CO and CO_2 Analysis in the Diving Gas of the Fishermen of the Yucatan Peninsula

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Background

Decompression Illness (DCI) is an epidemic among fishermen of the Yucatan Peninsula. Over 75% of 300 harvest fishermen in the Yucatan experience DCI annually.

Fishermen of the Yucatan utilize primitive hookah systems supplied by poorly-filtered gas compressors. Some systems have incorporated Carbon filters while others have not. Carbon monoxide (CO) and carbon dioxide (CO_2) are directly compressed into the fishermen's air supply; thus, we suspect that fishermen are being poisoned by CO and CO_2.

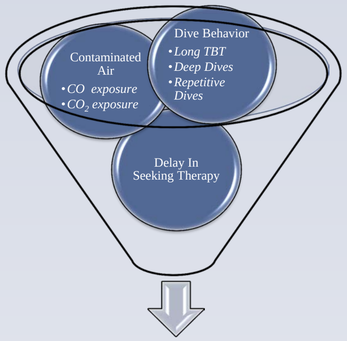
Exposure to excessive amounts of CO and CO_2 can lead to symptoms similar to DCI. This makes distinguishing injury and preventing future injuries difficult.

Distinguishing source of injury could lead to specifically targeted interventions for this population of fishermen.

Purpose

Symptoms of DCI, CO poisoning , and CO_2 poisoning are similar and oftentimes overlap each other.

In order to establish a clear intervention for addressing DCI, one must first address all other confounding sources of injury.



Symptomatic Patient

Itchy Skin, Pain in Joints and/or Muscles, Weakness, Dizziness, Nausea/Vomiting, Confusion, Loss of Consciousness, Labored Breathing, Muscle Twitching

Methods

Subjects
Consenting subjects were invited to participate in this single fishing cohort observational study. Hookah systems from 10 different fishermen (Avg. Age: 38, Avg. BMI: 33) were selected for gas analysis based upon convenience.

Materials
The hookah system utilized consists of a gas engine (5-6.5 HP), single stage compressor, and a 2.0 cubic foot volume tank.

Gas samples were collected through a Visi-Float® flowmeter (±5%). Dräger® CO 2/a Short-term Tubes (± 10%) and Dräger® CO_2 100/a Short-term tubes (± 10%) analyzed gas samples for CO and CO_2 content.

Gas Samples

1. A male quick disconnect was connected to the distal end of the fishermen's volume tanks.
2. Once the quick disconnect was secured to the origin of the fishermen's breathing hose on the volume tank, gas supply through the hose was opened via a 0.25" ball valve.
3. The system was observed for leaks; any corrections needed were implemented on site.
4. After flow was established, another male quick disconnect attached a three foot 0.25" hose to a flowmeter connected to a Dräger® tube holder.
5. The flowmeter was placed flat on the boat surface and set at 0.2 L/min.
6. Dräger® tubes were inserted into the holder downstream from the flowmeter
7. Time keeping was ensured with a 5 minute stopwatch before Dräger® tube results were interpreted.
8. Samples that were not collected in accordance with the preceding procedure were not included in our analysis.

Variables

CO
CO_2

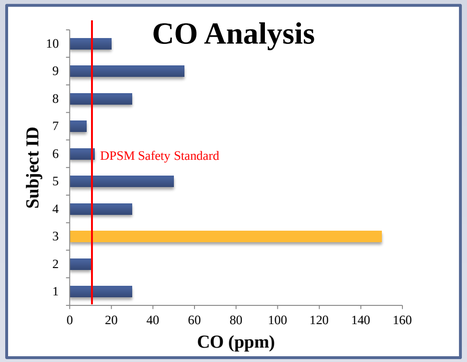
Data Analysis

IBM SPSS Statistical software package was used to generate the mean, median, and range of CO and CO_2 levels in the fishermen's diving gases.

The same software package was also used to conduct a Mann-Whitney *U* statistic to evaluate the effect of a Carbon filter on gas purity.

Results

	Mean (ppm)	Median (ppm)	Range (ppm)
CO			
Total (N = 9)	42	30	8-150
Filter (N = 3)	72	55	10-150
No Filter (N = 6)	27	30	8-50
CO_2			
Total (N = 8)	663	600	600-800
Filter (N = 2)	700	700	600-800
No Filter (N = 6)	650	600	600-700



	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
CO							
Filter	3	6.33	19.00	5.000	26.000	-1.050	0.294
No Filter	6	4.33	26.00				
CO_2							
Filter	2	5.25	10.50	4.500	25.500	-0.577	0.578
No Filter	6	4.25	25.50				

Comparative Analysis

Conservative safety standards for acceptable CO and CO_2 levels in diving gas have been established by the Health Safety Executive (HSE), the Diving Practice Safe Manual (DPSM), the U.S. Navy, and the Occupational Safety and Health Association (OSHA).

Safety Organization	CO (ppm)	CO_2 (ppm)
HSE	3	500
DPSM	10	1,000
U.S. NAVY	20	1,000
OSHA	35*	10,000*

*These are acceptable CO and CO_2 levels permitted in diving gas over an 8-hour period of time

Conclusion

CO and CO_2 measurements exceeded recommended diving norms of 10 ppm and 500 ppm, respectively.

Median CO levels in groups with and without Carbon filters were 55 ppm and 30 ppm, respectively; the distributions in the two groups did not vary significantly (Mann-Whitney $U = 5.0$, $n_1=3$, $n_2=6$, p=0.294 two-tailed).

Median CO_2 levels in groups with and without Carbon filters were 700 ppm and 600 ppm, respectively; the distributions in the two groups did not vary significantly (Mann-Whitney $U = 4.5$, $n_1=2$, $n_2=6$, p=0.578 two-tailed)

Gas filtration is needed to reduce the risk of both CO and CO_2 poisoning.

Discussion

Ambiguous symptomology among DCI, CO poisoning, and CO_2 poisoning in this population makes distinguishing injury difficult. Eliminating confounding variables will enable the implementation of interventions aimed at decreasing the risk of DCI.

Though mean rank between groups with and without Carbon filters was not statistically significantly different for groups with or without filters (p=0.294, 0.578), the lower mean rank of groups without filters suggests that filters are actually increasing Carbon exposure in the fishermen's air supplies.