Urgent Conversion of a DDC to a Temporary Saturation System: Experience in the Gulf of Mexico.

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INTRODUCTION

The treatment of divers past the extreme exposure limits of existing non-decompression tables often requires some form of saturation decompression. Saturation systems are complex, expensive, and of limited availability. Although rare, the need may arise to use saturation decompression to treat injured divers without a formal saturation system in place. In this event, some a priori knowledge of the hurdles involved may decrease morbidity and mortality.

CASE REPORT

Our deployment team was involved in the treatment of a commercial diver with severe CNS DCI, his inside tender, as well as a treating physician. Symptoms were not improved until a depth of 185 fsw was reached, and the time at depth dictated therapeutic decompression on a Miller Air Saturation Table. The standard DDC had to be modified on-site and under pressure to function as a saturation system. Modifications included: wiring of a CO2 scrubbing unit into the existing communication wiring; installation of new gas monitoring equipment; altering the plumbing to allow instillation of nitrogen for FiO2 control; and cooling/environmental control. Gas supply was also problematic to secure, even onshore. Finally, training of the crew in saturation system operations was needed. Each operation involved its own obstacles and required innovative solutions to achieve success.

RESULTS

The chamber was successfully modified both internally and externally. The FiO2 was maintained between 0.3 and 0.4; the CO2 levels maintained below 2600 ppm; and the inside temperature kept in the mid 80s F.

CONCLUSION

Icidents requiring this type of response are rare, even in our practice. However, when they do occur, the knowledge and materials needed for successful treatment may not be available. By presenting our experience, we hope to increase the awareness and capability of hyperbaric physicians who may, one day, be called upon to work under similar conditions.

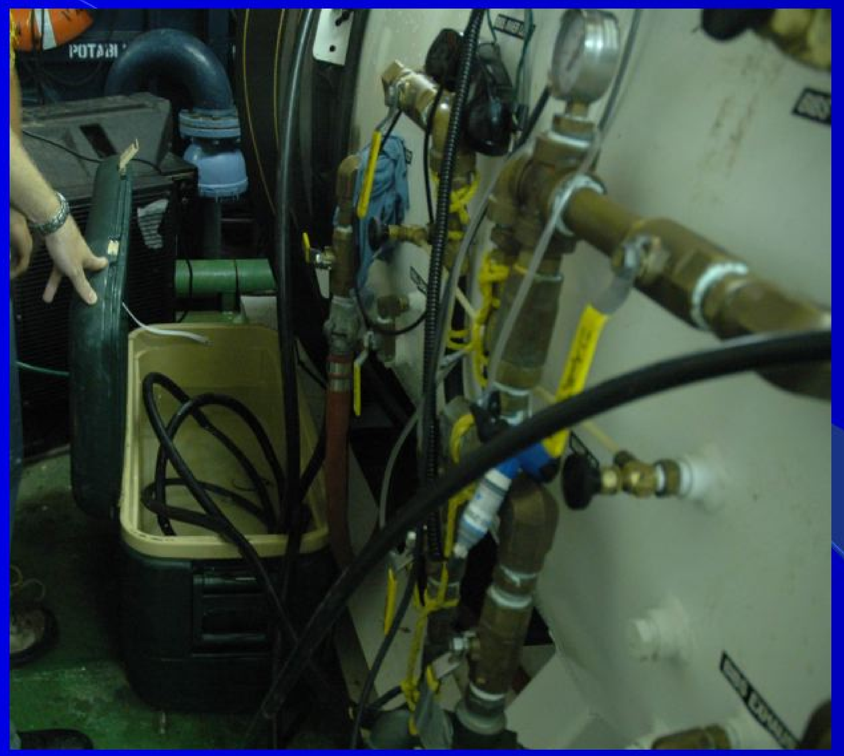
TEMPERATURE CONTROL

Of paramount importance in prolonged chamber treatments is temperature control. In our region, high summer temperatures correspond with the height of the offshore work season. Temperatures inside a DDC on the deck of a ship can reach 120 F without intervention, and such conditions increase the risk of dehydration and can worsen DCS.

Our efforts to control chamber temperature begin with tarpolin shading of the chamber to limit direct heating by radiation. This is usually followed by evaporative cooling through the use of water pumped over the chamber in combination with fans. Ice, if available, can be used to cool both the chamber walls as well as the air being blown by the fans. To augment the cooling achieved by venting, the air supply hoses can be submerged in a salted ice water bath. This provides cool air during venting and is very effective. These measures use materials commonly available on the dive support vessel and can be instituted while underway to dock.

On arrival to a dock, the DDC can be better enclosed to help control its ambient temperature. Window / portable air-conditioning units can be placed within this enclosure. Most recently, in conjunction with industry saturation techs, we developed a system of copper piping which is wrapped against the outer wall of the chamber. This is filled with anti-freeze and connected to a commercial cooling unit. Any available insulating material is placed around the coils. In our experience, this method was able to create frost on the outside of the chamber in August, and was very effective in maintaining a suitable chamber temperature.

During recent deployments, a combination of the above measures was able to successfully maintain an inner chamber temperature in the low 80 F range with 3 occupants inside. In the middle of the afternoon, this was > 10 F cooler than ambient temperature, and suitable for long term saturation.



SUPPLY LIST

DC Powered CO2 Scrubber	Otoscope	Phenergan Tab/Supp/Inj
MiniOx	Tuning Forks	Visteril Tablets
Various Sized Penetrators	Hypothermic Thermometer	Bactrim DS Tablets
Drager Analyzer	Skin marker	Ciprofloxacin Tablets
Sodasorb	IV Fluids	Vitamin E & C (MVI)
Flashlights	Catheters	Benedryl Tabs/Inj
Batteries	EZ IO System	Xanax Tablets
Appropriate Wrenches	Foley with Closed Drainage	Tylenol Tablets
Magnetic Hooks	Suture Sets	Aspirin Tablets
Ambu Bag	Sterile Gloves	Sudafed Tablets
Intubation Roll	Exam Gloves	Motrin Tablets
Tube Tamers	Betadine	Epinephrine (1:1000) Inj
NG Tubes	Povidine Ointment	Narcan Injectable
Cook Emergency PTX Set	Shur-Clens	Solumedrol Injectable
Tru-CLOSE Thoracic Ventilator	4 X 4 Gauze	Ancef Injectable
Chest Tubes	Kerlex Rolls	Lidocaine Injectable
Hand-Powered Suction	Assorted Tape	Ativan Injectable
#10 Scapel Blade	Coban	Valium Injectable
Assorted Syringes	20 & 23 gauge Lumbar Needles	Afrin Nasal Spray
ACLS Box	Tetanus Toxoid	Bactroban Ointmnet

AIR QUALITY & COMPOSITION

Saturation demands control of air quality and partial pressures of numerous gasses. In shallow air saturation, frequent venting removes accumulating CO2 and ensures correct oxygen partial pressure. However, in deeper saturation, ppO2 must be altered and an open system is no longer feasible. In a closed saturation system, CO2 must be maintained below certain levels: commonly 0.5% (5000ppm) for high O2 and 1.5% for air. A chemical scrubbing unit is commonly used for this purpose. In our system, we deploy with a DC powered CO2 scrubbing unit. Upon arrival, this unit is locked down, and through the hull penetrators, are placed while under pressure. The electrical wires are passed through, and then the scrubber can be powered from the ships normal supply. In this case, no penetrators could be used, and the scrubber had to be powered by pre-existing DC communications wiring in the chamber. This allowed the scrubber to be installed successfully and CO2 levels were controlled in the 2200 ppm range.

Monitoring of ppO2 and ppCO2 necessitates air sampling from the chamber periodically. We employ a MiniOx I unit for oxygen monitoring, drawing a sample from tubing connected to a Y fitting q hour. Carbon dioxide levels are monitored using a Draeger pipette system at surface or at depth. Surface values must be converted to inhaled partial pressures for accurate evaluation.

In cases such as this one, with saturation below standard air ranges, cumulative oxygen toxicity concerns mandate that the breathing mixture have reduced ppO2. In normal saturation, premixed heliox or other gases are available, and chambers are plumbed to allow multiple gas input. However, in emergency situations, chambers may have to be altered to allow multiple gas mixtures to be instilled. This involves adding new input piping to the valve assemblies. Accurate labeling of gas valves is essential to avoid error. In addition, pure gasses may have to be instilled into the chamber to alter the partial pressure of oxygen. In this most recent case, pure nitrogen was instilled to lower the ppO2. This was done while on a slow vent and while holding the depth constant. Occupants circulated air to avoid pockets of N2. While not ideal, this method proved successful and ppO2 was maintained at 1.4 ATA for a 3 day saturation.

PERSONNEL & PLANNING

In order to remain prepared for such an involved case, preplanning and training are paramount. Maintaining deployment lists, servicing equipment, as well as updating and replacing medications during the time between events will help ensure that hazardous omissions and mistakes do not occur when a hasty deployment is required. If helicopter transportation is required, weight of all equipment must be known and kept to a minimum. All equipment is prepackaged in water tight protective containers, with the weight labeled on the outside for easy coordination with helicopter crews.

Personnel requirements for these incidents are demanding. We have found that a team consisting of at least 2 hyperbaric physicians, along with 2 or 3 CHTs is advisable. Our CHTs are highly experienced in chamber construction as well as electrical operation of the devices used. They serve to teach new techs and physicians many of the techniques shown here. Their presence also allows us to give the boat tenders needed rest and simplifies instructions and procedures.