Davis Hyperbaric Laboratory

USAF HYPERBARIC NEWSLETTER

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CHAIRMAN'S CORNER

PILLARS UNDER PRESSURE:
Supporting the Parthenon With Hyperbaric Medicine

I recently returned from the Clinical Systems Program Assessment Review 6-7 Dec 96. The program was outstanding and enlightening. Lt General Roadman presented his thoughts and vision of the USAF Medical Service characterized by the Parthenon. The foundation consists of strategy, tactics, administration, logistics, professionalism and facilities. General Roadman made it very clear that strategy is the job of the Air Staff and that he is responsible for it. It is our job to take that strategy and develop tactics to support it. We further mold the foundation through the administration of our programs, logistics and facilities or physical plant. The cement is our professionalism that should bind all of the other foundation components.

The four pillars consist of 1) re-engineering medical readiness; 2) deploying Tricare; 3) rightsizing; and 4) building healthy communities. The pinnacle is customer satisfaction and will occur when the foundation and pillars are intact. All components of the USAF Health Service should contribute to the pillars. The USAF Clinical Hyperbaric Medicine Program (HBO) does just that.

Medical Readiness: The traditional readiness mission of the clinical hyperbaric units has been to treat battlefield casualties evacuated to CONUS. During Desert Shield, all units had operational plans to surge to up to three treatment sessions per day plus the capability to respond to emergency care. Indeed, supplemental personnel are required for full surge capability. Also during this time, the concept of true forward deployment of hyperbaric oxygen therapy was considered via placing hyperbaric units on Navy hospital ships and the forward deployment of small multiplace chambers to associated aeromedical staging facilities. The reinvention of building a concrete chamber (originally that of former USAF Surgeon General Schafer) from locally procured materials surfaced. Currently, the reinforced concrete chamber is a reality and awaiting final mechanical engineering code approval as well as a portable chamber that can be bolted together. A tri-service effort to study lightweight, portable hyperbaric chambers is pending. The addition of a hyperbaric specialty team unit tasking code (UTC) at each clinical facility is a viable goal.

Proposed medical readiness response calls for establishing aeromedical hubs where patients will be brought in on tactical aeromedical missions and stabilized by deployed surgical and intensive care teams. Patients will stay from two to five days. Patients who can benefit from hyperbaric oxygen can be triaged and treated where it will be the most effective. The proposed hyperbaric UTC will consist of a physician, nurse, physiologist, medical technician, and physiology technician. The team can be consulted for all non-self aid/buddy care level wounds, including post-surgical wounds, regardless of the adjunctive use of hyperbaric oxygen. This will allow the surgical team added surgical time and increase efficiency. Because of the makeup of the HBO UTC, the package will augment the current proposal. The physician will always have flight surgeon training and in most cases be residency trained in Aerospace Medicine. She or he can serve as an additional consultant on preventive measures and public health issues. The physiologist and physiology technician will serve as augmentees to the deployed physiology team described in the physiology reengineering proposal. Both the nurse and medical technician have critical care expertise, invaluable as consultants for the intensive care team.

Deploying Tricare: Hyperbaric medicine is a referral service similar to other specialties. As such, we are integrated into managed care and the Tricare system in a similar fashion. With each unit associated with a major medical health facility they should be considered a referral center for their respective Tricare region. Regardless, when considering the local Tricare base population and surrounding community capabilities, each facility offers competitive value for hyperbaric oxygen therapy.

Rightsizing: Battlestations II on 20 Nov 96 delineated the formula for determining our overall manning requirements called Total Operational Readiness Requirement (TORR). From a hyperbaric perspective it could not be named better. It is based on the wartime baseline determined by the 733 Study and wartime adjustment intersected with day-to-day operational requirements. These two factors equal the Operational Readiness Requirement (ORR). Finally, training and GME resources are added to the ORR to obtain the TORR. Each clinical hyperbaric facility has merely been manned for optimal operations, although manpower studies have shown additional authorizations necessary. These have been for day-to-day operations with the traditional readiness mission requirements occupying 100% of the present operational requirements. The addition of a deployable UTC package will directly impact the CONUS wartime mission capability. MIRROR FORCE offers a unique solution. There are presently no backfill positions for any hyperbaric medicine personnel. The IMA program is an ideal vehicle in which to satisfy the goals of MIRROR FORCE. Our goal is to have an IMA at each facility for every UTC team member to serve as backfill requirements. This will involve an education and training investment, but will pay dividends during war and peace operations. Maj Kemper is the POC.

Building Healthy Communities: Prevention is classified into three major areas: primary, secondary, and tertiary prevention. Primary prevention is the management of behavior and risk factors to decrease the incidence of disease. Secondary prevention is the early diagnosis and treatment of disease to prevent significant sequelae. Tertiary prevention is the management of symptoms or consequences of disease to minimize impact on function or quality of life. Hyperbaric medicine is active in all three. For example, we work closely with research units defining prebreathing profiles to prevent DCS. We also consult on extended treatment tables to prevent inside observers from becoming treatment casualties. The best example of secondary prevention is treatment of previously irradiated tissues prior to surgery in order to prevent wound breakdown, delayed healing, and subsequent surgery and hospital days. A tertiary prevention example is diabetic wound treatments. The landmark article by Cianci demonstrates $90K cost avoidance due to decreased amputation, hospital stays, and rehabilitation. The patient quality of life costs are immeasurable. A recent study by this office demonstrated that taking half of the cost avoidance ($45K) as a base will equate to $1.2M saved in DOD costs by a treatment series for only seven diabetic foot wound patients. This should put a new perspective on any unit's O&M budget versus cost outlays by DOD.

Research is another "foundation" area in my opinion as it in itself supports all four pillars. Since the Scientific Advisory Board in 1993, we have established work in the cellular/biochemical aspects of hyperbaric oxygen. The concrete chamber technology is near completion and the military/university collaboration program has reaped essential data for hyperbaric oxygen use particularly in the reperfusion injury arena. Patient research has added hyperbaric oxygen as an adjunctive therapy in intracranial abscess and current studies include its use in radiation proctitis and myocardial infarction. Since August 1996, we have joined forces with the US Navy in pending approval for a hyperbaric litter evaluation (deployable chambers) and the US Army with protocols pending on phosgene and trauma research.

In summary, the hyperbaric medicine program encompasses all of the major components of the "parthenon" advocated by the USAF Surgeon General. I encourage you all to share this information throughout your unit, facilities, and community.

E. George Wolf, Col, USAF, MC, CFS
Chief, Hyperbaric Medicine Division

Colonel Wolf brings an extensive operational history to the Davis Hyperbaric Laboratory. This has included Shuttle operations at Patrick AFB (Chief, Aerospace Medicine), flight/occupational medicine at Osan AB in Korea (Chief, Aerospace Medicine), and B-52 operations at Barksdale AFB (Squadron Commander).

Colonel Wolf is a “Bama” graduate having received his BS in Chemistry and his MD from the University of Alabama. In addition, he is a graduate from the Residency in Aerospace Medicine having studied at both Wright State University and USAFSAM. Since then, he has also obtained Master of Science degrees in Computer Resource Management and Health Care Management.

This academic and operational background will well serve Brooks AFB and USAF Hyperbarics. We all welcome Colonel Wolf to his new responsibilities.

WPB

RESEARCH & DEVELOPMENT

BASIC SCIENCE RESEARCH LABORATORY

The Research Branch of Davis Hyperbaric Laboratory (DHL) is expanding its basic science investigations. The research objective is to understand the interaction between elevated oxygen concentrations and increased ambient pressure (hyperbaric) on the structure and function of cells. Of particular interest is the influences of hyperbaric oxygen (HBO) on leukocyte differentiation with its associated expression and activation of “clusters of differentiation.” In addition, the role of HBO in fibroblast activation is being explored. And, finally, the ability of HBO to activate intracellular enzymes associated with healing, immune function, and xenobiotic metabolism is being investigated.

Laboratory techniques that make this research possible include cell/tissue culture, flow cytometry, confocal microscopy, polymerase chain reaction, chromatography, and electrophoresis. Specialized equipment is necessary for this important work. An FACS Caliber Flow Cytometer allows the rapid classification of thousands of cells looking at specific structural and functional characteristics. The Zeiss Confocal Microscope provides a way of examining individual cellular changes. In addition, high performance liquid chromatography can separate and quantify a variety of chemicals including proteins. A spectrophotometer and spectrofluorometer round out this impressive array of tools. They can be used for enzyme linked immunoassays (ELISA) and other chromogenic or fluorogenic assays.

Needless to say this laboratory's capabilities have not gone unnoticed. In fact, an historical Cooperative Research and Development Agreement (CRADA) was recently signed by Dr. Brendan Godfrey (Director, Armstrong Laboratory) and Dr. Martin Goland (CEO, Southwest Research Institute). This CRADA promises a long and productive collaborative future. Another recent collaboration with the Texas Center for Infectious Diseases has resulted in a joint project examining the therapeutic efficacy of HBO against pulmonary *Coccidiomycosis imitis* using the rat model. Furthermore, early discussions suggest a future relationship between the Army's Institute of Surgical Research (Burn Unit) and Davis Hyperbaric Laboratory.

Spearheading much of this research are two new civilian additions to the DHL. Dr. John Kalns, who received his Ph.D. in Pharmaceutics from Oregon State University, has been very interested in anticancer drug research. In fact, his initial work upon arrival focused on HBO and chemotherapy synergy using prostate cancer cell lines. Although he found no synergy of action, he did note a serendipitous anticancer action of HBO in one particular prostate cancer cell line. Further investigation is ongoing.

Joining Dr. Kalns is the familiar Dr. Edward Piepmeier. Dr. Piepmeier also comes from Oregon State University where he, too, earned his Ph.D. in Pharmaceutics. Recently, he joined the faculty of the University of Texas at Austin as an Assistant Professor. He has been interested in cellular activity under environmental stress since his first appointment at the University of South Carolina in 1991. His experimental work has included cell response not only in the HBO environment, but also, in microgravity aboard Shuttle flights. After four summers of research, he joins DHL full time.

The wealth of expertise represented by these researchers promise a very productive future for the basic science laboratory.

WPB

CONCRETE HYPERBARIC CHAMBER

The USAF and Engineered Medical Systems, Inc. of San Antonio have joined forces constructing the first post-tensioned concrete rectangular hyperbaric chamber. First suggested in a USAF technical report (late 1970's), it was not until 1987 that a formal feasibility study examined and supported this technology.

The prototype chamber, 20 feet wide by 30 feet long by 16 feet high, has been constructed at the Davis Hyperbaric Laboratory. This project was funded by the USAF via a Small Business Innovative Research Project. According to W.T. Workman of Engineered Medical Systems, the primary research objectives were to verify a cost reduction in chamber construction (compared to the traditional welded metal cylinder), to demonstrate the rationale of a spacious rectangular room (instead of horizontal cylinders with limited height clearance), to reduce patient apprehension and enhance patient comfort, and to expand critical care treatment opportunities.

Unique design features include an 18 inch by 48-inch rectangular window, 4 foot by 7 foot rolling doors fabricated for use by the 95th percentile female, an 18-inch square service lock. Additionally, the structure itself can be free-standing. It does not need to be "housed."

On 8 October 1996, all testing was completed on this chamber. Designed as a 3 ATA pressure vessel, the prototype surpassed all test objectives. According to Engineered Medical Systems, the chamber was successfully stress-tested to 2.9 times its design pressure of 3 ATA, reaching a maximum pressurization of 85 psi (6.8 ATA). Though cracking occurred (a test objective), it was superficial and did not result in a structural failure. Fatigue testing was completed after conducting over 25,000 pressure cycles. This testing verified that rectangular concrete hyperbaric rooms are feasible and cost effective (30% the cost of a comparable welded metal structure), structural strength is adequate (with a safety factor of 2.9), and at 6.8 ATA a 3 ATA rated concrete chamber will not catastrophically fail.

To date, reaction to this innovation in hyperbaric facility design has been extremely positive. Presentations on the technology have been given throughout this country, Argentina, and Europe---all with enthusiastic response. In March 1996, an international group of hyperbaric medicine experts met to establish design considerations for hyperbaric treatment systems for the year 2000 and beyond. One of their conclusions was to

"Consider constructing the chamber from less expensive materials such as concrete…"

Furthermore, the San Antonio Chapter of the American Concrete Institute presented its 1996 Outstanding Concrete Excellence Award recognizing this new application of concrete technology.

It is clear that the door is only beginning to open for applications of this "new" concept. Once standards have been defined by the ASME/PVHO, concrete chamber construction will certainly begin. Perhaps 20 years from now it will be as unusual to see clinical dive chambers as it is now to see clinical concrete chambers.

WT Workman
WP Butler

CLINICAL HYPERBARICS

DRIVING A CAR: A DCS ETIOLOGY?

Often the question of altitude exposure following scuba diving arises. This topic is the "flying after diving" scenario that is found in both the medical and lay literature. However, this topic also includes a more subtle scenario---one that is commonly posed by aircrew and infrequently addressed in the literature. How do you handle scuba divers who must cross a mountain pass to get home? Let's face it, there is no textbook answer.

First off, there are at least twenty-nine different published recommendations dealing with the *classic* "flying after diving" problem. This fact, in and of itself, reveals the lack of uniform opinion. The Divers' Alert Network (DAN) guideline for a single no-decompression stop dive is a 12 hour preflight Surface Interval (SI). For a decompression stop dive, repetitive diving, or multiday diving the SI should be >12 hours. The National Oceanic and Atmospheric Administration (NOAA) has a somewhat different approach: the "Group D rule". Prior to flying at a cabin altitude of 8000 feet (the usual commercial cabin pressure) the diver's SI should be of sufficient length to insure at least Repetitive Group Designation D. The USN guideline for a single no-decompression stop dive is a 2 hour SI; however, for decompression stop, repetitive, or multiday dives the SI should be 12 hours. The USAF guideline prohibits flying for 24 hours after any dive and recommends a 48 hour SI for decompression stop dives (AFI 11-401, 7.9.4 and AFI 11-403, 7.3).

Shedding some light on this situation is the "flying after diving" data presented at the 1996 UHMS Annual Meeting by the Duke University group headed by Dr. R.D. Vann. Using a standard dive profile----single dive = 60 ft/55 min; two dives = 60 ft/55 min--60 min SI--60 ft/20 min; three dives = 60 ft/55 min--60 min SI--60 ft/20 min--60 min SI--60 ft/20 min.----in conjunction with a 4 hour flight to 8000 feet, the variable of interest, preflight SI, could be carefully examined. With a preflight SI of 10 hours or more there was no DCS after a single dive. And, with a preflight SI of 16 hours or more there was no DCS after two or three dives. These results support those advocates of the 12 hour preflight SI for single, no-decompression stop dives and 24 hour preflight SI for repetitive dives.

Next, there are a number of "factoids" to factor into the equation. The USN Diving Tables were empirically designed to *accept* a <2% risk of DCS with no-decompression stop diving; however, with decompression stop diving there is a <5% risk of DCS. Generally speaking, this DCS consists of *minor* symptoms such as skin rashes or joint pains. It must be remembered that skin rashes (not *cutis marmorata*: mottling/marbling) may progress to Type II DCS with a 10% incidence and joint pains may progress to Type II DCS with a 30% incidence. The usual commercial cabin altitude is 8000 feet or 565 torr (mmHg). This amounts to about a 25% decrement in ambient pressure. As a result, any bubble would be expected to increase its volume by about 25% (Boyle's Law). And finally, the repetitive dive grouping can be modified with oxygen-breathing using NOAA data (incorporating the "Group D" rule).

Repetitive Dive Group	O2 Time Before Flying
Groups A - D	0:00
Groups E - G	0:30
Groups H - L	1:00
Groups M - Z	1:30

This also provides the opportunity to encourage all divers to have oxygen available should a decompression injury occur.

At this point, let's return to the question of a mountain pass crossing after diving. Is DCS simply a theoretical possibility or can it really happen? It is a reality and has been reported (by Sheffield and Cramer): A 25-year old male made a dive to 185 feet with a total bottom time of 25 minutes. He underwent an incremental ascent first to 160 feet then 120 feet for a total decompression time of 15 minutes. On his way home, he drove over a 4000 foot mountain pass (656 torr=14% pressure decrement). He developed a headache. Later that evening he developed joint pain (fingers, wrists, elbows, shoulders, and ankles) and dizziness. Neurologic exam was normal. Experiencing no improvement on 100% oxygen, he was transferred to a hyperbaric facility where he was successfully treated with a USN Treatment Table 5 (TT5).

It is clear that this diver exceeded sport diver recommendations: his depth exceeded 100 feet, his decompression time was woefully short, and he did not use standard decompression stops. However, he did not experience symptoms until altitude exposure---driving a mountain pass. Of note, he responded well to TT5. The authors are quick to point out that today the standard treatment would be a TT6.

Since this is no longer a theoretical discussion, how do you address this question when posed by aircrew?

1. Sport diving aircrew should not engage in decompression stop diving. Even when following the tables, there is a significant built-in risk of DCS (<5%). With a drop in ambient pressure, this risk increases further. An acceptable risk may well become an unacceptable risk. And, there is no guarantee that a serious neurological Type II DCS will not occur (a potential career threatening problem). If decompression stop diving is performed AFI 11-403 clearly "recommends **48 hours** elapse prior to aerial flight or altitude chamber exposure". This recommendation could logically be expanded to include mountain passes and/or elevated home bases.

2. Generally speaking, most sport divers do not limit themselves to one dive. Air crew are no different; thus, repetitive diving is probably the norm. Staying within the no-decompression tables, the risk of DCS seems acceptable (<2%). However, most sport divers will admit to *pushing the tables* on occasion. In light of Dr. Vann's data, divers should wait at least 16 hours prior to a 4 hour flight to 8000 feet. To be safe, rounding that delay (preflight SI) to 24 hours seems prudent. In fact, AFI 11-401 clearly states that "Aircrew members <u>will not fly</u> within **24 hours** of compressed gas diving (including scuba)..." Again this requirement could logically be expanded to include mountain passes and/or elevated home bases.

3. "Gee doc, it's only a half-hour drive over the mountains! It's not really flying, you know." This statement or some variation is almost a certainty. With certainty, there is no absolute answer to this implied question. Granted, there is less altitude and a lesser duration of exposure with a mountain pass (as opposed to flying), but there is a definite risk.

Concluding:

*****With decompression stop diving it is reasonable to recommend no altitude exposure for at least 48 hours.

*****With deep, multiple dives it is reasonable to recommend no altitude exposure for at least 24 hours.

*****With shallow, multiple dives it is reasonable to recommend at least a 16 hour wait.

*****With a single dive it is reasonable to recommend at least a 10 hour wait or the "Group D Rule" using Repetitive Group C as an extra safety measure (perhaps even supplementing with oxygen).

This is definitely a conservative approach to the problem; however, why risk a potential career threatening neurological DCS? Most dive sites are at or near "fun" places. Aircrew can plan their diving as they plan their flying---including "crew rest"!!!

Lt Col William P. Butler
Director, Hyperbaric Medicine Fellowship

A NEW INDICATION FOR HBO

In late 1996 the much awaited **Hyperbaric Oxygen Therapy: A Committee Report** of the UHMS was released. This report essentially reviews the world's literature with regard to hyperbaric diagnosis and treatment. The final outcome lists the maladies and "bare bones" reasoning underlying the diagnoses approved for HBO treatment. For the first time in a number of years a new diagnosis has been included.

This diagnosis is *intracranial abscess* (ICA). This term includes cerebral abscess, subdural empyema, and epidural empyema. In reviewing the literature results from numerous countries were tabulated. Current mortality is about 17%. This frightening percentage is expected to drop with more extensive use of diagnostic CT scanning, therapeutic CT guided aspiration, and improving antibiosis. However, certain ICA conditions warrant special interest---multiple abscesses, deep abscesses, or compromised hosts. Under these circumstances standard measures frequently fail. Nineteen patients have had adjunctive HBO added to their treatment regimen. There was 0% mortality.

Based on this data, it was felt that HBO could be offered to a select group of patients with ICA.

1. multiple abscesses
2. deep or dominant abscesses
3. compromised hosts
4. surgery is contraindicated (i.e., poor risk patient)
5. no response or deterioration despite standard care

It is recommended that HBO be administered at 2.4 ATA for 60 - 90 minutes up to 2 treatments daily. The endpoint is determined by the clinical response and radiologic findings. Presently, the average number of treatments has been 12.

Since there is such a small experience, any such patient should be shared with the Chairman of the UHMS Hyperbaric Oxygen Committee to bolster the database. With appropriate numbers and good results, general acceptance of HBO for ICA can be assured.

WPB

“HOT MI” UPDATE

Drs. Meissner and Warren have recently worked out the details for Travis AFB to join the “Hot MI” Trial. They can now begin adding their patients to this ongoing multicenter study. Earlier this year at an advanced conference on clinical Hyperbaric Medicine, the updated details of this study were presented. The latest data (submitted for publication) on 66 patients revealed the following:

	t-PA only (n=34)	t-PA + HBO (n=32)
age	59	59
inf. MI	62%	53%
admit CPK	238	210
12 hr CPK	2385*	1552*
24 hr CPK	1635*	1021*
pain relief time	664 min*	275 min*
LVEF at d/c	47%	52%
mortality	2	0

*p < 0.05

An additional 12 patients have been added since the above chart was completed, which has increased the difference in the left ventricular ejection fraction (LVEF) from 5% to 7%. No statistical analysis has yet been done, but the 7% figure is very close to significance (even with the small “n”). It is exciting to think a single HBO treatment in conjunction with t-PA can improve cardiac function significantly.

Colonel Benjamin Slade
Chief, Hyperbaric Medicine
Travis AFB, California

Editor’s Note---Once this multicenter trial is completed, the UHMS HBO Committee may well need to add another indication to its list of thirteen. *wpb*

CASE REPORTS

A 41 year old lady recently certified for recreational scuba diving vacationed in Roatan. While there she decided to do a “bit” of diving. During her week there she made 22 dives---3-5 dives daily. On her fourth day following her third dive she noted subcutaneous air over her anterior chest (crepitus) and left elbow pain. She felt this to be a direct consequence of an emergency ascent. Her computer had registered an empty tank. Within 20 minutes these symptoms disappeared. She made no further dives that day; however, the next day she made 5 dives.

She allowed 25 hours from her final dive and her homeward flight. The flight was 3.5 hours. Unfortunately, an hour into the flight she experienced nausea and vomiting. Shortly thereafter, right shoulder and upper arm pain began. This was accompanied by right facial numbness. There was a progressive deterioration despite landing.

Over the next 24 hours further symptoms appeared: right hip pain, right lateral leg numbness, right facial ache, right hand weakness. There was inappropriate fatigue, a right sided head pressure, and a feeling of mental “slowness.” More ominous was the appearance of right sided chest pain, shortness of breath, and a nonproductive cough.

Despite receiving 100% oxygen on transport from the Emergency Room, her condition worsened. On arrival at DHL, she was rapidly evaluated and treated with a USN Table 6. She rapidly improved with resolution of all symptoms following a single 30 minute oxygen extension at 60 fsw.

Examination post-dive and follow-up the next day were unremarkable. There was complete recovery without sequelae.

DX: 1) pulmonary overpressure incident
2) DCS—Type II
   a. joint
   b. neurologic
   c. “chokes”

Commentary: This woman was an inexperienced diver at best (only 8 logged dives). She made 22 dives over a 6 day vacation. Frequently her initial dive of the day was more shallow than later dives. And, in evaluating her carefully maintained log book, she was found to have accumulated over 400 minutes of missed decompression (235 minutes was her highest tally).

A number of predisposing factors were present: inexperience, utter dependency on her dive computer, repetitive diving (midweek, she did a 6 dive day), multiday diving, ignoring her “transient” dive incident, flying after such a rigorous diving exposure with only 25 hours rest.

This case cries extreme. However, this kind of “power diving” is occurring daily at vacation meccas throughout the world. Hard earned dollars spent on expensive dive vacations seek the greatest return. That means repetitive, multiday diving. This definitely places the diver at increased risk for significant evolved gas. All too often dive computers achieve god-like status. Cognitive function is frequently left at home. As a result, accidents such as this can occur.

It is important to remember that our job must also include the education of recreational divers. Preventing even one potentially life-threatening dive accident is worth the effort.

WPB

LITERATURE REVIEW

A review of the sharpened Rhomberg Test in diving medicine. B. Fitzgerald.
SPUMS 26(3):142-146,1996

Abstract: The use of the sharpened Rhomberg test (SRT) was evaluated in injured divers. Over a 12 month period, thirty five divers presenting with decompression illness (DCI) to the Naval Base in Auckland were assessed before hyperbaric treatment and at discharge. Their scores were compared with those of an age and sex matched control group (n=60). Abnormal SRT's were seen in 49% of divers (n=17) before treatment. These results were significantly improved at discharge ($p<0.001$). The results in injured divers were significantly lower than controls at presentation ($p<0.001$), but not at discharge. The SRT is consequently considered to be a valuable examination in divers who suffer DCI. It is proposed that the SRT be conducted in a standardized manner and be scored as the best attempt of four.

Commentary: This study clearly demonstrates the utility of a "sharpened" Rhomberg Test. This test has the patient in flatwear on a flat surface standing in tandem position (heel-to-toe). The arms are crossed with palms placed on opposite shoulders. Once stable the eyes are closed. Control data suggested a score of >48 seconds on a single trial is normal (i.e., mean +/- 2 standard deviations); however, the literature is variable including values of 15 seconds and 30 seconds. Divers with DCI were either normal (mean = 57 seconds) or grossly abnormal (mean = 6 seconds). Using this data an abnormal could be considered <22 seconds (i.e., 6 + 2 standard deviations).

Although not examined here, relatively quantitative evaluations could be made with this test. If 60 seconds is attained, the patient scores (60 x 4) 240. If the patient fails at 15 seconds and 30 seconds before attaining the 60 second mark, he/she scores {15 + 30 + (60 x 2)} 165. In this way there is no single result dependency. As is readily imagined, serial exams could be revealing. For example, early discovery of subtle improvements/deteriorations might be possible. Further evaluation of this tool is certainly a must.

WPB

OPERATIONAL HYPERBARICS

PROPER PRE-BREATHING PREVENTS POST PRESSURIZATION PROBLEMS

In hyperbaric operations, nothing is more important, yet causes more confusion, than decompression procedures. When we all received initial training in decompression procedures at USAFSAM/FP (USAFSAM/EDB for us older divers) we were taught three ways of decompressing: linear, curvilinear and staged. As you know, most decompression procedures used today are staged because they allow better control of ascent. Indeed, the staged air decompression tables used at all hyperbaric chambers are familiar to every Air Force diver. However, most treatment tables used by the Air Force use a combination of staged and linear decompression, and this can create confusion when determining decompression requirements.

A standard procedure in using these air decompression tables is to breath oxygen to increase the effectiveness and enhance the safety of the decompression. Of course, there are times when even following proper decompression tables that decompression sickness can occur. The key to proper decompression procedures is to know which tables to use, how to use them, how oxygen comes into play, and ensuring proper decompression procedures and techniques are followed. Two recent events, one here at the Davis Hyperbaric Laboratory (DHL) the other at an operational hyperbaric chamber, demonstrate the importance of ensuring proper decompression procedures are followed and how complex decompression procedures can become unless you are very familiar with all your decompression options, respectively.

The importance of following proper decompression requirements and technique was brought home not long ago when one of DHL's own staff suffered from a frightening case of neurologic decompression sickness. The staff member had been an inside observer on a Treatment Table 6 (TT6) which had been extended because the patient hadn't resolved completely after the first several treatments at 60 FSW. Decompression requirements for an extended Treatment Table 6 require the IO to go on oxygen 45 minutes prior to and during ascent to ground level. The IO went on oxygen at the proper time and the dive concluded with no problems - or so it was thought.

The next morning the IO reported to work complaining of short term memory loss, mood swings and a feeling of being “out of it.” When asked, the IO could not remember anything unusual about the previous night’s dive or having had any problems with the mask or regulator used to perform the decompression. The IO was treated with a TT6 with complete resolution of symptoms, and is now back on dive status. However, when quizzed again about any unusual problems during the previous night’s dive, the IO remembered having had problems getting a good mask fit and seal. The IO reported fiddling with the mask the entire oxygen decompression period. It was concluded that the IO probably did not have an adequate denitrogenation period which allowed the formation of bubbles in the brain.

Now, it must be emphasized that decompression requirements are not all the same. During weekly practice dives air decompression tables are generally used while breathing oxygen, as already mentioned. Remember, a dive to 165 FSW for 10 minutes requires a staged decompression stop at 20 feet for 2 minutes and 10 feet for 5 minutes (Table 7-2 using a 170/10 profile) ON AIR. Breathing oxygen during these periods enhances the safety of the decompression because we offload nitrogen 5 times faster breathing oxygen. This gives us a large decompression safety factor to prevent decompression sickness. However, in extreme dive exposures, such as treatment tables, the use of oxygen is mandatory; there is no margin of safety. You must breath oxygen because it is absolutely necessary to offload nitrogen 5 times faster if you want to ascend with the patient. Failure to acquire a proper mask fit and seal prevents adequate nitrogen elimination. The moral of this story is: 1) If a treatment table says the IO must be on oxygen, make sure the IO gets on, stays on and breaths only oxygen. 2) Prior to the dive the IO should be measured and fitted with a proper mask. 3) Perform thorough scheduled and pre-dive mask and regulator inspections to ensure proper operation.

Another recent case demonstrates how complicated decompression problems can become. Let’s pretend you, the reader, are the physiology consultant for this case. You are sitting in your office working on your resume when you receive a call from a hyperbaric unit which is treating a carbon monoxide patient. Unfortunately, things didn’t go too well on this dive and they need your help. Because of frequent ear blocks it took around 45 minutes to reach the prescribed treatment depth of 66 FSW (if you think that’s long, DHL once had a case that took 62 minutes to reach bottom on a CO case). When you get called the chamber is at 33 FSW and already 20 minutes into the first patient oxygen breathing at this depth. The flight surgeon covering this dive asks if this is a problem for the patient. What do you tell him? What do you recommend?

Is this a problem for the patient? Absolutely not. Once the chamber reaches the prescribed treatment pressure the patient is on oxygen for most of the dive. He or she has not only been washing out that nasty CO during this time, but also that nasty N_2. The patient will be fine.

The IO, on the other hand, has the problem. He has been sitting at depth soaking up nitrogen, which he has to get rid of before ascent.

Now remember, the CO table is not like other tables, it has a few quirks that you have to remember. The main quirk is that total bottom time (TBT) is measured from the time leaving 33 FSW, not 66 FSW. When quizzed, the doctor tells you the IO’s current TBT is 113 minutes. Normally, the CO table requires the IO to go on oxygen the last 25 minutes prior to ascent and for the 10 minute ascent to surface. Is this sufficient? The answer is probably not. Sound confusing?

It’s important to remember that decompression theory is not an exact science. All decompression profiles are based upon theoretical and operational experience, but they are far from perfect. That is why even the best tables can’t guarantee you won’t get DCS.

So, what do you do? Please remember, you have at your disposal that wonder gas oxygen, use it! A quick glance at Table 7-5, the oxygen decompression table in Air Force Manual 161-27, will show you that the very first schedule in the table, 70 feet for 120 minutes, is sufficient to meet the IO’s decompression requirement. Reading across the 70/120 row you find a 29 minute oxygen breathing stop at 30 feet. Since you are at 33 feet, which is close enough, simply have the IO go on oxygen immediately. Going on oxygen effectively stops the on-load of nitrogen. The moment the IO starts breathing oxygen his physiological TBT stops, because now he is off-gassing. The actual TBT will still be the moment you leave 33 FSW, which is what should be listed on the paper-work. By going on oxygen immediately you avoid extending the dive and you get a safe decompression.

Make sure the IO has a good mask seal and fit and stays on oxygen. Because we are now using an oxygen decompression schedule there is less room for error. Oxygen can be used to safely decompress an IO up to 66 FSW, but you must pay close attention to CNS and pulmonary oxygen toxicity, especially at 66 FSW. As you get shallower there is less risk of CNS and pulmonary toxicity.

Decompression procedures can be very tricky at times. If you have any problems please remember the staff of the Davis Hyperbaric Laboratory is on call 24 hours a day to answer any hyperbaric questions you may have. Please don’t hesitate to call with any perplexing decompression or other problems. That is why we are here.

In future editions of this news letter I will include other interesting and perplexing cases that occur. As I write this, I'm currently involved in the treatment of a family for CO poisoning. Because two of the members of this family include a 3 year old and a 14 month old it took us 33 minutes to get to depth. This just shows that what may seem to be a rare occurrence may not be. More often than not, life's little decompression lessons turn out to be more important than we think.

Captain Todd Dart
Chief, Operations Branch

A NEW MASK

Since the late 1970's Air Force hyperbaric facilities have been utilizing the Military Breathing Unit (MBU-5/P) aviators' mask with a unique adapter assembly as a way to safely exhaust exhaled breathing gas from inside a high pressure environment. Although the MBU-5/P mask remains available through depot, the modified adapter assembly is not. In order to purchase additional units, the adapter must be re-milled at considerable expense to the Air Force. Recently developed mask technology has evolved new systems which may provide increased comfort and reduced maintenance at less cost.

Early last year the Davis Hyperbaric Laboratory in conjunction with the Gentex Corporation started testing a modified aviators' MBU-20/P derivative oxygen mask (see photo) for its effectiveness and implementation in the hyperbaric environment. The modified MBU-20/P mask is being evaluated by Hyperbaric Technologists at 6.0, 3.0, 2.5, and 2.0 ATA using a pressure demand regulator and pressure transducers. A mass spectrometer determines if the modified mask can physiologically maintain levels of inspired oxygen while also exhausting expired carbon dioxide and other exhaled gases to a lesser ambient pressure.

Preliminary testing has identified the modified MBU-20/P derivative mask as a suitable substitute for implementation at hyperbaric facilities. Testing will be finalized in June 1997. Results will be presented at the Annual Meeting of the Undersea & Hyperbaric Medical Society. If you have questions or comments contact SSgt Massa or Lt Col Penne at DSN 240-3281.

SSgt Thomas Massa
NCOIC, Equipment Development & Support Sections

Editor's Note---Because of his yeoman's work not only with this project, but many others, SSgt Massa was awarded the 1995 AFMC Aerospace Physiology NCO of the Year. His honors did not halt there. Evaluated at the next level, he was also awarded the 1995 Air Force Aerospace Physiology NCO of the Year. *wpb*

CHAMBER WINDOWS

Travis AFB's *News Under Pressure* has reminded all HBO personnel that chamber windows have a 10 year life span. At that time, replacement is necessary. Of interest, each window (at Travis AFB) itself weighs 30 lbs. And, with its supporting ring, weighs 186 lbs.

At Travis AFB, destructive testing by the manufacturer is hoping to garner information allowing extension of the windows' life span. This is an important event for two reasons. First, a longer life span will reduce maintenance costs of removal and installation. Second, each window's replacement cost is about $1000. With 26 windows, that can become a significant savings rapidly.

Remember to avoid hot lamps near these windows and near monoplace shells. The heat can melt the windows "insides" producing bubbles, thus destroying its integrity. In fact, Travis AFB has a beautiful example of this phenomenon on display . Also, remember UV light can weaken the acrylic prematurely by disrupting chemical bonds. By avoiding these potential problems, unnecessary expenses can be minimized and safety can be maximized.

WPB

HYPERBARIC TRAINING AND EDUCATION

LECTURES

Recently, Travis AFB was graced with two exceptional speakers in October 1996. Dr. James Caruso, USN, presented "Forensic Aspects of Scuba Diving and Drowning." Dr. Caruso is currently training in Pathology and Hyperbaric Medicine at Duke University. Also, Dr. Stephen Thom presented "Hyperbaric Oxygen Therapy in CO Poisoning." Dr. Thom is Associate Professor of Emergency Medicine and Chief of Hyperbaric Medicine at University of Pennsylvania. Both delivered excellent presentations. In fact, they were videotaped and are available for viewing. POC is Capt Peters DSN 799-3987.

In addition, DHL has begun videotaping Staff/Fellow Conferences. These CME Category I accredited lectures form a core component of Fellowship training. Our initial experience was Dr. William Butler's presentation, "Long Term Health Effects of Diving." The videotape's quality was excellent. It is hoped that over the next several years a significant video library can be acquired, being available for review. POC is Capt Susen DSN 240-3281.

WPB

HYPERBARIC NURSING COURSE

The selection of nurses to USAF clinical hyperbaric chambers has historically been a board selection process controlled by HQ/AFPC. This process was reviewed by the Nurse Corps leadership in the fall of 1995 and the decision was made to change the selection process to an advertised assignment position. What this means to the Nurse Corps is that future vacancies in nurse positions at Brooks AFB, Wright-Patterson AFB, and Travis AFB will be advertised on the nurse assignment system through HQ/AFPC. The timing of this selection and training will continue to be coordinated through Brooks AFB and will be driven by staffing needs at each of the clinical facilities.

Nurses who are selected will continue to attend the 16 week Clinical Hyperbaric Nursing Course (CHNC) at Brooks AFB. By the way, the CHNC is the most extensive training program in Clinical Hyperbaric Medicine in the world. This advanced training course will be accomplished via TDY enroute to PCS to the assigned facility. Every attempt will be made to advertise openings as early as possible and to keep the advertisement on the nursing bulletin board for as long as HQ/AFPC will allow. The goal is to get the word out to as many AF nurses as possible so that hyperbaric facilities may continue to attract very qualified nurses that have a sincere interest in hyperbarics. The advertisements for planned vacancies are scheduled for the Spring 1997 time frame. For any questions please call **Capt Barbara Susen** at **DSN 240-3281** or commercial (210) 536-3281.

Nursing Student Profile

Captain Sue Ann Bradbury comes to us from Kadena AFB in Okinawa. As an avid scuba diver she has developed a great interest in Hyperbaric Medicine. She brings a broad base of clinical experience since earning her BSN in 1979 from Keuka College in New York. At the completion of her Fellowship, she will be joining the nursing staff at Travis AFB. *wpb*

HYPERBARIC NURSING

The Certified Hyperbaric Registered Nurse (CHRN) Exam turned one year old in November 1996. The exam has been given at eight different locations and fourteen hyperbaric nurses have successfully certified. The Baromedical Nurses' Association Certification Board (BNACB) consists of three members: Lizanne Peel, Wayne McHowell, and Ben Grimes. The members have been in frequent communication to make the certification process work smoothly for all candidates. A business meeting was held by conference call in July, and new Bylaws and job descriptions were accepted. In September all three members attended the National Board of Nursing Specialties meeting in Chicago, Illinois. BNACB attendance was supported by the USAF, the BNA, and the National Board of Diving and Hyperbaric Technology. The assistance and funding support of these three organizations has been instrumental in our growth as a professional board.

To obtain your study guide, application, and scheduled exam dates for the CHRN exam, call Pauline at the NBDHMT at (504) 366-8871. Please note that all documentation must be returned with the application 60 days before the scheduled exam date. For any additional questions, please feel free to contact any of the BNACB members. Phone numbers are located in the current BNA Directory.

Capt Lizanne Peel
Chief, Hyperbaric Nursing Service

ENLISTED HYPERBARICS

A Utilization and Training workshop for the Advanced Clinical Hyperbaric Medicine Training Course was held 23 - 27 September 1996. As a result, the advanced hyperbaric course is currently being rewritten to reflect the new proficiency training codes. This will result in a shorter advanced course, while meeting the needs of the field. Additionally, assignments and selection for the course were changed. Assignments to the clinical facilities will be made at MAJCOM level, facility level, or by "equal plus" depending on the AFSC and facility location. Attendance to the course will be pre-empted by an assignment to a clinical hyperbaric facility. Course dates for 1997 will be released as soon as they are approved by USAFSAM. If you have any questions regarding the changes affecting clinical hyperbarics, please contact **SSgt Jennifer Middendorf** (4N071) or **MSgt Dave Pridgen** (4M071) at **DSN 240-3281.**

FELLOWSHIP TRAINING FOR PHYSICIANS

The USAF School of Aerospace Medicine trains two physicians annually in a Clinical Hyperbaric Medicine Fellowship at the Davis Hyperbaric Laboratory. The primary emphasis of the program is clinical (i.e., wound care and adjunctive use of hyperbaric oxygen for wound healing). However, fellows also treat decompression sickness (DCS) cases that are referred from throughout the mid-south, and are consultants for USAF operational DCS cases occurring worldwide. The USAF has been treating aviator's DCS in hyperbaric chambers since 1959.

In 1974 the Surgeon General established a hyperbaric center (later named the Davis Hyperbaric Laboratory) at Brooks AFB to direct the development of operational and clinical hyperbaric medicine throughout the Air Force. Davis Hyperbaric Laboratory is the lead agent for all DoD clinical hyperbaric medicine programs.

The physician fellowship was established in 1978. It was the first clinical hyperbaric fellowship in the United States, and remains the only military hyperbaric fellowship.

In the year of training, fellows learn the latest techniques in the management of chronic nonhealing wounds. In addition, they learn the nuances of the other thirteen accepted indications for hyperbaric oxygen therapy. Included in that list is the operationally relevant altitude induced DCS. Fellows become singularly qualified in dealing with this malady. The current program achieves an exceptionally broad based experience with multiple outside rotations (i.e., diving medicine, monoplace chamber operations, international conference attendance).

Fellows actively participate in hyperbaric medicine education by teaching classes to physicians, nurses, and technicians at the School of Aerospace Medicine. Opportunities for basic and clinical research are available and encouraged.

Fellowship training incurs a two-year pay-back commitment. At the completion of training, fellowship trained physicians are assigned to one of the USAF's clinical hyperbaric medicine facilities located at Brooks AFB, Travis AFB, or Wright-Patterson AFB.

Physicians interested in fellowship training should contact **Lt Col William P. Butler**, Director, Hyperbaric Medicine Fellowship, Davis Hyperbaric Laboratory, Brooks AFB at **DSN 240-3281**.

Fellow profile

In June 1996, Lt Col Robert Todaro joined us from the USAF School of Aerospace Medicine (USAFSAM). For the past year his organizational skills have been tested directing many of the courses USAFSAM offers. These courses included Aircraft Mishap Investigation & Prevention, Operational Aeromedical Problems, and Occupational Medicine.

After earning his medical degree at New York Medical College, Dr. Todaro's initial residency training was in Family Practice (Flower Hospital Medical College of Ohio). In fact, this summer he successfully re-certified. In addition, he also holds Board Certification in Aerospace Medicine, having earned his MPH from Harvard and successfully completed the Residency in Aerospace Medicine/Occupational Medicine in 1995. Upon completing his Fellowship, he is expected to join the medical staff at Travis AFB. *wpb*

BEYOND THE USAF

US NAVY

Clinical Hyperbaric Medicine

Our USN colleagues have recently joined us in Clinical Hyperbaric Medicine. While involved with Diving Medicine from the beginning of time, this is somewhat new waters for them to sail. The clinical chamber at NAOMI in Pensacola is a fully staffed multiplace chamber able to treat four ambulatory patients simultaneously. In fact, this October, a family of three were successfully treated for acute CO poisoning.

Commander James Chimiak , who received his Hyperbaric Medicine training at Duke University, heads the Hyperbaric Team. Other team members are LT Greg Davis, Hyperbaric Nurse, and four DMT's (Hilton, Staudenraus, Jacquett, and Larisy). Supplemental personnel include thirteen 1st Class divers at NAOMI and a Master Diver from NDSTC in Panama City.

--*information supplied by LT Davis*

Diving Medicine Training for Uniformed Physicians, Physician Assistants, and Physiologists

The Naval Diving and Salvage Training Center (NDSTC), Panama City, Florida offers five graduate level diving medicine courses for interested DoD physicians, PA's, and physiologists. Quotas for training slots are offered based on operational need and order of application. This training is required for Navy Undersea Medical Officers and Navy residents in Aerospace Medicine and highly encouraged for all Flight Surgeons, Army Special Operations Medical Officers, and Aviation Physiologists.

The Recognition and Treatment of Diving Casualties courses (R & T) are 10 days long. Graduates receive 63 hours of CME credit and are certified to initiate hyperbaric treatment of dysbaric illnesses, to review diving duty physical exams, and to serve as inside tenders during recompression therapy. This course provides training necessary to safely and effectively perform as a medical advisor for diving operations. Students learn each job as part of the chamber team during diving accident scenarios and do several chamber dives, the deepest being 165 FSW. Applicants must have a current diving physical exam. There are no extra physical fitness requirements.

The Diving Medical Officer courses (DMO), a pipeline course for Navy Undersea Medical Officers, are 9 weeks in length. The course consists of one week of diving physics, 2 weeks of diving medicine which is almost identical to the R & T course, 5 weeks of dive training, and a final week of advanced diving medicine topics. Unlike the R & T students, DMO students must complete the rigors of Navy diver training which include daily strenuous physical training, one stressful week of SCUBA confidence training and certification dives to 190 FSW. DMO's become *bona fide* Navy divers qualified in open-circuit SCUBA and all Navy surface supplied rigs. They get a closed-circuit SCUBA familiarization which culminates in pool dives with the Draeger LAR-V. In addition to a current diving physical, applicants must pass a diver physical readiness test and a 1000 yard timed surface swim with fins. Graduates receive 95 hours of CME credits.

NDSTC, a tenant command on the Naval Coastal Systems Station, is considered to be one of the best diver training facilities in the world. These courses provide uniformed medical providers excellent continuing medical education opportunities and current, professional instruction in diving medicine. The are **no** course costs. Government messing and berthing are available. For more information and the 1997 and 1998 course dates, contact **LT Charles Howsare**, at DSN **436-5216/5** or COMM (904) 235-5216/5.

LT Charles Howsare
DMO Training Officer
NDSTC, Panama City, FL

US ARMY

The Army has decided to close the chamber complex at Ft. Rucker, Alabama. However, this is not the end of Army Hyperbaric Medicine. LTC Daniel Fitzpatrick, the Army's fellowship trained hyperbaricist, is moving to Eisenhower Regional Hospital on Ft. Gordon, Georgia. There, he will begin a Hyperbaric Medicine program. To accomplish this task, Davis Hyperbaric Laboratory is loaning their Sechrist monoplace unit to the Army. Incidentally, this chamber has just returned from the factory with a newly refurbished acrylic shell.

WPB

PERSONALS

USAF Hyperbaric Medicine is losing a number of valuable individuals:

Major Chris Philips, medical staff at Wright-Patterson AFB, will be leaving to pursue a residency in Preventive Medicine.

Major Doug Warren, medical staff at Travis AFB, has returned to full time Family Practice there. However, he still remains part of the Hyperbaric Medicine scene as a supplemental diver.

Lt Col Mike Ainscough, medical staff at Brooks AFB, is now at Scott AFB coordinating the USAF's AirEvac schedule.

Capt Lizanne Peel, nursing staff at Brooks AFB, is leaving to matriculate into Flight Nursing School. Following that course, she will enter the Air Force Reserves.

Capt Chris Peters, nursing staff at Travis AFB, is leaving to join the nursing staff in the AF Academy's Emergency Room.

Although it is tough for us to lose such quality people, we wish them great luck in their new endeavors and look forward to their return to Hyperbaric Medicine. And, speaking of returns:

Colonel Tommy Love, who received his Hyperbaric Medicine training in Houston with Dr. Caroline Fife, returns to active duty at Travis AFB.

Colonel Sal Wurjisemito is expected to return to full time Hyperbaric Medicine this summer. His exact destination is unknown as yet. Dr. Wurjisemito has been a practicing surgeon at McGuire AFB.

Colonel George Wolf has returned to Hyperbaric Medicine from Aerospace Medicine. He heads the Hyperbaric Medicine Division of Armstrong Laboratory here at Brooks AFB.

USAF Hyperbaric Medicine is also suffering through the upheavals of retirement.

Colonel John Bishop, who heads Hyperbaric Medicine at Wright-Patterson AFB, is expected to retire in 1997.

Colonel Merritt Davis is expected to retire in 1997.

Colonel Richard Henderson, who was at Wright-Patterson AFB, retired in 1996.

Colonel Ben Slade, who heads Hyperbaric Medicine at Travis AFB, is expected to retire in 1997.

Congratulations to these friends on their retirements. We wish them the best in their civilian pursuits. We look forward to future visits at any variety of conferences. *wpb*

EDITOR'S NOTES

This newsletter is a bunch of work; however, it is a load of fun! I am sincerely grateful to all who contributed to its final face.

Comments and suggestions are welcome! Articles, case reports, information letters, etc. are welcome!

Please send it all to:

USAF Hyperbaric Newsletter
AL/AOH
2509 Kennedy Drive, Suite 309
Brooks AFB, Texas 78235-5119

Lt Col William P. Butler, Editor

I apologize for the lateness of this publication; however, the review process here at Armstrong Laboratory can sometimes be truly arduous!!

WPB