DAN

RCN Bulletin:

A Newsletter of the DAN Recompression Chamber Network

WELCOME TO THE 4TH EDITION OF THE DAN RCN BULLETIN

WHAT'S INSIDE:

THE COVID-19 PANDEMIC

We are all currently weathering the COVID-19 pandemic, which has led to a slowdown in diving and hence a reduced number of diving accidents too.

While a very disconcerting and financially-challenging situation to so many of you, it could be an opportunity to find some time to catch-up with essential facility safety and maintenance planning. Please remember to download your free version of the DAN Risk Assessment Guide for Recompression Chambers. It contains most of what you would want to include in your safety manual, procedures and instructions.

One aspect that has really been brought to the fore is chamber disinfection. Most hyperbaric facilities have always taken disinfection seriously, although perhaps with a little less diligence than circumstances now require. With a poorly-understood virus, suitable disinfectants, contact times and disinfecting procedures are not readily available – even after several months of dealing with this.

Many RCN chambers are located in regions where access to COVID-effective disinfectants are not available. Yet another challenge to be overcome. However, we can tell you that the age-old technique of using a 2% bleach solution (25 ml per 1 liter of water) has been rated as effective by the US CDC. This is for standard household bleach with a concentration of the active ingredient (sodium hypochlorite) of ±5%. Contact time is 1 minute for soaking, or for surface wetting, and thereafter you can flush with clean water and allow to dry. There are other products, although one should always be wary of their effect on acrylic windows. Feel free to contact us if you need guidance in making decisions relating to suitable disinfectants

The UHMS in the USA published an article on guidelines for infection control during the first months of the pandemic.

Several of the hyperbaric societies have issued position statements on hyperbaric oxygen therapy and COVID-19. You can find some of these here: UHMS (USA), EUBS-ECHM (Europe), CUHMA (Canada), HTNA (Australia New Zealand)

In addition, there are position statements for the return to diving post suffering from COVID-19 on some of these sites. Our industry has been hard at work to provide as much guidance to us all as possible.

For those of you who have been approached or have wondered about the effectiveness of treating COVID-19 patients, please carefully review the current scientific literature on studies which are still in their early stages. You can follow their progress here. What-ever your decision, please remember that supporting a critically ill patient in a chamber requires both specialized equipment as well as advanced knowledge by the hyperbaric physician and chamber staff.

We have included a wide variety of articles for you to read in this the 4th in our series of newsletters, each written specifically for these publications by your peers in our industry. If any of you have a story to share, or would like to provide guidance to others, let us know and we will make space for you in subsequent editions.

Finally, remember to send your questions to us at rcn@dan.org. We have answered a range of questions in the period since the last newsletter, ranging from determining required staffing levels to painting the inside of a chamber. We look forward to these; they keep us connected with you.

We hope that you will find this edition interesting and even useful.

- Francois Burman and the DAN RCN Team

Pandemic: An Infection Control Wake-Up Call for Hyperbaric Chambers

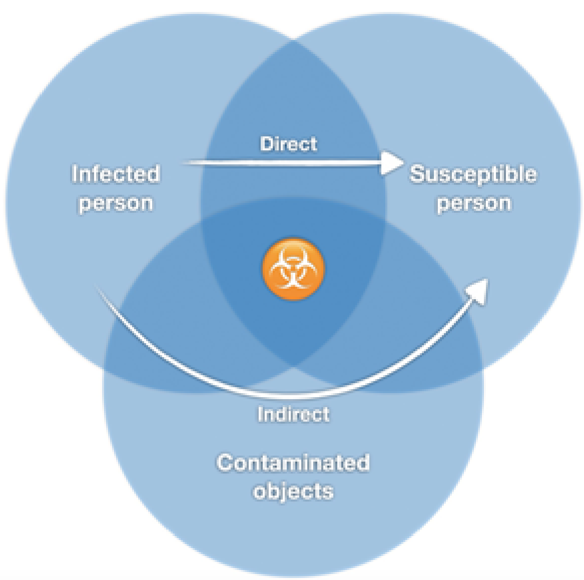
SHERYL SHEA

The COVID-19 pandemic has awakened a serious concern for the avoidance of infections in hyperbaric centers. In the past, most centers had disinfection protocols which they considered to be adequate. However, with the onset of the pandemic, the risk of infection transmission in the hyperbaric chamber has shot to the top of the priority list. Suddenly, "adequate" disinfection protocols are not enough – what is needed going forward are truly effective protocols that are diligently practiced.

It is essential to understand the basic principles of infection control. First, you must have a pathogen – something that can cause an infectious disease. These are bacteria, viruses, fungi and parasites. In order to transmit infections, pathogens need 3 things:

- A place to live – a person, animal, insect or contaminated object For example, a patient, staff member, stethoscope, BIBs breathing mask, or the chamber bilge.
- A way to reach a susceptible person – For example, direct contact through inhalation of airborne droplets produced by an infected person coughing or sneezing, or indirect contact by touching a contaminated object, splashing, aerosolization by medical equipment, puncture wounds, and insect bites.
- A susceptible person where the pathogen can invade and multiply – For example, an unvaccinated person, someone with a weakened immune system, or, such as with COVID-19, a new pathogen that nobody has been exposed to before, so there is not yet any natural immunity.

This process of infection can be visualized by the following diagram:



Since someone can be infected and show no signs of sickness, one must assume that everybody is infected. As caregivers, we are always in contact with patients So, to avoid new infections, interventions are directed at:

- Controlling or killing the pathogen at the source, such as the infected person taking an antibiotic, using a disinfectant to eliminate the pathogen on surfaces, or keeping the infected person isolated.
- Preventing the pathogen from moving from person to person via the use of, for example, frequent handwashing, physical distancing, use of personal protective equipment (PPE) - gloves, gowns, masks, face shields, goggles, and engineering controls such as hard-sided containers to deposit used needles.
- Increasing the defenses of susceptible people through vaccination, the injection of antibody-containing blood products such as immune globulin, or by chemical prevention such as antimalarial drugs.

Hyperbaric chambers represent a unique challenge for infection control. Multiplace chambers, where chamber occupants are in an enclosed space and in close proximity for an extended period of time, present an additional level of exposure to risk, especially to airborne infections such as tuberculosis and infections that spread by droplets, such as COVID-19. Both multiplace and monoplace chambers are no simple matter to clean and disinfect. They both have difficult-to-access areas, such as the bilge in a multiplace chamber, and under the bed and the foot end of monoplace chambers. Disinfectants must be effective against multiple pathogens but be non-toxic and safe for use on breathing equipment and on acrylic windows and other materials.

Infection control measures during treatment inside multiplace chambers for infections spread by droplets, such as COVID-19 and influenza, are aimed at limiting staff and patient exposure to ambient air while inside the chamber and limiting unnecessary exposures.

The Undersea & Hyperbaric Medical Society recommends limiting the number of chamber occupants to allow 1 meter (3 feet) between occupants, having the patient don hood or BIBs mask upon entering the chamber, and switching the gas from oxygen to air to effect air breaks. Chamber attendants have the option of wearing N95 masks upon entering the chamber and then switching to BIBs mask for decompression, or donning a BIBs mask upon entering along with the patient.

Eye protection or face shields may also be required. Hands should be thoroughly washed before and after entering the chamber. Treatment sessions should be limited to those that are absolutely necessary or urgent.

"Disinfectants must be effective against multiple pathogens but be non-toxic and safe for use on breathing equipment and on acrylic windows and other materials."

Having patients wear a surgical mask and wash their hands upon entering the chamber room and removing the surgical mask only while inside the chamber can also help mitigate the risk.

With other more well-known types of infections, such as wound infections, AIDS and hepatitis, PPE is donned according to standard precautions, based on the anticipated exposure, such as gloves for managing blood and body fluids, eye protection if splashes are possible, and of course, thorough hand-washing before and after donning/removing PPE. Non-alcoholic means of hand sanitization should be available.

After treatments are finished, the presence of pathogens on chamber surfaces must be dealt with. The lack of, or inadequate, daily cleaning of the chamber and equipment after HBO treatments may cause transmission of infections even though proper protocol was followed during the treatment. Indirect transmission can occur when susceptible people are exposed to pathogens sitting on surfaces. For example, the next patient puts on a BIBs mask that was not properly disinfected or a chamber attendant pricks their finger with a needle that was not removed and deposited in a sharps container. Periodic, thorough cleaning and disinfection of the entire chamber interior including the bilge should be part of the standard infection control protocol.

A suitable, non-corrosive, antiseptic (e.g. quaternary ammonium-based), human-friendly and synthetic (e.g. non-soap) detergent should be used to clean all surfaces following each treatment day. It can be a challenge to obtain a disinfectant that is both effective and safe to use in the chamber. A disinfectant commonly used in hyperbaric chambers and by the US Navy, and that was found by the US EPA to be effective against COVID-19, is Sanizide Plus. Also found effective against COVID-19 and non-toxic is Simple Green d Pro 5 (note: this is not regular Simple Green). In remote locations or when supplies are unavailable, common household bleach can be used at a ratio of 25 cc per liter (4 tsp. per quart) of water (2:100 dilution). The bleach solution must be left in contact with the surface for at least a minute, kept in a closed, light-resistant container and mixed fresh daily.

Safe and effective infection control protocols should address issues such as protective clothing, disposal of cleaning containers, disposal or cleaning of contaminated linen, inspection of chamber after cleaning, and adequate ventilation during cleaning and prior to treatments.

The visibility and life span of acrylic windows can be reduced by abrasion, surface damage and degradation due to chemical incompatibility. Disinfection chemicals should be suitable for acrylic viewports. A soft, lint-free cloth should be used to clean the acrylic window.

As this article goes to press, we are still in the midst of the lockdowns and high anxiety caused by COVID-19. The pandemic will eventually fade, but the risk of infections will always remain, and certainly from now on we will want to take greater care to do what we can to keep our patients and ourselves safe from contagious diseases.

> *“A suitable, non-corrosive, antiseptic detergent should be used to clean all surfaces following each treatment day.”*

USEFUL LINKS:

Infection Control, Centers for Disease Control and Prevention

- https://www.cdc.gov/infectioncontrol/index.html

Introduction to Epidemiology, Centers for Disease Control and Prevention

- https://www.cdc.gov/csels/dsepd/ss1978/lesson1/section10.html

Guidance on Preparing Workplaces for COVID-19, Occupational Safety and Health Administration

- https://www.osha.gov/Publications/OSHA3990.pdf

Infection control in hyperbaric chambers during COVID-19 outbreak, UHMS

- https://www.uhms.org/images/MiscDocs/UHMS_Guidelines_-_COVID-19_V4.pdf

Standard Precautions, Centers for Disease Control and Prevention

- https://www.cdc.gov/infectioncontrol/basics/standard-precautions.html

List N: Disinfectants for Use Against SARS-CoV-2, United States Environmental Protection Agency

- https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2

Cleaning and Sanitizing Diving Gear, USN Naval Experimental Diving Unit

- https://www.amronintl.com/downloads/dl/file/id/1205/product/11178/sanizide_navy_diving_article.pdf

Simple Green® d Pro 5 Safety Data Sheet

- https://simplegreen.com/industrial/products/d-pro-5/

Cleaning and Disinfecting Your Facility, Centers for Disease Control and Prevention

- https://www.cdc.gov/coronavirus/2019-ncov/community/disinfecting-building-facility.html

Is the Treatment of Decompression Illness a Predictable Event on a Remote Caribbean Island?

ARIANE ALLAIN

Turks and Caicos Islands, beautiful by nature, are known for magnificent beaches and breathtaking wall dives into the abyss. The multiplace hyperbaric chamber is located on the island of Providenciales at Associated Medical Practices. The island has multiple daily flights from the US, mid-week and weekend flights from Canada and bi-weekly flights from the UK. The turnover days on island are Saturdays and Sundays, when tourists traditionally arrive and depart.

With tourism in mind, how do we plan staffing of the hyperbaric chamber to cover 24 hours a day, 7 days a week, 365 days a year for diving emergencies? Could staffing needs be accurately predicted based on historical data?

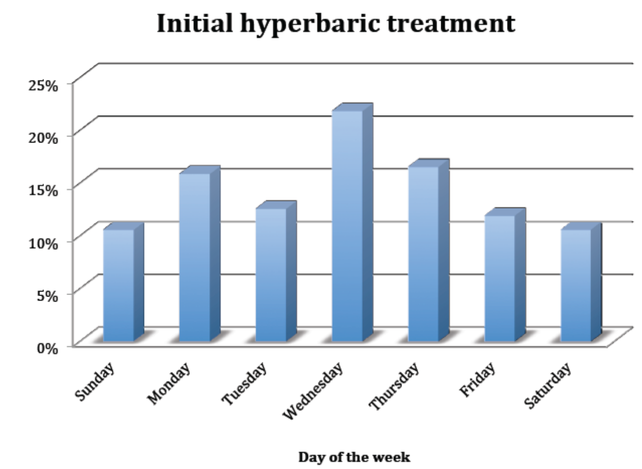
Does decompression illness have a pattern of occurrence on a Caribbean island? Anecdotally, the chamber is more likely to operate on a Thursday night than a Tuesday night, or at 8 pm instead of 2 pm. Definitive answers will be reached using the chamber logbook.

The Turks & Caicos chamber logbook is a faded green and brown account book. A vintage Shaw's specialist stationary ledger, record ruled, 35 lines per page, 300 pages. April 1995, first log entry in this book, a TT6. For some unknown reason, the chamber director at the time decided to start logging the information at the end of the book on page 304. Why there is a page stamped 304 in a 300-page book, no one knows. Every time the book is picked up, it must be flipped upside down. The book is a treasure trove of local diving history, with records of the chamber run supervisors, operators, and tenders.

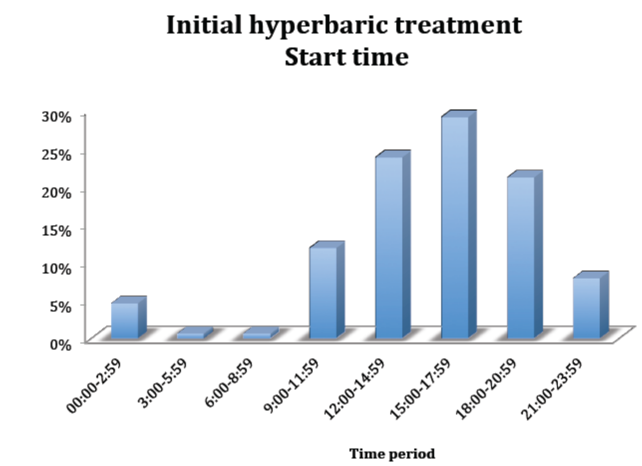
Fast forward to April 2020, 22 pages remain to be written.

Most dive operators on islands offer two tank morning dives and a single tank afternoon dive, and most exit the water from their second dive by 12 pm. The two Liveaboards in the area average 4 dives daily. Dive areas range from a mere 10 minutes from the docks to over an hour away. With most of the symptoms of decompression sickness manifesting within 6 hours, one would assume that the majority of injured divers would find their way to the clinic by 6 pm. But do they?

Data from January 2010 to March 2020 was analyzed, and the findings are as follows.



In 22% of cases, the first treatment in the chamber occurred on a Wednesday, with Thursday in second place at 17%. Surprisingly, Friday is a distant fourth with only 12% of the cases.



In 29% of cases, the start of the first chamber treatment for a patient occurred between the hours of 3 pm and 6 pm, with the second most popular time to start a first treatment being 12 pm to 3 pm. 79% of first-time treatments occur on a weekday, while 65% of all patients started their first hyperbaric treatment during the hours of 8 am to 6 pm.

In conclusion, although there is a sense that a pattern is occurring, with peak days being Wednesdays and Thursdays, the randomness of decompression illness justifies having a team on call 24 hours a day, 7 days a week, 365 days a year!

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Case Study: Split, Croatia

CHIARA FERRI, MARTA MARROCCO

A 52-year-old female advanced open-water diver from the Czech Republic, dove in the Croatian Adriatic Sea at the very beginning of Autumn.

At the end of October, the water temperature is between 16°C and 19°C, tourism is low, and weather is still quite good; the perfect time for a diving holiday far from crowded places.

The diver dove on air a total of 7 times in 4 days, using Nitrox for decompression.

On a Sunday she dove twice: the maximum depth of the first dive was 30 meters (98 feet) and total dive time (TDT) was 45 minutes, after a surface interval of approximately 3.5 hours, she dove again to a maximum depth of 29.3 meters (96 feet) for 45 minutes.

Approximately 20 minutes after surfacing, she reported the following signs and symptoms, respectively: marbled skin (Cutis Marmorata, in this case manifestations were symmetric reticulated cyanosis) involving the area of the trunk and upper extremities, one vomiting episode, pain in abdomen, upper and lower left limbs, and feeling of weakness in both legs.

The diving center crew quickly provided the diver with oxygen and arranged transportation to the closest medical center. Upon arrival about one hour and 15 minutes after surfacing, the need for immediate hyperbaric recompression was recognized. After another hour, she was transferred to the Neurology department of the local hospital.

After neurological examination and laboratory analysis, she was transferred to the hyperbaric chamber. Her arrival at the chamber was characterized by other symptoms such as severe pain in both shoulders, urinary retention, motor impairment of both lower extremities, particularly on left side and foot.

Blood tests showed significant dehydration, probably for not treating hydration adequately prior to diving, and cold-induced diuresis.

The diver, now patient, was given a U.S. Navy Treatment Table 6 as a first approach. Upon completion of the protocol, she presented with complete resolution of painful symptoms (shoulders) and partial resolution of skin lesions. Unfortunately, motor impairment of lower limbs didn't obtain a satisfactory therapeutic outcome.

The hyperbaric unit team, as tailing treatment, continued with U.S. Navy Treatment Table 9 and after two more days of treatment, complete recovery of cutaneous involvement and improvement of inferior limb motor function were reported, satisfactory bladder function regaining was outlined, but unfortunately the patient was still not able to stand up without assistance.

Unfortunately, at that point it was clear that the patient needed a long recompression therapeutic course, supplemented by physiotherapeutic sessions in order to recover as much motor function as possible.

At this stage, DAN Europe was contacted to help arrange the medical repatriation of the patient in order for her to continue the treatment in her country of origin.

The hyperbaric and DAN Europe Medical teams coordinated the repatriation: a fully equipped air ambulance, pressurized to 1 ATA with the patient in supine position was the best means of transportation for the 1000 km (621 miles) that separated her from the hospital where she would continue her care.

The patient was transported the following Tuesday and successfully reached the hospital where she continued her treatment. There, for the following six weeks she received a total of 42 sessions of HBOT (2.4 ATA/90'), physiotherapy, ergotherapy (occupational therapy) and vitamin supplementation.

Echocardiographic assessment performed during her stay confirmed the already suspected presence of a Patent Foramen Ovale (PFO) characterized by a moderate right to left shunting.

Brain MRI outlined small unspecified areas of gliosis, spinal cord MRI was normal; electromyography found bilateral motor neuron damage at the lumbosacral region (L5-S1) and muscle motor evoked potentials (MEPs) reported damage to the corticospinal tract at inferior extremities (L5).

With thanks to the therapies, the care provided by the medical personnel supporting her during her treatments, and of course to her own goodwill and positive attitude, the patient is nearly able to stand up and is self-supporting. She is able to walk for 500 meters (0.3 miles) with the help of two French crutches, and she is due to continue her rehabilitation regime via balneotherapy (hydrotherapy).

Courtesy of DAN E

Challenging CAGE Case Managed Successfully by Recompression Chamber in Remote Location

SHERYL SHEA

Evan, a 25 y.o. healthy male, travelled to Papua New Guinea for a New Year's holiday dive trip with some friends and their father, aboard a private vessel. On the day of the accident, they were diving about 200 miles off the coast of Lae, in Eastern Papua New Guinea. At noon on this day, he made one dive to a depth of 25 msw. He had ear equalization difficulties but made it to depth. He was at depth for about 11 minutes, when he made a rapid ascent to the surface for reasons unknown.

At the surface, he was found unconscious by his dive buddies, and brought back to the boat. He regained consciousness after some time. He was taken to the cabin for rest but was only semi-conscious, confused, thrashing around and having repeated seizures. His left arm and hand were trembling, and he began to complain of numbness and tingling in his left hand and fingers. His dive buddies did not have him try to stand or walk. He was able to take fluids by mouth. He became more alert with no other complaints, and then he fell asleep. They pulled anchor and headed for Lae, the nearest town, about 24 hours away by boat.

The next day, about 2 hours out from Lae, the boat owner phoned the DAN Emergency Hotline. DAN medical staff suspected probable pulmonary over-inflation syndrome and arterial gas embolism. They recommended to emergently med-evac the patient to Port Moresby for recompression. The medical director of the recompression chamber in Port Moresby was already aware and organizing a med-evac flight compressed at sea-level altitude from Lae to Port Moresby. Upon arrival by boat to Lae, he was taken to the local medical facility for evaluation and IV hydration while he awaited the med-evac flight. Oxygen was administered for the first time since the accident, an interval of 24 hours.

He was taken from the hospital to the airfield for the 45-minute flight to the recompression chamber facility. On the tarmac, he was agitated and confused with repeated seizures and jerky movements. He had left upper extremity weakness (3/5) and left lower extremity paralysis (0/5). His vital signs and oxygen saturation were normal. He was evacuated to Port Moresby around 3pm local time, with 100% oxygen administered during the entire flight.

Upon arrival at the recompression chamber facility, which is located right at the airport in Port Moresby, he was re-evaluated by the chamber medical director. He was unable to move his left leg at all, no sensation in both lower extremities, and continued weakness of the left upper extremity. No urinary or bowel involvement. He was drowsy and confused, GCS 14/15, with slurring of speech. He was able to obey commands. Unable to sit up or walk. Loss of facial sensation and facial paresis on the right side. Vital signs and oxygen saturation remained normal. Chest sounds were clear.

He was dehydrated and received 1 liter of IV normal saline, and a sedative and anti-emetic. He entered the chamber on a spine board for his first treatment, with a critical care nurse. At 4 pm local time, 28 hours after the accident, a USN TT6 with extensions was commenced. The treatment progressed well, and about 8:30 pm local time, he was able to dorsiflex his left foot, and weakly abduct his left thigh.

Around midnight, upon exiting the chamber via spine board, he was taken to hospital, which is at a different location about 5 minutes away. In the emergency room, a CXR and CT scan of the brain were done, as well as bloodwork consisting of hematology, biochemistry, and D-dimer. His c-reactive protein and liver enzymes were elevated. The CT of the brain showed no abnormalities. He was diagnosed with CAGE (cerebral arterial gas embolism) and left-sided hemiparesis.At 3 am local time, he was moved to the ICU to await his next recompression treatment.

His re-evaluation before the commencement of his second recompression treatment showed the left upper extremity weakness to be unchanged. The left lower extremity had improved strength, 2/5. He could sit up, stand and walk but with difficulty, and with a wide-based clumsy gait. He was alert, GCS 15/15. The right facial paresis continued. He had hyper-reflexia of left upper and lower extremities. His vital signs and oxygen saturation continued to be normal.

He was transported back to the recompression chamber for his second day of treatment. At 10:30 am, he crawled into the chamber, and self-applied the mask. A USN TT6 was commenced. At 4:15 pm the treatment was complete, and upon exiting, he was able to walk with a walker. He was discharged to stay with his friends.

The next day, his third day of recompression treatment, the re-evaluation before commencing treatment showed strength improvement of his left upper and lower extremity to 4.5/5. He was now cheerful, with no slurring of speech and no facial paresis. Reflexes returned to normal. He was able to walk into the chamber without assistance. He still had some sensory deficit in the left foot and above ankle. At 3:30 pm, a USN TT5 was commenced. After the treatment, he was feeling much better

He was discharged from recompression therapy. Rest and pool-physiotherapy were prescribed and carried out for 2 more days. He was re-evaluated on day #5 of treatment (6 days after the accident). The re-evaluation showed left upper and lower extremity strength returned to normal, except the left foot and shoulder which still showed a strength of 4.5/5. There were minor neurological residual deficits, but no sensory deficits. His gait was much improved. On the 7th day of treatment, after continuing with pool-physiotherapy, he was discharged. The strength deficit of 4.5/5 in the left upper and lower extremity continued, along with some coordination and fine movement deficits, but this was expected to improve with physiotherapy. He was cleared to fly home after a further waiting period of 7 days. Continued physiotherapy and a neurology consult were his discharge orders, along with no diving for 90 days, and being cleared to dive by a dive medicine doctor before doing so. Contributing factors to this dive accident were poor buoyancy control, rapid ascent and dehydration, according the treating physician.

Final note: This case is a great example of the treatment success that can be achieved even in a remote, basic recompression chamber, with well-trained staff working as a team. This was a severe case of DCI, with a significant delay in treatment, and yet the patient rapidly recovered during recompression and was discharged with the expectation of a full recovery.

Planning for the Future- The DAN Recompression Chamber Assistance Program

JOEL DOVENBARGER

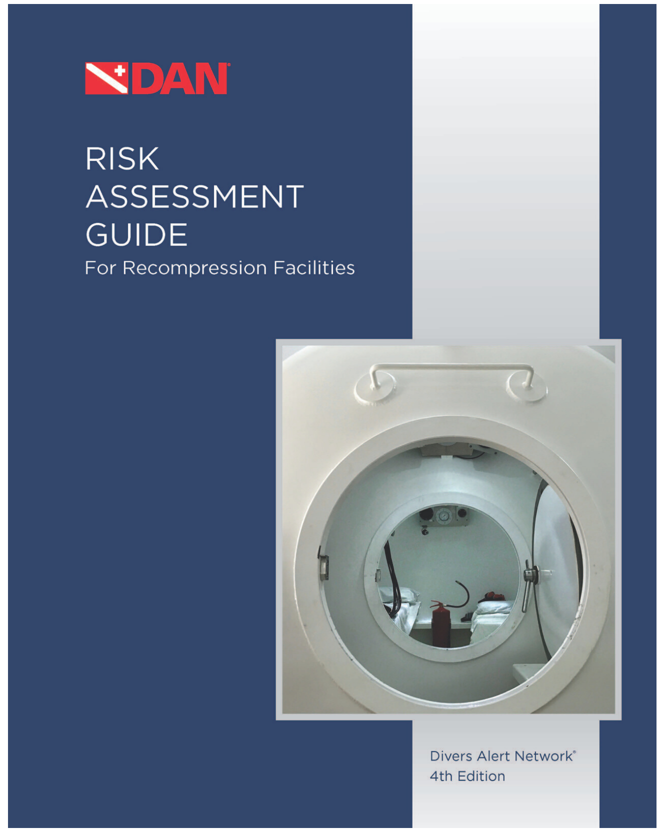
Roughly 32 years ago, DAN began a chamber program to reach out to hyperbaric chambers treating recreational scuba divers in the Caribbean and South America. At the time, there were less than 20 chambers regularly available to treat. Decompression sickness still occurs, and it still requires a working chamber. Unfortunately, many divers required transport to another location or to the US in order to have definitive care. This of course could delay treatment for a day or longer.

Seeing the problem, DAN took up the challenge to help local treatment facilities. First it was with chamber parts and gauges, oxygen units, visits and educational conferences for medical personnel and chamber operators. This was free to all attendees via the DAN program. This helped standardize protocols and procedures for the injured diver. DAN had help with the program. DAN members who believed in the value of emergency chamber care donated directly to the program. International educational seminars were hosted by DAN at Miami's Mercy Hospital and with direct support from Marc Kaiser of the hyperbaric unit at the hospital.

At about the same time, DAN Southern Africa was also working along the same line of thought. The program increased its output and services and became a worldwide effort for recreational divers everywhere to receive proper treatment and at available chambers.

DAN then took the educational seminars directly to each participating site. Not only for the operator, nurses and doctors, but for the local volunteer scuba instructors and divemasters who knew what an operating chamber could mean for an injured diver. The value to the health of their divers and local tourism was well understood. It wasn't just DAN members who could be treated. The local chambers treated everyone who needed the chamber. A singular advantage of a partnership with DAN and the recompression assistance program was that no matter who was being treated, no matter what time of day, they could pick up the phone and call DAN for assistance.

A trained hyperbaric physician was always available to advise them. It cost the island providers nothing. That cost was already covered by DAN members.



The chamber assistance relationship between DAN America and DAN Southern Africa remains the longest serving worldwide assistance program for chamber and ultimately the active recreational diver.

When the RCAP first began there were almost 200 chambers in the US willing to treat recreational divers and roughly 20 Caribbean chambers on a day to day basis. There are now almost 40 chambers in the Caribbean with trained personnel consistently available each day. Not all are the same, but almost all can treat divers appropriately.

Who could have known that by 2020, the 200 US based chambers for divers would shrink to less than 100 today? Of those, only 2 dozen or so are available on a 24-hour basis.

DAN didn't really know, but they knew there was an unmet need that required a solution. So, was the program beneficial for the future of diver travel? The answer must be yes. DAN was right to try to fix the issue before it became a problem, and when the problem came, the chambers were ready. We have to say "Thank You" for the support of dedicated DAN members who saw the need and kept RCAP running for everyone's benefit.

> *"A singular advantage of the partnership with DAN and the recompression chamber assistance program was that no matter who was being treated, no matter what time of day, they could pick up the phone and call DAN for assistance."*

Experiences in Selling, Installing, and Maintaining Recompression Chambers in Remote Areas

JAN LAGROUW
SUPPLEMENTED BY FRANCOIS BURMAN

Recompression chambers (RCCs) are often located in some of the really remote recreational diving regions across the globe. Based on significant experience in supplying and supporting such chambers, we would like to share what we have found works in these locations. The most important step is to start off with a proper feasibility study to ensure that all aspects of the project are understood, before any work in procuring a chamber is considered. This will put any future facility owner in a much better position to ensure long-term sustainability and avoid the many pitfalls suffered by others.

This following discussion is based on a typical twin-lock, multiple occupancy chamber facility.

Summary of factors to consider during initial planning. (You can find the full article with details on each aspect here)

1. Location of the RCC
   - The average weight of the typical RCC used in these locations (say diameter 60 inch) is approximately 4,000 – 5,000 kg (8,900 – 11,000 lbs). It is most likely the heaviest piece of equipment at the diving resort.
   - Special consideration needs to be made to move the chamber into the facility building.
2. Chamber room
   - The RCC room/housing needs an opening large enough to accommodate the chamber, be clean (dust and sand-free) and the floor should have a payload sufficient for the chamber during hydro-testing.
   - Other considerations include:
     - air-conditioning, lighting, clean and safe electrical power, and importantly, sufficient access around the chamber.
     - area for private examination, storage and change-room facilities.
3. Gas supply systems for the RCC
   - Compressed air, oxygen and in some cases mixed gases, such as heliox, will be required
   - Supply systems need to be selected based on practicality, such as available power, access to medical oxygen and other gases, and the ability to store gases in the event of any emergency situations. These should be sized to accommodate periods were supplies might be interrupted.
4. RCC requirements
   - The primary purpose of most RCC's in remote areas is the treatment of injured recreational and professional divers (instructors, dive leaders, and perhaps, local divers such as fishermen.)
   - The RCC should be kept simple so that maintenance, training and operational complexities are kept to a minimum. This facilitates training in emergency procedures, which require significant competence.
5. Shipping and customs considerations
   - RCCs and associated equipment are generally not a shipping challenge. It is the handling once at the main seaport that presents some challenges.
   - Marine and then delivery and installation insurance are essential items to consider.
   - Import duties, import licenses and customs procedures vary from country to country, and in some places, even region to region. Assistance from a local customs' clearing agent is essential to ensure that there is no undue delay in releasing the equipment.
6. Training
   - Thorough and recognized training is essential to providing effective and safe treatments, as well as keeping the chamber running at all times.
   - The attending medical physician will be taking responsibility for the entire treatment process, and apart from having appropriate diving medicine training themselves, they will need to have confidence in the abilities of their staff.
   - Training should include theory and hands-on aspects, include examination and skills-testing, and be fully documented.
   - Regular skills updates are also required.
7. Maintenance and on-going support
   - The RCC facility management will need to decide, prior to any contract being signed, how to manage maintenance. The options are whether to perform all maintenance in-house, whether to perform only selected maintenance (say on compressors and first line RCC systems) and have a support company perform periodic second-line maintenance, or whether to contract all maintenance out to a suitable specialist company – such as the manufacturer.
   - Essential spares will need to be on-hand – as supply routes are usually complex and often delayed. The manufacturer should train sufficient staff to be able to make such repairs.

The desire to install a recompression chamber is often the result of projections of diving accidents, the lack of rapid access to the closest chamber, or other motives such as prestige or even altruism. This is a decision that should be carefully considered if it is to be sustainable and not turn out to be a major drain on funding.

The attached document will give the reader much greater insight into the details making up each step of the process. The message here is: learn from the mistakes of others; here is your chance!

To Drill or Not To Drill... That's The Question

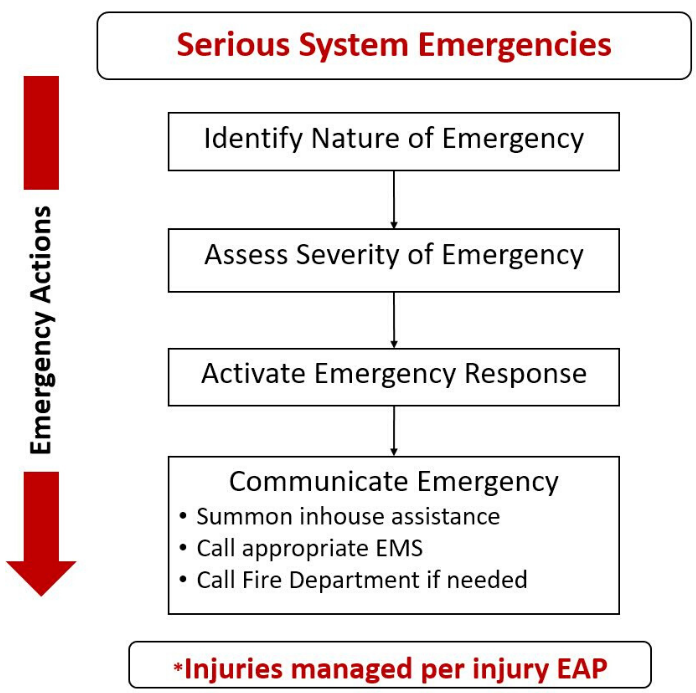
GUY THOMAS

In Francois Burman's article, published in our last newsletter, you could read about the need and advantages of Emergency Action Plans. This time we will look at one specific part of Emergency Planning and why it is important.

Chamber emergencies, such as fire or loss of pressure during treatments, are fortunately uncommon. By applying the appropriate risk mitigation actions, we reduce the possibility of such emergencies happening in the first place. This obviously is an ideal situation, but there is another risk that we might not consider and especially because emergencies hardly ever happen.

The risk with tasks that are almost never done is that you are not confident or fluent when doing them. This is normal, but when you are in an emergency this is exactly what you don't want to happen. In an emergency every second counts and your actions need to be fast and without hesitation or thinking about what needs to be done next. At that moment it is too late to read a manual or look where a certain valve was located.

So, how do we achieve efficiency and competence when tasks are hardly ever used? Here is where emergency drills and simulations play an important role. As with any kind of Emergency Action Plans, chamber emergencies need to be practiced periodically if you want staff members to react fast, correct, and without creating confusion. The only way to achieve this is by regularly organizing drills. In some remote locations there also is a frequent change in staff, which increases the need for these drills even more.




GEAS report, Cadaques 06-30, 2017

It might sound strange but doing simulations isn't only about staff preparedness, but it also is the perfect moment to check if your plan is effective and all needed materials work properly. Many chambers have, for example, a sprinkler in the chamber…but how many actually test the sprinkler installation? So, why not test it during an emergency drill or simulation. And that dump valve... can you easily get to it... How much time is needed?

You could also practice a generic fire alarm, such as a fire in the building or room and you need to interrupt treatment and evacuate staff and patients. Let's actually do it. Have your staff use the fire or emergency exit doors and check if they are easily accessible. Have your staff wear the smoke hood or fire protection materials. See if you encounter problems, while performing under pressure. Look for ways to improve, which also includes thinking about a plan B or adjust existing plans and redo the exercise when needed or when you made changes to the original plan. Emergency simulations are a perfect learning opportunity and will surely boost your confidence, but will also make it possible to improve your risk mitigation actions and become a safer facility.

As mentioned before, especially in remote locations, there could be a big staff turnover. Some of them might have worked in another chamber, but sometimes they haven't. Note, however, that emergency drills and simulations are not a replacement for proper training. They only enhance and rehearse what is learned before. This brings us to another part of risk mitigation; staff training. This deserves a separate article, but it is appropriate to mention now already that staff should be trained for the chamber they are using, and not take for granted that former training, if any, is sufficient.

Training should include the staff reactions to emergencies and after initial training, emergency drills and simulations will keep their level of training and preparedness high.

So, the answer to the question "to drill or not to drill?" is to drill. But in an appropriate way and periodically. Those few minutes of emergency simulations might come handy one day!

FREQUENTLY ASKED QUESTIONS

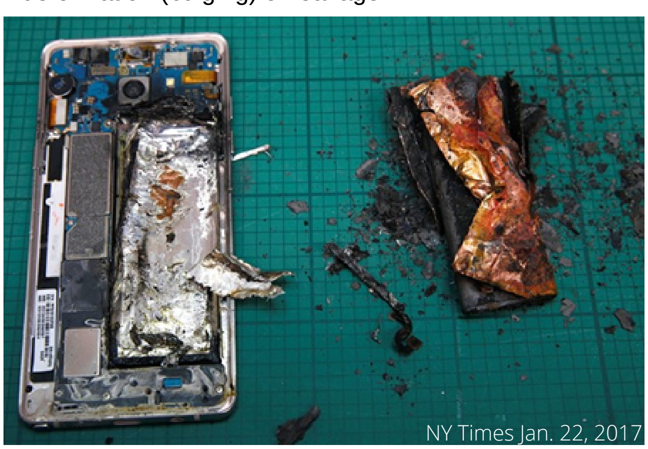
Q:Is it safe to use a lithium ion battery powered device inside the hyperbaric chamber?

A: Li-ion batteries have become the standard for most battery powered devices. In a hyperbaric chamber, we might find them in a diving light for emergencies, an otoscope, or internal analyzer units, but mostly in patient-support medical equipment, including implantable devices glucometer sensor units and pain pumps.

While we all hear the stories of Li-ion battery fires, the truth is that these are almost all as a result of either recharging issues or mechanical damage. We have not yet heard of an implantable device (such as a pacemaker) burning or exploding.

The biggest risk occurs during recharging and for this reason, one should never recharge any batteries inside the chamber. The best advice is to limit the use of any batteries inside the chamber, but where you need to use them, then consider the following additional recommendations:

- only use original equipment battery chargers for charging batteries (outside the chamber) and only use the manufacturers specific batteries: care is taken by the device manufacturer to manage recharging loads and to optimize the charge levels in the battery.
- do not leave batteries on charge overnight, for extended periods or when unattended, and do not keep Li-ion batteries at full charge levels unless you know you will need them.
- inspect Li-ion batteries regularly for any sides of damage, deformation (bulging) or leakage.



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- never tamper with parts of the battery, especially not the casing
- ensure that the battery leads, contacts and housings are always secure.
- develop, implement and practice an emergency action plan for any form of Li-ion battery fire: water will not extinguish a Li-ion fire; these fires will need foam, carbon dioxide or dry chemical extinguishers to extinguish them, so the best course of action is to lock the device out immediately you detect any abnormal heat, smoke, smell or suspected failure, but most of all...
- never take high energy devices (those that consume more power) into the chamber, such as cell phones, iPads, laptop computers or personal medical devices that use rechargeable li-ion batteries.

Disposable coin-size batteries are not regarded as unsafe, but where possible, these should be checked before each treatment, to ensure there has been no damage and that the batteries are secure. You may wish to read the full article “Use of Lithium-Ion Batteries in Hyperbaric Chambers”, either for free or for a 1 hour CHT or nurse CE credit, on the International ATMO site: https://learn.hyperbaricmedicine.com/activities/use-of-li-ion-batteries-in-hyperbaric-chambers-1-0-hour/

Finally, please feel free to reach out to the RCN team if you have questions such as what devices might be acceptable, or how to mitigate the risk if a high-energy device is required inside the chamber.

About The Authors

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Ariane is a CHT and technical dive instructor on Providenciales in Turks and Caicos Islands and works as safety, technical and operational technician at the Menzies recompression chamber facility. She has received extensive training in recompression chamber safety as well as technical aspects associated with chamber facilities. Ariane is one of the DAN RCAP scholarship beneficiaries.

Francois Burman

Francois is a registered professional engineer and Director of Underwater and Hyperbaric Safety at Divers Alert Network, based in Durham, NC (USA). He is the author of the Risk Assessment Guide for Recompression Chambers, first published in 2001, and has performed over 150 on-site recompression chamber safety assessments around the world. He has over 35 years' experience in designing, manufacturing, installing, supporting and providing training in recompression chambers, has been with DAN since 1996 and is very active in supporting recompression chambers, especially through education and training.

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Joel is a registered nurse and diving medicine information specialist. Although now retired, he was the Vice President of Medical Services at Divers Alert Network based in Durham, NC (USA). He was one of the very first dive emergency medical information specialists taking calls back in the 1980's; he was also instrumental in the founding and development of the DAN RCAP initiative.

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Chiara is a medical doctor with diving medicine specialist training. She is the Training Medical Supervisor of the DAN Europe Training Department and Assistant Medical Director at DAN Europe, based in Roseto, Italy. She manages diving medical emergency cases, engaging with medical professionals and recompression chambers, and provides specialist care to injured divers.

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Jan was the founder and managing director of Hytech (now Royal-IHC Hytech), a hyperbaric chamber and equipment manufacturer based in the Netherlands. His extensive experience includes manufacturing, installing, maintaining and supporting recompression chambers in many of the remote diving locations. He now works as a consultant and remains active in this field.

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Marta is a Case Manager for DAN Europe. A passionate diver, she has assisted DAN Europe members with diving medical emergencies for more than 7 years. Marta interfaces with regional diving medical doctors, coordinates emergency evacuations and admission to healthcare facilities, provides support to the DAN Europe emergency hotline.

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Guy is the Director of Diving Safety at Divers Alert Network based out of Roseto, Italy. He is an active EMT and rescue diver with the Italian Red Cross, and operates a rescue swimmer on a SAR helicopter for the Italian State Police. His extensive experience includes being a long-standing dive instructor, being in charge of DAN first aid training in Europe, has conducted recompression chamber safety assessments and currently manages safety programs.

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