



# Nobendem Quiz #6



## The Missed Deco Stop

Benton Zwart, Col, USAF, MC  
Davis Hyperbaric Laboratory



# The Setup

- ◆ 80 YO WM - CRAO X 16 Hrs
- ◆ 45 FSW - 30 Min O<sub>2</sub> / 10 min Air X 3
- ◆ 10 Min into #3 O<sub>2</sub> period, Chest Pain!
- ◆ Begin Immediate Ascent - 10 Min Rate
- ◆ The Problem: IO Not Denitrogenated!!
- ◆ What Do We Do??
  - No-Brainer = TT-5 for Asx Missed Deco = 2.5 Hr
  - No-Bendem = Sur-D O<sub>2</sub> = 60 Min!! (Could do in 50)



# The IO's Risk

- ◆ Healthy 24 YO HM - No prior Hx DCS
- ◆ ASx at Surface
- ◆ Only broke "USAF" tables by 5 Min
- ◆ Breaks Nobendem at SE = 17
- ◆ Breaks Nobendem SE = 55 at 14 FSW
- ◆ Derive the profiles SE of 17

## Safety Enhancement For Actual Profile

-0.693147181	30				N <sub>2</sub> Tissue Compartments								
Copyright (C) 1998 Benton P. Zwart			5	10	20	40	80	120	160	320	480	640	T1/2
Initial Tissue PN <sub>2</sub>	26.07		2.2990	2.0083	1.7060	1.3905	1.2726	1.2619	1.2548	1.2350	1.2208	1.2137	Slope
Safety Enhancement (20-100)	17		103.60	87.58	72.42	58.08	52.08	50.83	48.33	47.24	46.74	46.24	Intercept
Local Barometer (mmHg)	760		2.0421	1.8008	1.5499	1.2881	1.1902	1.1813	1.1754	1.1590	1.1472	1.1413	Safety Slope
Initial Steady State FiO <sub>2</sub>	0.21		90.41	77.11	64.53	52.63	47.65	46.61	44.53	43.63	43.21	42.80	Safety Intercept
Depth Gauge Must = 0 at Surface of Water!													
Linear Transition Time	7.00	1.5	43.55	35.72	30.89	28.40	27.20	26.81	26.62	26.34	26.25	26.21	PN <sub>2</sub> (t)
Transition O <sub>2</sub> Fraction	0.21												
Calculated Target PN <sub>2</sub>	61.62		207.24	178.09	149.30	120.73	109.41	107.68	104.84	102.86	101.72	100.90	Nxt Seg Ms
Initial PN <sub>2</sub> Inspired	26.07		182.45	158.26	134.36	110.66	101.26	99.82	97.47	95.82	94.87	94.19	Safety Ms
Target - Initial	35.55		138.90	122.55	103.47	82.25	74.06	73.00	70.84	69.48	68.62	67.99	Buffer
Segment 1 Conditions													
Segment Depth (FSW)	45		61.62	61.57	60.26	54.64	45.84	40.92	37.92	32.59	30.56	29.50	PN <sub>2</sub> (t)
Segment Time (Min)	90		103.60	87.58	72.42	58.08	52.08	50.83	48.33	47.24	46.74	46.24	Nxt Seg Ms
Inspired O <sub>2</sub> Fraction	0.21		90.41	77.11	64.53	52.63	47.65	46.61	44.53	43.63	43.21	42.80	Safety Ms
Calculated PN <sub>2</sub>	61.62		28.79	15.54	4.27	(2.01)	1.81	5.68	6.61	11.04	12.65	13.30	Buffer
45.00													
Linear Transition Time	10.00	1.5											
Transition O <sub>2</sub> Fraction	0.21		39.40	48.26	53.72	52.35	45.51	41.01	38.13	32.82	30.75	29.65	PN <sub>2</sub> (t)
Calculated Target PN <sub>2</sub>	26.07		51.01	28.85	10.81	0.27	2.14	5.60	6.40	10.81	12.47	13.15	Buffer
Initial PN <sub>2</sub> Inspired	61.62												
Target - Initial	-35.55												
Segment 2 Conditions													
Segment Depth (FSW)	0		39.40	48.26	53.72	52.35	45.51	41.01	38.13	32.82	30.75	29.65	PN <sub>2</sub> (t)



# The IO's Risk



- ◆ Derive the Minimum Safe Depth for a SE = 55
  - 55 is minimum dry dive SE for Nobendem
    - Use for age < 40 AND no Hx undeserved DCS
    - Use 65 SE if 40 or older, OR if any Hx undeserved DCS

# Minimum Safe Depth for 55 Safety Enhancement

-0.693147181	30				N <sub>2</sub> Tissue Compartments								
Copyright (C) 1998 Benton P. Zwart			5	10	20	40	80	120	160	320	480	640	T1/2
Initial Tissue PN <sub>2</sub>	26.07		2.2990	2.0083	1.7060	1.3905	1.2726	1.2619	1.2548	1.2350	1.2208	1.2137	Slope
Safety Enhancement (20-100)	55		103.60	87.58	72.42	58.08	52.08	50.83	48.33	47.24	46.74	46.24	Intercept
Local Barometer (mmHg)	760		1.4679	1.3371	1.2010	1.0591	1.0060	1.0012	0.9980	0.9891	0.9827	0.9795	Safety Slope
Initial Steady State FiO <sub>2</sub>	0.21		60.92	53.71	46.89	40.44	37.74	37.17	36.05	35.56	35.33	35.11	Safety Intercept
			Depth Gauge Must = 0 at Surface of Water!										
Linear Transition Time	7.00	1.5	43.55	35.72	30.89	28.40	27.20	26.81	26.62	26.34	26.25	26.21	PN <sub>2</sub> (t)
Transition O <sub>2</sub> Fraction	0.21												
Calculated Target PN <sub>2</sub>	61.62		207.24	178.09	149.30	120.73	109.41	107.68	104.84	102.86	101.72	100.90	Nxt Seg Ms
Initial PN <sub>2</sub> Inspired	26.07		127.06	113.94	100.98	88.13	83.04	82.25	80.98	80.09	79.57	79.20	Safety Ms
Target - Initial	35.55		83.51	78.22	70.09	59.73	55.84	55.44	54.36	53.74	53.32	53.00	Buffer
Segment 1 Conditions													
Segment Depth (FSW)	45		61.62	61.57	60.26	54.64	45.84	40.92	37.92	32.59	30.56	29.50	PN <sub>2</sub> (t)
Segment Time (Min)	90		136.11	115.95	96.49	77.69	70.01	68.60	65.98	64.61	63.91	63.30	Nxt Seg Ms
Inspired O <sub>2</sub> Fraction	0.21		81.62	72.54	63.79	55.33	51.87	51.24	50.06	49.44	49.12	48.85	Safety Ms
Calculated PN <sub>2</sub>	61.62		20.00	10.97	3.53	0.69	6.03	10.31	12.13	16.85	18.56	19.36	Buffer
45.00													
Linear Transition Time	10.00	1.0											
Transition O <sub>2</sub> Fraction	0.21		46.31	52.41	55.88	53.41	46.02	41.35	38.38	32.94	30.83	29.71	PN <sub>2</sub> (t)
Calculated Target PN <sub>2</sub>	37.13		35.30	20.13	7.91	1.92	5.85	9.89	11.68	16.50	18.30	19.15	Buffer
Initial PN <sub>2</sub> Inspired	61.62												
Target - Initial	-24.49												
Segment 2 Conditions													
Segment Depth (FSW)	14		46.31	52.41	55.88	53.41	46.02	41.35	38.38	32.94	30.83	29.71	PN <sub>2</sub> (t)



# Table Generation Concepts

- ◆ Getting The IO Denitrogenated
  - Protocol Suggests Missed Deco requires TT-5 if ASx
  - Standard Sur-D O2 requires Reco within 5 minutes
    - Std Sur-D O2 much more provocative than our case
    - Although we exceeded 5 min, IO Never had Sx's
- ◆ Lack Second IO for Multiplace Rx
  - Monoplace sure would have been a convenient option!!
  - At more risk for DCS waiting for second IO than self treating immediately
- ◆ Derive Sur-D O2 Profile (Use SE = 65)

# Surface Decompression Worksheet - Loading Profile

-0.693147181	30				N <sub>2</sub> Tissue Compartments								
Copyright (C) 1998 Benton P. Zwart			5	10	20	40	80	120	160	320	480	640	T1/2
Initial Tissue PN <sub>2</sub>	26.07		2.2990	2.0083	1.7060	1.3905	1.2726	1.2619	1.2548	1.2350	1.2208	1.2137	Slope
Safety Enhancement (20-100)	65		103.60	87.58	72.42	58.08	52.08	50.83	48.33	47.24	46.74	46.24	Intercept
Local Barometer (mmHg)	760		1.3168	1.2150	1.1092	0.9988	0.9575	0.9538	0.9513	0.9444	0.9394	0.9369	Safety Slope
Initial Steady State FiO <sub>2</sub>	0.21		53.16	47.55	42.25	37.23	35.13	34.69	33.82	33.43	33.26	33.08	Safety Intercept
Depth Gauge Must = 0 at Surface of Water!													
Linear Transition Time	7.00	1.5	43.55	35.72	30.89	28.40	27.20	26.81	26.62	26.34	26.25	26.21	PN <sub>2</sub> (t)
Transition O <sub>2</sub> Fraction	0.21												
Calculated Target PN <sub>2</sub>	61.62		207.24	178.09	149.30	120.73	109.41	107.68	104.84	102.86	101.72	100.90	Nxt Seg Ms
Initial PN <sub>2</sub> Inspired	26.07		112.48	102.28	92.20	82.20	78.24	77.63	76.64	75.95	75.55	75.26	Safety Ms
Target - Initial	35.55		68.93	66.56	61.31	53.80	51.04	50.82	50.02	49.60	49.30	49.05	Buffer
Segment 1 Conditions													
Segment Depth (FSW)	45		61.62	61.57	60.26	54.64	45.84	40.92	37.92	32.59	30.56	29.50	PN <sub>2</sub> (t)
Segment Time (Min)	90		103.60	87.58	72.42	58.08	52.08	50.83	48.33	47.24	46.74	46.24	Nxt Seg Ms
Inspired O <sub>2</sub> Fraction	0.21		53.16	47.55	42.25	37.23	35.13	34.69	33.82	33.43	33.26	33.08	Safety Ms
Calculated PN <sub>2</sub>	61.62		(8.46)	(14.02)	(18.02)	(17.41)	(10.71)	(6.23)	(4.11)	0.84	2.70	3.59	Buffer
45.00													
Linear Transition Time	10.00	1.5											
Transition O <sub>2</sub> Fraction	0.21		39.40	48.26	53.72	52.35	45.51	41.01	38.13	32.82	30.75	29.65	PN <sub>2</sub> (t)
Calculated Target PN <sub>2</sub>	26.07		13.76	(0.71)	(11.47)	(15.13)	(10.38)	(6.32)	(4.31)	0.61	2.51	3.44	Buffer
Initial PN <sub>2</sub> Inspired	61.62												
Target - Initial	-35.55												
Segment 2 Conditions													
Segment Depth (FSW)	0		39.40	48.26	53.72	52.35	45.51	41.01	38.13	32.82	30.75	29.65	PN <sub>2</sub> (t)

# Surface Decompression Worksheet - Deco Profile

-0.693147181	30				N <sub>2</sub> Tissue Compartments											
RNT for Seg1 Depth	118.9		5	10	20	40	80	120	160	320	480	640	T1/2			
Surface Interval (Min)	5		2.2990	2.0083	1.7060	1.3905	1.2726	1.2619	1.2548	1.2350	1.2208	1.2137	Slope			
Safety Enhancement (20-100)	65		103.60	87.58	72.42	58.08	52.08	50.83	48.33	47.24	46.74	46.24	Intercept			
Local Barometer (mmHg)	760		1.3168	1.2150	1.1092	0.9988	0.9575	0.9538	0.9513	0.9444	0.9394	0.9369	Safety Slope			
Surface Interval FiO2	0.21		53.16	47.55	42.25	37.23	35.13	34.69	33.82	33.43	33.26	33.08	Safety Intercept			
			40.59	61.62	Depth Gauge Must = 0 at Surface of Water!											
RNT Loading			61.62	61.61	61.04	57.09	48.94	43.74	40.38	34.14	31.68	30.37				
Linear Transition Time	2.40	1.5	58.22	59.42	59.82	56.60	48.84	43.74	40.42	34.20	31.72	30.40	PN <sub>2</sub> (t)			
Transition O <sub>2</sub> Fraction	0.21															
Calculated Target PN <sub>2</sub>	61.62		207.24	178.09	149.30	120.73	109.41	107.68	104.84	102.86	101.72	100.90	Nxt Seg Ms			
Initial PN <sub>2</sub> Inspired	26.07		112.48	102.28	92.20	82.20	78.24	77.63	76.64	75.95	75.55	75.26	Safety Ms			
Target - Initial	35.55		54.26	42.86	32.38	25.61	29.40	33.89	36.22	41.75	43.82	44.86	Buffer			
Segment 1 Conditions					Enter Segment Time Only! I Have Already Added The RNT!!											
Segment Depth (FSW)	45		0.91	7.43	21.15	33.65	37.66	36.78	35.50	32.04	30.38	29.43	PN <sub>2</sub> (t)			
Segment Time (Min)	30	151	115.33	97.80	81.09	65.14	58.53	57.22	54.66	53.47	52.90	52.36	Nxt Seg Ms			
Inspired O <sub>2</sub> Fraction	1	TBT	59.83	53.69	47.84	42.26	39.95	39.49	38.59	38.18	37.98	37.79	Safety Ms			
Calculated PN <sub>2</sub>	0		58.92	46.27	26.69	8.61	2.28	2.70	3.10	6.13	7.60	8.36	Buffer			
45.00																
Linear Transition Time	10.00	1.3														
Transition O <sub>2</sub> Fraction	0.21		26.69	22.67	26.83	35.09	38.19	37.22	35.90	32.33	30.59	29.60	PN <sub>2</sub> (t)			
Calculated Target PN <sub>2</sub>	30.02		33.13	31.02	21.01	7.17	1.75	2.27	2.70	5.85	7.38	8.18	Buffer			
Initial PN <sub>2</sub> Inspired	61.62															
Target - Initial	-31.6															
Segment 2 Conditions																
Segment Depth (FSW)	5		1.67	5.67	13.42	24.81	32.12	33.16	32.92	30.96	29.72	28.97	PN <sub>2</sub> (t)			
Segment Time (Min)	20		103.60	87.58	72.42	58.08	52.08	50.83	48.33	47.24	46.74	46.24	Nxt Seg Ms			
Inspired O <sub>2</sub> Fraction	1		53.16	47.55	42.25	37.23	35.13	34.69	33.82	33.43	33.26	33.08	Safety Ms			
Calculated PN <sub>2</sub>	0		51.49	41.88	28.83	12.42	3.01	1.53	0.90	2.48	3.54	4.11	Buffer			
5.00																
Linear Transition Time	0.50	0.2														
Transition O <sub>2</sub> Fraction	0.21		1.56	5.48	13.19	24.59	31.98	33.07	32.84	30.92	29.70	28.95	PN <sub>2</sub> (t)			
Calculated Target PN <sub>2</sub>	26.07		51.60	42.08	29.06	12.63	3.15	1.63	0.97	2.51	3.56	4.13	Buffer			



# Conclusions

- ◆ If Sx had developed - move to TT-5 or TT-6
  - Standard decision rules for TT-5
- ◆ Standard Precautions
  - No Fly, Dive, Exercise X 24 Hr; Avoid excessive EtOH
  - Report any DCS type Sx's immediately
- ◆ Potential Benefits
  - Decrease chamber time by 60% WRT TT-5
  - Small risk (not quantifiable) of DCS



# Conclusions

## ◆ Other Points

- Why go back to 45 FSW if missed Deco depth was 14 FSW?
- Why 10 min ascent to 5 FSW?
- Why use Air during Ascent?
- Why ascend to 5 FSW at all?
- Use Nobendem “Repet Dive” mechanism for Sur-D Modeling
- Three clocks: Nitrogen, CNS, and Pulmonary!
- Residual N<sub>2</sub> level = 7180 mm-min