Modeling Carbon Monoxide Reduction in a Single Compressor Hookah Dive System

UCLA

Gonda Center for Wound Healing and Hyperbaric Medicine

Walter Chin
BSN, CHT, ADMT

Chris Millbern
BS, W-EMT, CHT

Grace H. Wegrzyn
BS, EMT

Oswaldo Huchim
MD, PhD

Rachelle Jacoby
BS, EMT

Nisha Talati,
BS

Susan Sprau,
MD, MACP, FCCP, FAASM

Background

A hookah dive system (HDS) consists of a gas-powered engine, an air compressor, and a volume tank. The breathing hose attached to the volume tank enables divers to theoretically spend an infinite amount of time underwater.

In North America, the HDS is most commonly utilized by recreational divers; however, many under-developed countries utilize the HDS in artisanal fisheries. A knowledge gap concerning the safety and operations of the HDS can pose health risks to fishermen with limited mechanical and educational resources.

There are 300 artisanal fishermen in the Yucatan Peninsula that rely on a HDS eight hours a day, six days a week while diving. Both diving and governmental organizations have established safety standards for CO content in a diver's air supply (10 ppm).

Purpose

In the Yucatan Peninsula, there are groups of artisanal fishermen diving with a HDS. Our purpose for creating and validating a HDS model was to identify interventions that could reduce CO in their diving gas.

By quantifying the levels of CO in the air supply generated by a model HDS, we aimed to determine if separation of gas engine exhaust from compressor intake could produce CO levels within the range of existing diving safety standards.

Materials

Model HDS
A model HDS was constructed using a Hitachi® EC2510E 1ft^3 Gas Horizontal Air Compressor powered by a 5.5 HP engine (4,000 rpm) and delivering 145 PSI of gas pressure.

Measuring Devices
A 0.25" 4ft Swagelok® Special Tubing Natural hose was connected to the volume tank via a quick disconnect in order to collect gas samples.

Samples were analyzed by a C-Squared® Carbon Monoxide Analyzer (±1ppm) through a Visi-Float® flowmeter (±5%)

A GM816 1.5" LCD Portable Digital Wind Speed Meter Anemometer (±5%) measured wind speed.

Methods

Pre-Intervention Procedure

1. The compressor and engine idled for 20 minutes prior to acquisition of gas measurements.
2. The wind anemometer confirmed wind speeds did not exceed 1 mph (to mimic the environmental diving conditions of the artisanal fishermen).
3. Once the volume tank was full (145 PSI), the engine was turned off and a hose was attached to the volume tank via a quick disconnect.
4. Gas was flushed through the 0.25" hose for 60 seconds prior to acquisition of CO. measurements.
5. The flowmeter was set at 0.2 L/min.
6. A stopwatch ensured that samples were collected every 30 seconds.
7. Pre-intervention CO samples were collected (n=47).

Intervention
A 5ft Watts® 1-1/4 polyethylene hose with an attached large-particle filter was connected to the compressor intake and elevated 5ft above the engine exhaust.

Post-Intervention Procedure

8. The intervention was applied
9. The preceding procedure was repeated to generate post-intervention CO samples (n=47).

Applied Intervention

Data Analysis

IBM SPSS Statistical software package was used to generate the mean, median, and range of CO levels in the HDS gas source both before and after the intervention was applied.

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

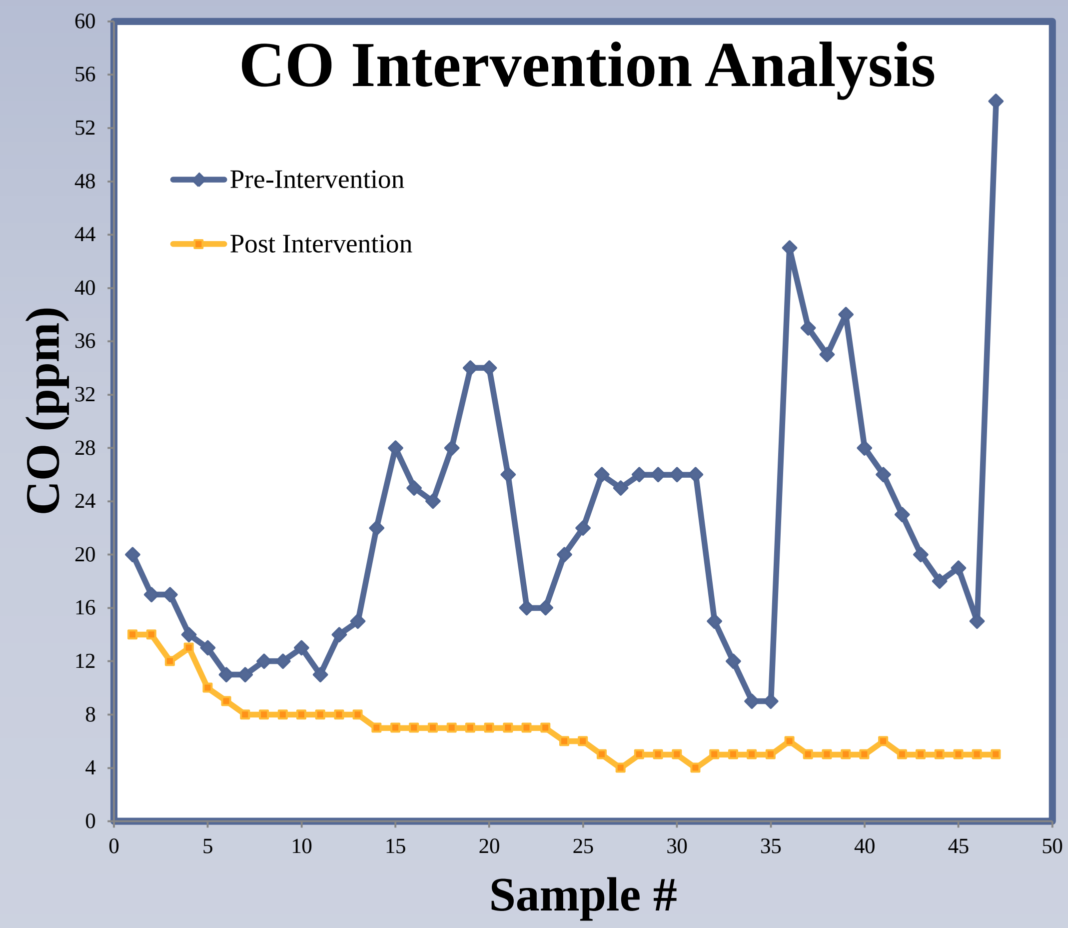
Results

CO Analysis

	N	Mean (ppm)	Median (ppm)	Range (ppm)
CO				
Total	94	14	11	4-54
Pre-Intervention	47	22	20	9-54
Post-Intervention	47	7	6	4-14

Gas Purity

	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Wilcoxon W	Z	*p* (2-tailed)
CO							
Pre-Intervention	47	70.14	3296.5	40.5	1168.5	-8.084	.000
Post-Intervention	47	24.86	1168.5				



Conclusion

The physical separation of the gas engine exhaust from the compressor intake reduced CO in the volume tank air supply.

Median CO levels in groups with and without the intervention were 6 ppm and 20 ppm, respectively; the distributions in the two groups were significantly different (Mann-Whitney $U = 40.5$ $n_1=47$ $n_2=47$, $p < 0.001$ two-tailed).

Discussion

This cost-effective intervention can easily be implemented to any HDS in order to reduce CO air supply contamination.

Specifically, this intervention can be a quick and cost-effective alteration to the HDS utilized by artisanal fishermen in the Yucatan Peninsula.