THE EFFECT OF INTERMITTENT EXPOSURE TO 3% CO_2 ON ACID-BASE BALANCE AND ELECTROLYTE EXCRETION

by

K. E. Schaefer
C. C. Morgan
A. A. Messier
and
M. J. Jacey

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Reviewed and Approved by:

Charles F. Gell, M.D., D.Sc.(Med)
Scientific Director
SubMedResLab

Reviewed and Approved by:

J. D. Bloom, CDR MC USN
Officer-in-Charge
SubMedResLab

Approved and Released by:

J. E. Stark, CAPT MC USN
COMMANDING OFFICER
Naval Submarine Medical Center

SUMMARY PAGE

THE PROBLEM

To determine the effects of intermittent exposure to increasing CO_2, rising at a constant rate from 0.03 to 3% CO_2 within a period of 15 hours followed by a nine-hour period of air breathing, on acid-base balance.

FINDINGS

Intermittent exposure of one subject for six days to increased CO_2 for fifteen hours per day produced an increase in hydrogen ion concentrations and PCO_2 in capillary blood during the air breathing periods of the fourth and fifth day. This CO_2 accumulation which could not be prevented by respiratory gas exchange was eliminated through renal mechanisms of increased hydrogen ion excretion during the fourth and fifth day of intermittent exposure. This renal mechanism was not found to operate under chronic exposure to 3% CO_2. The 17 hydroxysteroid excretion in the urine was not affected by intermittent exposure to CO_2 indicating that there was no significant stress effect.

APPLICATIONS

These findings are pertinent to submarine operations in snorkel type submarines in which CO_2 levels may be achieved intermittently for short periods of time.

ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit M4306.02-7050B -- The Effects of Intermittent CO_2 and Lowered Oxygen Levels on Diving and Submarine Personnel. The present report is No. 2 on this work unit. The manuscript was approved for publication on 16 July 1970, and designated as Submarine Medical Research Laboratory Report No. 635.

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ABSTRACT

The effects of intermittent exposure to CO_2 on acid-base balance was investigated. One subject was exposed for six days to increasing CO_2 rising at a constant rate from 0.03 to 3.0% CO_2 within a period of 15 hours followed by a nine hour period of air breathing. To assess the acid-base parameters "arterialized" capillary blood was taken from the finger twice daily at 8 AM and 11 PM corresponding with the beginning and end of the intermittent exposure to CO_2.

Urine specimens were collected at the same times daily while venous blood samples were obtained on alternate days.

Hydrogen ion concentrations and PCO_2 in the arterialized capillary blood were found increased during the air breathing periods of the fourth and fifth day but returned to normal during the sixth day. The elimination of this CO_2 accumulation in the blood was accomplished through renal mechanism showing a marked increase in urine volume, organic acids, titratable acidity, ammonia and hydrogen ion excretion during the fourth and fifth day. The stress effect produced by intermittent exposure to CO_2 in this subject must have been minimal since the 17-hydroxysteroid excretion did not change.

student, thoroughly experienced in air been repeatedly demonstrated.
tests performed.

Venous blood samples were taken

TABLE II. EFFECT OF INTERMITTENT EXPOSURE TO 3% CO_2 ON pH, P_{CO_2}, HCO_3 AND P_{O_2} OF VENOUS BLOOD

Condition		pH	P_{CO_2} mm Hg	HCO_3 mM/L	P_{O_2} mm Hg
Control 8 AM	Mean	7.360	53.4	29.7	26.6
	SEM	-	-	-	-
	N	1	1	1	1
Control 11 PM	Mean	7.323	58.2	29.3	20.0
	SEM	-	-	-	-
	N	1	1	1	1
Intermittent Exposure to 3% CO_2 - 9 hrs. on air, 8 AM	Mean	7.319	57.3	28.9	22.2
	SEM	.006	1.7	.5	3.8
	N	3	3	3	3
Intermittent Exposure - 15 hrs. on 3% CO_2, 11 PM	Mean	7.295*	59.4	28.6	31.9
	SEM	.003	2.4	1.3	2.4
	N	3	3	3	3
Recovery on air 8 AM	Mean	7.338	59.5	31.6	21.4
	SEM	.018	.5	1.1	7.7
	N	2	2	2	2
Recovery on air 11 PM	Mean	7.342	60.8	32.5	21.6
	SEM	.005	1.8	.5	4.5
	N	2	2	2	2

* Significantly different from corresponding controls at the 5% level and better.

venous blood increased during CO_2 breathing which confirms the findings on alveolar oxygen tensions (Figure 3).

The responses of the renal functions primarily involved in acid-base regulations are shown in Figures 4 and 5. There is an immediate response to CO_2 breathing on the first day as shown in an increase in urine volume and excretion of organic acids, titratable acidity, and ammonia, which is followed by a decline in these parameters during the next two days. However, during the fourth and fifth day, which are marked by an increased CO_2 excretion and acid load during the air breathing period, there is a marked increase in urine volume, organic acids, titratable acidity, ammonia, and hydrogen ion excretion. During the second day of recovery an opposite

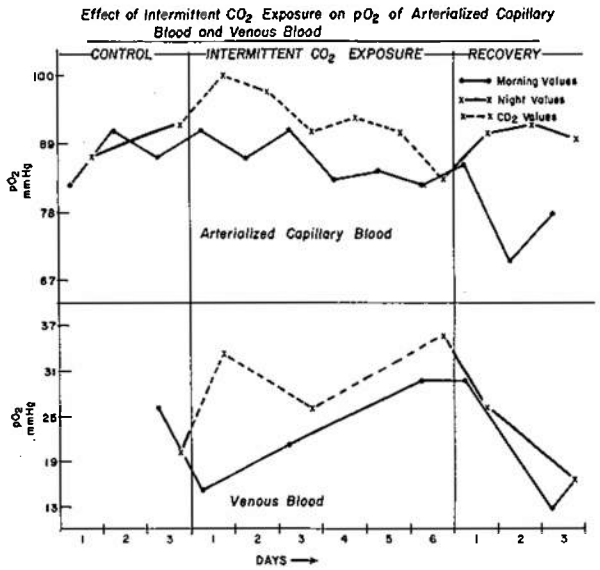

Fig. 3. Effect of intermittent exposure to CO_2 on PO_2 of arterialized capillary blood and venous blood. (Solid line: values obtained at 8 AM on air; Dotted line: values obtained at 11 PM after CO_2 exposure)

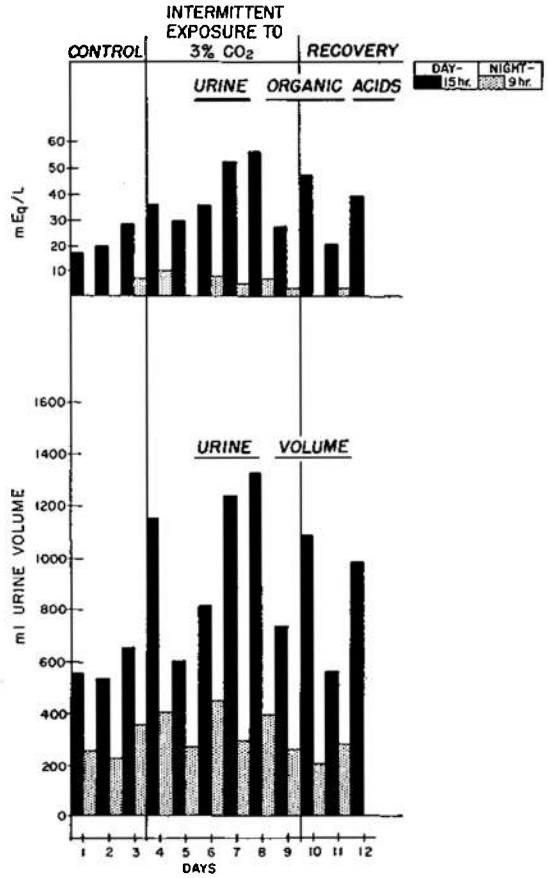

Fig. 4. Effect of intermittent exposure to CO_2 on urine volume and urinary excretion of organic acids. (Black blocks: 15 hour excretion from 8 AM – 11 PM; Stipled blocks: 9 hour excretion during night – breathing air)

trend can be noted which is characterized by a decreased excretion of ammonia and titratable acidity and a reduction in hydrogen ion excretion commensurate with a large increase in bicarbonate elimination.

Blood lactate and pyruvate and L/P ratio were not affected by intermittent exposure to CO_2 (Table III). The 17-hydroxysteroid excretion in the urine exhibited large diurnal variations which were not influenced by intermittent exposure to CO_2 (Table IV).

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