

Computing DCS Incidence at 4.37 psia

P = P1O2 = PO2i * exp(t * kO2), where PO2i is initial O2 pressure taken as 4.37 psia.

O2 Payback Time

The O2 payback time is the numbers of min of additional O2 PB time needed to compensate for an air break in PB within the range of tested conditions.

Computing O2 Payback Time

P = P0O2 = PO2i * exp(t * kO2), where PO2i is initial O2 pressure taken as 4.37 psia.

Computing DCS Incidence at 4.37 psia

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