Undersea & Hyperbaric Medical Society
2007 Annual Scientific Meeting

Program & Abstracts

June 14-16, 2007

Ritz-Carlton Kapalua
Maui, Hawaii

Undersea and Hyperbaric Medical Society Committees

Executive Committee

Bret Stolp, President
Lindell Weaver, Immediate Past President
Laurie Gesell, President Elect
Neil Hampson, Past President
Simon Mitchell, Vice President
Takkin Lo, Secretary
Robert Warriner, Treasurer
Kaye McClue, Associates Representative
Justin Everts, BNA Representative
Jim Joiner, Diving Corporate Representative
Michael Mueller, HBO Corporate Representative
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-Members at Large-

2007	Stephane Tremblay	Harriet Hopf	Ron Bangasser
2008	John Felmeier	R. Kelly Hill	Keith VanMeter
2009	Thomas Bozzuto	R. W. Bill Hamilton	Kevin Hardy

2007 Organizing & Scientific Program Committee

Brett Hart, Co-Chair
Laurie Gesell, Co-Chair
Dick Sample, Associates Program
Kathy Furnas, BNA Program
Lin Weaver, President, UHMS
Jim Holm, UHMS
Paul Sheffield, CME Representative Don Chandler, UHMS
Robert Warriner, Finance Committee
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Neil Hampson
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Committee Chairpersons

AMA Committee - Victoria Cassano
Associates – Kaye McClue
Awards – Simon Mitchell
Finance - Robert Warriner
By-Laws - Ron Bangasser
Decompression Illness Adjunctive Therapy- Richard E. Moon
Diving - Simon Mitchell
Education - Paul J. Sheffield
HBO Safety - Robert Sheffield
Hyperbaric Oxygen Therapy - Laurie Gesell
Federal & Regulatory Affairs Task Force - Robert Warriner
International Affairs - E. Cuauhtemoc Sanchez
Library - Richard D. Vann
Membership - J. Benjamin Slade
Military & Law Enforcement Liaison – Matthew Muller
Nominations – Laurie Gesell
Publications - Harriett Hopf
Research Foundation - Richard Moon
Research - John Feldmeier
Workshop - Charles Lehner
Wound Liaison - Jeffrey Niezgoda

Chapter Representatives

Great Lakes: Ron Linden
Gulf Coast: Helen Gelly, MD
Latin American: E.C. Sanchez, MD
Mid-West: John Feldmeier, DO
Northeast: J. Nicholas Vandemoer, MD
Pacific: Ralph Potkin, MD
Brazilian: Roberto Bammann, MD

Affiliates

Asociacion Mexicana de Medicina Hiperbarica y Subacuatica (AHMS)
Baromedical Nurses Association (BNA)
Comite Coordinador de Centros de Medicina Hiperbarica (CCCMH)
European Underwater and Baromedical Society (EUBS)
Gesellschaft für Tauch-und Über-druck-medizin e.V (GTUM)
Hyperbaric Technicians and Nurses Association (HTNA)
Japanese Society for Hyperbaric Medicine (JSHM)
Société de Médecine et de Physiologie Subaquatiques et Hyperbares de Langue Française (MEDSUBHYP)
South Pacific Underwater Medicine Society (SPUMS)
Southern African Underwater and Hyperbaric Medical Association (SAUHMA)

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Exhibitors

Best Publishing Company, Flagstaff, AZ:
"Best Publishing Company is proud to have become the largest publisher of books on hyperbaric medicine."
www.bestpub.com

Diversified Clinical Services, Jacksonville, FL:
Diversified Clinical Services is a national wound care company focused exclusively on collaborating with hospitals to establish and manage comprehensive wound healing centers. A wound healing center can be a strategic asset for a hospital, offering evidence-based clinical quality, high levels of patient satisfaction, integrated service to inpatient populations and responsible and appropriate financial returns. Centers operate under the hospital's identity in conjunction with local physicians. www.diversifiedclinicalservices.com

Environmental Tectonics Corporation, Southampton, PA:
ETC is a premier designer and manufacturer of clinical hyperbaric chambers serving a worldwide client base. The ETC BARA-MED? monoplace has many unique features including fully redundant automatic and manual control systems, user-friendly SMOOTH•RIDE? compression protocol that significantly reduces complications due to middle ear squeeze without adding to compression time, and hard-copy record of the actual treatment profile. For more information on our products and product support services visit us at www.etcBioMedical.com.

Fink Engineering Pty. Ltd., Victoria, Australia:
Fink Engineering has established an international reputation as the premier manufacturer of state-of–the-art user friendly Rectangular Hyperbaric Facilities for clinical and hospital hyperbaric oxygen therapy. In this regard, Fink Engineering excels in the continual design and development of its innovative rectangular concept in order to provide simple, safe and cost effective equipment for the hyperbaric medical community. www.fink.com.au

Giager Medical Systems (GMS), Broken Arrow, OK:
Giager Medical Systems (GMS) is a worldwide provider of hyperbaric oxygen (HBO) treatment systems. GMS employs engineers, designers, draftsmen, and specialists in the fields of hyperbarics and clinical construction to design and fabricate an efficient and cost effective HBOT facility. www.giagersystems.com

Gulf Coast Hyperbarics Inc. , Lynn Haven, FL:
Gulf Coast Hyperbarics, Inc. was established in 1984 by Jim McCarthy. The company is a small business entity that specializes in the design and manufacturing of clinical hyperbaric systems. www.GulfCoastHyperbarics.com

International ATMO, Inc., San Antonio, TX:
Since 1979, we have been a premiere provider of wound healing & hyperbaric medicine management, consulting, and education. International ATMO has trained thousands of medical professionals world-wide. www.hyperbaricmedicine.com

Masimo Americas, Inc., Irvine, CA:
Masimo is the inventor of motion and low perfusion tolerant pulse oximetry. Over 90 independent studies demonstrate the superior performance of Masimo SET™ pulse oximetry technology. Masimo now offers Rainbow SET Pulse CO-Oximetry™ technology which noninvasively and continuously measures Methemoglobin and Carboxyhemoglobin, along with Oxygen Saturation, Pulse Rate and Signal IQ. www.masimo.com

Medical Multiplex, Inc., Louisville, KY:
The technical experts in wound care & hyperbarics (and client relations), MMI has focused exclusively on this specialty since 1994. Medical Multiplex will bring experts in clinical and technical set up, reimbursement, medical protocols and the most advanced adjunctive treatments to your hospital. In fact, MMI is one of the only management firms that can provide certified physician and nurse education on-site, as well as install wireless, total electronic charting. MMI services range from single consulting engagements to implementation projects to our specialty – fully outsourced management of integrated wound and hyperbaric centers for hospitals. www.medicalmultiplex.com.

Medline Industries, Mundelein, IL:
Medline, headquartered in Mundelein, IL, manufactures and distributes more than 100,000 products to hospitals, extended care facilities, surgery centers, home care dealers and agencies and other markets. Medline has more than 700 dedicated sales representatives nationwide to support its broad product line and cost management services. Meeting the highest level of national and international quality standards, Medline is FDA QSR compliant and ISO 13485 registered. Medline serves on major industry quality committees to develop guidelines and standards for medical product use including the FDA Midwest Steering Committee, AAMI Sterilization and Packaging Committee and various ASTM committees. For more information on Medline visit our website. www.medline.com

OxyHeal Health Group, National City, CA:
OxyHeal Health Group is made up of three corporations that have collectively been in business for over 35 years, specializing in the delivery of "high dose oxygen," or Hyperbaric Medicine, and the treatment of complex wounds. OxyHeal's member companies encompass both medical device manufacturing and the clinical operation of Hyperbaric Systems and Wound Healing Centers in Hospital and University programs worldwide. In addition, one of OxyHeal's companies operates didactic and on-line training programs for physicians, nurses and technicians. OxyHeal Health Group's predominant product is the company's unparalleled knowledge, training and experience in the delivery of Hyperbaric Oxygen Therapy and advanced wound care to patients both in clinical and emergency settings. www.oxyheal.com

Exhibitors (Continued)

Pan-America Hyperbarics, Inc., Richardson, TX:
Pan-America Hyperbarics, Inc., "The Highest-Value Provider in Hyperbaric Technology" is a worldwide supplier of monoplace and multiplace hyperbaric chambers. Our expertise is not only in designing and building bold new cost effective hyperbaric treatment systems, but also in developing partnerships with our clients. To assist our clients in providing the best standard of care to their patients, Pan-America Hyperbarics, Inc. offers unprecedented purchase, finance, and lease options for our products. For more information please contact our Partnership Care Team: 1-888-PAHI-HBO, or visit www.panamericahbo.com

Perimed, Inc., North Royalton, OH:
With over 25 years of development, Perimed AB manufactures and markets state-of-the-art Laser Doppler Instruments for the measurement of microvascular perfusion. As a leader in the Wound Care and Hyperbaric Medicine departments, Perimed, Inc., offers the only combined Laser Doppler and Transcutaneous multi-channel monitor, the PeriFlux 5000 system. This system allows the user friendly flexibility of multiple site monitoring. PeriFlux instruments represent a commitment that begins with quality and performance, and continues with technical and applications support. Please visit our website at www.perimed.se

Radiometer America, Inc., Westlake, OH:
Radiometer is the world leader in the development, manufacture and distribution of technologically advanced critical care testing systems for blood gas, electrolytes and metabolites. www.radiometeramerica.com

Reimers Systems, Inc., Springfield, VA:
With decades of experience, we offer hyperbaric chambers, research chambers, altitude chambers, oxygen service solutions, manifolds and other accessories like hood drivers, gas selection panels and utility penetrators, site development and engineering services, chamber installation and maintenance. Our sister company, Hyperbaric Clearinghouse, offers quality pre-owned chambers and equipment. www.reimersystems.com

Sechrist Industries, Anaheim, CA:
For over 30 years, Sechrist Industries, Inc., continues to be a leading worldwide manufacturer of hyperbaric chamber systems, neonatal, infant and pediatric intensive care ventilators, and air/oxygen mixers along with other ancillary accessories. All products are manufactured in accordance with FDA and GMP regulations. www.sechristind.com

väsamed, Eden Prairie, MN:
väsamed designs, licenses, manufactures and distributes a range of noninvasive hemodynamic technologies for wound care, vascular, cardiovascular and emergency medicine diagnostics. Products presently include SensiLase PAD 3000 Skin Perfusion Pressure system, AcQtrac ICG Noninvasive Hemodynamic Assessment System, blood flow monitors, and tissue capnometry.
www.vasamed.com

Continuing Education

Overall Goal of the UHMS Annual Scientific Meeting 2007

The primary goal of the Undersea and Hyperbaric Medical Society ASM is to provide a forum for professional scientific growth and development of the participants. The meeting provides a basis for exchange of ideas, both scientific and practical, among physicians, researchers, and other health professionals. It affords an opportunity for participants to meet and interact past and present leaders of the Society, and to become active in societal affairs.

Continuing Education

In order to receive continuing education for the UHMS ASM you must complete and submit the yellow evaluation form found at the end of this book. There will be fees for those requesting physician CMEs or nursing CEUs. If you did not pre-pay for continuing education then you may complete the payment section on the back of the evaluation form.

Physician CME

The Undersea and Hyperbaric Medical Society (UHMS) is accredited by the Accreditation Council for Continuing Medical Education to provide continuing medical education for physicians.

The UHMS designates this educational activity for a maximum of 25.5 AMA PRA Category 1 Credits™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Nursing CEU

CNE have been applied for through the Baromedical Nurses Associate, California Board of Registered Nurses provider # CEP 6572. Full refund if the course is not attended. No partial units will be issued.

NBDHMT

This program has been reviewed and is acceptable for up to 25.5 Category A credit hours by the National Board of Diving and Hyperbaric Medical Technology.

Faculty Disclosures

All faculty members participating in continuing medical education programs sponsored by the Undersea and Hyperbaric Medical Society are expected to disclose to the program audience any real or apparent conflict(s) of interest related to the content of their presentation(s).

Schedule Overview

Wednesday, June 13		
0700-1700	Exhibitors Move In	Salon 1
0700-1700	Registration	Boardroom Foyer
0700-0900	Continental Breakfast	Salon Pre-Function
0700-0900	Workshop Committee	Kauai
0700-0900	Hyperbaric Oxygen Therapy Committee Meeting	Lanai
0700-0900	JACCHM Meeting	Amphitheatre
0900-1100	International Affairs Committee Meeting	Hawaii
0900-1100	Federal and Regulatory Affairs Task Force Meeting	Kauai
0900-1100	Accreditation Council Meeting	Amphitheatre
0900-1100	Military & Law Enforcement Committee	Lanai
1300-1500	Publications Committee Meeting	Hawaii
1300-1500	Membership Committee Meeting	Kauai
1300-1500	Adjunctive Therapy Committee Meeting	Lanai
1300-1500	Editorial Board Meeting	Amphitheatre
1500-1700	Associates Board Meeting	Hawaii
1500-1700	Education Committee Meeting	Kauai
1500-1700	Research Foundation/Research Committee Meeting	Lanai
1500-1700	Safety Committee Meeting	Amphitheatre
0800-1700	**Pre-Course:** *Transcutaneous Oximetry: Art, Science and Practice:* Caroline Fife	Salon 4
1000-1030	AM Break	Salon Pre-Function
1130-1300	Pre-Course Lunch	Salon 4
1430-1445	PM Break	Salon Pre-Function
1800-2100	UHMS Welcome Luau	Beach House Lawn
Thursday, June 14		
0700-1700	Registration	Boardroom Foyer
0700-0900	Continental Breakfast	Salon 1 & Pre-Function
0700-0830	BNA Executive Board Meeting	Maui
0730-0800	**President's Address** – Brett Stolp	Salon 3 & 4
0800-0900	**Plenary Session:** *The Undersea and Hyperbaric Medical Society 1967-2007*: 40 Years of Achievement - Richard Moon	Salon 3 & 4
0745-1500	Accompanying Persons Tour: Up-Country Scenic Tour	Lobby
0915-1030	**Session A** (oral): Decompression Bubbles, Models & Theory	Salon 3 & 4
0915-1030	**Session B** (poster): Clinical HBO2 & Wound Treatment	Salon 1 & Pre-Function
1000-1100	BNA Business Meeting	Maui
1030-1045	AM Break	Salon 1 & Pre-Function
1045-1200	**Session A** (poster): Decompression Bubbles, Models & Theory	Salon Pre-Function
1045-1200	**Session B** (oral): Clinical HBO2 & Wound Treatment	Salon 3 & 4
1200-1300	**Lunch Seminar:** *Hyperbaric Medical Equipment: Current Issues* - Dick Sample OR Lunch on Own	Salon 2
1200-1500	Finance Committee	Maui
1300-1400	**Plenary Session:** *The Veterinary Hyperbaric Medicine Society: Overview of the Current State of Veterinary Hyperbaric Medicine* – Fairfield Bain	Salon 3 & 4
1415-1530	**Session C** (oral): Hyperbaric Chamber Patient Management	Salon 3 & 4
1415-1530	**Session D** (poster): Diving Equipment and Operational Considerations	Salon Pre-Function
1530-1545	PM Break	Salon 1 & Pre-Function
1530-1700	Biomedical Oxygen Research Consortium	Maui
1545-1700	**Session C** (poster): Hyperbaric Chamber Patient Management	Salon Pre-Function
1545-1700	**Session D** (oral): Diving Equipment and Operational Considerations	Salon 3 & 4
1730-1930	CHT/CHRN - NBDHMT Exam	Maui
1900-2200	Board of Directors Meeting	Salon 3 & 4

(continued)

Schedule Overview (Cont'd)

Friday, June 15		
0645-1700	Registration	Boardroom Foyer
0645-0900	Continental Breakfast	Salon 1 & Pre-Function
0700-0750	**Breakfast Seminar:** *Rewards and Challenges of Rebreather Diving* - Dick Vann	Salon 2
0800-0830	**Plenary Session:** *The Year in Review: A Synopsis of HBO² Literature 2006* - Dick Clarke	Salon 3 & 4
0830-0900	**Plenary Session:** *UHMS Presidential Review* - Neil Hampson	Salon 3 & 4
0915-1030	**Session E** (oral): Hyperbaric Chamber Equipment Issues	Salon 3 & 4
0915-1030	**Session F** (poster): Decompression Illness Evaluation & Treatment	Salon Pre-Function
1030-1045	AM Break	Salon 1 & Pre-Function
1045-1200	**Session E** (poster): Hyperbaric Chamber Equipment Issues	Salon Pre-Function
1045-1200	**Session F** (oral): Decompression Illness Evaluation & Treatment	Salon 3 & 4
1045-1415	Accompanying Persons Tour: Atlantis Submarine Tour	Lobby
1200-1250	**Lunch Seminar:** "Hyperbaric Unit Guidelines for Practice - Practical insights into avoiding regulatory and accreditation pitfalls" Laura Josefsen OR Lunch on Own	Salon 2
1300-1400	**Kronheim Lecture:** *The History of Deep Sea Exploration* - Ralph White	Salon 3 & 4
1400-1700	**Associates Breakout Sessions**	Amphitheater
1415-1530	**Session G** (oral): Physiology, Education & Reviews	Salon 3 & 4
1415-1530	**Session H** (poster): Diving Mishaps & Non-DCI Illness	Salon Pre-Function
1530-1545	PM Break	Salon 1 & Pre-Function
1545-1700	**Session G** (poster): Physiology, Education & Reviews	Salon Pre-Function
1545-1700	**Session H** (oral): Diving Mishaps & Non-DCI Illness	Salon 3 & 4
1700-1800	UHMS Annual Business Meeting	Salon 3 & 4
Saturday, June 16		
0700-1700	Registration	Boardroom Foyer
0700-0800	Continental Breakfast	Salon 1 & Pre-Function
0700-0750	**Breakfast Seminar:** *Using Toyota Production Techniques to Design and Operate your Hyperbaric Facility* - Neil Hampson	Salon 2
0700-0900	Diving Committee	Boardroom
0800-0900	**Plenary Session:** *Point/Counterpoint: The Use of Deep Treatment Tables (>3ATA) for the Treatment of DCI in Sport Divers – Richard Moon & Richard Smerz*	Salon 3 & 4
0915-1030	**Session J** (oral): Diving Physiology & Cellular Mechanisms	Salon 3 & 4
0915-1030	**Session K** (poster): HBO2 Science & Cellular Mechanisms	Salon Pre-Function
1030-1045	AM Break	Salon 1 & Pre-Function
1045-1200	**Session J** (poster): Diving Physiology & Cellular Mechanisms	Salon Pre-Function
1045-1200	**Session K** (oral): HBO2 Science & Cellular Mechanisms	Salon 3 & 4
1200-1250	**Lunch Seminar***: Prophylactic Hyperoxia for Reperfusion Injury: Duck Soup or Paradox? – Steve Thom*	Salon 2
1315-1430	**Session L** (oral): Clinical HBO2 & Ischemia Treatment	Salon 3 & 4
1430-1445	PM Break	Salon 1 & Pre-Function
1445-1600	**Session L** (poster): Clinical HBO2 & Ischemia Treatment	Salon Pre-Function
1600	Exhibitors Break Down	
1700	Exhibit Co. breakdown exhibit booth	
1900-2100	Annual Awards Banquet	Aloha Garden
Sunday June 17		
0700-1000	Registration	Plantation Pre-Function
0800-1700	**Post Course:** Medical Legal Aspects of Fitness to Dive & Practice of Hyperbaric Medicine	Plantation 3
0800-1700	**Other Courses:** How to Prepare for Accreditation Survey	Plantation 1
1030-1045	AM Break	Plantation Pre-Function
1430-1445	PM Break	Plantation Pre-Function

Schedule Breakdown

Committee Meetings

Wednesday	0700-0900	Workshop Committee	Kauai
	0700-0900	Hyperbaric Oxygen Therapy Committee Meeting	Lanai
	0700-0900	JACCHM Meeting	Amphitheatre
	0900-1100	International Affairs Committee Meeting	Hawaii
	0900-1100	Federal and Regulatory Affairs Task Force Meeting	Kauai
	0900-1100	Accreditation Council Meeting	Amphitheatre
	0900-1100	Military & Law Enforcement Committee	Lanai
	1300-1500	Publications Committee Meeting	Hawaii
	1300-1500	Membership Committee Meeting	Kauai
	1300-1500	Adjunctive Therapy Committee Meeting	Lanai
	1300-1500	Editorial Board Meeting	Amphitheatre
	1500-1700	Associates Board Meeting	Hawaii
	1500-1700	Education Committee Meeting	Kauai
	1500-1700	Research Foundation/Research Committee Meeting	Lanai
	1500-1700	Safety Committee Meeting	Amphitheatre
Thursday	0700-0830	BNA Executive Board Meeting	Maui
	1000-1100	BNA Business Meeting	Maui
	12001500	Finance Committee Meeting	Maui
	1530-1700	Biomedical Oxygen Research Consortium	Maui
	1730-1930	CHT/CHRN Test	Maui
	1900-2200	Board of Directors Meeting	Salon 3 & 4
Friday	1700-1800	UHMS Annual Business Meeting	Salon 3 & 4
Saturday	0700-0900	Diving Committee	Boardroom

Plenary Sessions

Thursday	7:30 a.m.	**Presidents Address** / Brett Stolp	Salon 3 & 4
	8:00 a.m.	**Plenary Session:** History of UHMS / Richard Moon	Salon 3 & 4
	1:00 p.m.	**Plenary Session:** The Veterinary Hyperbaric Medicine Society: Overview of the Current State of Veterinary Hyperbaric Medicine / Fairfield Bain	Salon 3 & 4
Friday	8:00 a.m.	**Plenary Session:** The Year in Review: A Synopsis of HBO2 Literature 2006 / Dick Clarke	Salon 3 & 4
	8:30 a.m.	**Plenary Session:** UHMS Presidential Review / Neil Hampson	Salon 3 & 4
	1:00 p.m.	**Kronheim Lecture**: The History of Deep Sea Exploration / Ralph White	Salon 3 & 4
Saturday	8:00 a.m.	**Plenary Session:** Point/Counterpoint: The Use of Deep Treatment Tables (>3 ATA) for the Treatment of DCI in Sport Divers / Richard Moon & Richard Smerz	Salon 3 & 4

General Sessions

Thursday	a.m.	Session A & B	Salon 3 & 4
	p.m.	Session C & D	Salon 3 & 4
Friday	a.m.	Session E & F	Salon 3 & 4
	p.m.	Session G & H	Salon 3 & 4
Saturday	a.m.	Session J & K	Salon 3 & 4
	p.m.	Session L	Salon 3 & 4

Breakfast / Lunch Seminars (Additional Fee)

Thursday	12:00 p.m.	Hyperbaric Medical Equipment: Current Issues / D Sample	Salon 2
Friday	7:00 a.m.	Rewards and Challenges of Rebreather Diving / D Vann	Salon 2
	12:00 p.m.	"Hyperbaric Unit Guidelines for Practice - Practical insights into avoiding regulatory and accreditation pitfalls" / L Josefsen	Salon 2
Saturday	7:00 a.m.	Using Toyota Production Techniques to Design and Operate your Hyperbaric Facility / N Hampson	Salon 2
	12:00 p.m.	Prophylactic Hyperoxia for Reperfusion Injury: Duck Soup or Paradox? / S Thom	Salon 2

Pre-Course/Post-Course/Other Courses

Wednesday	8:00 – 5:00	Transcutaneous Oximetry: Art, Science & Practice	Salon 4
Sunday	8:00 – 5:00	Medical Legal Aspects of Fitness to Dive & Practice of Hyperbaric Medicine	Plantation 3
Sunday	8:00 – 5:00	How To Prepare for Accreditation	Plantation 1

Social Functions

Wednesday	1800-2100	UHMS Welcome Luau	Beach House Lawn
Saturday	1900-2100	Annual Awards Banquet	Aloha Garden

Thursday Morning General Session · June 14, 2007

7:00 a.m.	(all day)	Registration open until 5:00 p.m.	Boardroom Foyer
	(120 min)	Continental Breakfast until 9:00 a.m.	Salon 1 & Pre-Function
7:30 a.m.	(30 min)	**Presidents Address** / *Brett Stolp*	Salon 3 & 4
8:00 a.m.	(60 min)	**Plenary Session:** History of UHMS: 40 Years of Achievement / *Richard Moon*	Salon 3 & 4
9:15 a.m.	(90 min)	**SESSION A** Oral Presentations **(Moderators: R Vann, W Gerth)**	Salon 3 & 4
		SESSION B Visit Posters **(Moderators: B Slade, P Cianci)**	Salon Pre-Function

Session A: Decompression Models and Theory

	Abstract	Title	Authors
Oral Presentations	A1	A new class of biophysical models for determining the probability of decompression sickness in scuba diving	Goldman S
	A2	Probability models of mild and serious decompression sickness (DCS)	Weber PW, Howle LE, Denoble PJ, Vann RD, Pieper CF
	A3	A parameter estimation system with computational advantages for fitting probabilistic decompression models to empirical data	Howle LE, Weber PW, Vann RD
	A4	Difference in bubble formation using deep stops is dependent on length of bottom time; experimental findings and theoretical support	Gutvik CR, Møllerløkken A, Brubakk AO
	A5	Detection of stationary microbubbles in tissue using dual-frequency ultrasound	Bollinger BR, Alvarenga DL, Knaus DA, Magari PJ, Phillips SD, Buckey JC
	A6	Empirical evaluation of the efficacy of deep stops in air decompression dives	Gerth WA, Gault KA, Doolette DJ
	A8	Empirical evaluation of extensions to no- stop limits for deep air diving	Doolette DJ, Gerth WA, Gault KA
Posters Only	A9	Descriptive model of the influence of thermal exposure on diver susceptibility to decompression sickness	Gerth WA, Ruterbusch VL, Peacock JE
	A10	Does the V.O2mas value predict the formation of intravascular circulating bubbles during decompression of healthy divers?	Castagna O, Pontier JM, Vaz C, Blatteau JE
	A11	Noninvasive detection and assessment of gas microbubbles in blood and tissues	Larin KV, Manapuram RK
	A13	Research hypothesis upon the bubble formation in the connective tissue	Fiorito A, Bosco G, Di Tano G, Zanon V
	A14	A start toward micronucleus-based decompression models: altitude decompression	Van Liew HD, Conkin J
	A15	How do micronuclei generate bubbles?	Van Liew HD1, Raychaudhuri S2

10:30 a.m.	(15 min)	🔔 *BREAK & VISIT EXHIBITS*	Salon 1 & Pre-Function
10:45 a.m.	(90 min)	**SESSION B** Oral Presentations **(Moderators: B Slade, P Cianci)**	Salon 3 & 4
		SESSION A Visit Posters **(Moderators: R Vann, W Gerth)**	Salon Pre-Function

Session B: Clinical HBO2 and Wound Treatment

	Abstract	Title	Authors
Oral Presentations	B1	Stem cell mobilization in diabetics - responses to hyperbaric oxygen therapy	Yang BW, Milovanova TN, Hardy KR, Logue C, McCarthy VP, Thom SR
	B2	The effects of hyperbaric oxygen therapy on patients with muscle injury	Yagishita K, Yamami N, Togawa S, Nakayama T, Mano Y
	B4	The hyperbaric oxygen (HBO) treatment for lumbar canal stenosis (LCS)	Kato T, Kawashima M2 Yagishita K, Arai Y, Kawabata S, Shinomiya K
	B6	Hyperbaric oxygen stimulates epidermal reconstruction in human skin equivalents	Kairuz E, Long R, Upton Z, Dawson RA, Malda J
	B7	Hypospadias repair: the use of perioperative hyperbaric oxygen therapy	Perdrizet GA, Myer EG, Anderson CA, Marai S, Kim C, Ferrer FA
	B8	Clinical outcomes in a patients with severe diabetic foot ulcers treated with or without hyperbaric oxygen therapy	Perdrizet G, Anderson C, Solomon S, Worth P, Moher J, Shapter C
Posters Only	B3	Hyperbaric oxygen therapy in transient osteoporosis of the hip: a case report	Yagishita K, Yamami N, Togawa S, Jinno T, Koga D, Mano Y
	B5	Hyperbaric oxygen therapy for suppurative osteomyelitis	Kawashima M, Kawashima M, Tamura H, Takao K, Yamaguchi T, Miyata K
	B9	Wound complications following vascular surgery: role for hyperbaric oxygen therapy	Perdrizet GA, Qureshi I
	B10	Severe soft-tissue infections: use of emergent HBO2 therapy	Perdrizet GA, Shahmohammadi K, Shapter C
	B11	Traumatic amputation in a Jehovah's witness: options for enhancing oxygen delivery	Perdrizet G, Rutland R, Shapter C, Keating K, Abbensetts K
	B12	Update on the Duke randomized controlled trial of hyperbaric oxygen for osteonecrosis of the jaw in patients who have taken bisphosphonates	Freiberger JJ, Padilla-Burgos R
	B13	Salvage of complex bka stump healing failure with hyperbaric oxygen and multidisciplinary care	Bailey BB, Schechter RB
	B14	Putting the pressure on crush injury: hyperbaric therapy, wound care and management of a crush injury	Bregar P, Leon B, Thayer C, Deas L
	B15	Damn the HMO torpedoes, a novel approach to chronic wound healing, a case report	Smerz RW
	B16	Hyperbaric oxygen therapy (HBOT) in the delayed treatment of 8000-meter peak climber frosbites	Zanon V, Picchi GF, Garetto G, Bosco G
	B17	Hyperbaric oxygen therapy for calciphylaxis induced necrotizing fasciitis: a case study	Romeo L, Buza P, Briggs J, Heinl P

12:00 p.m. (60 min) **LUNCH ON YOUR OWN**

LUNCH SEMINAR: Hyperbaric Medical Equipment: Current Issues / *Dick Sample* Salon 2

Thursday Afternoon General Session · June 14, 2007

1:00 p.m.	(60 min)	**Plenary Session:** Veterinary Hyperbaric Medicine Society / *Fairfield Bain*	Salon 3 & 4
2:15 p.m.	(90 min)	**SESSION C** Oral Presentations **(Moderators: N Hampson, A Mahoney)**	Salon 3 & 4
		SESSION D Visit Posters **(Moderators: J Murray, D Doolette)**	Salon Pre-Function

Session C: Hyperbaric Chamber Patient Management

	Abstract	Title	Authors
Oral Presentations	C1	Rate of hyperbaric oxygen treatment in soft tissue radionecrosis: does it affect outcome?	Hampson NB, Corman JM
	C2	Trends and factors in blood pressure in HBO treatment	Clark S, Fowler SB
	C3	The variability of limb transcutaneous oxygen (TCOM) measurements breathing air and oxygen and their relationship to recorded vascular disease: a report from the Intellicure research consortium	Swaby K, Otto GH, Walker D, Fife CE
	C4	The effect of hyperbaric treatment pressure and air breaks on blood glucose levels: results of an ongoing study	Fife CE, Warriner III R, Pasceri R, Smith M, Hayes C, Otto GH
	C5	Hyperbaric oxygen therapy (HBOT) related adverse events in relation to treatment depth and blood glucose level, an on-going study from 48 centers	Beard T, Warriner III R, Pasceri P, Otto GH, Smith M, Hayes C, Fife CE
	C6	Spirometric changes with long term hyperbaric oxygen therapy: a prospective study	Lo T, Sample D, Lam T, Ward M, Iverson M, Park JK, Lee J, Zimmerman G
Posters Only	C7	Does hyperbaric oxygen therapy cause hypoglycemia in diabetic patients? A review of 119 diabetic patients treated in a multiplace chamber	Perdrizet GA, Gasho K, Fan L, Qureshi, I
	C8	CNS oxygen toxicity: unrecognized risk factors	Perdrizet G1, Magliato B2, Powers M2
	C9	Seizure during hyperbaric oxygen therapy for carbon monoxide toxicity: a case series	Sanders R1,3, Suyama J1, Akhtar J1,2, Katz, K1,2, O'Toole K1
	C10	Transcutaneous chest reference values and regional perfusion index in relation to vascular disease, smoking and leg TCOM	Baylor D1,2, Smith LA1,2, Maus E1,2, O'Malley E1,2, Otto GH3, Fife CE1,2
	C11	Arterial gas embolism causing cardiac arrest treated with hypothermia, lidocaine, and hyperbaric oxygen	Churchill S, Weaver LK
	C12	Hyperbaric patient discharge instructions	Rice JH, Kraft KL, Padilla-Burgos R, Brave,RJ, Moon RE, Doar PO, Boso AE
	C13	Effect of hyperbaric oxygen on cyclosporine-induced nephrotoxicity and oxidative stress in rats	Yildiz S, Aydinoz S, Ay H, Uzun G, Onem Y, Bilgi O, Topal T, Atasoyu EM
	C14	Incidence of oxygen seizures in HBO chamber attendants	Witucki P, Grover I, Ducknick J, Neuman T
	C15	Predictive validity testing of a claustrophobic screening instrument in a multi-place hyperbaric environment	Tyson J1, Smerz RW2
	C16	Cerebral air embolism during caesarean section	Spook-Fintl KG, Mathisen LC

3:30 p.m.	(15 min)	*BREAK & VISIT EXHIBITS*	Salon 1 & Prefunction
3:45 p.m.	(90 min)	**SESSION D** Oral Presentations **(Moderators: J Murray, D Doolette)**	Salon 3 & 4
		SESSION C Visit Posters **(Moderators: N Hampson, A Mahoney)**	Salon Pre-Function

Session D: Diving Equipment and Operational Considerations

	Abstract	Title	Authors
Oral Presentations	D1	Development of a scrubber gauge for closed-circuit diving	Warkander DE
	D2	Water temperatures for matched cold exposures in divers with or without wet suits during air decompression dives	Doolette DJ, Gault KA, Gerth WA
	D3	Nasopharyngeal pressure during middle ear equalization: a device to support investigation of aural barotrauma	Uguccioni DM1, Natoli MJ, Comfort BJ, Justus MA, Freiberger JJ, Vann RD
	D4	Thermal assessment of diving garments using aerogel super-insulation fabrics	Nuckols ML, Henkener JA, Chao J, Swiergosz M
	D5	Diver thermal protection in cold water: a new approach	Pendergast DR, Mollendorf JC
	D6	An active system to thermally protect divers in cold water	Mollendorf JC, Pendergast DR
	D7	Resting metabolic gas exchange within the enclosed hood of the mk10 submarine escape and immersion equipment (SEIE) suit	Fothergill DM, Horn WG
	D8	Buoyancy characteristics of the mk10 submarine escape and immersion equipment (SEIE) suit	Fothergill DM, Horn WG
Posters Only	D9	Effect of nasally administered surfactant on eustachian tube dysfunction	Gertner JW, Fothergill DM, Duplessis CA
	D10	Lightweight, faster decompression and portable alternative to u.s. navy mixed gas diving	Whelan HT, Dituri J
	D11	Urgent conversion of a deck decompression chamber to a temporary saturation system: experience in the gulf	Hardy S, Van Meter K, LeGros TL, Chamberlain B, Wilson J
	D12	Development of a fully submersible cognitive performance battery	Briggs JF, Boone HA
	D13	A simple conservative method for calculating safe standoff distance for diving near underwater electrical systems	Mints WH
	D14	Elastic and hydrostatic properties of three different rebreather bellow design	Frånberg O1, Ericsson M2, Gennser M1
	D15	Study of underwater ultrasonic hearing in humans	Qin MK, Schwaller D, Cudahy E

Friday Morning General Session · June 15, 2007

7:00 a.m.	(all day)	Registration open until 5:00 p.m.	Boardroom Foyer
	(120 min)	Continental Breakfast until 9:00 a.m.	Salon 1 & Pre-Function
7:00 a.m.	(50 mins)	**Breakfast Seminar:** Rewards and Challenges of Rebreather Diving / *Dick Vann*	Salon 2
8:00 a.m.	(30 min)	**Plenary Session:** The Year in Review: Synopsis of HBO2 Literature 2006 / Dick Clarke	Salon 3 & 4
8:30 a.m.	(30 min)	**Plenary Session:** UHMS Presidential Review / *Neil Hampson*	Salon 3 & 4
9:15 a.m.	(90 min)	**SESSION E** Oral Presentations **(Moderators: WT Workman, N Jett)**	Salon 3 & 4
		SESSION F Visit Posters **(Moderators: R Moon, J Ross)**	Salon Pre-Function

Session E: Hyperbaric Chamber Equipment Issues

	Abstract	Title	Authors
Oral Presentations	E1	Selecting skin care products for use in hyperbaric chambers may be dependent upon flammability acceptability indices score	McCord D1, Newton BE2, Fore JA3, Chiffoleau G2
	E2	Flow dynamics of patient hoods	Reimers SD
	E3	Continuation of V.A.C. therapy during hyperbaric multiplace oxygen therapy	Mosteller JA, Whitmore T, Kissau D
	E4	Pain pump utilization in the hyperbaric environment	Stack H
	E5	Pulscooximetry vs. Carboxyhaemoglobine in the diagnose of carbon monoxide poisoning. A comparative analysis	Desola J, Garcia-Mart"nez LL, de Haro M, Bassas L, Teixido D, Sala-Sanjaume J
	E6	Mechanical ventilation and monitoring of intubated patients in a monoplace chamber compressed with air	Gossett B
Posters Only	E8	Development of a certification matrix for the testing of biomedical equipment used in hyperbaric chambers	Hingeley EW, Millar IL
	E9	Serendipity: the use of the monoplace hyperbaric oxygen chamber for decompression illness and gas embolism	Hart GB
	E10	Sodium acetate therapeutic warming devices: effects of oxygen and pressure	Duchnick JJ, Osth C, Heaney DM, Grover I
	E11	Iodosorb used as palliative dressing with unexpected results	Williams R, Pontani B
	E12	Equipment malfunction resulting in decompression emergencies	Carbonaro D, Dilley-Dunn K, Gesell LB

10:30 a.m.	(15 min)	*BREAK & VISIT EXHIBITS*	Salon 1 & Pre-Function
10:45 a.m.	(90 min)	**SESSION F** Oral Presentations **(Moderators: R Moon, J Ross)**	Salon 3 & 4
		SESSION E Visit Posters **(Moderators: WT Workman, N Jett)**	Salon Pre-Function

Session F: Decompression Illness Evaluation & Treatment

	Abstract	Title	Authors
Oral Presentations	F1	A case of high doppler scores during altitude decompression in a subject with a fractured arm	Karlsson L, Linnarson D, Gennser M, Blogg SL, Lindholm P
	F2	Altitude decompression in simulated microgravity	Karlsson L, Blogg SL, Lindholm P, Linnarsson D
	F3	Portal venous gas associated with decompression sickness in sport divers: a case series	Koenig MD, Medak AJ, van Hoesen KB
	F4	Hyperbaric oxygen pretreatment reduces decompression sickness incidence in rats	Arieli R, Katsenelson K, Arieli Y
	F5	Potential fifty percent reduction in saturation diving decompression time using a combination of intermittent recompression and exercise	Gernhardt ML1, Abercromby AF2, Conkin J3
	F7	Comparison of v-4 and v-5 exercise/oxygen prebreathe protocols to support extravehicular activity in microgravity	Pollock NW, Natoli MJ, Vann RD, Conkin J, Gernhardt ML
	F8	Dysbaric osteonecrosis in uw sheep dissub study after a 3-hour oxygen pre-breathe followed by a 1-hour air break before dropout decompression	Sobakin AS, Lehner CE, Dueland RT, Wilson MA, Gendron-Fitzpatrick AP, Abraham JL
Posters Only	F6	Exploiting aerobic fitness to reduce risk of hypobaric decompression sickness	Conkin J, Gernhardt ML, Wessel JH
	F9	Investigation of delayed recompression treatment for limiting the induction of dysbaric osteonecrosis: sheep model of the diver	Lehner CE, Sobakin AS, Abraham JL, Dueland RT, Wilson MA, Gendron-Fitzpatrick AP, Crump PM, Keuler NS
	F10	Uw sheep dissub trials: oxygen pre-breathe before drop-out decompression offers a potential survival benefit	Lehner CE, Sobakin AS, Abraham JL, Dueland RT, Wilson MA, Gendron-Fitzpatrick AP, Crump PM, Keuler NS
	F11	Comparison of dysbaric osteonecrosis severity in the uw sheep model after a 24 hour dive at 60 FSW followed by either a 15-min, 1-h, 2-h oxygen pre-breathes before dropout decompression	Sobakin AS, Lehner CE, Dueland RT, Wilson MA, Gendron-Fitzpatrick AP, Abraham JL
	F12	The relationship between time to recompression treatment and clinical outcome for decompression illness treated in Scotland	Ross JAS, Sayer MDJ, Trevett AJ, Wilson CM
	F14	15 and 45 minutes of oxygen pre-breathe significantly reduces severe decompression illness after saturation dropout in 70 kg swine	Mahon RT, Dainer HM, Soutiere SE, Steinbach T
	F16	Two month delayed hyperbaric recompression of DCS from injury at depth misdiagnosed as musculoskeletal strain and post-concussive syndrome	Wierzbicki DA, Harch PG

12:00 p.m.	(60 min)	**LUNCH ON YOUR OWN**	
		LUNCH SEMINAR: "Hyperbaric Unit Guidelines for Practice - Practical insights into avoiding regulatory and accreditation pitfalls" Laura Josefsen	Salon 2

Friday Afternoon General Session · June 15, 2007

1:00 p.m. (60 min) **Kronheim Lecture**: The History of Deep Sea Exploration / *Ralph White* — Salon 3 & 4

2:15 p.m. (90 min) **SESSION G** Oral Presentations **(Moderators: J Freiberger, H Hopf)** — Salon 3 & 4

SESSION H Visit Posters **(Moderators: R Smerz, H Whelan)** — Salon Pre-Function

Session G: Physiology, Education & Reviews

	Abstract	Title	Authors
Oral Presentations	G1	Canadian physicians' knowledge and attitudes regarding hyperbaric oxygen therapy	Evans AW, Sosiak TS, Gill R, Valiulis AO, Lou WYW
	G2	Hyperbaric medicine - the international arena	Sonnenrein R
	G3	Reported disability and morbidity in united kingdom professional divers working before 1991	Ross JAS, Macdiarmid J, Watt SJ
	G4	Physical and psychological correlates of musculoskeletal and hearing loss symptoms in UK professional divers working before 1991	Ross JAS, Macdiarmid J, Watt SJ, Dick F
	G5	10,000 dives: a review of inside attendant decompression events in a multiplace hyperbaric chamber	Pontani BA, Alexander K, Geiger J, Williams RL
	G6	10,000 dives: a comprehensive review of 14 years of experience	Pontani BA, Alexander K, Williams RL
	G7	CNS oxygen toxicity: from a means of protection to a better understanding?	Arieli Y, Eynan M, Kotler D, Hochman A, Arieli R
	G8	Simulation, ACGME and the hyperbaric fellowship	Stolp BS, Hobbs GH
Posters Only	G9	Feasibility of simulation training for hyperbaric team skills	Hobbs GW, Taekman JM, Stolp BW
	G10	Recommended key words for undersea and hyperbaric medical literature	Lackey CS, Hobbs GW, Carden VR, Koonts RS, Peterson RA, Thibodeau PL
	G11	Hyperbaric oxygen for acute ischemic stroke: need for a better study	Helms AK, Torbey MT, Whelan HT
	G12	Off label use of HBO2T: historical perspective and current challenge	Perdrizet GA
	G13	Simplifying bed selection for hospitalized patients results in more optimal patient care that is cost-effective	Williams R, Meyers T, Pontani B
	G14	Carbon monoxide poisoning in Utah 1996 – 2005	Weaver LK, Churchill S, Deru K, Legler J, Morgan J, Grey T
	G15	Hope in the future: beginning, development and present situation of hyperbaric medicine in brazil	Vinhaes ENG, Bammann RH
	G16	Benefits of a CNS in a multi-hospital hyperbaric program	Peters PM, Skarban MR

3:30 p.m. (15 min) *BREAK & VISIT EXHIBITS* — Salon 1 & Pre-Function

3:45 p.m. (90 min) **SESSION H** Oral Presentations **(Moderators: R Smerz, H Whelan)** — Salon 3 & 4

SESSION G Visit Posters **(Moderators: J Freiberger, H Hopf)** — Salon Pre-Function

Session H: Diving Mishaps & Non-DCI Illness

	Abstract	Title	Authors
Oral Presentations	H1	Identification of candidate genes that control differences in HPNS seizure susceptibility	McCall RD, Frierson D, Blum JE
	H2	Predictors of "chest squeeze" in breath-hold divers	Potkin R
	H3	Pulmonary barotrauma associated with "lung packing"	Potkin R, Firestein S
	H4	Effects of glossopharyngeal insufflation on cardiac function: an echocardiographic study in elite breath-hold divers	Potkin R, Siegel R, Cheng V
	H5	Neurological symptoms after glossopharyngeal insufflation (lungpacking) in breath-hold divers suggesting cerebral arterial gas embolism	Lindholm P, Muth CM, Severinsen SÅ
	H8	Application of the Pareto principle to recreational diving deaths	Denoble PJ, Caruso JL, Dear GdeL, Pieper CF, Vann RD
	H9	Statistical validation of the Pareto principle as applied to recreational diving deaths	Vann RD, Denoble PJ, Caruso JL, Dear GdeL, Pieper CF
	H10	Fatalities in divers using re-breathers	Denoble PJ, Ellis J, Vann RD
Posters Only	H6	Cerebral oxygenation and neurological problems during prolonged breath-holds	Pancaro C, Diaz E, Lindholm P, Ferrigno M
	H7	Fluoroscopic study of glossopharyngeal insufflation and exsufflation	Sun S, Jacobson F, Braver JM, Lindholm P, Ferrigno M
	H12	What can the medical community do for technical divers?	Hobbs GW, Armstrong BM, Armstrong HC, Schreiber JS, Kaylor ZM, Vann RD
	H13	Drugs downed divers did	Smerz, RW
	H14	Incidence of middle ear barotrauma following 10-metre bounce dives for naval diver selection	Arulanandam S, Ng ES, Chan CTG
	H15	Conjunctivitis outbreak among health care providers while scuba diving - a case report	Olsson D, Grant W
	H16	Gastric rupture in a diver due to rapid ascent	Mathisen LC, Landsverk SA, Spook-Fintl KG
	H17	The absence of memory disturbance in deep sea saturation divers	Ozawa K, Iwakawa T, Matsunaga T, Ohtsuka H

Saturday Morning General Session · June 16, 2007

7:00 a.m.	(all day)	Registration open until 5:00 p.m.	Boardroom Foyer
	(120 min)	Continental Breakfast until 9:00 a.m.	Salon 1 & Pre-Functions
7:00 a.m.	(50 min)	**Breakfast Seminar:** Using Toyota Production Techniques to Design and Operate your Hyperbaric Facility / *Neil Hampson*	Salon 2
8:00 a.m.	(60 min)	**Plenary Session:** Point Counterpoint: The Use of Deep Treatment Tables (>3ATA) for the Treatment of DCI in Sport Divers / Richard Moon & Richard Smerz	Salon 3 & 4
9:15 a.m.	(90 min)	**SESSION J** Oral Presentations **(Moderators: I Millar, O Boneta)**	Salon 3 & 4
		SESSION K Visit Posters **(Moderators: T Lo, J Feldmeier)**	Salon Pre-Function

Session J: Diving Physiology & Cellular Mechanisms

	Abstract	Title	Authors
Oral Presentations	J1	High pressure effects on spike generation by isolated NMDA receptor synapse may only partially explain cns hyperexcitability	Mor A, Grossman Y
	J2	Involvement of gabaergic neurotransmission in neurochemical disturbances under single or repetitive nitrogen narcosis	Lavoute C, Weiss M, Sainty JM, Rostain JC
	J3	Reactive oxygen and nitrogen species generation by hyperbaric stress in naive versus experienced divers	Cameron BA, McLellan TC, Eaton DJ, Rhind SG
	J4	Heat shock protein 70 is upregulated in blood leukocytes from experienced divers in response to repetitive hyperbaric stress	Rhind SG, Cameron BA, Eaton DJ
	J5	The evaluation of oxidative stress and antioxidant status following repeated hyperbaric oxygen in patients with decompression illness	Kongoji J, Yamami N, Togawa S, Yagishita K, Mano Y
	J6	Effect of increased respiratory resistance on carbon dioxide levels and hemodynamics in the submerged exercising diver	Cherry AD, Forkner IF, Pollock NW, Freiberger JJ, Stolp BW, Longphre JP, Conard JL, Ma AC, Rhodes MA, Natoli MJ, Schinazi EA, Doar PO, Boso AE, Alford EL, Walker AJ, Frederick HJ, Moon RE
Posters Only	J7	Comparison of end-tidal versus arterial measures of carbon dioxide during immersed exercise at surface and depth	Pollock NW, Cherry AD, Forkner IF, Natoli MJ, Frieberger JJ, Stolp BW, Longphre JP, Conard JL, Rhodes MA, Schinazi EA, Doar PO, Boso AE, Alford EL, Walker AJ, Frederick HJ, Moon RE
	J8	The effect of static lung load on hemodynamics and gas exchange during prone immersed exercise at 122 FSW	Moon RE, Forkner IF, Pollock NW, Freiberger JJ, Stolp BW, Longphre JP, Conard JL, Natoli MJ, Schinazi EA, Doar PO, Boso AE, Alford EL, Walker AJ, Ma AC, Frederick HJ, Cherry AD
	J9	Changes of immune function in rats after 60-meter air simulated dives	Xu WG, Tao HY, Li RP, Sun XJ, Liu K, Liu Y
	J10	The relationship of sickle cell trait and other hemoglobinopathies on scuba diving safety in Caribbean divers	Latham EM, Medak AJ, Grover IR
	J11	Respiratory muscle training enhances swimming and respiratory performance at depth	Ray AD, Pendergast DR, Simpson A, Lundgren CEG
	J12	Changes in cardiac autonomic nervous function and stress hormones during heliox saturation dives to 4.5mpa	Nakabayashi K, Hirayanagi K, Ohiwa H, Ohtsuka H
	J13	Change of serum free radicals and antioxidant potential in rebreather divers	Yamami N, Yagishita K, Togawa S, Kongouji J, Nakayama H, Shibayama M, Suzuki N, Yamamoto K, Nozawa T, Kawashima M, Mano Y
	J14	Mild dyspnea after scuba diving: blood gas analysis	Togawa S, Sugiyama M, Yamami N, Yagishita Y, Kongoji J, Nakayama H, Mano Y
	J15	Effects of endotoxin (LPS) on rats subjected to decompression	Butler BD, Little T
	J16	Return to diving after bleomycin therapy - case report and review	Latson GW, Hill JP

10:30 a.m.	(15 min)	*BREAK & VISIT EXHIBITS*	Salon 1 & Pre-Function
10:45 a.m.	(90 min)	**SESSION K** Oral Presentations **(Moderators: T Lo, J Feldmeier)**	Salon 3 & 4
		SESSION J Visit Posters **(Moderators: I Millar, O Boneta)**	Salon Pre-Function

Session K: HBO2 Science & Cellular Mechanisms

	Abstract	Title	Authors
Oral Presentations	K1	Mechanisms of extension of HBO2 tolerance by intermittent air breaks	Chavko M, Mahon RT, McCarron, RM
	K2	Long term follow up for hyperbaric oxygen treatment of osteoradionecrosis of the mandible	Freiberger JJ1, Flachofsky E, Dear GD, Moon RM, Piantadosi CA
	K3	Neuronal NOS and glutamate decarboxylase s-nitrosylation before oxygen seizures	Demchenko IT, Atochin DN, Suliman HB, Tatro L, Allen BA, Huang PL, Piantadosi CA
	K4	Congestive heart failure and HBO2T: brain-type atrial natriuretic peptide monitoring	Perdrizet GA, Lantos D
	K5	Hyperbaric oxygen attenuate the cardiac neural dysfuntion in streptozotocin induced diabetic rats	Sun TB, Yang CCH, Kuo TBJ
	K6	Inhibition of neutrophil beta-2 integrins by hyperoxia: specificity and mechanism	Thom SR, Bhopale, VM
Posters	K7	The effect of HBO treatment on brown recluse spider venom intoxication in vitro	Pendon JD, Brower GL, Barrett JM, Kalns JE
	K8	Oxygen-regulated vegf levels in ovarian cancer cells	Vuk-Pavlovic S, Knutson GJ
	K9	Effect of hyperbaric oxygenation on experimental colitis in rats	Olsson DJ, Gregory M, Nandi J
	K10	Prevention and suppression of pyrogenic fever in rabbits by hyperbaric oxygen	Niu KC, Kao CH, Lin MT

12:00 p.m.	(60 min)	**LUNCH ON YOUR OWN**	
		LUNCH SEMINAR: Prophylactic Hyperoxia for Reperfusion Injury / Steve Thom	Salon 2

Saturday Afternoon General Session · June 16, 2007

1:15 p.m. (90 min) **SESSION L** Oral Presentations **(Moderators: C Piantadosi, B Pontani)** Salon 3 & 4

Session L: Clinical HBO2 & Ischemia Treatment

	Abstract	Title	Authors
Oral Presentations	L1	Direct effect of carbon monoxide on the nervous system cells	Watanabe S, Shinomiya N, Suzuki S
	L2	Hyperbaric oxygen therapy in cyclophosphamide-induced acute hemorrhagic cystitis: report of six cases	Davis FM, Sames C, Macdonald H
	L4	Hyperbaric oxygen in lower limb trauma (HOLLT): designing a randomized controlled multi-centre study	Millar IL, Williamson OD, Cameron PA
	L5	Identification of the early time window post stroke for hyperbaric oxygen efficacy in the treatment of acute stroke: a retrospective statistical analysis	McCormick JG, Houle TT, Saltzman HA, Whaley RC, Roy RC
	L6	Hyperbaric oxygen preconditioning cost-effectively improves myocardial function & clinical outcome following ischemic reperfusion injury	Yogaratnam JZ, Laden G, Bennette S, Riggs C, Hong H, Gower S, Evans P, Smith RO, Saleh A, Guvendik L, Cowen M, Cale A, Griffin S
	L7	The cardioprotective effects of hyperbaric oxygen preconditioning prior to ischemic reperfusion injury involves a synergistic link between enos & sicam-1	Yogaratnam JZ, Laden G, Madden LA, Guvendik L, Cowen M, Greenman M, Seymour AM, Cale A, Griffin S
	L8	Hyperbaric oxygen preconditioning promotes cardioprotection following ischemic reperfusion injury by improving myocardial function, limiting necrosis & enhancing the induction of hsp72	Yogaratnam JZ, Laden G, Madden LA, Guvendik L, Cowen M, Greenman M, Seymour AM, Cale A, Griffin S
	L9	The kinetics of the selecting group of adhesion molecules following hyperbaric oxygen preconditioning improve myocardial function & pulmonary flow in a human model of ischemic reperfusion injury	Yogaratnam JZ, Laden G, Madden LA, Guvendik L, Cowen M, Greenman M, Seymour AM, Cale A, Griffin S
Poster Presentations	L3	Fractionated stereotactic radiotherapy using gamma unit after hyperbaric oxygenation on recurrent high-grade gliomas	Kohshi K, Yamamoto H, Nakahara A, Katoh T, Tamaki H, Takagi M
	L10	Quality of life improved after hyperbaric oxygen therapy for late radiation effect injuries induced by radiated brachial plexus	Skarban M, Simanonok J, Niezgoda J, Orlowski B
	L11	Isolated peripheral CN VII and phrenic nerve palsies following oxygen-enriched therapeutic air saturation decompression: a case report	Hardy S, Wilson B, Van Meter K, LeGros TL
	L12	Acute carbon monoxide poisoning from volitional hookah smoke inhalation	Wilson B, Wierzbicki D, Hardy S, LeGros TL, Murphy-Lavoie H
	L13	Hyperbaric oxygen therapy (HBO) for idiopathic sudden deafness on scaled out cases	Inoue O, Shinhama A, Hasegawa M, Ganaha A, Suzuki M, Kukita I
	L15	Hyperbaric oxygen therapy used to treat intractable anemia due to radiation induced esophagitis and gastritis	Williams R, Feste M, Pontani B
	L16	Cerebral air-gas embolism due to removal of quinton catheter	Williams R, Pontani B
	L17	Acute peripheral ischemia from heparin induced thrombocytopenia: treatment with hyperbaric oxygen therapy	Pontani BA, Williams RL, Carwile J

2:30 p.m. (15 min) *BREAK & VISIT EXHIBITS* Salon 1 & Pre-Function

2:45 p.m. (90 min) **SESSION L** Visit Posters **(Moderators: C Piantadosi, B Pontani)** Salon Pre-Function

4:00 p.m. **Adjourn**

SESSION A: Decompression Models and Theory

A1

Oral Presentation: 0915 - 0927
Poster Presentation: 1045 - 1200

A NEW CLASS OF BIOPHYSICAL MODELS FOR DETERMINING THE PROBABILITY OF DECOMPRESSION SICKNESS IN SCUBA DIVING

Goldman S
University of Guelph, Guelph, Ontario, Canada

BACKGROUND: Interconnected compartmental models have been used for decades in physiology and medicine to account for the observed multi-exponential washout kinetics of a variety of solutes (including inert gases) both from single tissues and the body as a whole. They are used here as the basis for a new set of biophysical probabilistic decompression models. These models are characterized by a relatively well-perfused, risk-bearing, central compartment, and one or two non-risk-bearing, relatively poorly perfused peripheral compartments. The peripheral compartments affect risk indirectly by diffusive exchange of dissolved inert gas with the central compartment.

MATERIALS AND METHODS: The interconnected models and the independent parallel compartment model against which they were compared, made use of the same dissolved phase risk function, were based on linear kinetics, and were calibrated against the same dataset. The model parameters were determined by calibrating against total DCS incidence rate data, using "Maximum Likelihood".

RESULTS: On the basis of the accuracy of their respective predictions beyond the calibration regime, the three-compartment interconnected models were found to be significantly better than both the two-compartment interconnected models, and the independent parallel compartment model used for comparative purposes. The interconnected models predict that inert gas washout during decompression is relatively fast, initially, but slows rapidly with time, as compared to the more uniform washout rate predicted by the independent parallel compartment model.

CONCLUSIONS: A new class of decompression models based on interconnected compartments has been developed. Their washout rate characteristics differ significantly from those of independent parallel compartment models. If the washout characteristics of the interconnected models are empirically verified, this may have important implications for diving practice.

A2 (President's Competition)
Oral Presentation: 0927 - 0939
Poster Presentation: 1045 - 1200

PROBABILITY MODELS OF MILD AND SERIOUS DECOMPRESSION SICKNESS (DCS)

Weber PW[1], Howle LE[1], Denoble PJ[2], Vann RD[2], Pieper CF[3]
[1]Department of Mechanical Engineering and Materials Science, Duke University, [2]Divers Alert Network, Center for Hyperbaric Medicine and Environmental Physiology, Department of Anesthesiology, and [3]Center for Aging, Division of Biostatistics and Bioinformatics, Duke University Medical Center, Durham, NC

BACKGROUND: Serious DCS (cerebral and motor manifestations) is of greater medical and operational concern than mild DCS (sensory, pain, cutaneous, and constitutional manifestations), and each has a different acceptable DCS probability (1). Distinction by severity makes the DCS probabilities trinomial (no-DCS, mild-DCS, serious-DCS) rather than binomial (no-DCS, DCS). We tested the hypothesis that differentiating mild from serious DCS improves the goodness-of-fit of a probabilistic model to empirical data.

MATERIALS AND METHODS: The "linear-exponential" (LE) model of Thalmann (2) was adapted for use with the trinomial probability equations of Gault (3) as well as with an alternate trinomial model derived by Howle. These were applied to the "BIG292" calibration data that included 190 binomial DCS cases (equivalent to 170 mild cases and 20 serious cases in trinomial representation) in 3,322 dives (4). Marginal cases were omitted from consideration since Thalmann had weighted them as 0.1 which precluded formal comparison of binomial and trinomial likelihoods by the likelihood ratio test (2).

RESULTS: The trinomial probability equations have one more parameter than the binomial equations and collapse into the binomial equations for an appropriate parameter choice (3). Upon optimization of the LE model to the "BIG292" calibration data, the best binomial and trinomial maximum likelihoods were found to be -967.8 and -741.9, respectively.

CONCLUSIONS: Differentiating mild from serious manifestations improved the goodness-of-fit of the LE model to the "BIG292" calibration data. For designing DCS procedures, this would allow application of different acceptable DCS probabilities according to manifestation severity (1).

REFERENCES:
1. Van Liew. UHM 32:187. 2005.
2. Thalmann. UHM 24:255. 1997.
3. Gault. UHM 22:249. 1995.
4. Survanshi. NMRI Report 97-36:77. 1997.

A3

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

A PARAMETER ESTIMATION SYSTEM WITH COMPUTATIONAL ADVANTAGES FOR FITTING PROBABILISTIC DECOMPRESSION MODELS TO EMPIRICAL DATA

Howle LE1, Weber PW1, Vann RD2
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BACKGROUND: Parameter values for probabilistic decompression models can be estimated directly from empirical calibration data. A modular parameter estimation system was created with computational benefits including object-oriented programming methods, use of analytic instead of numerical techniques, a library of optimization methods including hybrid gradient ascent algorithms and parallel processing. Reliability of the approach was tested by reproducing the results of earlier work that fit "exponential-exponential" (EE) and "linear-exponential" (LE) models to a standard calibration database (1).

MATERIALS AND METHODS: Code was developed with an engine written in C#.NET. Exact integrations of risk functions for the EE and LE models were derived and employed to reduce computation time. A baseline parameter optimization method was developed and compared with several techniques from the C#.NET library. Parallel processing techniques were also developed to apportion tasks to multiple networked computers and on stand-alone multiprocessor computers. Previously published calibration data was used in this system to estimate previously published parameters, and these parameters were used as a basis of comparison (1, 2).

RESULTS: Excellent agreement with previously published results was obtained with this system. Re-optimizing the parameters with the system also produced improved results. The non-normal, non-analytic behavior of one variant of the LE model caused problems not previously reported. Complete optimization for a 9-parameter LE model required approximately ten minutes with exact integration and approximately one month with numerical integration. Optimization techniques from a commercial C#.NET library produced optimization times which were 30-fold less than the baseline. Homogeneous parallel processing reduced model optimization time by 40%, and grid computing offered performance improvement even with network communication delays.

CONCLUSIONS: The modular parameter estimation system developed produced results that were in agreement with those of previously published systems and offered advantages in computation speed and portability.

REFERENCES:
1. Thalmann. UHM 24:255. 1997.
2. Gerth. UHM 24:275. 1997.

A4 (President's Competition)
Oral Presentation: 0939 - 0951
Poster Presentation: 1045 – 1200

DIFFERENCE IN BUBBLE FORMATION USING DEEP STOPS IS DEPENDENT ON LENGTH OF BOTTOM TIME; EXPERIMENTAL FINDINGS AND THEORETICAL SUPPORT

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BACKGROUND: Deep decompression stops compared to more conventional shallower stops have recently been introduced. Most findings and theoretical work on excess gas phase models suggest an apparent advantage of using deeper stops. However, some reports indicate that the incidence and/or risk of decompression sickness may actually increase following such procedures.

MATERIALS AND METHODS: The impact of different decompression schedules was tested on pigs compressed in a dry chamber monitored using ultrasonic imaging. A total of 26 pigs were divided into 4 groups of 6 and one group of 2 (aborted protocol). Two groups performed a shallow/long (30 msw / 70 min) dive. One group followed a Bühlmann / Uwatec decompression procedure while the other followed a procedure generated by the Copernicus bubble model. The three last groups did a deep/short (65 msw / 20 min) dive followed by a Bühlmann decompression procedure, a Copernicus procedure (aborted profile) and a revised Copernicus procedure respectively.

RESULTS: The long/shallow dive achieved a significant decrease of vascular bubbles following the procedure with deeper initial stops (Copernicus schedule) compared to the controls (Bühlmann schedule). However, on the deep/short dive the procedure with deeper stops gave a dramatic increase of bubble formation, resulting in the protocol to be aborted after two trials. A new revised Copernicus schedule with the deepest stops removed, gave a significant decrease of vascular bubble formation.

CONCLUSIONS: A new stabilizing mechanism for bubble nuclei had to be developed in order to simulate and reproduce the findings in this study. "Traditional" bubble models will in general suggest that adding some deep stops is beneficial for decompression outcome, however this may not always be true. The presented studies suggest that deep stops are not recommended on shorter dives.

A5 (President's Competition)
Oral Presentation: 0951 - 1003
Poster Presentation: 1045 - 1200

Financial Disclosure to be made

DETECTION OF STATIONARY MICROBUBBLES IN TISSUE USING DUAL-FREQUENCY ULTRASOUND

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BACKGROUND: Normally occurring microbubbles in tissue may play a key role in decompression sickness. The microbubble hypothesis is based on indirect evidence: no technique currently exists to directly measure stationary microbubbles in tissue. In this paper the capability of dual-frequency ultrasound to detect stationary microbubbles in tissue is demonstrated using microbubble contrast agent and a swine model.

MATERIALS AND METHODS: Dual-frequency ultrasound exploits the fact that resonating bubbles act as nonlinear mixers. Bubbles are insonified at two frequencies: one set to resonate the bubbles and a second carrier or "image" frequency. Bubbles of the appropriate size (resonating bubbles) emit the sum and difference of the two insonification frequencies. Encapsulated microbubbles with diameter order 1 um (Definity® ultrasound contrast agent) are used to model microbubbles. Solid polymer microspheres (SPM) are used to model non-resonant particles of similar size. Definity® solutions of varying concentration were injected into the thigh of an anesthetized swine. SPM and saline controls were also injected. The sites were measured for various insonification frequencies and powers. Baseline measurements were made prior to injection.

RESULTS: Pump and image frequencies of 2.25MHz and 5.0MHz respectively were found to be optimal. No mixing signals were detected at any site prior to injection or at the control sites (saline and SPM) after injection. Mixing signal was detected at the Definity® sites for Definity® concentrations greater than 5E7 particles/ml. Undiluted Definity® was detected at transmit pressures above 40kPa (CW), and increased linearly until saturation at transmit pressures of 200kPa.

CONCLUSIONS: This is the first demonstration that stationary microbubbles can be detected in tissue using dual-frequency ultrasound. Research is underway using the technique to try to detect endogenous microbubbles in tissue, which are of unknown size, location and occurrence. This research could lead to improved understanding of the mechanics of bubble formation during decompression.

A6

Oral Presentation: 1003 – 1015
Poster Presentation: 1045 - 1200

EMPIRICAL EVALUATION OF THE EFFICACY OF DEEP STOPS IN AIR DECOMPRESSION DIVES

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BACKGROUND: Classical decompression algorithms limit hypothetical tissue gas contents and prescribe decompressions that advance rapidly to shallow stops where most of the total stop time (TST) is scheduled. Recent bubble-based algorithms limit calculated bubble profusion and size and prescribe decompressions with TST skewed toward deeper stops. Navy Experimental Diving Unit (NEDU) has completed a controlled comparative study of these approaches.

MATERIALS AND METHODS: Divers wearing swimsuits and t-shirts, breathing surface-supplied air via full face masks, and immersed in 86 ºF water in the NEDU Ocean Simulation Facility wetpot were compressed at 60 fsw/min to 170 fsw. They performed 115 Watt cycle ergometer work during an ensuing 27.2 minutes at bottom and were decompressed at 30 fsw/min with stops prescribed by one of two schedules, each with 174 min TST. Schedule 1, with first stop at 40 fsw, was prescribed by the man-tested, deterministic gas content, VVAL18 Thalmann Algorithm. Schedule 2, with first stop at 70 fsw, was the optimum distribution of TST according to the man-dive calibrated, probabilistic BVM(3) bubble model. Decompression sickness (DCS) incidence with these schedules was compared under the sequential stopping rules of reject-high if DCS risk > 7% or reject-low if DCS risk < 3% with 95% confidence.

RESULTS: The trial was terminated after midpoint interim analysis. Neither schedule was rejected, but DCS incidence in Schedule 2 (deep stops, 11 DCS/198 dives) was significantly higher than in Schedule 1 (3/192, p=0.030, one-sided Fisher Exact). On review, one Schedule 2 DCS was excluded, but the result remained significant (p=0.047). Most DCS was mild, late onset, Type I, but two Schedule 2 cases involved rapidly progressing CNS manifestations.

CONCLUSIONS: The deep stops schedule had a greater risk of DCS than the matched conventional schedule. Slower gas washout or continued gas uptake offset benefits of reduced bubble growth at deep stops.

A7

ABSTRACT WITHDRAWN

A8

Oral Presentation: 1015 – 1030
Poster Presentation: 1045 - 1200

EMPIRICAL EVALUATION OF EXTENSIONS TO NO- STOP LIMITS FOR DEEP AIR DIVING

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BACKGROUND: The man-tested, deterministic VVAL18 Thalmann Algorithm underlies U.S. Navy closed-circuit nitrox decompression tables, diver-carried Navy Dive Computers, the Topside Decompression Monitor, and the Navy Dive Planner. Two structurally different probabilistic models fit to extensive databases of man-dives, BVM(3) and USN93, are prototype replacements for VVAL18 in some of these applications. Air diving decompression schedules based on VVAL18, BVM(3), or USN93 generally prescribe longer decompressions than the U.S. Navy Standard Air tables (USN57) but permit longer no-stop limits for dives deeper than 100 fsw. Only limited test data exist for these longer limits.

MATERIALS AND METHODS: Selected no-stop limits were to be tested with 100 man-dives each under the sequential stopping rule of decompression sickness (DCS) risk exceeding 5% with 90% confidence. Divers wearing 5-7mm neoprene wetsuits, breathing surface-supplied air via full face masks, and immersed in 55 ºF water in the NEDU Ocean Simulation Facility wetpot, were compressed at 60 fsw/min, performed 100 Watts cycle ergometer work while on bottom, and then were decompressed directly to surface at 30 fsw/min.

RESULTS: Series A testing was terminated early after the fourth DCS. Although the raw incidence was acceptable, 1.4% (0.5%, 3.2% 90%CL), all DCS were Type II with CNS manifestations. Subsequent tests of shorter (Series B) no-stop limits for a lower incidence of severe DCS were terminated after the second Type II CNS DCS.

Series	Depth/BT (fsw/:min)		Man-dives	DCS
A	130/:20	VVAL18	84	2
	150/:15	VVAL18	100	1
	190/:11	USN93	100	1
B	130/:16	BVM(3)	57	0
	150:12	BVM(3)	51	1
	190/:9	VVAL18	40	1

CONCLUSIONS: The severity of DCS makes these no-stop limits unacceptable. Deep, working, no-stop dives of any duration may predispose to CNS DCS. Testing of USN57 no-stop limits, initially released on the basis of four DCS-free test dives each, is in progress.

A9

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

DESCRIPTIVE MODEL OF THE INFLUENCE OF THERMAL EXPOSURE ON DIVER SUSCEPTIBILITY TO DECOMPRESSION SICKNESS

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BACKGROUND: Evidence indicates that diver thermal status is a risk factor for decompression sickness (DCS).1 Divers wearing swimsuits and t-shirts performed experimental working, air decompression dives while fully immersed in water at temperature controlled independently [warm (36.1 ºC) or cold (26.7 ºC)] during bottom time (BT) and decompression phases. Here we report a descriptive model that systematizes those results and allows quantification of the thermal effects.

MATERIALS AND METHODS: Four-hundred man-dives were completed with 21 cases of DCS in seven series of dives to 120 feet of seawater (fsw) with different combinations of thermal conditions and BT from 25 to 70 min, but with the same U.S. Navy Standard Air 120 fsw/70 min decompression schedule (stops: 30 fsw/9 min, 20 fsw/23 min, 10 fsw/55 min). Observed effects of water temperature on DCS risk during BT (TW,B), water temperature during decompression (TW,D), and different BT were isolated with a fitted logistic model.

RESULTS: A model of form, logit = b_0 + b_1 ln(BT) + b_2 T_W,B + b_3 T_W,D , fit the data with log likelihood (LL) significantly higher than the null model LL ($P<<0.0001$) and significant chi-square goodness-of-fit ($P = 0.85$, d.f. = 6). Additional interaction terms were explored and found insignificant. The DCS odds ratio (OR) for a 10 ºC increase in TW,B was 23.8 (95% CI = 3.77 ñ 132), while the OR for a 10 ºC increase in TW,D was 0.010 (95% CI = 0.002 ñ 0.114). The DCS OR for a doubling of BT was 33.3 (95% CI = 5.05 ñ 194).

CONCLUSIONS: The inverse of the OR for a 10 ºC increase in TW,D was about five times the OR for the same increase in TW,B, indicating that beneficial effects of warm conditions during decompression predominated over deleterious effects of warm conditions during BT. Effects of a 10 ºC increase in TW,D were comparable to effects of halving BT.

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1Ruterbusch et al. Undersea Hyperb Med 2004;31:336.

A10

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

DOES THE V.O2max VALUE PREDICT THE FORMATION OF INTRAVASCULAR CIRCULATING BUBBLES DURING DECOMPRESSION OF HEALTHY DIVERS?

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BACKGROUND: To study a possible correlation between the individual V.O2max value and the quantity of intravascular bubbles formed at the end of a dive.

MATERIALS AND METHODS: 42 male divers took part in this study. At least one week prior to the experimental dive, each subject underwent an incremental maximum test to determine maximal oxygen uptake (V.O2max) on a cycloergometer. The divers had been told to avoid any physical exercise 48 hours prior to the dive. The subjects were divided into two sub-groups. Sixteen of them completed a dive in a dry hyperbaric chamber and 26 in the open sea. The two dives had the same profile: 30 min at 400 kPa with a 9 min stop at 130kPa (French military decompression table MN90). The age, Body mass index and the V.O2max values of the two sub-groups were similar: respectively 33.3± 3.7 years; 24.1± 1.5 kg.m-2 and 51.7± 8.1 ml.kg-1.min-1 in the case of the divers in hyperbaric chamber v. 37.8± 7.5 years; 24.5±2.1 kg.m-2 and 48.9± 4.5 ml.kg-1.min-1 for those diving in the sea. Circulating venous bubbles were detected on precordial area using a pulsed Doppler 2 MHz, 30, 60 and 90 min. after surfacing.

RESULTS: Bubble formation in both types of dive was significantly correlated to the age and Body mass index of the divers. However there was no significant relationship between the V.O2max values and bubble formation for the two sub-groups.

CONCLUSIONS: While it is still true that V.O2max roughly reflects a subject's level of physical activity, which is known to influence bubble formation, V.O2max does not seem to be a good parameter to predict the formation of intravascular circulating bubbles during the decompression of healthy divers.

A11

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

NONINVASIVE DETECTION AND ASSESSMENT OF GAS MICROBUBBLES IN BLOOD AND TISSUES

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BACKGROUND: Noninvasive functional imaging, monitoring and quantification of micro bubbles forming in blood and tissues upon rapid changes in barometric pressure are extremely important for effective therapy and diagnostics of several diseases. However, current techniques are incapable of imaging and efficiently detecting bubbles with diameter less than 50 micrometers. Here we propose novel Optical Coherence Tomography (OCT)-based sensor capable of real-time, sensitive, accurate, and noninvasive imaging, monitoring, and quantification of microbubbles in skin and whole blood.

MATERIALS AND METHODS: Experiments were performed with fresh human blood. Once withdrawn (an anticoagulant was added), the blood samples were placed in a specially designed syringe with clear plastic walls. All experiments were performed at 22 ºC using a portable fiber-based OCT system (in-depth resolution ~20 mkm) with electro-optical peizo fiber-based in-depth scanning system. Continuous OCT imaging of blood optical properties was performed upon application of different negative pressure in the syringe. The acquired images were 450 by 450 pixels. The in-depth scanning was up to 2.2 mm, while the lateral scanning was 2.4 mm.

RESULTS: The OCT imaging was performed at the same position of the syringe before and after application of the negative pressure. Formation of gas bubbles with diameter of 100-200mkm upon application of the negative pressure was clearly detected and assessed. Application of phase-sensitive measurements indicated superior sensitivity of OCT for assessment of changes in refractive index of biofluids (up to 10E-6). These indicate that submicron bubbles could be potentially detected and analyzed in a real-time.

CONCLUSIONS: Obtained results demonstrate capability of OCT technique to image formation of micro bubbles in whole blood. However, resolution of this system was limited to approximately 20mkm that might be insufficient for detection of small gas bubbles. Currently, we are improving this limit of detection by application of phase-sensitive and spectroscopic methods.

A12

ABSTRACT WITHDRAWN

A13

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

RESEARCH HYPOTHESIS UPON THE BUBBLE FORMATION IN THE CONNECTIVE TISSUE

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BACKGROUND: Bubble generation following underwater activity is a prerogative of imperfect systems. Amid the most accredited theories, as per the basis for bubble formation, you can find some of them either considering the presence of gaseous micronuclei or assuming the formation of cavitation nuclei. A "baby-bubble" does become evident in a mixed microenvironment: in fact while at one side you can find the vascular bed, the extra-cellular tissue drainage system, at the other side the cell inner elements. In both cases, or in the bubble peripheral formation thesis at least, the event location appears to be the extracellular matrix: the connective tissue. This hypothesis does appear to be confirmed thanks to the following two observations: the first observation is related to those so-called "minor" clinical presentations that seem to be due to a lymphatic system impairment (therefore to a deficit that is starting out just from the very inner part of the matrix); the latter observation is a recent meaningful observational clinical occurrence of ours.

MATERIALS AND METHODS: Ten subjects suffering from Type-II Decompression Illness (DCI) neurological sequelae were treated with a phytotherapic extract (Abies-pectinata, Castanea-vesca, Juglans-regia,Vitis-vinifera, Eritrite, Uncaria-tomentosa) with specific capabilities to drain the connectival tissue: 50 drops in a glass of water, 3 times/day, for three months. On 30th-Day we submitted the subject to an interview test, followed by a neurological clinical examination (included both a hypoesthesia zone mapping and a muscular impairment grading).

RESULTS: We observed both subjective and objective sharp improvements in the whole group.

Patient's initials	Diagnosis at patient DHM-Unit admittance	Neurological examination	Tx protocol applied	Symptoms at the end of the treatment	Symptoms at 3 mths from the treatment Outcome: (---+++)
ES	Type II – DeCompression Illness (DCI) [medullar involvement]	Left foot sensorial impairment. Omolateral strength loss. Hyperreflexia.	US NAVY TT6 + 20 FT (*) + § (**)	Spotted hypoesthesia.	Outcome +++ Restitutio ad integrum.
DA	Type I - DCI [an osteo-myo-articular pain presentation]	Left scapular-humeral pain and inguinal saddle anaesthesia.	USN TT5 + § (**)	Saddle anaesthesia persistence.	Outcome +++ Restitutio ad integrum.
AC	Type I – DCI [vestibular kind]	Vertigo. Vomiting. Tinnitus.	US NAVY TT6 + 10 FT (*) + § (**)	Tinnitus and unstableness persistence.	Outcome +/++ Tinnitus persistence.
RC	Type II – DCI [medullar involvement]	Lower limb anaesthesia (up to the right knee and left ankle respectively). Impossibility to keep the upright position due to the strength loss.	US NAVY TT6 + 17 FT (*) + § (**)	Right foot and right hyperreflexia persistence.	Outcome +++ Restitutio ad integrum.
PC	Type II – DCI [medullar involvement]	Pain and upper limb motory impairment.	US NAVY TT6 + 15 FT (*) + § (**)	Movement impairment (mostly right upper sectors with concomitant strength loss).	Outcome ++/+++ An almost total strenght loss recovery but a slight right motory hindrance persistence.
FC	Type II – DCI [medullar involvement]	Left foot anaesthesia and saddle one. Less intense similar counterlateral symptoms. Bladder paralysis. Marked uneasiness.	US NAVY TT6 + 20 FT (*) + § (**)	Bladder recovery. Saddle anaesthesia areas persistence.	Outcome ++ Saddle anaesthesia persistence, diminished as per area extension.
LS	Type II – DCI [medullar involvement]	Left (foot and leg) strenght loss.	US NAVY TT6 + 10 FT (*) + § (**)	Mild left claudicatio	Outcome +++ Restitutio ad integrum.
GE	Type II – DCI [medullar involvement]	Bilateral lower extremity anaesthesia (up to the knees).	US NAVY TT6 + 15 FT (*) + § (**)	Right foot anaesthesia.	Outcome +++ Restitutio ad integrum.
FB	Type II – DCI [medullar involvement]	Paraparesis and complete bilateral sensibility loss.	US NAVY TT6 + 10 FT (*) + § (**)	Early recovery, started at the very first Tx (assistance given within 5').	Outcome ++/+++ Spotted hypoesthesia still left.
MM	Type I – DCI [vestibular kind]	Dizziness. Vomiting.	US NAVY TT6 + § (**)	Subjective unstableness.	Outcome +++ Restitutio ad integrum.

(*) Any further treatment (FT) according the following standard: 25'x3 O_2 and 5'x2 interposed air-breaks @ 15 meters of water column (2.5 ATA, ≈147.1 kPa).
(**) All the considered cases have been treated with the phytotherapic extract soon after the last HBO_2 programmed therapy. § stands for: Abies-pectinata, Castanea-vesca, Juglans-regia,Vitis-vinifera, Eritrite, Uncaria-tomentosa; dose applied: 50 drops in a glass of water, three times a day (before meals), for three months.

CONCLUSIONS: While there is no control group, as the study started as a practical application of a specific phytotherapic expertise more than with the classical scientific approach usually due, it nevertheless does seem to validate that to improve the connective tissue drainage could be useful both at the epicrisis time and at the functional recovery stage of a DCI occurrence.

A14

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

A START TOWARD MICRONUCLEUS-BASED DECOMPRESSION MODELS: ALTITUDE DECOMPRESSION

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BACKGROUND: Do gaseous micronuclei trigger the formation of bubbles in decompression sickness (DCS)? Most previous instructions for DCS prevention have been oriented toward supersaturated gas in tissue. We are developing a mathematical model that is oriented toward the expected behavior of micronuclei. The issue is simplified in altitude decompressions because the aviator or astronaut is exposed only to decompression, whereas in diving there is a compression before the decompression.

MATERIALS AND METHODS: The model deals with four variables: duration of breathing of 100% oxygen before going to altitude (O2 prebreathing), altitude of the exposure, exposure duration, and rate of ascent. Assumptions: a) there is a population of micronuclei of various sizes having a range of characteristics, b) micronuclei are stable until they grow to a certain "critical nucleation radius," c) it takes time for gas to diffuse in or out of micronuclei, and d) all other variables being equal, growth of micronuclei upon decompression is more rapid at high altitude because of the rarified gas in the micronuclei. To estimate parameters, we use a dataset of 4,756 men in altitude chambers exposed to various combinations of the model's variables.

RESULTS: The model predicts occurrence of DCS symptoms quite well. It is notable that both the altitude chamber data and the model show little effect of O2 prebreathing until it lasts more than 60 minutes; this is in contrast to a conventional idea that the benefit of prebreathing is directly due to exponential washout of tissue nitrogen.

CONCLUSIONS: The delay in response to O2 prebreathing can be interpreted as time required for outward diffusion of nitrogen; when the micronuclei become small enough, they are disabled, either by "crushing" or because they cannot expand to a critical nucleation size when the subject ascends to altitude.

A15

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

HOW DO MICRONUCLEI GENERATE BUBBLES?

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BACKGROUND: The idea that decompression bubbles are generated from gaseous micronuclei is gaining acceptance. It is not clear what the hypothetical micronuclei are, so our answer to the question of the title will be conjectural. Our objective here is to present a plausible scenario for the nucleation process.

THEORY: We assume that micronuclei occur in various sizes and are free-standing, permeable, gas-containing aggregates of surfactant molecules. We are able to characterize the stability of a micronucleus and a critical nucleation radius mathematically from considerations of surfactant chemistry. Micronuclei can be expected to be compressed when a diver goes to depth. Until inert gas has washed into the tissues, a micronucleus has higher inert gas partial pressure than its surroundings so the contents will tend to diffuse out, making the micronucleus even smaller than it was when first compressed. When the diver returns to the surface, the micronucleus is decompressed and then enlarges more as inert gas diffuses into it from the now supersaturated tissues around it. The surfactant molecules tend to resist surface tension pressure and changes of size brought on by ambient pressure changes and gas diffusion, so the micronucleus is able to maintain its integrity as it shrinks and grows. However, if the micronucleus reaches a "critical nucleation radius," the stabilizing capacity of the surfactant molecules fails and the gas inside grows rapidly into a free bubble by inward diffusion from the supersaturated blood and tissues around it; there is a positive feedback process -- an enlarging surface area begets more rapid inward diffusion.

CONCLUSIONS: From this narrative, it is seen that whether nucleation occurs depends on the resting size of the micronucleus, how small it becomes during the dive, and how large it becomes afterward.

SESSION B: Clinical HBO2 and Wound Treatment

B1 (President's Competition)
Oral Presentation: 1045 - 1057
Poster Presentation: 0915 – 1030

STEM CELL MOBILIZATION IN DIABETICS - RESPONSES TO HYPERBARIC OXYGEN THERAPY

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BACKGROUND: Exposure to hyperbaric oxygen (HBO2) has been shown to mobilize bone marrow stem cells in normal humans, patients with a history of radiation exposure, and in animal models. The goal of this study was to determine whether similar events occur in diabetic patients undergoing HBO2 therapy.

MATERIALS AND METHODS: Patients referred for HBO2 with Wagner class 3 or 4 refractory foot ulcers or for radiation necrosis who gave informed consent were involved in this study. To date, five patients have completed a course of 20 treatments at 2.0 ATA O2 daily, six days/week. Blood was drawn for flow cytometry analysis before and after the 1st, 10th and 20th treatments.

RESULTS: Responses to HBO2 were more variable than in previous trials with non-diabetic radiation-exposed patients, and differing patterns of stem cell sub-populations were observed. Overall, HBO2 resulted in a 27+/-17% (mean+/-SE, n=5) elevation in circulating CD34+ stem cells in response to the first HBO2 treatment, an elevation of 41.8+/-11% ($p<0.05$) following the 10th treatment, and no further elevation in response to the 20th. Absolute CD34+ cells per 100,000 monocytes counted demonstrated a consistent, increasing trend over the course of therapy and the difference from control was statistically significant at the 10th treatment. Mean CD34+ counts in healthy controls were 258+/-27 (n=8). Prior to the 1st HBO2 treatment, the mean CD34+ count among diabetic patients was 220+/-74, prior to the 10th treatment 576+/-99 ($p<0.05$) and prior to the 20th 1062+/-702.

CONCLUSIONS: We conclude that variations in metabolic status and diabetic management are likely to influence stem cell mobilization responses to HBO2. Despite the variability observed in the first 5 patients in this trial, there is evidence that stem cell mobilization occurs in diabetics and this may play a role in HBO2-mediated neovascularization.

B2

Oral Presentation: 1057 - 1109
Poster Presentation: 0915 - 1030

THE EFFECTS OF HYPERBARIC OXYGEN THERAPY ON PATIENTS WITH MUSCLE INJURY

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BACKGROUND: Muscle injury is the primary injury associated with sports activity. Hyperbaric oxygen therapy (HBO) application for soft tissue injuries, including muscle injury, has been reported by several authors. As HBO is indicated for compartment syndrome, HBO should reduce edema after injury. Rapid improvement of muscle strength by HBO application in rat model has been reported. Thus, HBO should theoretically be effective for the patients with muscle injury. The purpose of this study was to evaluate the effect of HBO on patients with muscle injury.

MATERIALS AND METHODS: Twenty patients, who sustained muscle injury during sports activity and were admitted to our hospital within seven days after injury, were included in this study. The patients were administered HBO at 2.8 ATA for 1 hour for one to seven sessions. At the time of both pre-treatment and post-treatment, visual analog scales (VASs) regarding rest pain, motion pain, and patients' subjective evaluation of edema were measured 32 times in 15 patients. Muscle stiffness was measured with muscle tonometer 18 times in 14 patients, and leg volume was measured with the water-filled volumetric gauge 10 times in 5 patients with gastrocnemius muscle injury.

RESULTS: The VAS values at pre-treatment and post-treatment were respectively 83.4 points and 87.5 ($p<0.005$) in rest pain, 64.8 points and 72.8 ($p<0.005$) in motion pain, and 78.3 points and 79.1 points ($p>0.05$) in patientsí subjective evaluation of edema. Muscle stiffness averaged 61.5 points at pre-treatment, and 59.9 points at post-treatment ($p<0.01$). Leg volume averaged 3963 cm3 at pre-treatment, and 3903 cm3 at post-treatment ($p<0.001$).

DISCUSSION: In this study in patients with muscle injury, HBO was effective on the VAS values, muscle stiffness, and leg volume. HBO was effective in patients with muscle injury. Further study should be necessary for assessment of healing acceleration and intermediate term results in patients with muscle injury.

B3

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

HYPERBARIC OXYGEN THERAPY IN TRANSIENT OSTEOPOROSIS OF THE HIP: A CASE REPORT

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BACKGROUND: Transient osteoporosis of the hip (TOH) is a disorder in the femoral head, which is characterized by pain, osteoporosis, and bone marrow edema. The symptoms mostly disappear within 4-9 months with a conservative treatment. However, pain at peak levels is severe and continuation of pain would restrict the patients' activity. The effects of hyperbaric oxygen therapy (HBO) on reduction of tissue edema and progression of osteogenesis have been reported. Thus, it is anticipated that HBO would be effective in patients with TOH. We report a case of TOH treated with HBO.

CASE REPORT: A 35-year-old man had gradual onset of pain in his right hip and the upper thigh, and he was referred to our university hospital for application of HBO two weeks after the onset. The patient presented a limp, pain, and limited range of motion as 95 degrees in flexion in the right hip, whereas 125 degrees in the left hip. The patient was diagnosed as having TOH by MRI. HBO administration to the patient was performed at a pressure of 2.0 ATA for 1 hour. The patient received HBO four times a week on average and for a total of 30 sessions within 2 months.

RESULTS: One and one half months after onset, the patient was pain free during full weight bearing, with a range of right hip motion reaching 120 degrees in flexion. Two months and 20 days from the onset, MRI showed remarkable improvement with mostly normal signal. Three months and 10 days from the onset, the patient revealed complete resolution of symptoms, which represented a rapid recovery compared with the average course of TOH.

CONSLUSIONS: Accelerated recovery was observed in the patient with TOH treated with HBO. HBO would be effective for accelerated recovery time in patients with transient osteoporosis of the hip.

B4

Oral Presentation: 1109 - 1121
Poster Presentation: 0915 - 1030

THE HYPERBARIC OXYGEN (HBO) TREATMENT FOR LUMBAR CANAL STENOSIS (LCS)

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BACKGROUND: Lumbar canal stenosis (LCS) is suggested in the states of ischemia in cauda equina and/or nerve roots. Administration such as prostaglandin (PGE) is performed and availability is reported. Hyperbaric oxygen (HBO) treatment supplies oxygen to a cell or tissue of anoxia and has been used for treatment such as carbon monoxide poisoning, gas gangrene, or severe acute myelopathy. We performed conservative treatment for LCS by HBO to be aimed for blood flow improvement. We report the efficacy of HBO as a new standard treatment for LCS.

MATERIALS AND METHODS: From March 2005 to 2006, we performed HBO on 70 LCS patients, and followed other 30 LCS patients without HBO. HBO group got pure O2 for 60 minutes in 2.0 ATA at least three times a week. Evaluations were based on Japanese Orthopaedic Association (JOA) score, VAS and SF-36v2 and performed on first HBO time and one month later. We evaluated the control group in the same time schedule. We examined the results between the two groups.

RESULTS: In HBO group improvement of chief complaints was found significantly compared with control group. As for the JOA score, HBO: 14.8 to 18.9 points, control: 15.4 to 17.8, as for the VAS, HBO: 7.9 to 3.4, control: 6.9 to 5.3, improvement was found in HBO group significantly. PGE administration did not affect our results. In SF-36v2 we could not find significant deference between the two groups.

CONSLUSIONS: We could assume availability of HBO from the clinical condition in LCS, but no data has been reported. In this report, it is found that regardless of PGE administration HBO expect enough availability that improvement was found in even JOA score and VAS than control group significantly. We suggest that HBO could be used a new effective conservative treatment for LCS.

B5

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

HYPERBARIC OXYGEN THERAPY FOR SUPPURATIVE OSTEOMYELITIS

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BACKGROUND: In the present time various antibiotics have been developed. But suppurative osteomyelitis has been very difficult to cure still up to now. If it fails to treat at the initial treatment, it recurs often. Many patients are annoyed by the recurrence. Moreover, increases in multiple resistance bacteria, opportunistic infection and traumatic osteomyelitis make them complex to treat. Many osteomyelitis patients have been treated with Hyperbaric Oxygen Therapy (HBOT) in Kawashima Orthopaedic Hospital since 1981. We reported the results sometime in past. We will report the results of treatment for the last twenty-four years.

MATERIALS AND METHODS: Before the surgical treatment we took an x-ray, bone scintigraphy, MRI and sinogram to check the range of focus. All cases took antibiotics and 30 sessions of HBOT. If the case shows an improvement, patients take a week of pause of HBOT. After the pause, another 30 sessions of HBOT were given. If the case did not change or deteriorated, sequestrum or fistula were curated completely and closed irrigation suction therapy was carried out. After the irrigation therapy, 30 sessions of HBOT were carried out again. From June 1981 to December 2005, 553 (368 cases were male, 185 cases were female) suppurative osteomyelitis patients were treated.

RESULTS: Include closed irrigation therapy 95% of cases a good result occurred.

CONCLUSIONS: Cases that have fistula, sequestrum, foreign material or vast range of osteonecrosis is difficult to cure completely with only HBOT. In such cases, they should have curettage and closed irrigation. In the recent 3 years, 19 cases were caused by MRSA, 10 cases were MSSA. We realized MRSA is increasing as the cause of suppurative osteomyelitis.

B6

Oral Presentation: 1121 - 1133
Poster Presentation: 0915 - 1030

HYPERBARIC OXYGEN STIMULATES EPIDERMAL RECONSTRUCTION IN HUMAN SKIN EQUIVALENTS

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BACKGROUND: Oxygen is one of the critical nutrients during wound healing and plays a central role in the reparative process. The requirement for oxygen during the process of wound healing provides the underlying rationale for hyperbaric oxygen (HBO) therapy. Though often used, the clinical application of HBO therapy to assist healing of chronic wounds remains a subject of great debate. Moreover, current in vitro data on the effect of HBO is limited and inconclusive and the effects of HBO on keratinocytes and re- epithelialisation are even less well understood. Therefore, we sought to determine if repetitive HBO treatments would influence the reconstruction of an epidermis using an ex vivo human skin equivalent (HSE) model.

MATERIALS AND METHODS: Human skin equivalents were constructed from de-epidermised skin and cultured at the air-liquid interface for up to 5 days. HBO treatments (90 min, 100% oxygen at 2.4ATA) were given daily using our custom-designed laboratory-scale hyperbaric chamber.

RESULTS: Image analysis of hematoxylin and eosin stained cross- sections of the HSE models revealed that the reconstructed epidermal layer in HBO-treated samples was significantly thicker at both day 3 and day 5 compared to the non-treated controls. In addition, immunohistological characterization of the HSEs using various epidermal markers, including P63, cytokeratins 1/10/11, 6 and 14 and collagen type IV, confirmed the earlier onset of epidermal differentiation within the HBO-treated constructs. Moreover, after 3 days of culture, the populated surface area (lateral migration) was significantly greater for the HBO-treated samples compared to the controls. Although a similar difference was observed between the HBO- treated and non-treated samples after 5 days, this was not significant.

CONCLUSIONS: Taken together these results demonstrate, for the first time, that HBO stimulates early onset of the re-epithelialisation, epidermal maturation and stratification using a relevant ex-vivo human model. These findings will further facilitate the elucidation of mechanisms underlying the HBO therapy.

B7

Oral Presentation: 1133 - 1145
Poster Presentation: 0915 - 1030

HYPOSPADIAS REPAIR: THE USE OF PERIOPERATIVE HYPERBARIC OXYGEN THERAPY

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BACKGROUND: Disrupted microcirculation of the penile tissues is one factor known to play a role in the development of hypospadias complications. Administration of hyperbaric oxygen therapy (HBO2T) to compromised skin flaps and grafts has been reported to reduce tissue loss and improve outcomes. We report the first series of hypospadias repairs using perioperative HBO2T to optimize tissues threatened by ischemia.

MATERIALS AND METHODS: The records of all pediatric patients who underwent HBO2T in the immediate postoperative period following urethral reconstruction were reviewed. Patients were identified within a single urology practice, who were judged to have significantly scarred and devascularized penile tissues prior to surgery, and were evaluated preoperatively for HBO2T. Treatment consisted of exposure to 100% oxygen at 2.4 ATA for 90 minutes (total of five treatments over three days). The treatment protocol was modified from the Hyperbaric Oxygen Therapy Committee Report 2003 for compromised skin flaps and grafts. Follow up modalities consisted of meatal calibration, PVR, and uroflowmetry.

RESULTS: Six patients were identified. Initial diagnoses were proximal hypospadias (4), distal hypospadias (1), and strangulation injury (1). Median number of procedures, including all surgeries to correct complications, was 2.5. The most recent repairs included a modified Johanson two stage hypospadias repair (3), pedical flap (2), and a tabularized incised plate (1). Median number of complications prior to HBO2T was 1.5/patient (range 1-7). Median follow up following HBO2T was 9 months (range 5-24). Five patients are voiding with a straight stream and adequate flow. No meatal stenoses or strictures were noted. Postoperative complications include one patient with a persistent fistula noted at 1 month.

CONCLUSIONS: HBO2T offers a potential to improve outcomes in redo hypospadias reconstruction and injuries to the phallus in the setting of devascularized tissues. This preliminary series would suggest that larger prospective randomized trials are warranted.

B8

Oral Presentation: 1145 - 1200
Poster Presentation: 0915 - 1030

CLINICAL OUTCOMES IN A PATIENTS WITH SEVERE DIABETIC FOOT ULCERS TREATED WITH OR WITHOUT HYPERBARIC OXYGEN THERAPY

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BACKGROUND: Data from randomized controlled trials demonstrate the efficacy of Hyperbaric Oxygen Therapy (HBO2T) in the treatment of severe diabetic foot ulcers (DFU, Wagner Grade 3 & 4). We present a series of 50 patients treated in our center, one-half of whom received HBO2T.

MATERIALS AND METHODS: A series of sequential patients who presented for treatment of a DFU that received ≥ 30 HBO2 treatments over a 6-week period, and for whom there was ten-week follow-up data available. Standard demographics, wound parameters and vascular assessments were obtained from the patients' clinical record. Outcomes include percentage healed/not healed and percentage of amputations (minor and major) at 10 weeks after completion of HBO2T. The same data was obtained for an age and gender matched cohort of patients who did not receive HBO2T.

RESULTS: A total of 25 patients met inclusion criteria as having a severe DFU, received ≥ 30 HBO2T and ≥ 10 ten week follow-up available. The data and comparison between the matched cohort appears in the table. The mean follow-up time for the DFU plus HBO2T group was 47 ± 42 weeks.

	DFU- with HBO2T	DFU-without HBO2T
Number of Patients	25	25
Mean age (yrs)	64±14	75±12
Gender (F:M)	8:17	11:14
Wound size (cm2)/range	20±22 (0.2-84)	15.4±15(0.5-46)
Wound age (months)	4.2±4.9	4.3±3.7
Mean TCpO2(mmHg)	31±18	42 ±22
ABI	1.1±0. 5	0.8±0.6
% healed (# healed/not healed)	56 (14/11)	32 (8/17)
% amputation (# amp/ no amp)	16 (4/21)	32 (8/17)

CONCLUSIONS: Diabetic patients treated with HBO2T for severe foot ulcers had 56% chance of healing and 16% chance of amputation. Diabetic patients not receiving HBO2T had a 32% chance of healing and a 32% chance of amputation.

B9

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

WOUND COMPLICATIONS FOLLOWING VASCULAR SURGERY: ROLE FOR HYPERBARIC OXYGEN THERAPY

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BACKGROUND: Vascular surgical therapy for critical limb ischemia a common procedure for limb preservation. High risk patients are undergoing vascular bypass procedures which improve blood flow to the foot while creating a surgical wound in a compromised lower leg. Hyperbaric oxygen therapy (HBO2T) has been shown to heal diabetic foot ulcers in this same patient population and thus could potentially aid in the healing of these post-operative surgical wounds.

CASE REPORT: A 71 year old white male with Type II diabetes mellitus received an situ saphenous vein bypass graft from the popliteal artery to the distal anterior tibial artery for an ischemic right foot and gangrenous toes. The patient was discharged on postoperative day 4. One month following discharge, the patient experienced dehiscence of the tibial surgical wound with resultant exposure of the arterialized venous graft and was hospitalized. Local wound care, bed rest and systemic antibiotics were administered and the wound site monitored for twelve days without evidence of healing. Plastic surgical consultation for wound closure indicated there were no surgical options for wound coverage. The distal ray amputation sites were healing, reflecting the success of the revascularization procedure. HBO2T was initiated on post-operative day 46. Treatment consisted of 2.4 ATA, 90 min. of 100% oxygen for a total of 30 treatments. Diligent, comprehensive wound care was continued. Aggressive nutritional therapy and blood sugar control was also initiated. The wound was successfully closed with a split-thickness skin graft one week following completion of HBO2T. At 11 months the patient is alive and well with a patent bypass graft and intact skin graft.

CONCLUSIONS: HBO2T was used to manage a wound healing complication associated with peripheral vascular surgery. We anticipate a more frequent need for multidisciplinary wound care techniques to maintain current high rates of successful vascular surgical outcomes.

B10

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

SEVERE SOFT-TISSUE INFECTIONS: USE OF EMERGENT HBO2 THERAPY

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BACKGROUND: Severe soft-tissue infections (SSTI) represent a spectrum of aggressive infections associated with poor outcomes (35-76% mortality). Hyperbaric oxygen therapy (HBO2T) has been reported to reduce mortality in the setting of SSTI. We report using HBO2T in the management of 20 diagnosed with SSTI.

MATERIALS AND METHODS: Retrospective chart review of a sequential series patients presenting to a tertiary-care, university-based hospital with the diagnosis of SSTI and managed with an emergent, multidisciplinary algorithm including intensive care, surgical debridements and HBO2T. IRB approval was obtained for patient record review.

RESULTS: Twenty adult patients (mean age 51±12 yrs) with SSTI (14 of the trunk and 6 of limbs) were treated with fluid resuscitation, IV antibiotics, surgical debridement and adjunctive HBO2T. Patients received 2.8ATA for 90-120 minutes and an average of 6±1 HBO2T treatments, ranging from 2-10 treatments, according to guidelines established by the Undersea and Hyperbaric Medicine Society, Committee on Therapy. Obesity (80%) and diabetes mellitus (60%) were the most common co-morbid conditions. Most tissue cultures (60%) yielded mixed Gram positive and negative flora. The mean time from presentation to HBO2T was 35±15 hours. Patients received an average of 1.6 debridements and wound closure was achieved in 67% during the initial hospitalization. All patients were discharged alive from the hospital.

CONCLUSIONS: The management of patients with SSTI is a resource intensive clinical event. Adjunctive HBO2T can be integrated into standard surgical and critical care therapies. With this case series, it is difficult to fully demonstrate a therapeutic advantage which HBO2T might have had. However, the mortality rate in our series was 0% and is better than expected based on a review of the literature. A randomized controlled trial should be designed to directly test the effect of HBO2T in this challenging setting.

B11

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

TRAUMATIC AMPUTATION IN A JEHOVAH'S WITNESS: OPTIONS FOR ENHANCING OXYGEN DELIVERY

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BACKGROUND: The management of traumatic injuries relies upon blood transfusion to support oxygen delivery. Jehovah's Witnesses do not accept the administration of blood or blood products for any medical indication. The development and degree of oxygen debt will determine outcome. We present a case in which a Jehovah's Witness presented to our trauma for treatment of a severe soft-tissue injury.

MATERIALS AND METHODS: Case report, Level I trauma center, University teaching hospital which is also designated as a "Bloodless Surgical Center" for Jehovah's Witnesses.

RESULTS: A 49 year old white male, Jehovah's Witness was transferred to our center for the management of a severe crush injury of the right upper extremity following a motorcycle crash. The patient required emergent shoulder disarticulation. The initial serum hemoglobin level dropped from 9 to 3 gm/dL following surgery. Arterial oxygen saturation was maintained at 98-100% at all times. Sedation, neuromuscular blockade and mechanical ventilation were instituted to limit metabolic demands and oxygen consumption. Normothermia was maintained by the combined use of a cooling blanket and systemic antipyretic therapy. It was determined that Jehovah's Witnesses will accept transfusion of stromal-free hemoglobin preparations, so plans were made to administer PolyHeme per manufacturer's guidelines. HBO2T (2,4 ATA, 90 min, daily x 10) was started on hospital day 2 to support wound healing and aid in systemic oxygen delivery. The patient remained hemodynamically stable (cardiac index of 5.3 L/m2) for 7 days with no evidence of metabolic acidosis, cardiac ischemia or elevated serum lactate. During hospital day 7 the patient became febrile (103 ºF), serum hemoglobin decreased to 2.6gm/dl and the patient succumbed to septic shock on hospital day 10.

CONCLUSIONS: The management of severe anemia in the setting of major trauma is a challenging problem that may benefit from a multi-disciplinary approach involving HBO2T.

B12

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

UPDATE ON THE DUKE RANDOMIZED CONTROLLED TRIAL OF HYPERBARIC OXYGEN FOR OSTEONECROSIS OF THE JAW IN PATIENTS WHO HAVE TAKEN BISPHOSPHONATES

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BACKGROUND: Osteonecrosis of the jaw (ONJ) has been recognized as associated with bisphosphonate therapy, however there is little information on the natural history, treatment or prevention strategies for this condition. A previous Duke case series showed that 14 of 16 patients improved in ONJ stage and that the size and number of ONJ lesions decreased pre to post HBO2 ($p<.001$ and $p=.008$ respectively). Patients who continued on BP treatment had a shorter time to failure (8.5 months; 95% CI 7.1 to 9.8) than those who did not (20.1 months; 95% CI 17.5 to 23.9) $p=.006$. This information encouraged us to design a randomized controlled trial of HBO for this condition.

MATERIALS AND METHODS: The design is an interventional, prospective, randomized trial with 24-month follow-up. Seventy subjects will be randomized to 40 HBO treatments over a 4-week period or to normal oral care. The analysis will compare remission rates while controlling for age, gender, race, previous local trauma or surgery, tumor type, diabetes, immunosuppression, bisphosphonate duration, indication, thalidomide and dental hygiene. It will also test if exposure to HBO induces NFKB through RANK/RANKL and co-activation of the PI3K/Akt survival pathway. RANKL is a key mediator of osteoclastogenesis. The clinical phenotype of RANKL deficiency results in osteopetrosis in mice, a condition that bisphosphonate ONJ closely resembles.

RESULTS: IRB approval was granted August-17-2006 and 32 subjects have been interviewed to date (2/15/2007) with 7 enrolled, 2 treated and 1 withdrawn. Reasons for declining to participate include: previous radiation treatment, not meeting the criteria for ONJ (3 months of exposed mandibular or maxillary bone), life expectancy less than 24 months, unwillingness to travel to travel and unwillingness to be randomized.

CONCLUSIONS: Recruitment is improving as the knowledge of the study disseminates to oral surgeons, oncologists and dentists in the region.

B13

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

SALVAGE OF COMPLEX BKA STUMP HEALING FAILURE WITH HYPERBARIC OXYGEN AND MULTIDISCIPLINARY CARE

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CASE REPORT: A 57 year old smoking Type II diabetic, obese, but protein deficient construction supervisor with severe PAD experienced failure of proximal right leg angioplasty. He underwent subsequent femoral tibial bypass that clotted due to hypercoaguablility mediated by anti-phospholipin 3 antibody. After thrombectomy, successful restoration of graft patency was demonstrated. Nevertheless, gangrene developed to mid-calf, and the incision for the distal (tibial) anastamosis was non-healing, necrotic and profoundly edematous. As such, the patient was considered for AK amputation.

The patient requested attempted preservation of the limb at BK level to allow for future ambulation with prosthesis. After smoking cessation, strict glycemic control, protein supplementation, anabolic steroid administration, and anti-coagulation therapy, the proximal tibial wound demonstrated development of granulation tissue after two weeks of vacuum assisted closure therapy. The patient then underwent BKA and subsequent Hyperbaric treatments. The stump wound dehisced creating a large defect requiring extensive repeated debridements and further vacuum assisted closure therapy, simultaneous with the HBOT. After complete granulation, STSG's were applied with "take" augmented by vacuum assisted closure device installed over the grafts and left in place five days. HBOT continued for ten post-operative treatments. Graft take was 95%. Residual open areas were treated with Iodosorb every other day and debridement, with subsequent further closure. The patient is currently undergoing fitting of a BK prosthesis.

CONCLUSIONS: This case represents a prime example of the potential enhancement of outcome that can be brought about by the comprehensive multidisciplinary team approach to wound care and hyperbaric medicine.

B14

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

PUTTING THE PRESSURE ON CRUSH INJURY: HYPERBARIC THERAPY, WOUND CARE AND MANAGEMENT OF A CRUSH INJURY

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BACKGROUND: A 76 year-old diabetic female presented to the clinic three days after dropping a toolbox on her right foot. The crush injury resulted in an 8.2 cm x 5.2cm blister on the dorsum of her right foot. Radiographs revealed no bony injury.

MATERIALS AND METHODS: The treatment plan included hyperbaric therapy at 2.5 atmospheres for ninety minutes daily for twelve treatments, silver hydrofiber to the blister and a compression wrap for edema control. Oral antibiotics and pain medication were prescribed. Upon completion of hyperbaric therapy, therapeutic ultrasound was ordered to assist in reducing the edema and hematoma. Sharp debridement was performed to remove devitalized tissue on week eight and ten. On week eight, the primary dressing was changed to a silver hydrogel. On week ten, the patient reported the silver hydrogel caused pain and burning so plain hydrogel was ordered.

RESULTS: The patient healed after seventeen weeks of treatment.

CONCLUSIONS: Hyperbaric oxygen therapy, in conjunction with therapeutic ultrasound and appropriate wound care, was effective in the treatment of a crush injury.

B15

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

DAMN THE HMO TORPEDOES, A NOVEL APPROACH TO CHRONIC WOUND HEALING, A CASE REPORT

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BACKGROUND: A 60 year old very experienced male scuba diver developed a skin infection of the right lower leg while diving in Papua, New Guinea six years ago from a coral scrape. This resulted in hospitalization in Australia for IV antibiotics. Initially, he appeared to heal but later developed recurrent infections at the same site of injury. He was treated repeatedly with antibiotics over the last 6 years without complete resolution. He had MRSA. Being aware of the use of hyperbaric oxygen in treatment of chronic wounds, he sought referral to our facility for care. Because his wound was complicated by the co-existence of venous stasis, his HMO would not cover the cost of treatment, and he was unable to pay out of pocket. Undaunted he decided to perform his own clinical trial, utilizing scuba in an attempt to ameliorate his condition. This paper reports on the outcome of his experimentation with his full permission to do so.

MATERIALS AND METHODS: The subject donned open circuit scuba gear using 100% O2 and made a total of 10 dives to 25fsw (1.75ATA) for 65-70 minutes. He made 2 dives in June, 4 in July, and one per month from August through November. The dives were conducted in a sheltered inlet of Waimanalo Bay. He photographed his wound to document progress.

RESULTS: He reported that his leg was almost completely healed, the MRSA is gone, he is no longer in pain, is without tenderness to touch, has decreased leg edema, and has increased sensation of the leg. His vascular surgeon has been monitoring his progress, though not condoning this experiment. In the future, he intends to continue with monthly treatments using a semi-closed rebreather he recently purchased and for which he has received training.

CONCLUSIONS: Where there's a will, there's a way!

B16

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

HYPERBARIC OXYGEN THERAPY (HBOT) IN THE DELAYED TREATMENT OF 8000-METER PEAK CLIMBER FROSBITES

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BACKGROUND: HBOT in frostbite lesions is still considered investigational in many countries. At the present time, in Italy HBOT use in these conditions is allowed as extension of "peripheral vascular insufficiency with trophic lesions" indication. With this kind of access, we have already successfully treated the freezing cold injury case of an inadequately clothed heroin-addicted subject.

MATERIALS AND METHODS: Four expert climbers arrived at our attention with cold-related illness; such occurrences were registered at the end of complicated ascensions. Two of them (A, B; patient code: 3124, 3125) were from the well-known "Cortina's Squirrels" climbing group, at the end of the 2004 K2-Expedition (August 2004), the other two cases (C, D; patient code: 3527, 3610) regarded two independent ascensionists (August and November 2005). An accurate mild progressive re-warming was applied at the base-camp trying to limit, during a prolonged thawing phase, that additional reperfusion component of the injury.

Corresponding to the above mentioned cases:
- A: lesion to left hand's middle finger distal phalanx,
- B: serious injury affecting right hand, left and right foot,
- C: mild frostbite involving both first fingers of patient's feet,
- D: grade three cold-related gangrene of the right hand.

Cases A, C and D underwent 5 HBO-Tx on their arrival at our institution [@2.5 ATA (15msw, 147,1 kPa), 25'x3 in O2 plus 5'x2 'air'-pause interposed] with further treatment (up to 15Tx in a home DHM-unit); Case B underwent 15 HBO-Tx, at same depth and O2-exposures. The highly predictive technetium99 bone scanning was not applied within the usual 48-72 hour interval, due to logistic limitations.

CONCLUSIONS: Clearly improved the functional end result, with single case minimal differences as per light subamputation needs. A 24 and 12 months follow-up confirmed: 1) the good general conditions, 2) the protection to the known higher morbidity in the following months to further easier frostbites, and 3) the better course compared to the expected end scenery.

B17

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

HYPERBARIC OXYGEN THERAPY FOR CALCIPHYLAXIS INDUCED NECROTIZING FASCIITIS: A CASE STUDY

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CASE REPORT: A 68-year-old white male with a previous brief history of hemodialysis developed multiple deep ischemic wounds cavitating to the thoracic and abdominal wall in March of 2006. This case begins in 2001 with a history of chronic renal insufficiency due to hypercalcemia, which was secondary to elevated vitamin D 1,25 levels. The patient was treated with prednisone at 20mg dose per day. He also, underwent bilateral renal artery stenting in 2001. By 2005 he was placed on hemodialysis for 4 months and then discontinued when his renal status improved. One year later he developed lesions on his chest and abdomen initially treated with debridement and antibiotic therapy. His parathyroid function was found to be normal (20.9 pg/L). Biopsy was performed and found fat necrosis, fibrosis and dystrophic calcification. He was hospitalized twice during the months of March and April 2006 for antibiotic therapy and debridement and then was transported to Shands Hospital in Gainesville, Florida for further investigation. While there, hyperbaric oxygen therapy was initiated for a total of 20 treatments. He was discharged home to Melbourne, Florida, where he began hyperbaric oxygen therapy at our facility. Our treatment consisted of 2.4 ATA for 120 minutes with 90 minutes total time on oxygen. Air breaks of 5 minutes each were delivered after each 20-minute oxygen phase. About midway through his therapy, he underwent colon resection for a perforated bowel resulting in a new midline incision, to heal as well. Our total of 86 treatments was divided into multiple phases to accommodate his surgeries. The patient had resolution of all lesions.

CONCLUSIONS: The results of our case add to the body of evidence that hyperbaric oxygen therapy may be useful in the treatment of calciphylaxis induced necrotizing fasciitis.

SESSION C: Hyperbaric Chamber Patient Management

C1

Oral Presentation: 1415 - 1427
Poster Presentation: 1545 - 1700

RATE OF HYPERBARIC OXYGEN TREATMENT IN SOFT TISSUE RADIONECROSIS: DOES IT AFFECT OUTCOME?

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BACKGROUND: Soft tissue radionecrosis is treated with hyperbaric oxygen (HBO2), typically with 30-40 treatments. It is not known whether the effectiveness of HBO2 differs as a function of the rate of administration of those treatments. Various hyperbaric facilities treat such patients from 5-7 days weekly and from 1-2 times daily, depending upon patient preference and scheduling constraints. To determine whether the rate of HBO2 administration influences outcome, we analyzed the results from our patient population treated for soft tissue radionecrosis of the bladder (radiation cystitis).

MATERIALS AND METHODS: Records of patients treated with HBO2 for hemorrhagic radiation cystitis at Virginia Mason Medical Center from 1988 to 2006 were reviewed. Data extracted included patient demographic and disease information, hyperbaric treatment details, and response to therapy with regard to hemorrhage. Patients were classified as responders (hemorrhage significantly improved or resolved) and nonresponders (hemorrhage unchanged or worse) following an initial course of HBO2 therapy. Response was then compared to hyperbaric treatment details.

RESULTS: Of 94 total patients, 78 (83%) were responders to HBO2 on an intent-to-treat basis. There was no significant difference in outcome between patients who averaged 5 or fewer HBO2 treatments per week vs. those who received more than 5 treatments per week ($p=0.2794$, Fisher's Exact Test), or between those who averaged < 3 vs. > 7 treatments weekly ($p=1.000$). Responders averaged from 2 to 12 treatments per week over their course (mean 5+1), while nonresponders averaged from 2 to 10 treatments per week (6+2). Total number of treatments administered, however, did correlate with response. Those who received 30 or more total treatments had a better response rate than those who received fewer ($p=0.0432$).

CONCLUSIONS: Among patients treated for this form of soft tissue radionecrosis, we found no difference in response related to rate of hyperbaric treatment. Once or twice daily treatment can be administered with equal confidence for similar outcome.

C2

Oral Presentation: 1427 - 1439
Poster Presentation: 1545 - 1700

TRENDS AND FACTORS IN BLOOD PRESSURE IN HBO TREATMENT

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BACKGROUND: Clinically it is noted that BP is often elevated after HBO treatment, in patients with/without a history of hypertension. Even though blood pressure increases, and heart rate decreases, the cardiac output stays the same. National standards are lacking for blood pressure monitoring and management in patients undergoing hyperbaric oxygen therapy. Standards generally acknowledge that a clinical history be obtained before treatment, and during therapy, physiologic and clinical monitoring is done and side and adverse effects monitored with reassessment of the patient as indicated. The purpose of this study is to investigate trends in blood pressure following hyperbaric oxygen treatments and explore factors that may influence BP in patients undergoing HBO.

MATERIALS AND METHODS: This is a descriptive, correlation study involving a convenience sample of adults (N=10), inpatients and outpatients. Subjects will complete the state portion of the State-Trait Anxiety Inventory (STAI) (Y Form) before the 2nd through 6th (5 occasions). Subjects will undergo HBO treatment as prescribed and vital signs will be taken according to routine established in HBO area but patient will be lying down. If SBP is > 20 mmHg above baseline and/or DBP > 10 mmHg above baseline, patient will be asked questions regarding possible symptoms and pain, and be instructed to lie quietly for 5 minutes and BP will be repeated.

RESULTS: Descriptive statistics for demographic variables; Means, SD, and ranges for anxiety, pain, SBP, and DBP; ANOVA in BP changes over time; Pearson correlation coefficients for possible relationship between BP, pain, and anxiety; analysis of covariance to separate those with history of HTN and anxiety disorders; Cronbach alpha to determine reliability of anxiety tool.

SUMMARY/CONCLUSIONS: Implications for practice will focus on answers to the following questions: Does the patient experience symptoms with an elevated blood pressure? What factors influence blood pressure trends after treatment?

C3

Oral Presentation: 1439 - 1451
Poster Presentation: 1545 - 1700

THE VARIABILITY OF LIMB TRANSCUTANEOUS OXYGEN (TCOM) MEASUREMENTS BREATHING AIR AND OXYGEN AND THEIR RELATIONSHIP TO RECORDED VASCULAR DISEASE: A REPORT FROM THE INTELLICURE RESEARCH CONSORTIUM

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BACKGROUND: Although widely used, the optimal methods for interpreting TCOM data are still under debate. To date no studies have evaluated all limb electrodes and their response to oxygen. We provide a level 4 electronic medical record (EMR) specific to hyperbaric medicine and wound care (Intellicure, Inc, Houston, TX) which records TCOM data and all other aspects of medical care.

MATERIALS AND METHODS: 17 facilities experienced with the Intellicure EMR in 12 states contributed de-identified data as part of the Intellicure Research Consortium on 7,410 patients (16,437 wounds) treated between 8/31/2001 and 11/24/2006. Point of service, daily clinic data is collected in SQL format and stored on individual clinic servers, then transmitted nightly via secure ftp download to the Intellicure data repository. Data queries are designed and launched in SQL and exported into SPSS for final analysis.

RESULTS: There were 310 TCOM studies with an average of 5 electrodes per study. 65% of studies included sea level oxygen challenge data. In approximately 8% of these cases, at least one TCOM value decreased in going from sea level air to sea level oxygen. Average limb value breathing oxygen was 44 mmHg (range: 0-135); Ave Oxygen 135 mmHg (1-436). The average of "lowest leg" value was 27 mmHg and on oxygen was 75 mmHg. In patients whose medical history included current smoking, heart disease or known vascular disease, average leg values were lower than in patients without these diseases. Sea level oxygen values <100 mmHg were considered abnormal and these were related to reported known vascular disease. TCOM variability increases with sea level oxygen breathing.

CONCLUSIONS: Patients with at least one very low limb value are more likely to have generally low limb values and/or a poor oxygen response (<100mmHg). There is a correlation between low values and history of vascular disease.

C4

Oral Presentation: 1451 - 1503
Poster Presentation: 1545 - 1700

THE EFFECT OF HYPERBARIC TREATMENT PRESSURE AND AIR BREAKS ON BLOOD GLUCOSE LEVELS: RESULTS OF AN ONGOING STUDY

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BACKGROUND: It is not known whether the observed decrease in blood glucose (BG) after HBOT is a direct effect of HBOT or a temporal association. We report an ongoing monitoring project among Diversified Clinical Services (DCS) hyperbaric centers utilizing the NetHealth database (Pittsburgh, PA), an Internet based program which records key metrics of interest, including pre and post HBOT blood glucose levels.

MATERIALS AND METHODS: Analysis was performed of 33,747 hyperbaric treatment records from 1,835 diabetic patients at 48 DCS facilities. Changes in BG were analyzed in relation to treatment pressure at 2.0, 2.4 and 2.5 ATA and according to varying air breaks (AB) protocols. DCS policy requires feeding patients whose BG <150 mg/dl prior to HBOT but the database does not report whether this was done. Data were stratified for analysis by <150 and >150 predive BG because of likely feeding.

RESULTS: Ave. predive BG in the group < 150 = 124 mg/dl (25% of patients). Ave. predive BG in the >150 mg/dl group = 226 mg/dl. For those not fed, BG decrease is greater as treatment depth increases. For those who are fed, the postprandial increase in BG is reduced as treatment depth increases. At 2 ATA, fed patients increased 2 gm/dl; those not fed decreased 39mg/dl. Changes at 2.4 and 2.5 were not different from each other ($p=0.735$) but showed that mean decrease without feeding was 47 mmHg, significantly different from 2 ATA ($p<0.001$). Air breaks were associated with higher treatment pressures making complicating separate analysis of the air break effect but a data model suggests that air breaks blunt the BG drop non-fed patients.

CONCLUSIONS: This study supports our previous observations that treatment pressure has an effect on the magnitude of the decrease in BG after HBOT and may suggest this phenomenon is a direct effect of therapy.

C5

Oral Presentation: 1503 - 1515
Poster Presentation: 1545 - 1700

HYPERBARIC OXYGEN THERAPY (HBOT) RELATED ADVERSE EVENTS IN RELATION TO TREATMENT DEPTH AND BLOOD GLUCOSE LEVEL, AN ON-GOING STUDY FROM 48 CENTERS

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BACKGROUND: Adverse Events (AE) of HBOT include ear and sinus barotrauma, oxygen seizures (SZ), confinement anxiety (CE) and pulmonary edema (we describe as chest events). The relationship of these events to treatment pressure or blood glucose has not been evaluated in a large dataset. Certain Diversified Clinical Services (DCS) hyperbaric centers utilize the NetHealth database (Pittsburgh, PA), an Internet based program that records various adverse events.

MATERIALS AND METHODS: 48 DCS centers participate in an ongoing analysis of AE. 90,186 HBOT treatments were evaluated. 85,806 records were complete. 14 different diagnoses were identified, treated at pressures of 2.0, 2.4 and 2.5. AE data from 2.4 and 2.5 were combined.

RESULTS: Ear barotrauma (EB) was the most common AE, the incidence of which differed significantly by treatment pressure (0.75% vs. 0. 89%) ($p = 0.023$). Confinement anxiety (CA) was the next most common problem (0.3%), followed by sinus barotrauma (SB; 0.06%), neither of which differed by treatment pressure ($p=0.286$ and $p=0.288$). Occurrence of "chest events" (CE) seemed less frequent at 2.0 (0.033% vs. 0.66%). Seizures were statistically related to treatment pressure (0.028% at 2.0 ATA; 0.11% at 2.4/2.5; $p < 0.001$). 83% (156/186) of adverse events occurred in persons whose post treatment blood sugar (BS) was <70 ($p<0.001$).

CONCLUSIONS: The overall the incidence of AE with HBOT is low. 2.0 ATA has a significantly lower incidence of seizure, ear barotrauma and "chest related" complaints which may be CHF. The incidence of confinement anxiety and sinus barotrauma is not changed by treatment pressure. When the incidence at 2.0 and higher pressures are grouped, the overall event rates are: EB 0.82%, CA 0.34%, SZ 0.07%, SB 0.059%, CE 0.050%. BS < 70 increases the incidence of all AEs, finding noted for the first time in this study.

C6

Oral Presentation: 1515 - 1530
Poster Presentation: 1545 - 1700

SPIROMETRIC CHANGES WITH LONG TERM HYPERBARIC OXYGEN THERAPY: A PROSPECTIVE STUDY

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BACKGROUND: Prolonged exposure to elevated oxygen concentration has been reported to result in detrimental outcomes.[1] The purpose of this study is to determine if long-term HBOT causes any significant spirometric changes reflective of pulmonary injury.

MATERIALS AND METHODS: A prospective study of spirometric testing is performed on 29 subjects prior to the first HBOT treatment, then again after every 5 consecutive treatments until completion of treatment course. Repeated follow-up testing was done at 3, 6 and 12-month intervals. Various respiratory parameters obtained over time are recorded and analyzed for statistical significance.

RESULTS: 29 patients (20 males and 9 females) were enrolled with an average age of 61.3 years old. Patients had a variety of diagnoses including radionecrosis (41.4%), diabetic wound (31.0%), compromised graft (17.2%), and osteomyelitis (10.3%). All patients completed a minimum of 20 treatments. Changes in respiratory parameters over time showed no statistical significance ($p>0.05$). See table below.

Respiratory Measurements of Patients undergoing HBOT over Time	
Respiratory Parameters	**P-values***
Forced Vital Capacity (FVC)	**0.27**
Forced Expiratory Volume in one second (FEV1)	**0.12**
FEV1/FVC	**0.44**
Forced Expiratory Volume in six seconds (FEV6)	**0.31**
FEV1/FEV6	**0.34**
Peak Expiratory Flow	**0.84**
Forced Expiratory Flow at 25% and 75% FVC	**0.34**
Forced Inspiratory Vital Capacity	**0.68**
Peak Inspiratory Flow	**0.37**
Maximum Vital Capacity	**0.38**
Maximum Voluntary Ventilation	**0.28**
* P-values calculated using repeated measures Paired T-Test.	

CONCLUSIONS: This preliminary study revealed no significant statistical differences in spirometric parameters of patients undergoing long-term HBOT. Further investigation on a larger patient population is ongoing at this time.

Reference:
1McAdams RM, Mustafa SB, Shenberger JS, PS, Henson BM, Digeromino RJ. Cyclic stretch attenuates the effects of hyperoxia on cell proliferation and viability in human alveolar epithelial cells. [i]Am J Physiol Lung Cell Mol Physiol [/i] doi:10.1152/ajplung.00160.2005, Feb 3 2006.

C7

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

DOES HYPERBARIC OXYGEN THERAPY CAUSE HYPOGLYCEMIA IN DIABETIC PATIENTS? A REVIEW OF 119 DIABETIC PATIENTS TREATED IN A MULTIPLACE CHAMBER

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BACKGROUND: Hyperbaric oxygen therapy treatment (HBO2T) is an effective treatment for Wagner's Grade III/IV diabetic foot ulcers. There is a perception that diabetic patients are at risk for hypoglycemic reactions while receiving HBO2T. We established a policy of frequent blood sugar monitoring of all diabetic patients referred for HBO2T.

MATERIALS AND METHODS: Blood sugars were tested at three time points during HBO2T (PRE, DURING and POST) by standard point of care testing methodology. Medical records were reviewed following IRB approval. HBO2T for all patients was according to guidelines set by the UHMS, Committee on Therapy. Data was collected and group means were compared using the Student's t-test. Hypoglycemia is defined as a blood sugar < 60mg/dL. Significant differences occurred when p values were < 0.05.

RESULTS: One-hundred and nineteen diabetic patients received HBO2T over a 3-year time period (8/2003-8/2006). A total of 3,450 blood sugar values were collected. The mean blood sugar values decreased during treatment; PRE=174±43mg%, DURING= 137±36mg% and POST=157±42mg%. The differences between PRE and the DURING or POST time points were statistically significant, p< 0.04. The overall incidence of hypoglycemic episodes was found to be 68 out of 2,068 (3.3%) blood sugar values which occurred in 24 out of 119 (20%) patients.

CONCLUSIONS: Mean blood sugar values are significantly elevated above normal in patients presenting to our center for daily HBO2T. Mean blood sugar values do decrease during HBO2T, however the majority of patients remain in the hyperglycemic range. The incidence of hypoglycemia is low and likely reflects our policy of aggressive blood sugar monitoring and liberal administration of glucose (juice and crackers) for blood sugars less than 70 mg/dL. No episodes of symptomatic hypoglycemia nor associated untoward events were observed.

C8

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

CNS OXYGEN TOXICITY: UNRECOGNIZED RISK FACTORS

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BACKGROUND: Since opening a 10-person multi-place hyperbaric oxygen chamber at a university-based tertiary care hospital we have experienced a growing percentage of acute and critically ill patients presenting for HBO2 treatment. We wish to share our clinical experience by reviewing six episodes of presumed CNS-oxygen toxicity during a three-year period.

MATERIALS AND METHODS: Adverse events associated with HBO2T are routinely reported and tacked by the HBO2 Medicine program. Adverse events are divided into two categories, Clinical or Technical. Clinical adverse events include otic barotraumas (TM perforations), pulmonary barotrauma (pneumothorax), seizure activity and discontinuation of treatment secondary to confinement anxiety, decompression illness and mortality during or within 1 week of completing HBO2T. All patients are examined by a staff physician, certified in HBO2 medicine, prior to HBO2T to determine the risk-benefit profile for each patient.

RESULTS: During the 3 year period (8/03-8/06) a total of 6,682 patient treatments were provided (2,433 chamber compression episodes). Six seizure episodes were observed in 5 adults and one child. All 6 patients were found to have head CT scans and neurologic evaluations within normal limits. There were no significant untoward events (injury, MI etc) associated with the seizure episodes within the chamber environment. Three patients completed their HBO2T without subsequent adverse events. The incidence of seizure activity for all patient treatments was 6/6,682 exposures = 0.075%. Risk factors for CNS oxygen toxicity will be reviewed as they relate to this series of patients, including the potential role played by age and sleep deprivation.

CONCLUSIONS: The incidence of HBO2-induced seizures is very low for patients being treated in a multi-place chamber at a tertiary care hospital. The establishment of a national database which tracks all adverse events related to the use of HBO2 as a medical therapy is needed.

C9 (President's Competition)
Oral Presentation: N/A
Poster Presentation: 1545 - 1700

SEIZURE DURING HYPERBARIC OXYGEN THERAPY FOR CARBON MONOXIDE TOXICITY: A CASE SERIES

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BACKGROUND: Hyperbaric oxygen (HBO) therapy is currently recommended to reduce delayed neurologic sequelae resulting from carbon monoxide (CO) toxicity. Although HBO is generally well tolerated, there exists a rare risk of seizure in patients with predisposing factors including: fever, hypothermia, anxiety or prior seizure or brain injury history. We present two cases of seizures associated with the use of HBO therapy during treatment for CO toxicity (three 90-minute HBO dives to 2.8 ata over 24 hours) in patients without known risk factors.

CASE REPORTS:
Case #1: A 54 year-old woman was found unresponsive in her apartment during a structure fire. Initial emergency department (ED) serum carboxyhemoglobin (COHgb) level was 17.3%, and ethanol was 164 mg/dL. Additional labs included: normal CBC, electrolytes, glucose and troponin I. The patient regained consciousness and was asymptomatic with normal vital signs (VS) and physical exam (PE) in the ED. Within 45 minutes of initiating HBO therapy, the patient experienced a two-minute grand mal seizure. HBO therapy was discontinued, and after supportive measures the patient recovered uneventfully and was discharged within 24 hours.

Case #2: A 65 year-old man called EMS after he was unable to arouse his granddaughter while using an outdoor cooking grill to heat his camper. He had an ED serum COHgb level of 32.9% with unremarkable VS, PE, EKG, glucose and troponin I. During the initial treatment, at 50 minutes of HBO, the patient suffered a three-minute grand-mal seizure. HBO was discontinued; the patient recovered uneventfully and was discharged within 24 hours.

CONCLUSIONS: HBO therapy is commonly used in the treatment of CO toxicity to prevent delayed neurologic sequelae. Treating physicians must be aware of the associated risk of seizure. Further study is needed to elucidate additional potential risk factors associated with this phenomenon.

C10

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

TRANSCUTANEOUS CHEST REFERENCE VALUES AND REGIONAL PERFUSION INDEX IN RELATION TO VASCULAR DISEASE, SMOKING AND LEG TcpO2

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BACKGROUND: The ratio of the TCOM in the 2nd intercostal space to that on the extremity is the regional perfusion index (RPI). Its value is unclear.

METHODS: We maintain a longitudinal database of TCOM studies in a level 4 EMR (Intellicure, Inc, Woodlands, TX) and performed an analysis of data on 103 patients in relation to other medical information collected in this point of service EMR.

RESULTS: Age ave 63, 62% males, 32 patients underwent HBOT. Ten current smokers (ave. pack year 34), 19 past smokers (ave pack years: 30). 99/103 had a chest reference, average 6 extremity electrodes per test. Average chest reference (CR) on air = 58 mmHg, ave. CR on 100% Oxygen at sea level = 222 mmHg. In 26/99 patients (26%), CR was < at least one leg TCOM value. RPI on air ranged from 0.3 to 1.2 on air. The difference between RPI in air and RPI in O2 indicated that the RPI in air was greater than the RPI in O2 69.3 % of the time (correlation coef = 0.61). RPI on air was lower in patients with a history of vascular disease ($p=0.033$) but this effect was lost breathing oxygen. There were no differences in RPI for CHF or previous smoking, but those who smoked at the initial evaluation had significantly lower RPI in air ($p=0.014$). There was no effect on O2. The relationship of RPI to outcome could not be tested in this sample size.

CONCLUSIONS: Current smokers had a lower RPI breathing air than patients who did not smoke. Sea level oxygen changes both the nature of the RPI and its relation to underlying medical conditions. A low RPI on air may correlate with the presence of vascular disease.

C11

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

ARTERIAL GAS EMBOLISM CAUSING CARDIAC ARREST TREATED WITH HYPOTHERMIA, LIDOCAINE, AND HYPERBARIC OXYGEN

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BACKGROUND: A patient with cardiac arrest due to gas embolism was treated with hypothermia, lidocaine, and hyperbaric oxygen therapy.

CASE REPORT: A 45 y/o female had a CT-guided transthoracic needle biopsy (18 gauge Coax) for a left lower lobe nodule. She immediately felt poorly, then lost consciousness and had pulseless electrical activity (PEA) requiring ACLS. Air was present by CT in the left ventricle and coronary circulation, requiring 43 minutes of CPR for PEA arrest (Epinephrine, Vasopressin, Amiodarone, CaCl, Sodium Bicarbonate). Subsequent coronary and cerebral angiography was normal. Lidocaine was started at 2 mg/minutes after 70 mg load.[1] Therapeutic hypothermia (32-34 ºC)[2] was achieved 5.5 hours after spontaneous circulation, with no pupillary response (GCS=3). She was treated with HBO2 6.5 hours after circulation restored (delayed pending hypothermia) with continuous monitoring of ECG, arterial blood pressure, airway pressures, and bladder temperature (thermister). ABG (pH/PaCO2/PaO2) before HBO2 (100% O2/10 PEEP): 7.37/24/157. At 3 ATA (100% O2/10 PEEP): 7.36/27/1344. Due to gas exchange abnormalities, a USN TT6 was avoided.3 She received HBO2 without air periods (3 ATA for 60 minutes, then 2.4 ATA for 60 minutes). HBO2 was repeated the following day (2.4 ATA, 120 minutes, no air). Lidocaine was stopped after 48 hours, and the patient was rewarmed. HBO2 was discontinued due to improving mental status and desire to extubate.

RESULTS: Within 4 days of arrest, she was awake and communicative, with short-term memory and vestibular problems. Cardiac EF was 45%, Troponin I peaked at 2.33, and day 5 brain MRI was normal. She was discharged to inpatient rehabilitation 12 days after arrest. The nodule was a hamartoma.

CONCLUSIONS: AGE is a rare risk (0.061%) 4 of percutaneous lung needle biopsy. This case presents an unexpected favorable outcome following prolonged CPR due to arrest from AGE treated with lidocaine, hypothermia, and HBO2.

1. Mitchell SJ. Undersea Hyperb Med. 2001;28(3):165-74.
2. The Hypothermia after Cardiac Arrest Study Group. N Engl J Med 2002; 346:549-556.
3. Weaver LK, Churchill SK. Undersea Hyperb Med. 2006;33(1):11-5.
4. Tomiyama N, Yasuhara Y, Nakajima Y, et al. Eur J Radiol. 2006;59(1):60-4.

C12

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

HYPERBARIC PATIENT DISCHARGE INSTRUCTIONS

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BACKGROUND: Since many HBOT patients are seen as outpatients and are discharged directly home after therapy, a set of patient instructions is warranted for patient safety and to satisfy regulatory agency requirements.

MATERIALS AND METHODS: Common post-treatment issues were addressed on a patient discharge instruction summary. These included but were not limited to temporary visual and auditory changes, return of symptoms, hydration, rest and exertion recommendations and myringotomy care. The most common discharge instructions are needed for Carbon Monoxide poisoning, Decompression Illness and a Daily Treatment Instruction form for patient's completing a prescribed course of therapy for an approved indication.

RESULTS: A comprehensive tool of patient discharge instructions for Carbon Monoxide Poisoning, Decompression Sickness and Daily Treatment Instructions. The discharge tool has been submitted to Forms Approval Committee and Risk Management. Data Collection is ongoing. The efficacy of the forms will be evaluated by the number of return visits and calls received from the patients post-therapy.

CONCLUSIONS: We developed an efficient patient education tool and point of contact for post therapy patient issues. The information on these forms will reduce the liability exposure of both the hyperbaric practitioners and the facility. This document will provide a means of satisfying regulatory agency requirements for patient documentation and education.

C13

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

EFFECT OF HYPERBARIC OXYGEN ON CYCLOSPORINE-INDUCED NEPHROTOXICITY AND OXIDATIVE STRESS IN RATS

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BACKGROUND: Reactive oxygen species have been suggested to be involved in cyclosporine nephrotoxicity. Hyperbaric oxygen is known to induce generation of reactive oxygen species in tissues. The aim of this study was to investigate whether the use of hyperbaric oxygen concurrently with cyclosporine potentiates cyclosporine nephrotoxicity by inducing oxidative stress in kidneys.

MATERIALS AND METHODS: The study consisted of four groups of rats: a control group, a cyclosporine group (15 mg/kg/day intraperitoneally for 14 days), a hyperbaric oxygen group (60 min. every day for five days at 2.5 atmospheric pressure), and a cyclosporine + hyperbaric oxygen group (cyclosporine 15 mg/kg/day intraperitoneally for 14 days + hyperbaric oxygen for 60 min. at 2.5 atmospheric pressure every day for five days on the last five days of cyclosporine treatment). Oxidative stress was determined by measuring renal thiobarbituric acid-reactive substances content, renal superoxide dismutase and glutathione peroxidase activities.

RESULTS: Cyclosporine increased serum urea and creatinine levels, indicating development of nephrotoxicity, and induced significant oxidative stress in rat kidneys. Hyperbaric oxygen alone did not alter any of the biochemical and oxidative stress parameters compared to the control group. When used concurrently with cyclosporine, hyperbaric oxygen significantly reduced cyclosporine-induced oxidative stress, but it neither attenuated nor aggravated cyclosporine-induced nephrotoxicity.

CONCLUSIONS: These results suggest that reactive oxygen species are involved in cyclosporine nephrotoxicity, but are not the direct cause of the toxicity. Although concurrent use of cyclosporine and hyperbaric oxygen did not exacerbate cyclosporine nephrotoxicity in this model, we recommend that the renal functions of patients be monitored periodically when these drugs are used concurrently.

C14

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

INCIDENCE OF OXYGEN SEIZURES IN HBO CHAMBER ATTENDANTS

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BACKGROUND: Central nervous system oxygen toxicity is a very real complication of HBO treatments. The most striking manifestation of this complication is a seizure. In 1984, the Hyperbaric Medicine Center at UCSD introduced a method for the decompression of inside chamber attendants utilizing oxygen breathing in an attempt to decrease the risk of DCS. Three different protocols are used based on the duration of HBOT during standard 45 fsw treatments. Two of these protocols involve the attendants breathing oxygen at depth for 15 or 30 minutes respectively. We report here the incidence of oxygen toxicity seizures using these two protocols.

MATERIALS AND METHODS: The records of all HBO treatments utilizing oxygen breathing by inside attendants were reviewed. 19,377 treatments were evaluated. 18,681 involved the attendant breathing oxygen for the last 15 minutes of the treatment and 696 involved oxygen breathing for the last 30 minutes. The diagnosis of seizure was not restricted and left to the clinical judgment of the physician monitoring the HBOT. Confidence interval analysis was then used to determine the incidence of oxygen seizures in these attendants.

RESULTS: The incidence of oxygen seizures was zero for both protocols. The upper limit of the incidence of oxygen seizures is thus: Protocol 1 evaluated 18,681 treatments with zero cases of seizure (95% CUI, 0, 0.00021) and Protocol 2 evaluated 696 treatments with zero cases of seizure (95% CI, 0, 0.00549).

CONCLUSIONS: The institution of oxygen breathing by inside chamber attendants during HBOT resulted in a seizure incidence of zero in 19,377 exposures. These protocols not only achieve an acceptable risk of DCS among chamber attendants, but do so while producing a very acceptable risk of oxygen seizures as well.

C15 (President's Competition)
Oral Presentation: N/A
Poster Presentation: 1545 - 1700

PREDICTIVE VALIDITY TESTING OF A CLAUSTROPHOBIC SCREENING INSTRUMENT IN A MULTI-PLACE HYPERBARIC ENVIRONMENT

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BACKGROUND: All too often patients may be lost to hyperbaric oxygen treatment (HBOT) and many provide reasons for doing so which do not hint at their fear or anxiety of confinement. This IRB approved study intends to test the validity of a claustrophobic screening instrument in a multi-place hyperbaric chamber setting. The screening instrument under evaluation, the Claustrophobia Questionnaire (CLQ) developed by Radomsky, et al, was found to be a valid indicator of claustrophobic symptoms in other settings such as Magnetic Resonance Imaging settings. Finding positive validity of the CLQ in the hyperbaric environment would allow chamber staff a means to quickly identify patients who may benefit from additional preparation before beginning HBOT.

MATERIALS AND METHODS: Consenting patients who are scheduled to undergo HBOT at the Hyperbaric Treatment Center's multi-place chamber are administered the CLQ prior to their initial treatment. After each treatment participants are administered a second self-report instrument to gauge heightened anxiety and panic symptoms encountered during treatment. Confounding variables arising from the chamber environment are also noted by the chamber technician, such as number of additional persons in the chamber; the presence of bulky equipment, e.g. wheelchairs; and medications. Participants are tracked during their first 30 HBOT sessions, with the first and third data sessions of most interest for this study's statistical analysis which will be done using multiple regression and ANOVA to correlate the patients' experience and perceptions with the initial questionnaire in an attempt to validate the CLQ's predictive ability. The ideal sample size was determined to be 20 subjects.

RESULTS: The study is currently ongoing. To date, 17 participants have been enrolled, with 13 completing their treatments/data-sets. Preliminary analysis of data is trending towards significant correlation between CLQ scores and both observable and patient perceived occurrences of anxiety during HBOT.

C16

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

CEREBRAL AIR EMBOLISM DURING CAESAREAN SECTION

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BACKGROUND: We present a case of a severe systemic (paradoxical) air embolism occurring during spinal anaesthesia in an otherwise healthy 31-year-old parturient.

CASE REPORT: A caesarean section was preformed due to placenta previa. Uncomplicated spinal anaesthesia and satisfactory surgical anaesthesia were obtained. No sedatives were used, and the patient was awake and tolerated the procedure well. Following transecting of the placenta to deliver the foetus, the patient became unconsciousness, hypotension and had trouble maintaining open airways. Intubation was performed without the use of any anaesthetics. The following day she complained of diplopia, weakness and numbness in the left arm, and numbness in her right leg. A neurological exam was preformed confirming this, in addition weaker reflexes in her left arm was found. History and findings were suspicious of perioperative cerebral/spinal air embolism. The patient underwent a standard US Navy table 6, and spontaneously reported improvement in her symptoms after about 10min at 20m (3.0 ATA). A neurological status were obtained after the first treatment and showed only numbness in her right leg. She underwent two more treatments (US Navy table 14/90). At discharge 10 days later the patient neurological status was normal.

CONCLUSIONS: Air embolism during caesarean section is seldom recognized, but is likely to be more common than reported. The treatment of choice is hyperbaric oxygen therapy.

SESSION D: Diving Equipment and Operational Considerations

D1

Oral Presentation: 1545 - 1557
Poster Presentation: 1415 - 1530

DEVELOPMENT OF A SCRUBBER GAUGE FOR CLOSED-CIRCUIT DIVING

Warkander DE
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BACKGROUND: Currently a diver breathing on a closed-circuit underwater breathing apparatus (rebreather) has no way to know how much CO2 absorbency remains during a dive. Time limits are established for assumed workloads, but they have to be conservative. Therefore, in most cases a dive might be safely extended if the performance of the scrubber could be known in real time. Similarly, a dive might need to be shortened to avoid excessive CO2 exposure from unexpectedly poor absorbent performance or a workload that is greater than anticipated. A CO2 sensor is of limited use: since typically no CO2 leaves the scrubber until late in a dive, such a sensor would not allow any predictions.

MATERIALS AND METHODS: Since the absorbent releases heat when CO2 is absorbed, temperatures were recorded at selected sites inside the scrubber of a rebreather. Unmanned testing was performed at several minute ventilations at the full range of depths, water temperatures, and absorbents. CO2 was measured in the diver's inspired gas.

RESULTS: The temperature recordings from more than 200 dives were analyzed, and a method that gives readings on a gauge that is essentially independent of depth, temperature, and minute ventilations was developed. The gauge, which has a read-out like a car's fuel gauge, predicted the endurance time with an error that was typically less than 10% even early in both unmanned and manned dives.

CONCLUSIONS: A gauge that shows the remaining capacity of a CO2 scrubber has been developed. It provides real-time knowledge of scrubber activity and may allow better planning, thereby resulting in enhanced safety, flexibility, mission duration, and diver confidence, as well as reduced cost.

ACKNOWLEDGMENT: Funding was provided by the Office of Naval Research, Ocean Engineering and Marine Systems.

D2

Oral Presentation: 1557 - 1609
Poster Presentation: 1415 - 1530

WATER TEMPERATURES FOR MATCHED COLD EXPOSURES IN DIVERS WITH OR WITHOUT WET SUITS DURING AIR DECOMPRESSION DIVES

Doolette DJ, Gault KA, Gerth WA
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BACKGROUND: Much of the military decompression data used to calibrate probabilistic models was obtained from divers wearing wet suits in cold water (mean 62 ºF). A decompression trial requiring divers dressed in swimsuits and t-shirts necessitated identifying a water temperature to approximate diver thermal exposures in earlier trials because diver thermal status is an important determinant of decompression sickness (DCS) risk.

MATERIALS AND METHODS: To represent earlier decompression data, twelve divers wearing 5-7mm neoprene wet suits and immersed in 60 ºF (16 ºC) water in the Ocean Simulation Facility wetpot were compressed to 100 feet of seawater (fsw) at 60 fsw/min, performed intermittent 125 Watt cycle ergometer work during the remaining 28.3 minutes at bottom, and then rested during 99 minutes of decompression. For each diver, skin temperature at four locations was recorded continuously, and subjective thermal status scores from 0 (comfortable) to 10 (unbearably cold) were elicited every 15 minutes. Two days later, eleven of the same divers wearing swimsuit and t-shirts and immersed to 3 fsw in 85 ºF (29 ºF) water performed 115 Watt cycle ergometer work for 30 minutes, and then rested for 180 minutes. Thermal status scores were elicited every 15 minutes.

RESULTS: Among divers in wet suits, mean skin temperature stabilized between 80 and 85 ºF after ergometer work. In divers wearing swimsuits and t-shirts mean skin temperature is near water temperature. Under both dive conditions, thermal status scores rose from an initial median of 1 and stabilized at 5 (occasional shivering). Thermal status scores under the different dive conditions were not significantly different during the final 60 minutes of immersion (paired Wilcoxon test).

CONCLUSIONS: During prolonged decompression dives, cold stress for divers without wet suits in 85 ºF water is similar to that for divers wearing wet suits in 60 ºF water.

D3

Oral Presentation: 1609 - 1621
Poster Presentation: 1415 - 1530

NASOPHARYNGEAL PRESSURE DURING MIDDLE EAR EQUALIZATION: A DEVICE TO SUPPORT INVESTIGATION OF AURAL BAROTRAUMA

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BACKGROUND: The most common question to DAN Medics concerns aural barotrauma which occurs during diving when the Eustachian tube fails to equalize the middle ear and environmental pressures. Eustachian tube function is traditionally measured by tympanography, but previous work indicated little correlation between tympanography and barotrauma (Denoble PJ et al. UHM 2006; 33:364). We developed a device to measure nasopharyngeal (NP) pressure during middle ear equalization at sea level.

MATERIALS AND METHODS: The device measured NP pressure at the time of middle ear equalization as determined by peak ear canal pressure change. Pressure transducers were connected via tubing to an ear canal and nostril with the other nostril manually blocked. Pressures were recorded for five seconds while the subject performed a middle ear equalization maneuver. We report on measurements in 20 divers. Sixteen individuals were tested on one day and four individuals were tested on three days of diving. Ear pain, congestion and medications taken during diving were recorded.

RESULTS: 168 measurements of NP pressure (three per diver ear) were made in 20 divers who conducted 56 dives. 142 NP measurements (85%) were considered acceptable. Measurements were rejected if the NP pressure change did not coincide with the maximum ear canal pressure change. Mean NP pressures at ear equalization ranged from -26.0 to 111.1 cm H2O. There were no reports of aural barotrauma. The distribution of mean NP measurements is shown below.

Mean NP Pressure (cm H_2O)	N
<0	9
>0 to ≤20	12
>20 to ≤40	14
>40 to ≤60	6
>60 to ≤80	6
>80 to ≤100	3
>100 to ≤120	1

CONCLUSIONS: Our eventual objective is to test the hypothesis that the nasopharyngeal pressure at which the middle ear equalizes is associated with the risk of aural barotrauma.

D4

Oral Presentation: 1621 - 1633
Poster Presentation: 1415 - 1530

THERMAL ASSESSMENT OF DIVING GARMENTS USING AEROGEL SUPER-INSULATION FABRICS

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BACKGROUND: An area of primary interest in diving safety and effectiveness is improving the ability of free-swimming and tethered divers to operate in thermal extremes through improved suit materials. The objective of this study, sponsored by the Office of Naval Research, was to compare the thermal protection afforded to divers using garments constructed from recently developed aerogel super-insulation materials with that of commercially-available garments.

MATERIALS AND METHODS: Six U.S. Navy male divers conducted long-duration cold-water dives (up to 3 hour durations) in a 5-meter deep test pool with water temperature maintained between 1.7 and 4.4 ºC (35 and 40 ºF). During successive dives, separated by a minimum of 40 hours, divers alternately wore drysuits with liners constructed from either an experimental aerogel super-insulation or a commercial 400-weight Thinsulate fabric. Core, finger, toe, and mean skin temperatures were recorded as the divers remained immobile on the bottom of the test pool, and diver comments concerning thermal comfort were recorded at 30-minute intervals.

RESULTS: The experimental aerogel garment resulted in increased dive durations for all dive subjects, on average 43% greater than dives with the commercial Thinsulate liners. Finger, toe, and mean skin temperatures likewise showed improvements (on average 4 ºC higher finger temperatures one hour into the dives, 5 ºC higher toe temperatures, and 3 ºC higher mean skin temperatures based on a four point weighted average). Diver surveys, during and after the testing, confirmed the overall thermal subjective comfort benefits of the experimental liner constructed from the aerogel super-insulation fabric.

CONCLUSIONS: This investigation has demonstrated that significant improvements in diver thermal protection can be achieved by incorporating aerogel super-insulation fabrics into drysuits. The thermal properties of these materials have also been shown to be minimally impacted by water immersion or compression.

D5

Oral Presentation: 1633 - 1645
Poster Presentation: 1415 - 1530

DIVER THERMAL PROTECTION IN COLD WATER: A NEW APPROACH

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BACKGROUND: Diver thermal protection is an important issue in all forms of diving, even in insulated suits, since most terrestrial waters are above or below the thermal-neutral temperature of homoeothermic man. The present study assessed the capability of an active diver thermal protection system (DTPS) to protect divers (n = 3, 18-30 yrs old) in water temperatures ranging from 10 ºC to 40 ºC, at rest and during exercise; as well as its energy requirements and the effect of insulation thickness. The DTPS was powered by a battery pack.

MATERIALS AND METHODS: Divers wore a tube suit perfused at 30 ºC (critical water temperature), a 3 mm or 6 mm thick wet suit, the DTPS and SCUBA at 4 fsw, both at rest or during exercise for 1-4 hrs (thermal steady state). Core, skin, and tube suit inlet and outlet temperatures were measured along with heat flux and VO2.

RESULTS: The DTPS maintained core temperatures at ± 0.5 ºC, skin temperatures between 25-30 ºC and digit temperatures between 2-25 ºC, even in 10 ºC water. The metabolic heat production averaged 105W and 698W, at rest and during exercise, respectively. Suit energy requirement ranged from 244-366W, with the latter in 10 ºC; with 11%, 32%, 17%, 6%, 22% and 12% to the head, torso, arms, hands, legs and feet, respectively. The insulation layer did not affect the metabolism; however the power for the 3mm wetsuit was twice that of the 6 mm wetsuit.

CONCLUSIONS: The DTPS maintained thermal balance and comfort of divers in water as cold as 10 ºC for up to four hours with current battery technology; both at 4 fsw and at least to 50 fsw, based on the 3mm wetsuit data. The DTPS is autonomous, has few moving parts with redundant systems, does not use consumables and may be useful in hot water as well.

(ONR grant NOOO14-02-1-0278)

D6

Oral Presentation: 1633 - 1645
Poster Presentation: 1415 - 1530

AN ACTIVE SYSTEM TO THERMALLY PROTECT DIVERS IN COLD WATER

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BACKGROUND: Physiological protection of divers in cold water has not worked, suggesting the need for an engineering approach.

MATERIALS AND METHODS: Technology for a diver thermal protection system (DTPS) was evaluated and an active DTPS manufactured.

RESULTS: The DTPS technology is comprised of active heating/cooling units incorporated in a backpack and a tube suit (MedEng) that the diver wears under a wet or dry suit. The DTPS can be powered from any source (32 volts DC). The DTPS has six pumps (B&D Pumps, Inc., UGP-2000P (24VDC)) that circulate water through the tube suit. Heating is by five thermal electric modules (Peltier effect) (TEC, Supercool US, Inc., DL-290-24) in parallel with their inlet-supplied form a manifold that receives water returning from the tube suit and their outlet into a manifold that perfuses the tube suit. A programmable controller varies the power to the TECs to achieve a selected outlet manifold temperature. The tube suit was designed and commercially built and has six independent zones (head, torso, arms, hands, legs, feet) that are perfused at optimal flows of 0.5 ñ 1.0 L/min. The system can be powered by surface supplied hose, generator, or batteries; or, in the free-swimming mode, by multiple modular battery packs. The latter are "sticks" of eight lithium ion batteries (Panasonic 18650) that are encased in pressurized tubes and nine sticks are bundled in aluminum triangles that fit in the curvatures around scuba tanks. The DTPS is 18" by 13" by 3" and although it weights 44 kg in air it is neutrally buoyant in water. In its experimental mode, in addition to the manifolds, the tube suits inlet and outlet temperatures are measured and thus serves as a total body calorimeter.

CONCLUSIONS: Using the battery packs this DTPS has protected divers in a wide range of submersed water temperatures for up to four hours.

(ONR grant NOOO14-02-1-0278)

D7

Oral Presentation: 1645 - 1700
Poster Presentation: 1415 - 1530

RESTING METABOLIC GAS EXCHANGE WITHIN THE ENCLOSED HOOD OF THE MK10 SUBMARINE ESCAPE AND IMMERSION EQUIPMENT (SEIE) SUIT

Fothergill DM, Horn WG
Naval Submarine Medical Research Laboratory, Groton, CT

BACKGROUND: The SEIE suit is designed to enable free ascent from a stricken submarine. It incorporates an enclosed ascent hood for buoyancy and breathable air during escape. Prolonged breathing from the enclosed volume of the hood could lead to dangerous levels of hypercapnia and/or hypoxia. The aim of the current study was to determine the change in concentration of O2 and CO2 over time within the ascent hood in resting partially immersed subjects at 1 ATA.

MATERIALS AND METHODS: Subjects were 12 male US Navy trained divers or submariners, age 37.8±9.9 (mean ± SD) yrs, height 1.77±0.05 m, weight 89.9±9.3 kg. Subjects wore the SEIE suit with the stole fully inflated and the hood fully closed while dry (condition A), immersed with the water level 2 inches above the hood vent (condition B) and while floating erect (condition C). Inspired and end-tidal O2 and CO2 were monitored continuously at the mouth using a mass spectrometer. A trial continued for 10 minutes of rebreathing or until FiO2 reached 13% or FetCO2 exceeded 9%.

RESULTS: Condition A continued for 10 minutes with the mean ± SD for PiO2 and PiCO2 stabilizing at about 138±4.8 mmHg and 18.6 ± 3.4 mmHg, respectively. Conditions B and C were terminated due to reaching the FiO2 limit after 162 ± 29 s and 198 ± 47 s, respectively. The mean ± SD PiCO2 at the end of trials B and C were 41 ± 1 mmHg and 42 ± 2 mmHg, respectively. Body volume, weight, and surface area all showed high significant negative Pearson product-moment correlations with test duration (r=-0.79 to -0.91).

CONCLUSIONS: Submariners breathing from the enclosed volume of the SEIE suit hood while partially immersed at 1 ATA will approach dangerous hypoxia levels after 2 to 3 minutes of rebreathing. As the SEIE suit is one-size fits all, larger submariners will reach critical hypoxia levels earlier than submariners of smaller body size.

(Supported by NAVSEA 00CM).

D8

Oral Presentation: 1645 - 1700
Poster Presentation: 1415 - 1530

BUOYANCY CHARACTERISTICS OF THE MK10 SUBMARINE ESCAPE AND IMMERSION EQUIPMENT (SEIE) SUIT

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BACKGROUND: The MK10 SEIE suit is designed to enable free ascent from a stricken submarine from depths down to 180 meters. The suit, which includes a stole and ascent hood, keeps the escapee dry and protected from cold shock during escape, and provides sufficient lifting force to take the escapee from the submarine to the surface. The aim of the current study was to determine the buoyancy force of the SEIE suit in completely immersed subjects.

MATERIALS AND METHODS: Subjects were 12 male US Navy trained divers or submariners, age 37.8 ± 9.9 (mean ± SD) yrs, height 1.77 ± 0.05 m, weight 89.9±9.3 kg. Subjects wore overalls, a thermal liner and the outer SEIE suit and were submerged with the stole and hood fully inflated (condition S+H) and with hood inflated only (condition H) in a fresh water tank using a pulley system attached to a waist strap. A force transducer attached to one end of the pulley system measured the buoyancy force. The association between buoyancy forces and height, weight, BMI, body surface area, and body volume was explored using the Pearson product-moment correlation. A paired t-test compared conditions S+H and H. Significance was set at $p<0.05$.

RESULTS: There was no significant difference in the mean ± SD buoyancy force between conditions S+H (36.6 ± 4.2 kg) and H (35.7 ± 5.3 kg). In sea water the above buoyancy forces will increase by approximately 2.69%. The only anthropometric variable that showed a significant correlation with buoyancy force was height (r=-0.74 and -0.64 for H and S+H, respectively).

CONCLUSIONS: During lockout escape, with a fully inflated SEIE suit, submariners are expected to encounter buoyancy forces between 32.2 and 44.7 kg (observed maximum and minimum buoyancy forces with correction for sea water). As the MK 10 suit is one-size fits all, submariners of shorter stature will experience the highest buoyancy forces.

(Supported by NAVSEA 00CM)

D9

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

EFFECT OF NASALLY ADMINISTERED SURFACTANT ON EUSTACHIAN TUBE DYSFUNCTION

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BACKGROUND: Eustachian tube dysfunction (ETD), or difficulty equalizing the pressure in the middle ear, is associated with middle-ear barotraumas (MEB), which is one of the most prevalent medical complications in the diving, aviation, and hyperbaric communities. It has been observed that the Eustachian tube is coated with surfactant, similar to that found in the lungs, which may play an important role in establishing patency to allow for pressure equalization. The purpose of this trial was to determine efficacy of nasally administered surfactant to decrease the incidence of ETD and resulting MEB.

MATERIALS AND METHODS: Eight navy-trained divers were exposed to repeat dives after taking surfactant, Mucomyst, oxymetazoline, or nasal saline via a nasal inhaler, or oral pseudoephedrine. The trial was conducted as a double-blinded, randomized, crossover study. Effects were measured using nine-step tympanograms (NST), sonotubometry to measure Eustachian tube opening pressure (ETOP), and diver holds during the dive.

RESULTS: Among all the conditions tested, there were no significant findings and results were inconsistent between tests. The ETOP provided highly variable results in each diver, the NSTs did not follow any consistent pattern, and there were very few holds among the divers which did not allow for adequate comparisons among all the medications.

CONCLUSIONS: This investigation was unable to determine that any treatment was superior to placebo. Selection of subjects with more difficulty in equalizing their middle ears and a more precise way to measure ETD than basic sonotubometry should be established prior to re-testing these medications.

D10

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

LIGHTWEIGHT, FASTER DECOMPRESSION AND PORTABLE ALTERNATIVE TO U.S. NAVY MIXED GAS DIVING

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BACKGROUND: Conventional U.S. Navy deep diving is limited to 300 feet and requires the support of large surface platforms and a minimum of 13 divers. The breathing media used is HeO2 and the diving apparatus is the MK-21. Recompression chambers, storage racks and equipment in excess of 50,000 lbs. are required on site.

MATERIALS AND METHODS: By employing the use of alternate breathing media and new technology, deep diving can be accomplished in a more compact space with less decompression and to deeper depths with increased safety. Data will be presented from experimental dives as proof of concept.

RESULTS: Incorporating new knowledge of decompression tables and algorithms would allow the depth limit to be increased to 600 feet. The use of constant Partial Pressure of Oxygen rebreathers and dive computers can increase safety and decrease required decompression time. The incorporation of inflatable chambers and rebreathers would also reduce the required footprint and weight of a team as well as vessel required.

CONCLUSIONS: A team of 12 highly trained divers could be deployed worldwide with six rebreathers, one inflatable chamber, two sets of SCUBA bottles and a laptop computer. These divers could rapidly deploy on any commercial airline with all required material as checked luggage. Once on station, they could transit to the problem area on nearly any vessel suitable for the conditions.

D11 (President's Competition)
Oral Presentation: N/A
Poster Presentation: 1415 - 1530

URGENT CONVERSION OF A DECK DECOMPRESSION CHAMBER TO A TEMPORARY SATURATION SYSTEM: EXPERIENCE IN THE GULF

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

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

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

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

D12

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

DEVELOPMENT OF A FULLY SUBMERSIBLE COGNITIVE PERFORMANCE BATTERY

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BACKGROUND: Currently no functioning mechanism exists for measuring the real-time cognitive performance of a submerged diver. This limits the capability of Navy Experimental Diving Unit (NEDU) to make valid, reliable recommendations about how environmental stressors, equipment, or procedures affect mission performance. In the past, the Systematic Investigation of Diver Behavior at Depth (SINDBAD) battery was used to assess submerged diver performance. Developed in the 1970s, this battery is incompatible with modern operating systems, is cumbersome, lacks portability, and can no longer be used to collect data. Currently NEDU relies on measures taken after an exposure to measure cognitive performance. However, this method is incapable of determining when decrements in functioning occur or whether deficits subside upon surfacing. Thus, because NEDU lacks a system for collecting real-time performance data from submerged divers, we have developed equipment capable of assessing the performance of a fully submerged diver.

MATERIALS AND METHODS: The equipment consists of a topside computer, monitor, keyboard/mouse, and communication system that are connected to a control system interfacing with the submerged monitor, keyboard/mouse, camera, and communications system.

RESULTS: From a topside location, the researcher can have private communications and interactions with the submerged diver. Various assessments can be controlled and displayed by the researcher as he/she monitors the reactions of the test subject via the camera monitor and computer. The test subject can react by keyboard entries, the mouse, or direct verbal responses.

CONCLUSIONS: NEDU now has the capability to assess the behavior of a fully submerged diver at depths targeted down to 1000 feet of seawater. This equipment is compatible with current operating systems, can easily be transported and deployed, and allows the researcher to assess a submerged diver in real time. Because this equipment is computer based, this systemís uses are extensive.

D13

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

A SIMPLE CONSERVATIVE METHOD FOR CALCULATING SAFE STANDOFF DISTANCE FOR DIVING NEAR UNDERWATER ELECTRICAL SYSTEMS

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BACKGROUND: Divers are frequently required to work near energized underwater electrical systems. A simple method to calculate safe standoff distances from these electrical systems would greatly benefit divers. Finding relevant guidance in a usable format is challenging. Much of the literature pertaining to underwater electrical safety is more than twenty years old and often addresses only a narrow aspect of the topic or is purely theoretical, with limited practical applicability.

MATERIALS AND METHODS: A review of the pertinent electrical safety literature yielded the necessary elements for calculating safe standoff distance for diving near underwater electrical systems. By employing worst-case scenarios, this calculation method yields conservative yet simple guidance.

RESULTS: Underwater electrical safety guidance is contained in the U.S. Navy Diving Manual and is based on guidelines adopted in 1987 from the Association of Offshore Diving Contractors (AODC). AODC 035 gives the formulae for calculating a safe standoff distance for a diver in an electric field. This distance is a function of the ratio of maximum fault current (Io) to the safe body current (Ib) and is highly dependent on the conductivity of the water. The equation for fresh water is given below.

D = SQRT [1+ Io/(40*Ib)] -1, where D is the standoff distance in meters

When calculating the safe standoff distance for water of unknown salinity, it is prudent to take a conservative approach and use the equation for fresh water. The current rating of the circuit breaker protecting the underwater electrical system should be selected as the value for (Io) and the AODC code limit of 10 mA AC as (Ib).

CONCLUSIONS: A conservative method for calculating safe standoff distance for diving near energized electrical systems is demonstrated. A table derived as a function of common circuit breaker ratings provides a simple, usable format for diver guidance.

D14

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

ELASTIC AND HYDROSTATIC PROPERTIES OF THREE DIFFERENT REBREATHER BELLOW DESIGNS

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BACKGROUND: The European norm for rebreathers EN1414-3:2003 allows for hydrostatic pressure differences of -25 to +20 mbar relative to the suprasternal notch. Warkander, Clark and Lundgren suggest limits for hydrostatic imbalance1 of +3 to -17 mbar and limit the elastance1 to 7 mbar/l. Different breathing bellow designs were tested to investigate how well they conform to the standard and proposed limits.

MATERIALS AND METHODS: The bellow designs tested were a breast mounted split breathing bag, a back mounted cylindrical bellow moving outwards from the diver, and a back mounted hinged bellow incorporating weights to counteract the hydrostatic imbalance, all in semi closed designs. The tests were carried out in accordance with the test method for hydrostatic imbalance in EN1414-3. The breathing simulator was set at 25 bpm and the tidal volume at 2.5 l.

RESULTS: In the prone position, the hydrostatic imbalance of the breast mounted breathing bags was 22 mbar and the elastance 8.8 mbar/l. The back mounted cylindrical bellow had a hydrostatic imbalance of -35 mbar and an elastance of 0.8 mbar/l. The back mounted hinged bellow without weights had a hydrostatic imbalance of -23 mbar and an elastance of ñ3.2 mbar/l. Adding 8 kg weights reduced the hydrostatic imbalance to -18 mbar. The elastance switched sign and decreased to 1.2 mbar. Doubling the weights further decreased the hydrostatic imbalance but resulted in a pronounced resonance phenomenon of the bellow.

CONCLUSIONS: Testing of three different types of bellows used in existing and widely used diving systems show that two conform to the European norm, but none to the limits proposed by Warkander, Clark and Lundgren.

REFERENCES: 1Warkander DE, Clarke JR and Lundgren CEG. Undersea and hyperbaric medicine 2001:28(suppl)(Abstract)150.

D15

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

UNDERSTANDING THE EFFECTS OF UNDERWATER ULTRASOUND ON HUMAN DIVERS

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BACKGROUND: The frequency response of the human auditory system is generally described as extending from approximately 20 Hz to 20 kHz. However, recent psychophysical experiments have documented that human divers can detect underwater sounds in the 100 kHz range. While the detection of ultrasound has been documented in previous bone-conduction literature, the underlying mechanism for human ultrasonic hearing is not understood. The aim of this study is to confirm that the reported underwater detection of ultrasonic frequencies is neither due to lower-frequency source distortions nor lower-frequency distortion products in the water medium.

MATERIALS AND METHODS: All measures were made in an anechoic pool, with divers submerged to a depth of 15 feet. Underwater hearing thresholds were obtained from 4 male U.S. Navy divers. Hearing thresholds were measured at 5 kHz and 100 kHz. High resolution acoustic measurements of the sound field were made prior to behavioral threshold measurements. To measure potential lower-frequency distortions in the known human auditory range, an additional mechanically-tuned lowpassed hydrophone (<50 kHz) was used.

RESULTS: When the hydroacoustic projector was outputting at 100 kHz with a 200 dBSPL (re 1 uPa) tone, the lowpassed hydrophone registered a <50 dBSPL noise floor. In the known frequency range of human hearing, the most sensitive underwater threshold of hearing is >70 dBSPL. The mean behavioral hearing threshold at 5 kHz was 102 dBSPL and at 100 kHz was 174 dBSPL.

CONCLUSIONS: No distortion products were found at the hydroacoustic projector or in the water medium. Human divers are indeed responding to the 100 kHz stimulus itself, rather than to some lower-frequency distortion. We hypothesize that non-linearity in the skull, soft tissue, and/or cerebral spinal fluid demodulates the ultrasonic frequencies down into the audible frequency range.

SESSION E: Hyperbaric Chamber Equipment Issues

E1

Oral Presentation: 0915 - 0927
Poster Presentation: 1045 - 1200

Financial Disclosures to be made

SELECTING SKIN CARE PRODUCTS FOR USE IN HYPERBARIC CHAMBERS MAY BE DEPENDENT UPON FLAMMABILITY ACCEPTABILITY INDICES SCORE

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BACKGROUND: Current protocols call for a cessation of adjunctive skin care treatments during hyperbaric care. The elevation of the oxygen fraction along with the increased pressure in the hyperbaric chamber dramatically increases the flammability potential of the materials in the hyperbaric atmosphere, leading to the need for rigorous standards to prevent the possibility of flame ignition. A scientific method of evaluating the flammability risks associated with the use of skin care products in the hyperbaric setting would be a clinically helpful tool.

MATERIALS AND METHODS: Independent studies were conducted comparing the oxygen compatibility for leading skin care products. Oxygen compatibility was determined using the autogenous ignition temperature (AIT) testing, oxygen index (OI) testing and heat of combustion (HoC) testing. Products with a high AIT, a high OI and a low HoC are recognized as being more compatible in oxygen-enriched environments. An Acceptability Index (AI) was calculated, using the above results for the tested products, to rank overall material compatibility in oxygen-enriched environments.

RESULTS: The AIT results did not have a pattern as to the absence or presence of petroleum-based ingredients. The OI of the non-petrolatum containing skin products was significantly higher than products containing petroleum derivatives. The HoC testing revealed that products containing petroleum derivatives had a HoC that equaled or exceeded the HoC of gasoline, whereas the products without petroleum- based ingredients had significantly lower HoC. The silicone-containing, petroleum free products tested received up to a 25 times better AI than petrolatum-based products.

CONCLUSIONS: There is wide variation in the safety profile of skin products. Skin products being considered for use in oxygen-enriched environments should be screened for flammability risks prior to use in hyperbaric settings. This will afford informed decisions about the fire safety of the products allowed. Further research is indicated.

E2

Oral Presentation: 0927 - 0939
Poster Presentation: 1045 - 1200

FLOW DYNAMICS OF PATIENT HOODS

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BACKGROUND: For many years, "standard practice" for management of patient hoods had been to supply them with a steady flow of about 28 to 30 liters per minute (lpm, actual volumetric liters at chamber conditions) regardless of the size of the patient. It has also been considered "standard practice" that the oxygen supplied to the hood should be humidified. Certain types of flow circuits used with patient hoods have been found to be vulnerable to "shrink wrap" accidents where the hood collapses around the patient's head.

MATERIALS AND METHODS: The flow dynamics of patients hoods were analyzed using analytical techniques similar to those used for analyzing the performance of open circuit diving helmets. CO2 and humidity levels in the hoods were analyzed as a function of patient size, patient activity level and hood flow rates. Several types of commonly used hood flow circuits were reviewed with respect to their ability to avoid shrink wrap accidents and their ability to function satisfactory at chamber pressures close to surface pressure where overboard dump systems typically don't work very well.

RESULTS: Large patients may require flow rates above the customary 30 lpm, and small patients such as children can safely use much lower rates. Hood humidity can be controlled by managing the hood flow rate. Charts for recommended flow rates based on patient weight are presented. Also presented are procedures for accurately reading commonly used flowmeters and recommendations for hood circuits that are resistant to shrink wrap accidents.

CONCLUSIONS: While current practice is satisfactory for most patients, hood supply flow is not a "one size fits all" situation.

E3

Oral Presentation: 0939 - 0951
Poster Presentation: 1045 - 1200

CONTINUATION OF V.A.C. THERAPY DURING HYPERBARIC MULTIPLACE OXYGEN THERAPY

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BACKGROUND: As the use of vacuum assisted closure (VAC) in complex non-healing wounds increases, the need to continue VAC treatment during hyperbaric therapy has become apparent. Although it is permissible to clamp off the VAC for two hours while the patient is in the chamber, it would be preferable to continue VAC therapy without interruption. Caution is indicated as vacuum pressure may reach 912 mmHg at a treatment depth of 40 fsw. KCI sets their VAC machines at 125 mmHg and considers 200 mmHg as potentially harmful, thus adjustment is necessary to limit vacuum pressure to less than 140 mmHg. We tested if the VAC could be safely continued during hyperbaric therapy.

MATERIALS AND METHODS: An imitation wound was tested on the VAC machine to prove that it wouldn't leak. After dressing integrity was established, chamber suction was adapted with tubing from a KCI wound VAC machine. The vacuum was set at 125 mmHg. A technician monitored the vacuum pressure constantly during descent and ascent. The pressure was noted in 5 fsw increments. Depth was noted every time an adjustment vacuum pressure was made. Several tests for ease of use, safety and reliability were performed.

RESULTS: As predicted, the vacuum pressure increased or decreased with chamber pressure differential. As vacuum pressure was achieved via the pressure differential between atmospheric and treatment pressure, vacuum pressure increased on descent and decreased during ascent. Readjusting the vacuum pressure was easy and the changes were both subtle and readily corrected. The vacuum pressure never rose above 140 mmHg.

CONCLUSIONS: Monitoring and safely adjusting the vacuum during chamber pressure changes without being distracted from patient observation was easy. Clamping the VAC tubing during travel further reduced the risk of hazardous vacuum changes. Use of these methods allowed for improved continuity of wound VAC therapy.

E4

Oral Presentation: 0951 - 1003
Poster Presentation: 1045 - 1200

PAIN PUMP UTILIZATION IN THE HYPERBARIC ENVIRONMENT

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BACKGROUND: Testing of two infusion pain pumps was undertaken (On-Q PainBuster Soaker® and the Stryker Pain Pump®) to determine the effects of increased ambient pressure on pump function. Under normobaric conditions, the standard administration rate of the On-Q PainBuster and the Stryker Pain Pump tested were 5ml/hr and 2.08ml/hr respectively.

MATERIALS AND METHODS: The On-Q PainBuster, at normal room temperature, was filled with 240ml of water and placed in the hyperbaric chamber. The Stryker Pain Pump, at normal room temperature, was filled to 120ml of water and placed in the hyperbaric chamber. The catheter tips were located approximately 4cm above the reservoir and compressed to 2.5 atmospheres absolute. Both pumps were compressed at 3psi/minute, at pressure for 110 minutes, and decompressed at 3psi/minute, for a total time of 124 minutes. After testing the On-Q PainBuster under pressure, it was refilled to 240cc. The Stryker Pain Pump was refilled to 120cc, after testing under pressure. Each were placed on a counter surface, and again tested for 124 minutes at normal room temperature, with the flow of the catheter in an upward flowing position to duplicate exactly the same circumstances as in the hyperbaric chamber. The output of the On-Q PainBuster and the Stryker Pain Pump, during each testing phase, was measured in a 10cc syringe. This exact testing was repeated three times.

RESULTS:

	Testing Phase I	**Testing Phase II**	**Testing Phase III**
On-Q Pain Buster *hyperbaric chamber*	11ml of H2O	11ml of H2O	11ml of H2O
On-Q Pain Buster *counter surface*	11ml of H2O	11ml of H2O	11ml of H2O
Stryker Pain Pump *hyperbaric chamber*	11.4ml of H2O	10 ml of H2O	10 ml of H2O
Stryker Pain Pump *counter surface*	4.16ml of H2O	4.15ml of H2O	4.16ml of H2O

CONCLUSIONS: The results of this study demonstrate that the On-Q PainBuster consistently delivered the appropriate volume independent of ambient pressure. The Stryker Pain Pump consistently delivered volumes in excess of the designed specifications while at pressure.

E5

Oral Presentation: 1003 - 1015
Poster Presentation: 1045 - 1200

PULSCOOXIMETRY VS. CARBOXYHAEMOGLOBINE IN THE DIAGNOSE OF CARBON MONOXIDE POISONING. A COMPARATIVE ANALYSIS

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BACKGROUND: Diagnosis of Carbon Monoxide Poisoning (CMP) is based on clinical findings and on the epidemiologic/toxicological environment. The determination of Carboxyhaemoglobin (HbCO) is useful to confirm the diagnosis, but it is an invasive measure not always available. Pulse-Cooximetry (SpCO) detects the colour spectrum of HbCO with a presumed reliability similar to Pulse-Oximetry. An average of 200 cases of CMP are treated every year in CRIS-UTH, with an overall series over 2800 cases. The preliminary results on the comparison of SpCO and HbCO determinations have been analyzed.

MATERIALS AND METHODS: Patients sent to the old Red Cross Hospital of Barcelona with the suspicion of suffering from acute or chronicle CMP during the years 2006-2007. A Masimo Rad-57 Pulse-COoximeter, was applied to the patients on arrival. HbCO was also determined with a 682 IL Cooximeter. HbCO percentages higher than 8% were compared to the values shown on the screen of the Pulse-COoximetre at the precise moment that the blood sample was obtained. The results were analyzed by means of the Student-Test for both independent and matched data.

RESULTS: The average of HbCO was 13.92 ± 2.86 (8-19). The average of SpCO was 10.8 ± 6.48 (4-24) n=70. SpCO offered 22.7% lowest values ($p<0.001$) but results were always clinically consistent. Neither false negatives nor false positives were produced.

CONCLUSIONS: Determinations of Carbon Monoxide Saturation by Pulse COoximetry, and Carboxyhaemoglobin by blood COoximetry, in patients suffering from Carbon Monoxide Poisoning, were not exactly coincident in this study, but results followed the same trend and both were valuable aids for diagnose. Being that Pulse-COoximetry is easy, autonomous, portable, and non-invasive, it is a valid technique in the early diagnose of CMP, with a potential great utility in emergency conditions.

E6

Oral Presentation: 1015 - 1030
Poster Presentation: 1045 - 1200

Financial Disclosures to be made

MECHANICAL VENTILATION AND MONITORING OF INTUBATED PATIENTS IN A MONOPLACE CHAMBER COMPRESSED WITH AIR

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BACKGROUND: Logistical problems with an ongoing closed head trauma RCT required changing from our multiplace to a monoplace chamber. These critically ill patients all required mechanical ventilation, head elevation, and an array of lines and monitoring wires. The complexity of these patients required careful selection of a chamber and a ventilator. We wanted to monitor the ventilatory status of these patients with more than was possible with the Wright Respirometer. We wanted to compress with air because of increased fire safety, cost savings, and flexibility to use alternate methods for monitoring.

MATERIALS AND METHODS: We purchased the new 34-inch BARA-MED XD® monoplace hyperbaric chamber from Environmental Tectonics Corporation. Aware of limitations with the Sechrist 500A hyperbaric ventilator we began working with Oceanic Medical Products, Inc. and their Magellan ventilator, which does not require an oxygen atmosphere for entrainment. After approximately a year of testing and modifying we were satisfied that the Magellan ventilator would meet our needs. For monitoring the patient's ventilatory status we replaced the Wright Respirometer with the Ohmeda 5410 Volume Monitor. The sensor for this unit was safely adapted for use in an air filled chamber with the monitor itself placed outside. Air breaks can be given using an air-oxygen "switching unit" that supplies the ventilator's drive gas.

RESULTS: To date, we've completed 33 treatments, without any ventilatory complications, using the Magellan ventilator and the Ohmeda monitoring system.

CONCLUSIONS: The 34-inch BARA-MED XD® monoplace chamber, with custom-designed door penetrations, is suitable for providing hyperbaric oxygen to critically ill head-injured study patients with multiple invasive neurosurgical monitoring devices. The modified Magellan ventilator allowed compression of the chamber with air. The Ohmeda 5410 Volume Monitor allowed detailed monitoring of ventilation parameters and safe and accurate ventilation during treatment.

E7

ABSTRACT WITHDRAWN

E8

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

Financial Disclosures to be made

DEVELOPMENT OF A CERTIFICATION MATRIX FOR THE TESTING OF BIOMEDICAL EQUIPMENT USED IN HYPERBARIC CHAMBERS

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BACKGROUND: Ideally, biomedical equipment used in hyperbaric chambers should be certified for hyperbaric service by both the manufacturer and licencing and regulatory authorities. Unfortunately this status applies to very few devices at present. Risk avoidance and a stringent regulatory environment necessitate robust certification processes and there are few manufacturers prepared to put their equipment through hyperbaric specific certification. For hospitals and independent testing laboratories, there is a lack of guidelines and standards against which to test equipment. We therefore attempted to develop a more robust approach than used in the past.

MATERIALS AND METHODS: The parent documents that apply to approval of biomedical devices, primarily AS3200.1 / IEC 60601-1, proved to have no hyperbaric specific aspects. We therefore reviewed existing hyperbaric equipment standards, relevant texts and the hyperbaric equipment approval procedures of a number of institutions, including our own. We then developed a matrix of factors that categorize device type, intended HBO environment, intended usage methodology and a range of risk rating outcomes.

RESULTS: The matrix is complicated but provides pathways that can guide testing. We used this process to guide installation and testing of the Philips Intellivue intensive care monitoring system in our multiplace chamber. The monitoring system was found to work satisfactorily, with acceptable risk and relatively minor changes to operation and calibration. The configuration used has the module racks, multi-measurement servers, "speedpoint" controller and an LCD screen inside with the main touch screen unit outside. This enables control and viewing from both inside and outside the chamber.

CONCLUSIONS: Further refinement of the process is needed but we would welcome input from others interested in this problem with the hope that it might be possible to evolve an international best practice document that could provide the basis for future hyperbaric biomedical equipment specific testing and approval Standards.

E9

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

SERENDIPITY: THE USE OF THE MONOPLACE HYPERBARIC OXYGEN CHAMBER FOR DECOMPRESSION ILLNESS AND GAS EMBOLISM

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BACKGROUND: Recently, mention was made as to the origination of an uninterrupted oxygen (O2) table. Correctly, the first successful uninterrupted O2 table was described in 1939, quote: "We have found O2 therapy begun at 60 feet and reaching the 30 foot level after a period of 1 hours was sufficient to afford permanent relief to 49 of 50 patients." Note that "air breaks" weren't used during the table.

CASE REPORTS: A 39 Y CDR MC USN 3.5 hours post Table 4, while taking a hot shower had sudden onset of severe vestibular dysfunction (1969). Transport to the nearest available pressure chamber for compression within an hour best achieved by transport to USNH's Vickers CH3 and arrange for air trans to USN Shipyard RCC. Vestibular function returned to normal 20 minutes @ 3 ATA O2, calculating tissue 1/2 life the N2 washout would require less than 90 minutes. Further, he refused direct orders from his commanding officer to be transported back to the shipyard chamber by answering with a question: "would you reload the gun that shot you"? The CO acquiesced but required admission and observation. This sequence recurred about a month later after another table IV, the monoplace chamber was again successfully applied! This table (wash in/washout) (based on total cardiopulmonary bypass data) would be for a sum total of a 120-minute exposure counting time of compression and decompression. BUMED was notified, the multiplace systems carefully checked and rechecked for equipment and delivery system flaws, none were found. The symptoms recurred 3 months later after another Table 4 exposure. DCI recurred within an hour outside the Shipyard RCC (no hot shower) and he elected transport to the Naval Hospital, repeated the treatment formulated for the monoplace system with the same result.

A corpsman and inside tender, diagnosed as DCI, refused treatment in the Shipyard RCC, preferring treatment in the monoplace chamber. They became asymptomatic with same treatment schedule. These initial cases were reported in 1970. However, "air breaks" have been successfully used in the monoplace system.

The Long Beach Naval Shipyard RCC was approved to use the Table 6's in 1971.

DISCUSSION: The delay in the use of oxygen tables in DCS was in the interest of safety as noted by Sheffield. Thus properly stated the table used by Hart is a Yarbrough/Behnke Table variant!

E10

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

SODIUM ACETATE THERAPEUTIC WARMING DEVICES: EFFECTS OF OXYGEN AND PRESSURE

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BACKGROUND: Therapeutic warming devices are prohibited from use inside of hyperbaric chambers because of their unpredictable behavior and increased risk of fire in the presence of increase partial pressures of oxygen. Air-activated chemical devices and those which use lighter fluid have been implicated in hyperbaric chamber mishaps. Warming devices that do not rely on oxygen to produce heat are not reflected in the literature. Occasions occur where the use of an external warming device would be beneficial in maintaining patient temperature inside of the hyperbaric chamber environment.

MATERIALS AND METHODS: Tests of sodium acetate warming devices were conducted in a class "A" hyperbaric chamber utilizing a metal test box at pressures of 1.0, 2.36 and 2.81 ATA with exposure to air and 100% oxygen. Fire deluge, hand line fire protection, emergency breathing masks for the tender, and an oxygen monitoring device were employed. Temperature readings were obtained using an infrared thermometer with an accuracy of +/- 3 ºF. Temperature readings were taken at thirty-second intervals throughout testing.

RESULTS: No measurable changes were observed when the warming devices were exposed to varying pressures and concentrations of oxygen.

CONCLUSIONS: Sodium acetate therapeutic warming device behavior is not influenced by changes in surrounding oxygen partial pressures or increased atmospheric pressure.

E11

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

Financial Disclosures to be made

IODOSORB USED AS PALLIATIVE DRESSING WITH UNEXPECTED RESULTS
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BACKGROUND: Cadexamer Iodine was instituted as a palliative measure for ischemic wounds on distal lower extremities with the following rationale: 1) Antimicrobial effect of iodine to prevent onset of wet gangrene, and 2) Absorptive capacity of cadexamer beads to facilitate dry gangrene progressing to auto-amputation.

MATERIALS AND METHODS: Patients had type II diabetes, hypertension, and macrovascular disease. Wounds involved toes and were demonstrated to have infection. Due to physical or psychosocial issues constraints, limbs were not amenable surgical revascularization. Palliative therapy was instituted in hopes of delaying amputation of limbs for as long as possible. As such, cadexamer iodine was applied to wounds daily. Wounds were cautiously debrided in clinic with minimal to no blood loss when necessary. Exudate and loose necrotic tissue were removed to prevent build up of a barrier that might mitigate the desired effects of cadexamer iodine.

RESULTS: Progression of dry gangrene was encouraged by the drying effect of cadexamer iodine and wet gangrene was avoided by preventing microbial growth and invasion. Patients never developed systemic symptoms of infection. Localized swelling and erythema resolved. Cadexamer iodine also facilitated autolytic debridement, granulation, and even epithelialization of wounds involving severely malperfused limbs.

CONCLUSIONS: Cadexamer iodine when combined with periodic and limited sharps debridement is an effective palliative dressing for ischemic wounds that can delay and even avert amputation of limbs not thought to be salvageable.

E12 (President's Competition)
Oral Presentation: N/A
Poster Presentation: 1045 - 1200

EQUIPMENT MALFUNCTION RESULTING IN DECOMPRESSION EMERGENCIES
Carbonaro D, Dilley-Dunn K, Gesell LB
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BACKGROUND: Hyperbaric medicine chamber accidents are rare. Incidents result from: operator fatigue, failure to practice emergency response protocols, contraband smuggled by patients, tampering, or equipment failure. Equipment failure is exceedingly uncommon. Mishaps may involve system contamination, excessive wear or lack of proper maintenance. We report two cases of mechanical failure resulting in a slowed rate of decompression and an arrest of chamber decompression.

CASE SERIES: Events involving decompression failures in two patients undergoing routine hyperbaric therapy are described. Case one: the decompression rate was abnormally slow. This resulted from a worn regulator plunger and blocked seat. No adverse events occurred during decompression. Case two: slowed decompression was initially noted. There was no improvement with increasing gauge decompression rate. Decompression stopped at 5.25 psig. Total decompression time: one hour, 40 minutes. Surface decompression was achieved by turning chamber off to prevent further gas inflow and then performing a slow, controlled opening of the purge valve to provide a semi-controlled decompression. No adverse events occurred. Manufacturer inspection identified a malfunctioning main metering valve in the Moore regulator.

RESULTS: Hyperbaric chambers are built to exacting standards; many safety rules are in place regarding facility and vessel construction. Hyperbaric chambers, however, like other precision medical equipment are subject to malfunction ñ the results of which may be disastrous. Strict adherence to maintenance schedules will help reduce the number of incidents. Our chambers had been properly maintained; in case number two the chamber was actually less than 1 year old. Regulatory personnel note that mechanical failures are essentially nonexistent. Even though incidents are rare it is essential to have predefined emergency evacuation plans should an event occur.

CONCLUSIONS: Chamber accidents despite their rarity do occur. A practical understanding of your chambers design and functioning along with exit strategies that have been well rehearsed may prove lifesaving.

SESSION F: Decompression Illness Evaluation and Treatment

F1 (President's Competition)
Oral Presentation: 1045 - 1057
Poster Presentation: 0915 - 1030

A CASE OF HIGH DOPPLER SCORES DURING ALTITUDE DECOMPRESSION IN A SUBJECT WITH A FRACTURED ARM

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BACKGROUND: The subjects participated in an experimental series with altitude decompression to simulate the protocol for extravehicular activity (EVA; "space walks") performed by Russian cosmonauts during space flight.

MATERIALS AND METHODS: The Russian pre-EVA/EVA decompression regimen was simulated in an altitude chamber. Twenty subjects were decompressed to an altitude of 7500 meter (0.38 bar) after 1 h of oxygen breathing, and continued to breathe oxygen for 2 hours (n=10) or 6 hours (n=10). Subjects were strictly supine and performed intermittent arm exercise of moderate intensity. Every 5-15 min pre-cordial Doppler ultrasound was used to monitor the subject's heart for venous gas emboli (VGE) and the subjects were also monitored for symptoms of decompression illness. Subjects were studied in pairs with two attendants present.

RESULTS: During the preceding medical examination one subject reported a tender right lower arm (the dominant side). He had had these symptoms for 19 days and also visited a physiotherapist. During the examination he showed slight right-sided weakness and it was believed at the time to be a muscle strain or tear. Five days after the experiment x-ray showed fractures in the scaphoid bone and the head of the radial bone. The subject with the broken arm had large numbers of detectable VGE (KM Doppler scores of grade III or above) after 56 minutes at altitude and at 5 occasions during the ensuring 38 minutes before recompression. The other subjects had Doppler scores of zero for at least 2 h (n=18) and for some for 6 h (n=8) (see separate report).

CONCLUSIONS: This unintentional exposure of a subject with a relatively recent arm fracture to altitude decompression suggests that the local inflammatory process and/or local endothelial damage in the fractured area could be a locus of minor resistance for formation of, or entry of, decompression gas bubbles in the blood.

F2 (President's Competition)
Oral Presentation: 1045 - 1057
Poster Presentation: 0915 - 1030

ALTITUDE DECOMPRESSION IN SIMULATED MICROGRAVITY
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BACKGROUND: The space suits used during extravehicular activity (EVA; "space walks") have an internal pressure of approximately 1/3 of that on the International Space Station, where the pressure is 1.0 bar. On the ground, such decompressions are associated with unacceptable rates of venous gas emboli (VGE) and decompression illness (DCI), even after one hour of oxygen breathing before decompression. Nevertheless, no DCI events have been reported from the US and Russian space activities so far.

MATERIALS AND METHODS: The Russian pre-EVA/EVA decompression regimen was simulated in an altitude chamber. Twenty subjects were decompressed to 0.38 bar after 1 h of oxygen breathing, and continued to breathe oxygen for 2 hours (n=10) or 6 hours (n=10). Subjects were strictly supine and performed intermittent arm exercise of moderate intensity. Every 5-15 min pre-cordial Doppler ultrasound was used to monitor the subject's heart for VGE and the subjects were also monitored for symptoms of DCI. Subjects were studied in pairs with two attendants present.

RESULTS: The table shows number of subjects.

Group	Total	No VGE to		EVA aborted due to	
		2 h	6 h	VGE	Other
2 h	10	8	-	1	1
6 h	10	10	8	0	2

Of the 20 subjects, there was only one in whom large numbers of detectable VGE (KM Doppler scores of grade III or above) were measured and it was found later that this subject had a relatively recent arm fracture (see separate report). In addition, one attendant who performed intense loading of the upper and lower extremities while attempting to open a medical lock, had both large numbers of circulating VGE (KM score >III) and symptoms of DCI.

CONCLUSIONS: The horizontal posture and the complete lower-extremity unloading appeared to prevent substantial formation of VGE. This lends support to the notion that Russian cosmonauts have a very low, if any, risk of DCI.

F3 (President's Competition)
Oral Presentation: 1057 - 1109
Poster Presentation: 0915 - 1030

PORTAL VENOUS GAS ASSOCIATED WITH DECOMPRESSION SICKNESS IN SPORT DIVERS: A CASE SERIES

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BACKGROUND: Hepatic portal venous gas (HPVG) has been detected by ultrasound in a volunteer after an experimental dive, but it has not been reported to be associated with decompression sickness (DCS). We report three cases of HPVG on abdominal computed tomography (CT) in two divers presenting with abdominal pain and symptoms of DCS after recreational diving.

CASE SERIES: 1) 34 yo M diving on Trimix presented with left arm numbness, syncope, abdominal pain, and rash over his abdomen. Patient's dive profile was 105 fsw for 65 minutes with a two hour surface interval (SI) followed by 105 fsw for 56 min with a 12 min decompression stop. History and physical exam were consistent with DCS. Abdominal CT showed HPVG. 2) 55 year old male presented with abdominal pain and a rash. Patient's dive profile was 115 fsw for 30min with a 2.5 hour SI followed by 85 fsw for 44 min. Abdominal CT revealed gas in his IVC and portal veins. 3) The same 55 year old male who presented above returned four months later with abdominal pain, left arm pain, and left leg numbness. Patient's dive profile was 80 fsw for 50 min with a 1.5 hr SI followed by 60 fsw for 62 min. Abdominal CT revealed gas within the IVC, intrahepatic portal veins, and transverse colon mesenteric vessels. All divers were treated with USNTT6 and experienced complete resolution of their symptoms. A repeat CT of one diver showed resolution of HPVG after treatment.

CONCLUSIONS: This is the first report of three cases of DCS presenting with abdominal pain who had documented HPVG and gas in the IVC and mesenteric vessels. It is unclear if this is an incidental finding or whether this is a common occurrence in divers with provocative dive profiles. Further prospective study is indicated.

F4

Oral Presentation: 1109 - 1121
Poster Presentation: 0915 - 1030

HYPERBARIC OXYGEN PRETREATMENT REDUCES DECOMPRESSION SICKNESS INCIDENCE IN RATS

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BACKGROUND: We have previously shown in the transparent prawn that pretreatment with hyperbaric oxygen (HBO) can reduce the number of bubbles which grow during decompression, probably by replacing the inert gas in the gas micronuclei with oxygen. Our objective was to evaluate whether HBO pretreatment would reduce decompression sickness (DCS) in the rat.

MATERIALS AND METHODS: Male Sprague-Dawley rats weighing 261-284 g were pretreated with HBO at 101, 203, 304, 405 and 505 kPa for 20 min (20 rats each). After pretreatment, rats were exposed to air at 1010 kPa for 33 min, followed by fast decompression (180 kPa/min). Control rats were exposed to the same pressure for 32 min, without HBO pretreatment. On reaching the surface, the rat was immediately placed in a cage rotating at ~3 m/min for 30 min. The animal's gait enabled us to make an early diagnosis of DCS according to the following signs: walking difficulties, abnormal breathing pattern, forelimb and/or hind limb paralysis, rolling about the cage, convulsions, and death. The rat was examined again after 2 and 24 h.

RESULTS: Within 2 h of decompression, 65% of the control rats suffered DCS; in 45% the outcome by 2 h was death. In the HBO-pretreated groups, the percentage that suffered DCS was: 45% (death in 10%), 45% (death in 25%), 40% (death in 15%), 40% (death in 15%) and 35% (death in 15%) for HBO at 101, 203, 304, 405 and 507 kPa, respectively. At 24 h after decompression, no further deaths were observed in the control or HBO-pretreated groups. All rats that suffered DCS and did not die within the first 2 hr, had completely recovered.

CONCLUSIONS: HBO pretreatment reduces the incidence of DCS in rats decompressed from 1010 kPa, most probably by reducing the effective gas micronuclei.

F5

Oral Presentation: 1121 - 1133
Poster Presentation: 0915 - 1030

POTENTIAL FIFTY PERCENT REDUCTION IN SATURATION DIVING DECOMPRESSION TIME USING A COMBINATION OF INTERMITTENT RECOMPRESSION AND EXERCISE

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BACKGROUND: Conventional saturation decompression protocols use linear decompression rates that become progressively slower at shallower depths, consistent with free gas phase control vs. dissolved gas elimination kinetics. If decompression is limited by control of free gas phase, linear decompression is an inefficient strategy. The NASA prebreathe reduction program demonstrated that exercise during O2 prebreathe resulted in a 50% reduction (2 vs. 4 h) in the saturation decompression time from 14.7 to 4.3 psi and a significant reduction in decompression sickness (DCS: 0 vs. 23.7%). Combining exercise with intermittent recompression, which controls gas phase growth and eliminates supersaturation before exercising, may enable more efficient saturation decompression schedules.

MATERIALS AND METHODS: A tissue bubble dynamics model (TBDM) was used in conjunction with a NASA exercise prebreathe model (NEPM) that relates tissue inert gas exchange rate constants to exercise (mL O2/kg-min), to develop a schedule for decompression from helium saturation at 400 fsw. The models provide significant prediction ($p<0.001$) and goodness of fit (Hosmer-Lemeshow) with 430 cases of DCS in 6437 laboratory dives for TBDM ($p=0.77$) and with 22 cases of DCS in 159 altitude exposures for NEPM ($p=0.70$). The models have also been used operationally in over 25,000 dives (TBDM) and 40 spacewalks (NEPM).

RESULTS: The standard U.S. Navy (USN) linear saturation decompression schedule from saturation at 400 fsw required 114.5 h with a maximum Bubble Growth Index (BGImax) of 17.5. Decompression using intermittent recompression combined with two 10 min exercise periods (75% VO2 peak) per day required 54.25 h (BGImax: 14.7).

CONCLUSIONS: Combined intermittent recompression and exercise resulted in a theoretical 53% (2.5 day) reduction in decompression time and theoretically lower DCS risk compared to the standard USN decompression schedule. These results warrant future decompression trials to evaluate the efficacy of this approach.

F6

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

EXPLOITING AEROBIC FITNESS TO REDUCE RISK OF HYPOBARIC DECOMPRESSION SICKNESS

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NASA Environmental Physiology Laboratory

BACKGROUND: Decompression sickness (DCS) is multivariable. But we hypothesize an aerobically "fit" person is less likely to experience hypobaric DCS than an "unfit" person given that fitness is exploited as part of the denitrogenation (prebreathe, PB) process prior to an altitude exposure. Aerobic fitness is peak oxygen uptake (VO2pk, ml/kg/min).

MATERIALS AND METHODS: Treadmill or cycle protocols were used over 15 years to determine VO2pks. We evaluated dichotomous DCS outcome and venous gas emboli (VGE) outcome detected in the pulmonary artery with Doppler ultrasound associated with VO2pk for two classes of experiments: 1) those with no PB or PB under resting conditions prior to ascent in an altitude chamber, and 2) PB that included exercise for some part of the PB. There were 165 exposures (mean VO2pk 40.5 + 7.6 SD) with 25 cases of DCS in the first protocol class and 172 exposures (mean VO2pk 41.4 + 7.2 SD) with 25 cases of DCS in the second. Similar incidence of the DCS (15.2% vs. 14.5%) and VGE (45.5% vs. 44.8%) between the two classes indicates that decompression stress was similar. The strength of association between outcome and VO2pk was evaluated using univariate logistic regression.

RESULTS: An inverse relationship between the DCS outcome and VO2pk was evident, but the relationship was strongest when exercise was done as part of the PB (exercise PB, coef. = -0.058, p = 0.07; rest or no PB, coef. = -0.005, p = 0.86). There was no relationship between VGE outcome and VO2pk (exercise PB, coef. = -0.003, p = 0.89; rest or no PB, coef. = 0.014, p = 0.50).

CONCLUSIONS: A significant change in probability of DCS was associated with fitness only when exercise was included in the denitrogenation process. We believe a fit person that exercises during PB efficiently eliminates dissolved nitrogen from tissues.

F7

Oral Presentation: 1133 - 1145
Poster Presentation: 0915 - 1030

COMPARISON OF V-4 AND V-5 EXERCISE/OXYGEN PREBREATHE PROTOCOLS TO SUPPORT EXTRAVEHICULAR ACTIVITY IN MICROGRAVITY

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BACKGROUND: The Prebreathe Reduction Program (PRP) used exercise during oxygen prebreathe to reduce necessary prebreathe time prior to depressurizing to work in a 4.3 psi suit during extravehicular activity (EVA). Initial testing produced a two-hour protocol incorporating ergometry exercise and a 30 min cycle of depress/repress to 10.2 psi where subjects breathed 26.5% oxygen/balance nitrogen (Phase II - 10 min at 75% peak oxygen consumption [VO2 peak] followed by 40 min intermittent light exercise [ILE] [~5.8 mL/{kg*min}], then 50 min of rest). The Phase II protocol (0/45 DCS) was approved for operations and has been used on 40 EVAs, providing significant timesavings compared to the standard 4 h resting oxygen prebreathe. The Phase V effort focused on performing all light in-suit exercise.

MATERIALS AND METHODS: Two oxygen prebreathe protocols were tested sequentially: V-4) 160 min prebreathe with 150 min of continuous ILE. The entire protocol was completed at 14.7 psi. All exercise involved upper body effort. Exercise continued until decompression. V-5) 160 min prebreathe with 140 min of ILE - first 40 min at 14.7 psi, then 30 min at 10.2 psi (breathing 26.5% oxygen) after a 20 min depress, simulating a suit donning period. Subjects were then repressed to 14.7 psi and performed another 50 min of lower body ILE, followed by 50 min rest before decompression.

RESULTS: The V-4 protocol was rejected with 3 DCS/6 person-exposures. Initial V-5 testing has produced 0 DCS/11 person-exposures (ongoing trials). The difference in DCS rate was significant (Fisher Exact p=0.029).

CONCLUSIONS: The observations of DCS were significantly lower in early V-5 trials than in V-4 trials. Additional studies are required to evaluate the relative contribution of the variables in exercise distribution, the 10.2 psi depress/repress component, and pre-decompression rest.

(Funded by NASA.)

F8

Oral Presentation: 1145 - 1200
Poster Presentation: 0915 - 1030

DYSBARIC OSTEONECROSIS IN UW SHEEP DISSUB STUDY AFTER A 3-HOUR OXYGEN PRE-BREATHE FOLLOWED BY A 1-HOUR AIR BREAK BEFORE DROPOUT DECOMPRESSION

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Dept. of Surgical Sciences, Dept. of Radiology UW Hospital and Clinics, Comparative Pathology Laboratory, Research Animal Resources Center, University of Wisconsin-Madison, Madison, WI

BACKGROUND: The UW Diving Physiology Laboratory has demonstrated that oxygen pre-breathes (15-min, 1-h, and 2-h) before "drop-out" decompression may reduce DCS morbidity/mortality risk in personnel of disabled submarine (DISSUB). But even a 2-h O2 pre-breathe did not prevent the induction of dysbaric osteonecrosis (DON) in the UW sheep model of the decompressed human. In this study, we investigated the potentially mitigating effect of 3-h oxygen pre-breathing followed by a 1-h air break.

MATERIALS AND METHODS: Nine adult female sheep (86-105 kg) underwent dry chamber air exposure at 60 fsw (2.79 atm abs) for 24 hours, followed by an oxygen (88-92%) pre-breathe for 3-h plus a 1-h air break before "dropout" decompression at 30 feet/min (0.9 atm/min) to surface. One month after decompression, we used 99mTc-methylene diphosphonate (MDP) bone scans of radii and tibiae to monitor "hot spots" of remodeling DON lesions. Alizarin complexone fluorochrome was injected IV to visualize DON repair. One week later, sheep underwent necropsy to observe DON pathology.

RESULTS: Nine out of 9 animals (100%) survived the provocative "drop-out" decompression. All nine sheep showed frank signs of limb bends. All sheep were ambulatory at four hours and none required early euthanasia. DON developed in all sheep with 100% having bone scan abnormalities indicative of active remodeling typical of DON. The average number of DON lesions per long bone was 2.4 (range 1-4). There were 13 DON lesions observed in the radius (59% of all lesions) and 9 in the tibia. Gross pathology confirmed new bone remodeling repair of DON in bone scan "hot spots."

CONCLUSIONS: This study indicates that 3-h O2 pre-breathing followed by a 1-h air break that emulated submarine escape and rescue did not prevent DON in the decompressed sheep.

(Research was funded by NAVSEA, U.S. Navy. We acknowledge the assistance Dr. Ed Flynn.)

F9

Oral Presentation: 1145 - 1200
Poster Presentation: 0915 - 1030

INVESTIGATION OF DELAYED RECOMPRESSION TREATMENT FOR LIMITING THE INDUCTION OF DYSBARIC OSTEONECROSIS: SHEEP MODEL OF THE DIVER

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University of Wisconsin-Madison/Diving Physiology Laboratory, Madison, WI

BACKGROUND: Decompression studies in the UW Diving Physiology Laboratory have investigated the induction of dysbaric osteonecrosis (DON) using the sheep model of the diver and prolonged compressed air exposures and provocative "dropout" decompressions. Dysbaric osteonecrosis may lead to the joint collapse of disabling secondary osteoarthritis.

MATERIALS AND METHODS: Twenty-seven adult female sheep (90.5 ± 15.5 SD kg) underwent dry-air chamber exposures at 2.27 atm abs (43 fsw, 12.8 msw) for 24 hours, then rapid or "dropout" decompression at 30 feet/min (0.9 atm/min) to surface followed by air recompression treatment (Modified USN Table 1A) with latencies of 4, 8, 10, or 14 hours. One month after decompression, sheep were injected with 99mTc-methylene diphosphonate (MDP) for bone scans of radii and tibiae to identify "hot spots" signifying long-bone DON lesions. Alizarin complexone fluorochrome was injected IV to visualize DON. Necropsies were used to confirm DON lesions.

RESULTS: Of 27 sheep that underwent recompression in the 4 groups, 12 sheep sustained DON lesions with active remodeling. Logistic regression showed that DON occurrence was significantly associated with hours of delayed recompression (Wald $p = 0.0146$), with the odds of developing DON about twice as large for each additional hour of recompression delay (odds ratio = 1.99; 95% CI [1.15, 3.45]). Based on the logistic model, predicted incidence of DON rose from 4% at 4 hours to 98% at 14 hours, with DON incidence predicted to be 50% at 8.47 hours of delay (95% CI [5.30, 10.52]).

CONCLUSIONS: Delaying recompression treatment of limb bends can markedly elevate the incidence of DON and potentially disabling osteoarthritis in the affected diver.

(Research was funded by the UW Sea Grant Institute, and the State of Wisconsin. We acknowledge the assistance of Teng-Fu Lin, Manju Kunchur, Ralph Stauffacher, Janet Welter, Rick Nordheim, Bruce Wienke and Glen Moen.)

F10

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

UW SHEEP DISSUB TRIALS: OXYGEN PRE-BREATHE BEFORE DROP-OUT DECOMPRESSION OFFERS A POTENTIAL SURVIVAL BENEFIT

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BACKGROUND: In submarine rescue, disabled submarine (DISSUB) personnel may experience prolonged increased ambient pressure and abrupt emergency decompression when exiting to the surface. Scientific, recreational and operational scuba divers experiencing a saturation hyperbaric exposure and emergency decompression face similar decompression risks. We used the UW sheep model to test human "drop-out" risk of a 24-h exposure at 60 fsw (2.79 atm abs) and abrupt decompression. Would even a brief O2 pre-breathe before drop-out decompression increase survival and reduce decompression sickness (DCS) risk in emergency decompression?

MATERIALS AND METHODS: We investigated the efficacy of O2 pre-breathes (15-min to 120-min) for minimizing decompression risk in adult sheep. Decompression findings were analyzed by logistic regression. All 18 ewes (85-127 kg ±10.85 SD) underwent air exposure at 60 fsw for 24-h and 14 inspired an O2 (88-92%) pre-breathe (15 min, 1-h, or 2-h) before drop-out decompression (30 fsw/min) to surface pressure. Approximately 5-6 weeks after drop-out decompression, bone scans of the radii and tibiae were performed. Sheep underwent necropsy to observe gross pathology.

RESULTS: Twelve out of 18 sheep survived drop-out decompression; all 4 sheep breathing only air died of fulminant chokes, a respiratory DCS (RDCS), with pulmonary edema. Surviving sheep with O2 pre-breathes all showed frank limb bends and most developed dysbaric osteonecrosis (DON); two showed CNS-DCS. Gross pathology confirmed bone scan DON lesions. Logistic regression showed a significant relationship between survival and O2 pre-breathe duration ($p = 0.045$) concomitant with decreasing RDCS severity. The odds of survival were 25 times higher for each hour increase in O2 pre-breathes.

CONCLUSIONS: This study suggests that O2 pre-breathes can greatly reduce DCS morbidity/mortality risk in provocatively decompressed submariners and divers.

(Research was funded by the U.S. Navy and UW Sea Grant Institute. We acknowledge the assistance of Ed Flynn, Bruce Wienke, Jim McCarthy and Jim Schwarz.)

F11

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

COMPARISON OF DYSBARIC OSTEONECROSIS SEVERITY IN THE UW SHEEP MODEL AFTER A 24 HOUR DIVE AT 60 FSW FOLLOWED BY EITHER A 15-MIN, 1-H, 2-H OXYGEN PRE-BREATHES BEFORE DROPOUT DECOMPRESSION

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BACKGROUND: After a provocative dive, bubble formation in fatty long bone marrow may lead to a bone compartment syndrome with bone and marrow ischemia and necrosis. We evaluated oxygen pre-breathes (15-min, 1-h, and 2-h) to determine which would be most likely to provoke dysbaric osteonecrosis (DON) and where DON would occur.

MATERIALS AND METHODS: Twelve adult female sheep (99 ± 14 kg SD) underwent dry chamber air exposure at 60 fsw (2.79 atm abs) for 24 h followed by oxygen (88-92%) pre-breathe (15-min, 1-h, and 2-h) before "dropout" decompression 30 fsw/min (0.91 atm/min). One month later, 99mTc-methylene diphosphonate (MDP) bone scans of radii and tibiae were used to detect "hot spots" of remodeling DON lesions. Alizarin complexone fluorochrome was injected IV to visualize sites of DON repair. Six weeks post "dropout" decompression, sheep underwent necropsy to observe DON pathology. Images of long bone gross pathology were taken. Using Scion Image software (Scion Corporation, Frederick, MD), we mapped the areal extent of alizarin complexone deposition as the index of DON severity. DON severity was compared by ANOVA.

RESULTS: Alizarin complexone deposition was greater in sheep experiencing 15-min O2 pre-breathe dives than 1-h O2 pre-breathe dives ($P<0.05$), and sheep DCS incidence was lowest in the 2- h oxygen pre-breathe group. Proximal radii accumulated more alizarin complexone in the 15-min O2 pre-breathe group than in the 1-h group ($P<0.05$). The proximal tibia appeared most affected in the 2-h O2 pre-breathe dive group ($P<0.05$).

CONCLUSIONS: Brief 15-min O2 pre-breathe dives show greater DON severity than 1-h and 2-h O2 dives. In humans, DON often may trigger secondary osteoarthritis. These findings indicate that even a 2-h O2 pre-breathing did not prevent DON in decompressed sheep, but enabled "dropout" survival.

(Research was funded by NAVSEA, U.S. Navy. We acknowledge the assistance Dr. Ed Flynn.)

F12

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

THE RELATIONSHIP BETWEEN TIME TO RECOMPRESSION TREATMENT AND CLINICAL OUTCOME FOR DECOMPRESSION ILLNESS TREATED IN SCOTLAND

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BACKGROUND: The clinical evidence supporting the importance of time to treatment in decompression illness (DCI) is sporadic. Accordingly, we conducted a study of the relationship between time to treatment and clinical outcome for consecutive cases in Scotland from 1991-2003.

MATERIALS AND METHODS: A questionnaire was completed for each case. Information gathered included time to recompression from the onset of symptoms, manifestations of illness and days spent in hospital. Other factors influencing the severity of illness were gathered: maximum depth of dive; repetitive diving; poor buoyancy control. The treatment outcomes tested were full recovery on first treatment, full recovery on discharge and the presence of significant residua defined as any ataxia, motor paresis, a urinary catheter or cerebral impairment. Binary logistic regression was used to calculate the odds of poor outcome with adjustment for confounding variables.

RESULTS: The audit captured 535 consecutive cases. 90% of cases were treated in less than 6 hours after presentation. It was possible to use 390 cases in the analysis. There was a definite relationship between time to treatment and outcome for pain or sensory presentations. For more severe disease, where significant sequelae were possible, a weak relationship was shown after adjustment. Here the risk of sequelae rose by a mean of 0.5% hour-1 delay.

Outcome (n = 390)	Fitting cases	Adjusted OR hr^{-1} mean, 95% CI	p
Incomplete resolution on first recompression	44.0%	1.038 (1.022-1.054)	<0.001
Any symptoms on discharge	34.6%	1.011, 1.004-1.018	0.001
Significant sequelae (ataxic, paretic, cerebral)	9.5%	1.005, 1.001-1.010	0.028

7 cases first presented, within 2 hours of symptoms, to chambers outside our network. 4 of these cases had a poor outcome, 2 of whom died.

CONCLUSIONS: Rapid treatment in inadequate clinical facilities is unjustified since the delay imposed by transfer to a competent unit in Scotland is not associated with clinically significant risk.

F13

ABSTRACT WITHDRAWN

F14

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

15 AND 45 MINUTES OF OXYGEN PRE-BREATHE SIGNIFICANTLY REDUCES SEVERE DECOMPRESSION ILLNESS AFTER SATURATION DROPOUT IN 70 KG SWINE

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BACKGROUND: Breathing 100% O2 prior to decompression reduces the incidence of altitude decompression illness (DCI). Similarly, we have previously demonstrated that an isobaric oxygen prebreathe (OPB) of 1 h will eliminate lethal DCI. However, the use of OPB < 1 h has not been studied in the hyperbaric environment. This study reports the results of OPB of < 1 h in a swine model of saturation at 2.8 ATA (60 fsw) followed by rapid decompression to surface.

MATERIALS AND METHODS: Unrestrained, catheterized, male Yorkshire swine (68.5 kg +/-2.4kg) were placed in individual Plexiglas boxes within a large animal hyperbaric chamber. The chamber was compressed with air to 2.8 ATA for 22 h. Following saturation and while still at depth, gas to the boxes was remotely switched so that the animals received either 1) 45 min O2 pre-breathe; 2) 15 min O2 pre-breathe, or 3) no O2 pre-breathe (control) prior to rapid decompression (0.91 ATA/min) to surface. Animals were then observed for signs of DCI. Animals with severe DCI (cardiopulmonary or neurologic) were euthanized and sent for necropsy. Animals without severe DCI were observed for 6 days and then underwent necropsy. The lungs were inflated with 1.5% agarose in isotonic saline, fixed, and counterstained with H and E.

RESULTS: 45 min of OPB at 2.8 ATA eliminated severe DCI from saturation dropout. DCI was reduced from 73% (8/11) in control animals to 8% (1/13) with 15 min OPB. Both periods of OPB represent a statistically significant improvement ($p<0.0001$) over no OPB. OPB also resulted in significant decreases in cutis marmorata ($p<0.0005$). No evidence of lung histopathologic abnormalities was observed in swine that did not suffer from DCI.

CONCLUSIONS: OPB of 15 and 45 minutes significantly reduces severe DCI following dropout decompression from saturation at 2.8 ATA in 70 kg swine. These results demonstrate that even very short periods of OPB could be expected to improve outcome in a disabled submarine scenario.

(Supported by NAVSEA Work unit number 603713N.84C.A0606.)

F15

ABSTRACT WITHDRAWN

F16

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

TWO MONTH DELAYED HYPERBARIC RECOMPRESSION OF DCS FROM INJURY AT DEPTH MISDIAGNOSED AS MUSCULOSKELETAL STRAIN AND POST-CONCUSSIVE SYNDROME

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BACKGROUND: Injuries occurring at depth are potential sites for abnormal gas exchange that can predispose to DCS. We report a case of injury at depth misdiagnosed as cervical strain and post-concussive syndrome that responded to recompression two months after injury.

CASE REPORT: A 35 year-old male surface supplied air commercial diver, struck on the head and neck by a 1,200 lb pig sled at 75fsw, experienced transient dizziness and immediate neck pain. Headache during surface decompression worsened over the next 48 hours as he developed fatigue, cognitive problems, and left sided: hand weakness, eye dryness, and olfactory hallucinations. His M.D. and neurologist diagnosed post-concussive syndrome, cervical strain, and reactive depression after MRI of the brain and C-spine showed diffuse white matter lesions and DJD. Complaints persisted despite two months of therapies. Diving physician second opinion revealed left sided motor, sensory and sacral plexus findings, mild neuropsych impairments, two millimeter PFO on TEE, and abnormal SPECT brain imaging. Standard recompression commenced and was tapered to lower pressure treatments over 6 weeks.

RESULTS: Cervical complaints resolved following 4 HBOTís. Remaining symptoms and physical findings resolved or plateaued at 36 HBOTís. Neuropsych re-evaluation showed significant improvement in previous deficits as well as multiple normal tests on baseline evaluation. Repeat SPECT brain was improved consistent with improved symptoms, physical exam, and neuropsychological testing. Four year follow-up reveals minimal symptoms and an "A" average in college.

CONCLUSIONS: This case demonstrates the importance of recompression regardless of delay and that symptoms post dive are DCS until proven otherwise. It also suggests the probability that injury at depth predisposes to DCS at the sites of injury.

SUSAN KRONHEIM MEMORIAL LECTURE

Dr. Susan Kronheim was born in Bielefeld, Germany in 1936 and immigrated to the United States with her family when still a small child. She graduated from Brandeis University and then earned a Master's degree in bacteriology from Western Reserve University in her home town of Cleveland, Ohio. She was employed by the Office of Naval Research (ONR) upon completing her Master's degree and was assigned to the Underwater Physiology Research Program. Susan knew absolutely nothing about diving…at first.

During her first years with the Navy, the Office of Naval Research conducted the SEALAB I and SEALAB II operations and further research in support of SEALAB III and TEKTITE I. It was the period in which saturation diving was developed from a visionary concept into a practical reality for Navy and commercial diving. Dr. Kronheim's first formal meeting to discuss the subject of underwater physiology and exchange scientific information was in Panama City, Florida…chaired by none other than Jacques Cousteau.

Susan caught the vision of the need for underwater physiology research and in 1970 she was approved for a two year sabbatical from her work at ONR to begin a Ph.D. program at the University of Pennsylvania under the mentorship of Dr. Christian Lambertsen. At the time she applied for her Ph.D. program, Dr. Kronheim had been already diagnosed with breast cancer, but that didn't stop her. Her indomitable spirit kept her going strong against all odds.

Dr. Kronheim was well known to almost every underwater research scientist in the United States through the pivotal importance of her position in the ONR diving program. She was both a bridge and a guardian of the two-way path between government and academic science. She was friendly and helpful to all researchers who sought her aid, although that assistance could as well be through her excellent eye for critical experimental detail as in the unbundling of administrative red tape. The meticulous investigations for her own Ph.D. dissertation proved her to be an excellent scientist in her own right. Upon her return from completing her Ph.D., Dr. Kronheim assumed full responsibility for the underwater physiology research program at the Office of Naval Research.

She continued to work until cancer sapped her physical strength and she had to retire from the government after 18 years of dedicated service to the Office of Naval Research…and to every person who was involved in underwater physiology research during those years. Susan died on 7 July 1979. Dr. Arthur J. Bachrach, a former President of the, then, Undersea Medical Society (UMS) and Dr. Leonard Libber, Susan's first boss at ONR, determined that a memorial lecture at the UMS annual scientific meeting was a fitting tribute to one whose work had, in one way or another, touched every member of the UMS. This unbroken lecture series began July 9, 1980 in Athens, Greece at the UMS annual scientific meeting where Dr. Leonard Libber, Susan's former boss, introduced the first Susan Kronheim Memorial lecturer, Dr. David H. Ingvar of the University of Lund, Sweden.

History of Deep Sea Exploration

Guest Lecturer: Ralph White

Ralph White will present a cinematic trip through several of history's greatest underwater finds including pictures of the Titanic, Volcanic Vents, unique deep sea marine life and other tantalizing finds. In one hour you see three decades of the greatest underwater explorations ever done on our planet! Ralph White enjoys a very distinguished professional career as an award-winning cinematographer, video cameraman and editor, with over 30 years of production experience and hundreds of motion picture and television credits to his name.

The History of Deep Sea Exploration: In 1975 Emory Kristof and Ralph White initiated the "Beebe Project" at the National Geographic Society. It was to be a ten year exploration of our planet's depths, which is still on going. They started off in Loch Ness, Scotland looking for the fabled "Nessie", and went on to discover two Revolutionary Wrecks and the oldest U.S.N. / M.I.A's in Lake Ontario. From there to the frozen North and the wreck of the H.S.M. Breadalbane above the Artic Circle. They did the imaging that proved the theory of Plate Tectonics, found the first deep sea volcanic vents, and their unique life forms, which could be the start of life on Earth. We utilized underwater baiting to bring in some of the rarest deep-sea animals ever imaged "In Situ", including the largest flesh eating Shark ever photographed, in Suruga Bay, Japan. Also included are deep dives in remote Lake Baikal, Siberia, The Titanic, and many other interesting sites, including the first survey of the USS Arizona, and "Sacred Wells" in the Yucatan of Mexico

Session G: Physiology, Education and Reviews

G1

Oral Presentation: 1415 - 1427
Poster Presentation: 1545 - 1700

CANADIAN PHYSICIANS' KNOWLEDGE AND ATTITUDES REGARDING HYPERBARIC OXYGEN THERAPY

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Departments of [1]Anaesthesia and [2]Public Health Sciences, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada

BACKGROUND: Hyperbaric oxygen therapy (HBOT) is an adjunctive treatment that reduces the risk of major amputations following the development of neuroischemic diabetic foot ulcers. In Canada, this complication of diabetes is usually managed by surgeons via referrals from primary care physicians. Optimal treatment and appropriate referral for HBOT is thus dependent upon the knowledge and attitude regarding the utility value of HBOT among primary care physicians. Little is known about primary care physician decision-making involving HBOT. This study explored knowledge and attitude regarding HBOT among Canadian primary care physicians.

MATERIALS AND METHODS: A 24-item questionnaire was completed by 313 physicians attending a primary care medical conference in May 2006. The main outcome measures included self-reported knowledge and attitude toward HBOT.

RESULTS: Less than 10% of respondents had good knowledge of HBOT and 57% had good attitude toward HBOT. Knowledge and attitude toward HBOT were correlated ($p<0.0001$). Good knowledge of HBOT is associated with male gender ($p=0.0552$), older age ($p=0.0884$), years of medical practice ($p=0.0698$), having patient requests for HBOT referrals ($p=0.0170$), and having previously referred patients for HBOT ($p<0.0001$). More than 20 years of medical practice ($p=0.0593$) and receiving patient requests for HBOT ($p=0.0394$) were multivariate predictors of good knowledge. Good attitude toward HBOT was associated with older age ($p=0.0621$) and having previously referred patients for HBOT ($p=0.0021$). Moreover, multivariate analysis showed that physicians who were male ($p=0.0026$), received patient requests for HBOT ($p<0.0001$), and had good knowledge ($p=0.0129$) and attitude ($p=0.0488$) were more likely to refer patients for HBOT.

CONCLUSIONS: Primary care physicians have underdeveloped knowledge of HBOT, but their generally positive attitudes toward its use suggest that they may be receptive to educational interventions. Our study shows that future efforts should address physician subgroupsí knowledge gaps.

G2

Oral Presentation: 1427 - 1439
Poster Presentation: 1545 - 1700

HYPERBARIC MEDICINE - THE INTERNATIONAL ARENA

Sonnenrein R
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BACKGROUND: Thousands of hyperbaric chambers are being used for patient treatments around the world every day. The types of chambers utilized (monoplace and multiplace) as well as indications treated vary greatly between the countries. We gathered statistics about the number of facilities, types of chambers, indications treated and recent HBO research in selected countries, grouped by continent.

MATERIALS AND METHODS: The majority of sources for the statistics on types of chambers, number of facilities and indications treated were UHMS, EUBS, ICHM etc. member physicians and/or chapter presidents through direct questioning. The main source for information on research being conducted was a prominent research service. We cross-referenced the gathered information through web searches where possible.

RESULTS: The approximate number of facilities by continent are as follows: North America (US, Canada and Mexico): >1000; Central and South America: >200; Africa: 13; Australia: 9; Europe (incl. Russia): >3000; Asia: >4000; Antarctica: 3. Indications treated range from one (dive recompression only) to over 60 listed indications. Research is being conducted in a number of countries (animal model and clinical trials), on UHMS/EUBS indications as well as a wide variety of trauma and neurological topics.

CONCLUSIONS: The availability of hyperbaric therapy varies greatly by geographic region. Reasons for treating certain indications in individual countries appear to range from insurance reimbursements to philosophical perspectives. Conversely, the research being conducted internationally does not adhere to the same geographical boundaries and could serve as a basis for the global advancement of hyperbaric therapy.

G3

Oral Presentation: 1439 - 1451
Poster Presentation: 1545 - 1700

REPORTED DISABILITY AND MORBIDITY IN UNITED KINGDOM PROFESSIONAL DIVERS WORKING BEFORE 1991

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BACKGROUND: A Norwegian Government Commission Report (1) showed frequent musculoskeletal and cognitive complaint in Norwegian oilfield divers working before 1991. 40% were under medical treatment generally with 25% being under treatment for the complaints reported. Almost 19% were on a disability pension and this was more common than the 11% expected in the general age matched male population. We have examined the UK population of pre-1991 professional divers.

MATERIALS AND METHODS: A lifestyle, occupation and health status questionnaire was completed by 1540 (56% response) divers and 1035 offshore worker non-diving controls (51% response). Information retrieved included employment status and work in the offshore oil industry.

RESULTS: 3% of participants reported ill health retirement or being off-work on sickness benefit with no difference between groups. Health related quality of life (SF12) was within normal limits for both groups but the mental component score was higher in divers who were also less likely to be receiving medical treatment. Divers were more likely to report "forgetfulness or loss of concentration" (18% vs 6%, OR 3.8 95%CI 2.7-5.3), musculoskeletal symptoms (41% vs 34%, OR 3.8 95%CI 2.7-5.3) and "impaired hearing" (16% vs 11%, OR 1.6 95%CI 1.2-2.0). These differences were attributable to increased symptom reporting in oilfield divers and were not present for non-oilfield divers, with the exception of cognitive symptomatology which was more common in both oilfield divers (22%, OR 4.8 95%CI 3.4-6.8) and non-oilfield divers (9% OR 1.9 95%CI 1.1-3.3) than in non-divers (6%).

CONCLUSIONS: There was increased symptom reporting in oilfield divers. There was, however, no evidence to suggest any major impact on long term health of UK divers who had started their career before 1991. Psychosocial issues may underlie the Norwegian experience.

1) Lossius PA et al. Pionerdykkerne I nordsj¯en. Norges offentlige utredninger 2003:5. ISSN 0333-2306. 2003.

G4

Oral Presentation: 1439 - 1451
Poster Presentation: 1545 - 1700

PHYSICAL AND PSYCHOLOGICAL CORRELATES OF MUSCULOSKELETAL AND HEARING LOSS SYMPTOMS IN UK PROFESSIONAL DIVERS WORKING BEFORE 1991

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BACKGROUND: UK professional divers active before 1991 express more hearing loss (hrs) and musculoskeletal symptoms (mrs) than non-divers but show evidence of a tendency to somatise. Accordingly, we conducted a clinic based study on a 10% random sample of responders to a previous health status questionnaire ñ 151 divers, 120 non-divers.

MATERIALS AND METHODS: Mental (MCS) and Physical (PCS) summaries were calculated from the SF12 questionnaire. The Hospital Anxiety and Depression score for anxiety (HADSa) and depression (HADSd) were elicited. Subjects underwent a physical examination, screening audiometry and reported musculoskeletal and hearing loss symptoms.

RESULTS: Being a diver was associated with a higher MCS and PCS in a model adjusted for symptoms, signs and mood. Mrs were associated with physical signs in 54% of all subjects with no difference between groups. Mrs were associated with poorer PCS and HADSd for both groups but also with poorer MCS and HADSa in divers. 29% of divers with symptoms had clinically significant levels of anxiety (p=0.001 Chi2). Anxiety was more common in divers (15%) than in a normative population (9%). Hrs were more common in divers and were strongly associated with reduced hearing thresholds on audiometry. 31% of divers were within the 20th percentile and 13% were within the 5th percentile in contrast to 19% and 4% respectively of non-divers . Hearing loss was of the noise-induced pattern (NIHL). Hrs were associated with reduced PCS in divers but had no psychological interactions.

CONCLUSIONS: Divers suffer more NIHL than non-divers and this clearly needs to be addressed. Mrs indicated an increased level of physical abnormality but were associated with a very high level of clinically significant anxiety in divers. Quality of life in divers may be improved if anxiety is addressed and health promotion efforts made to bring home the underlying physical and mental benefits of a diving career.

G5

Oral Presentation: 1451 - 1503
Poster Presentation: 1545 - 1700

10,000 DIVES: A REVIEW OF INSIDE ATTENDANT DECOMPRESSION EVENTS IN A MULTIPLACE HYPERBARIC CHAMBER

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Southeast Texas Hyperbaric Medicine Center, Conroe, TX

BACKGROUND: The issue of attendant staff safety in the multiplace hyperbaric environment is of paramount importance. The Southeast Texas Hyperbaric Medicine Center opened in 1991 with a Reimer's Multiplace Hyperbaric Chamber. We reached 10,000 Hyperbaric treatments in July 2005. A review of all attendant staff events was undertaken to evaluate our safety record and decompression protocols.

MATERIALS AND METHODS: A comprehensive review of the logbooks for all of the hyperbaric treatments performed at SETX HMC was undertaken. All events that involved attendant staff and subsequent treatment were reviewed. Medical records were reviewed when available.

RESULTS: A total of 10028 treatments were reviewed (carried through July 2005 for ease of data tabulation). 1829 hyperbaric treatments took place between 1992 and 1993. 15 hyperbaric staff decompression events were documented: 4 in 1992, 7 in 1993, 1 in 1994, 1 in 1996, 1 in 1997, and 1 in 2000. 3 events were suffered by one technician, who had offshore professional diving experience, 2 events were suffered by another technician who had USN diving experience, and 2 events were suffered by one RN with scuba experience. Of the other eight attendant events, 3 had previous diving experience, while 5 did not. Modified attendant decompression protocols and predive assessment of inside attendants, increased training dives, and adjustment of work schedules were instituted at the end of 1993.

CONCLUSIONS: Most of the events occurred during the early years and at a time of rapid increase in the size of our practice. Increasing the time on oxygen for decompression, reducing the workload of the inside attendants, increasing their education and experience, and increasing the knowledge and experience of the attending physicians has reduced our rate of occurrences to zero.

G6

Oral Presentation: 1451 - 1503
Poster Presentation: 1545 - 1700

10,000 DIVES: A COMPREHENSIVE REVIEW OF 14 YEARS OF EXPERIENCE

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BACKGROUND: The Southeast Texas Hyperbaric Medicine Center opened in 1991 with a Reimer's Multiplace Hyperbaric Chamber. We reached 10,000 hyperbaric treatments in July 2005. A review of our experiences over that time was undertaken to assess our complication rates vs. published statistics, as well as to assess our mix of treatment types.

MATERIALS AND METHODS: A comprehensive review of the logbooks for all hyperbaric treatments performed at SETX HMC was undertaken. All events outside a standard 45 fsw/90 minute Oxygen treatment were reviewed. Medical records were reviewed when available.

RESULTS: A total of 10028 treatments were reviewed (carried through the end of July 2005 for ease of data tabulation.) 50264 patient treatments occurred during that time. 6 total seizures were documented, rate of 1.2 per 10,000 patient treatments. Three were caused by hypoglycemia, one by ETOH intoxication and two by Oxygen toxicity. 202 patients were aborted due to otic barotrauma, rate of 1 per 250 patient treatments. 48 patients were aborted due to medical causes, ranging from dyspnea, chest pain, nausea or vomiting, and one due to acute latex anaphylaxis to the neck ring; rate of 1 per 1000 patient treatments. 92 gas gangrene treatment tables and 26 carbon monoxide treatment tables were performed. 13 Treatment Table 6 were performed for patient treatments. 6 patients were treated on a ventilator. There were zero events requiring CPR, intubation or chest tube placement in the chamber. None of the medical events requiring extraction resulted in patient mortality. 15 hyperbaric staff decompression events were documented

CONCLUSIONS: Our patient complication rates reflect published data regarding CNS toxicity with seizures, as well as other medical problems and otic barotrauma. Only 1.3% of our total hyperbaric treatments were for emergencies requiring other than a standard 45 fsw / 90 minutes oxygen table.

G7

Oral Presentation: 1503 - 1515
Poster Presentation: 1545 - 1700

CNS OXYGEN TOXICITY: FROM A MEANS OF PROTECTION TO A BETTER UNDERSTANDING?

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BACKGROUND: Reactive oxygen species (ROS) are a major factor in the generation of central nervous system oxygen toxicity (CNS-OT). In stress situations, such as hyperoxia, the balance between ROS production and scavenging is upset by their increased production. A great deal of effort has therefore been put into finding means of providing protection against CNS-OT. Long-term heat acclimation is known to provide cross-tolerance to various forms of stress in different organs, such as the brain. It is also known that preconditioning to high O2 protects the lungs against oxygen toxicity. This review presents our recent findings in the rat.

MATERIALS AND METHODS: Following treatment (heat acclimation to 32 ºC or hyperbaric O2 preconditioning), rats were exposed to oxygen at 608 kPa, and the EEG was recorded continuously until the appearance of the first electrical discharge. Immediately thereafter rats were sacrificed, and samples were taken from the brain, blood, and heart for biochemical investigation.

RESULTS: Latency to CNS-OT was twice as long in the heat-acclimated rat. This protection continued for two weeks during deacclimation, and was associated with elevation of HSP-72 and Cu/ZnSOD. Catalase and glutathione peroxidase (GPer) activity in the blood increased by 22% and 30%, respectively, following HBO preconditioning, whereas G6PD and GST activity decreased by 37.3% and 30%, respectively. We found that the percentage change in latency increased with the activity of ROS scavengers in the hippocampus (G6PD, GST, GPer, and GRx); an inverse correlation was found for these parameters in the cortex. However, time to CNS-OT did not increase significantly following hyperbaric O2 preconditioning on the protocol we used.

CONCLUSIONS: We conclude that the protection afforded by heat acclimation is produced in part by the over-expression of HSP-72 and Cu/ZnSOD. Although preconditioning to HBO at 202 kPa does not prolong the latency to CNS-OT, despite its effect on the activity of major ROS scavenger enzymes, the mechanism by which this protection is induced probably does nevertheless involve changes in the activity of these enzymes. The role HSP72 plays in providing protection against CNS-OT is yet to be investigated.

G8

Oral Presentation: 1515 - 1530
Poster Presentation: 1545 - 1700

SIMULATION, ACGME AND THE HYPERBARIC FELLOWSHIP

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BACKGROUND: The ACGME (Accreditation Council for Graduate Medical Education) Fellowship in Undersea and Hyperbaric Medicine is a 12-month program associated with ACGME accredited programs in emergency medicine, preventive medicine or anesthesiology. The required curriculum is an intensive course of study that is evaluated for its ability to satisfy the core ACGME competencies of patient care, medical knowledge, practice-based learning and improvement, interpersonal and communication skills, professionalism and systems-based practice. Instructional and assessment methods typically involve a variety of didactic formats, conferences, standardized patients, and role playing but have not utilized high fidelity simulation adapted for use in the hyperbaric chamber.

MATERIALS AND METHODS: The Duke Hyperbaric Center is a large multiplace facility consisting of seven hypo/hyperbaric chambers. A Laerdal high fidelity SimMan (Wappingers Falls, NY) simulator was placed on a stretcher in a 3.20 M by 4.42 M multiplace chamber. The control computer cables were routed through the single medical lock to the outside. An Apple PowerBook G4 laptop computer affixed with an iSight camera (Cupertino, CA) and Vara Software Wirecast v.2.6.4 Software (London, UK) was utilized to capture audio and video of the training scenarios both inside and outside the chamber. Tasks are described Hobbs et. al. this meeting. Hyperbaric medicine interns, residents and staff were presented with a patient scenario then asked to evaluate and treat the "patient". Audio and visual recordings of both the inside personnel as well as the chamber operator were obtained throughout the exercise for post exercise debrief and feedback.

DISCUSSION: High fidelity simulation training has been used extensively as a training modality in order to improve safety in both the aerospace industry and for anesthesiology but has not been described before for use in hyperbaric fellowship training. Scenarios involve briefing, simulation and debriefing sessions and provide trainees a multidisciplinary experience that satisfies the majority of the ACGME requirements for teaching and implementation of the core competencies. High technology simulation exercises can be adapted to include hyperbaric technicians, nurses, and MDs as a method of education, task training and evaluation.

G9

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

FEASIBILITY OF SIMULATION TRAINING FOR HYPERBARIC TEAM SKILLS

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BACKGROUND: The Duke Center for Hyperbaric Medicine and Environmental Physiology fellowship in hyperbaric medicine certified by Accreditation Council for Graduate Medical Education under the American Board of Preventive Medicine. Training using simulation was recommended method for training following the Institute of Medicine patient safety reports. Simulation training has been used for years in the aviation and nuclear power industries to improve outcomes of team interactions. Our goal is to evaluate the feasibility of simulation training for development and improvement of team skills.

MATERIALS AND METHODS: The Duke Center is multiplace facility consisting of seven chambers. Simulation was set-up inside "Alpha" Chamber, a 3.20 M by 4.42 M cylinder. A Laerdal SimMan (Wappingers Falls, NY) simulator was placed on stretcher. Apple PowerBook G4 affixed with iSight camera (Cupertino, CA) and Vara Software Wirecast v.2.6.4 Software (London, UK) utliized to capture audio and video of the training scenarios

Tasks: Individual team tasks were delineated so individual performance could be evaluated. Tasks split into the following categories. Equipment: Set-up of chamber for dive, operation of chambers, fire precautions. Patient specific tasks: ear tubes, myringotomy, chest tube care, Ventilator use, medical communications. Situation awareness/ group dynamics: communication (verbal, non-verbal), errors, human error, simultaneity, sequencing. The video recordings were utilized during post treatment debriefing to identify aspects of the defined tasks.

CONCLUSIONS: The use of human simulation in hyperbaric team training is a very clear and effective method of conducting and evaluating knowledge and skills needed for safe effective patient care. Discussions surrounding the simulations provided more interactive learning than classroom lectures alone. The use of simulation training for introduction of new equipment, improved care techniques, and understanding of human error was shown. Both facilitators and fellows found this to be a safe, effective, and fun way of learning.

G10

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

RECOMMENDED KEY WORDS FOR UNDERSEA AND HYPERBARIC MEDICAL LITERATURE

Lackey CS[1], Hobbs GW[2,3], Carden VR[1], Koonts RS[1], Peterson RA[1], Thibodeau PL[1]
[1]Duke University Medical Center Library, [2]Duke Center for Hyperbaric Medicine and Environmental Physiology, and [3]Rubicon Foundation, Inc., Durham, NC

BACKGROUND: In 2005, The Undersea and Hyperbaric Medical Society relocated their collection of scientific literature to the Duke Medical Center Library and Archives with the library providing reference and document delivery services to Society members. The collection consists of government documents from around the world, reprints of articles, original manuscripts, images, books, journals, and other materials relating to diving and hyperbaric medicine. The library has established guidelines for adding the materials to its collections and has developed creative ways for making hundreds of print reports accessible through the web. Archives received collections of papers from key society leaders, as well as major figures in the field, and has created web-based finding aids providing access to these unique resources. In order to ensure better information retrieval and indexing of these resources, a new set of keywords was established for the collection.

MATERIALS AND METHODS: Keyword sets are established through a process of compiling the available terms for a given topic and merging like terms until one set of all-inclusive terms has been established. These terms should allow for easier retrieval of the source material. For the field of diving and hyperbaric medicine, the initial list was complied from the indices of Bennett and Elliott's The Physiology and Medicine of Diving 5th edition edited by Brubakk and Neuman; Deeper Into Diving 2nd edition by Lippmann and Mitchell, and Hyperbaric Medicine; and Practice 2nd edition by Kindwall, Wound Care Practice edited by Sheffield, Smith, and Fife.

RESULTS: The current list of keywords is 484. The headings were selected by using the Library of Congress and MeSH subject headings.

CONCLUSIONS: We are presenting our proposed keyword list for Undersea and Hyperbaric Medicine. This list should be used for the indexing of new items introduced to the field and applied to older parts of the collection.

G11

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

HYPERBARIC OXYGEN FOR ACUTE ISCHEMIC STROKE: NEED FOR A BETTER STUDY

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BACKGROUND: Hyperbaric oxygen (HBO) therapy of cerebral ischemia has been evaluated in a number of human and animal studies; however, there is presently no consensus on its efficacy.

MATERIALS AND METHODS: We performed a systematic review of the literature searching Medline database from 1966-2005 using the terms: hyperbaric, hyperbaric oxygenation, cerebrovascular accident, stroke, ischemia, and infarction. We identified 603 articles and selected 89 as relevant.

RESULTS: Animal studies of HBO have shown promise by reducing infarct size and improving neurologic outcome. Early reports in humans also suggested benefit in stroke patients treated with HBO. Recent randomized, controlled human studies, however, have not shown benefit. All but one of the studies evaluating HBO therapy of ischemic stroke have used a dose of 1.5 ATA, based upon concerns for increased risk of oxidative stress with higher doses suggested in a single study from 1977. Despite concerns for increased oxidative stress, the patients who received the higher doses of HBO did not have seizures or worsening of neurologic deficits. The single study which assessed the use of HBO at 2.5 ATA in acute stroke did raise concerns of worsened stroke outcome at the higher dose, but was limited by several factors. First, most patients were treated after 12 hours. Second, the control group was subjected to 100% O2 at 1.14 ATA, which is not standard care. Third, there was no cut-off for stroke severity, such that very mild strokes were included, making evaluation of the effect of HBO difficult. Important differences between animal and human studies suggest HBO might be more effective in stroke within the first few hours and at a pressure of 2 to 3 ATA.

CONCLUSIONS: Clinical trials of HBO in acute ischemic stroke should be designed to evaluate treatment administered earlier and in higher doses to more clearly address its efficacy.

G12

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

OFF LABEL USE OF HBO2T: HISTORICAL PERSPECTIVE AND CURRENT CHALLENGE

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BACKGROUND: The off-label of medications and medical devices by health care practitioners has a short and evolving medical history. While the ethics and rules governing the off-label use of mediations are commonly misunderstood by the practitioner, this option is considered an important method by which medical science and practice advances. The off-label use of HBO2T poses both common and unique problems related to off-label usage. Clinicians practicing hyperbaric medicine will be approached and challenged by patients and their families for access to off-label use of this therapy. A prior understanding of the off-label use issues as they relate to the practice of HBO2T is essential if the clinician is to successfully give guidance to patients and enable legitimate expansion of this evolving therapy.

MATERIALS AND METHODS: A brief historical review of the ethical principles and practical issues around the off-label of use of medical therapies will be presented as a basis for the logical extension into the practice of hyperbaric medicine. A distinction between legal and illegal practices will be outlined. Boundaries between clinical care and research will be drawn. Practical guidelines for the busy practitioner will be presented for discussion. Considerations for the off-label treatment of multiple sclerosis, complex regional pain syndromes, and chronic refractory bacterial prostatitis will be used as examples.

CONCLUSIONS: There are clearly delineated guidelines for the off-label use of HBO2T. Practitioners of hyperbaric medicine must be clear on the role off-label use plays in the practice of hyperbaric medicine to maximize benefits to the patient and profession as a whole.

G13

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

SIMPLIFYING BED SELECTION FOR HOSPITALIZED PATIENTS RESULTS IN MORE OPTIMAL PATIENT CARE THAT IS COST-EFFECTIVE

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BACKGROUND: Sleep support surfaces play an important role in preventing pressure injury in hospitalized patients. There are hundreds of specialty beds and mattresses available through scores of companies. Due to differences in terminology, product capabilities, and facility contracts, it can be difficult for physicians caring for hospitalized patients to select the support surface appropriate for each patient. Because of this confusion, clinicians in our facility were unknowingly placing suboptimal mattress overlays on top of beds that provided more optimal pressure reduction alone without the overlay, and at a greater expense to the hospital since the overlays were rented. A pocket sized chart was devised for easy reference to facilitate clinician selection of the most appropriate and cost effective sleep support surface for each individual hospitalized patient in our facility.

MATERIALS AND METHODS: The chart was based on the beds and mattresses available to our hospital, either owned or available through rental contracts. By using the chart, clinicians were directed to base bed selection on the following patient and institution-specific issues:

1. Mobility of patient.
2. Ulcer present or history of previous ulcer.
3. Weight and height of patient.
4. Skin moisture control issues.
5. Beds owned or rented by facility.

CONCLUSIONS: The chart enabled clinicians to effectively select appropriate support surfaces based on individual patient needs and to utilize support surfaces that were available in our institution cost-effectively. The chart directed clinicians from rentals when facility-owned surfaces were as or more effective. This institution-specific chart not only enabled clinicians to provide better pressure reduction when needed, but it helped clinicians effectively utilize relief surfaces owned by the hospital. By not renting surfaces less effective than those owned, a savings of $100,000 was projected for the first year the chart was used.

G14

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

CARBON MONOXIDE POISONING IN UTAH 1996 - 2005

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BACKGROUND: The incidence of CO poisoning in the USA is unknown, and has been estimated at 10,000 emergency department (ED) visits/year.1 A 1994 ED survey across 3 western states extrapolates a CO incidence of 40,000 ED visits/year in the USA (18.1 per 100,000 residents).2 In Utah, ED visits and hospital admissions are submitted to the Department of Health and death is recorded by the Office of the Medical Examiner.

METHODS: We searched the Utah Department of Health electronic database for CO poisoning (ICD-9 986 or appropriate E code) from 1996-2005, including age, gender, etiology, and disposition. We reviewed all cases of CO-caused death. No patient was counted twice.

RESULTS: From 1996-2005, 4,766 CO poisoned patients were diagnosed: 4,161 seen at EDs, 277 admitted to hospitals, and 328 died (228 suicide, 84 accidental, 16 unknown). Victims were 63% male, age=31±19 (mean±1 SD), range=0-94 years. Annual ED visits = 18.9/100,000 residents. The number of ED visits per year did not decrease over time, but the incidence by population seemed to decrease by approximately 1% per year (R2=0.58). Limitations of our study include inaccurate recording or lack of recognition of CO poisoning.

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
ED	403	495	532	373	416	414	393	345	469	312
Hospital	17	27	27	30	32	27	27	29	32	29
Died*	44(66)	40(73)	43(63)	33(88)	21(76)	33(70)	36(75)	25(72)	24(75)	29(41)
Total*	464(6)	562(5)	602(4)	436(7)	469(3)	474(5)	456(6)	399(5)	525(3)	379(3)

* Number (% Suicide)

CONCLUSIONS: The number of poisonings over this 10-year interval has remained relatively constant. The Utah incidence of CO poisoning is similar to that found by Hampson,2 and extrapolates to 56,700 ED CO visits per year. Since signs and symptoms of poisoning are non-specific, our data may underestimate the actual incidence of CO poisoning.

1) Hampson NB. Undersea Hyperb Med 1999; 26(1):47-8.
2) Hampson NB. J Emerg Med 1998; 16(5):695-8.

G15

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

HOPE IN THE FUTURE: BEGINNING, DEVELOPMENT AND PRESENT SITUATION OF HYPERBARIC MEDICINE IN BRAZIL

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BACKGROUND: Hyperbaric Medicine started in Brazil with Dr. Almeida's original work in the 30's. Civil engineering projects like the Rio-Niteroi Bridge and the Subway in Sao Paulo city and the training of Brazilian Navy physicians in diving medicine in the 70¥s opened the way to private hyperbaric medical facilities in the 80's. The Brazilian Hyperbaric Medical Society (SBMH) was founded in 1983. Since then, the number of medical facilities has been increasing continuously throughout almost all the country. This study was conducted in order to organize and save the historical evolution of Hyperbaric Medicine in Brazil.

MATERIALS AND METHODS: Data was obtained from registers of established hyperbaric facilities, personal interview with some of the most experienced Brazilian hyperbaric physicians and from the active hyperbaric medical organizations in Brazil (SBMH, Divers Alert Network ñ DAN LA hotline, and UHMS Chapter Brazil).

RESULTS: Actually there are 65 hyperbaric medical facilities in activity in Brazil - 56 privates / 9 militaries. Monoplace chambers are present in 48.1% while multiplace chambers are in 51,9% of these facilities. The SBMH has 200 members and the UHMS Chapter Brazil has 53. Three National Medical Congresses, 4 regional meetings and 2 forums on safety and quality in hyperbaric medicine were conducted until today. An officially approved list of accepted conditions for hyperbaric treatment maintain the minimal quality of medical care. There are 4 regular courses: one Brazilian Navy (31st), one DAN (4th), one SBMH (12th) and one UHMS approved (3rd) on undersea and hyperbaric medicine.

CONCLUSIONS: Hyperbaric Medicine is an established medical treatment in Brazil. It's history and actual situation in Brazil may help other countries in Latin America to develop a safe and solid model on Hyperbaric Medicine.

G16

Oral Presentation: N/A
Poster Presentation: 1545 - 1700

BENEFITS OF A CNS IN A MULTI-HOSPITAL HYPERBARIC PROGRAM

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BACKGROUND: Aurora St. Lukeís Medical Center has been a known leader in the field of hyperbaric medicine. In 2006, the Aurora Metro Region Hyperbaric program received accreditation with distinction. Of particular importance to the hyperbaric nursing practice component was the value of the clinical nurse specialist (CNS). The CNS guided nurses to a broader perspective and understanding of their role.

MATERIALS AND METHODS: Within the Aurora Health Care Metro Region the current CNS practice model is based upon the 2004 published statement by the National Association of Clinical Nurse Specialists (NACNS). The statement articulates competencies and outcomes of CNS practice across three spheres of influence. The three spheres are: Patient/Client, Nurses and Nursing Practice, and Organization/System. The term "Sphere of Influence" reflects an emphasis on an outcome driven model for CNS practice. The NACNS states the goal of CNS practice is to assist in achieving quality, cost-effective, patient focused outcomes across all three spheres of influence.

The CNS has a direct reporting relationship to the Metro Region Director, Advanced Practice Nursing. This allows the CNS and manager to work together as dyad partners creating a leadership team for the unit or program.

RESULTS: Outcomes of the program include benchmark patient education and orientation competencies for the multiplace and monoplace chambers, certified staff, nurse practice advancement and a shared decision making model that promotes evidenced based practice and continuity among program sites.

CONCLUSIONS: A CNS, providing clinical expertise and leadership, can enhance a hyperbaric program striving for accreditation with distinction.

SESSION H: Diving Mishaps and Non-DCI Illness

H1

Oral Presentation: 1545 - 1557
Poster Presentation: 1415 - 1530

IDENTIFICATION OF CANDIDATE GENES THAT CONTROL DIFFERENCES IN HPNS SEIZURE SUSCEPTIBILITY

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BACKGROUND: Inherited differences in susceptibility to the HPNS seizure elicited by fast compression (167 msw min-1) in heliox are controlled by a quantitative trait locus (QTL) on chromosome (Chr.) 17 of the mouse. Here we report an attempt to characterize the QTL.

MATERIALS AND METHODS: A physical map of the relevant ~15 Mb Chr. 17 region comprising seizure phenotype data from a BXD recombinant inbred strain panel was constructed at the GeneNetwork's website www.genenetwork.org. Because the seizure is at root a CNS phenomenon, congruence of gene expression was investigated for genes in the region of the HPNS QTL and genes in the brains of BXD mice in the same chromosomal region. This was done using the following mRNA data bases representing gene activity in the brains of mice from the BXD panel: UCHSC Whole Brain, HBP/Rosen Striatum, Hippocampus Consortium, GE-NIAAA Cerebellum, and Eye M430V2 RMA.

RESULTS: The HPNS QTL contains one broad peak and two sharply defined ones. Peak activity of brain genes shows close correspondence, in one or more brain regions, to the peaks of the HPNS QTL in the following way: The first, sharp HPNS peak is at the peak activity of glutamate receptor, metabotropic 4 (Grm4); the broad HPNS peak (~10Mb) contains peak activities of vacuolar protein sorting 52 (Vps52), ring finger protein 1 (Ring1), flotillin 1 (Flot1), all linked to the major histocompatibility H2 "loci" in region A (H2-Aa, -Ab1), Cb4, D (H2-DMb1), K (H2-K1, -e2, -e6), and T (H2-T17, -T23, -T24); in the saddle between the HPNS broad peak and the second sharp peak lies the significantly expressed methylmalonyl-coenzyme A mutase (Mut); and exactly matching the sharp peak is ectonucleotide pyrophosphatase 5 (Enpp5).

CONCLUSIONS: The congruent expression of the genes listed are all highly statistically significant. They are, therefore, candidate genes for producing HPNS seizure phenotypes.

H2

Oral Presentation: 1557 - 1609
Poster Presentation: 1415 - 1530

PREDICTORS OF "CHEST SQUEEZE" IN BREATH-HOLD DIVERS

Potkin R
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BACKGROUND: Hemoptysis has been observed in breath-hold divers. The source and cause of the bleeding has not been well characterized. Possible sources include the pulmonary parenchyma, trachea and/or sinuses. Breath-hold divers perform a variety of maneuvers to optimize performance, increase depth and breath hold time. These include ventilation exercises, purging, peak inhalation, packing, reverse packing and negative diaphragm exercises. To better understand possible factors associated with the phenomenon of chest squeeze a web-based questionnaire was developed.

MATERIALS AND METHODS: A questionnaire was posted via the internet on 3 web sites, www.worldfreedivingmedicalassociation.com, www.deeperblue.com, and www.performancefreediving.com and the results were analyzed. The data was collected over a 1-year period. Chest squeeze was defined for the purpose of this study as coughing up any amount of blood. Variables tested for statistical significance included age, sex, number of dives, depth of dives, preexisting medical conditions, medications taken, cold or shivering, problems with equalization, packing and use of negative pressure exercises.

RESULTS: There were 63 respondents; 48 reported at least one episode of "chest squeeze" and 15 respondents had no episodes. The parameters analyzed described above were subjected to a stepwise logistical regression statistical analysis. The only variable that was clearly associated with the occurrence of chest squeeze was negative pressure training. ($p=.0008$) and an odds ratio of 3.0.

CONCLUSIONS: 63 breath hold divers completed a web-based questionnaire in an attempt to determine factors associated with chest squeeze. Negative diaphragm exercises create a physiological state comparable to greater lung depths, which can be performed by the diver dry, on the surface or in the water. However, the use of negative pressure exercises is highly predictive of the occurrence of chest squeeze.

H3

Oral Presentation: 1609 - 1621
Poster Presentation: 1415 - 1530

PULMONARY BAROTRAUMA ASSOCIATED WITH "LUNG PACKING"

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BACKGROUND: GLOSSOPHARYNGEAL insufflation commonly referred to as buccal pumping or lung packing is a method of increasing lung volume above total lung capacity used by breath-hold divers. This maneuver has been associated with hypotension and impaired cardiac output. Lung volumes increase significantly by this maneuver and may result in pulmonary barotrauma. Recently a case report of pneumomediastinum after lung packing has been published.

MATERIALS AND METHODS: Two elite breath-hold divers underwent chest CT scanning. Using a GE LightSpeed Plus helical multi channel scanner, multiple images were obtained through the chest. Images were obtained at full inspiration in pre-packing and post packing mode.

RESULTS: Neither participant had prior pulmonary problems nor symptoms or abnormalities on physical examination at the time of the chest imaging. Previously measured lung volume changes with packing demonstrated baseline Vital capacity (VC) of 7.01 liters (131% predicted) to post packing (VC) of 10.26 liters (191% predicted or 46% increase in the first diver and previously measured (VC) 5.73 liters (130% predicted) and post packing VC of 7.31 liters (166% predicted or 31% increase) in the second diver. Chest CT scans in both divers demonstrated pneumomediastinum.

CONCLUSIONS: Glossopharyngeal insufflation is associated with asymptomatic chest CT scan abnormalities diagnostic for pneumomediastinum. The source of the extra pulmonary air is not clear. It is possible that the air inters the mediastinum from the upper airways as it is forced into the lung. An alternative source may be from ruptured alveoli secondary to the high transpulmonary pressures and/or created by increased lung volumes. Glossopharyngeal insufflation may induce pulmonary barotrauma in asymptomatic participants and could potentially result in air embolism.

H4

Oral Presentation: 1609 - 1621
Poster Presentation: 1415 - 1530

EFFECTS OF GLOSSOPHARYNGEAL INSUFFLATION ON CARDIAC FUNCTION: AN ECHOCARDIOGRAPHIC STUDY IN ELITE BREATH-HOLD DIVERS

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BACKGROUND: Competitive breath-hold divers utilize a variety of techniques to increase lung capacity to achieve greater diving depths. One technique is glossopharyngeal insufflation. (GI) has been thought to decrease venous return, causing a fall in cardiac output and arterial blood pressure (BP).

MATERIALS AND METHODS: Transthoracic echocardiography (TTE) was performed on 5 elite breath-hold divers at rest and during (GI) Blood pressure (BP) and heart rate were also monitored.

RESULTS: During GI heart rate increased in all divers and systolic BP dropped from a mean of 112 mmHg to a mean of 52. Diastolic BP was not detectable. GI resulted in significantly decreased left ventricular end diastolic area (46%) reduction and volume (70%) reduction. Right ventricular end diastolic area and volume increased by 49% and 160% respectively. Right ventricular ejection fraction decreased from .75 to .39 and left ventricular ejection fraction decreased from .60 to .30. Wall motion abnormalities developed in both ventricles. The inferior vena cava (IVC) was well seen in 2 divers and was normal in size with normal aspiratory collapse at rest and dilated without inspiratory collapse during GI. Marked spontaneous contrast appeared.

CONCLUSIONS: GI induces hypotension and causes right ventricular dilatation, biventricular cardiac failure and segmental wall motion abnormalities. The echocardiographic pattern of right ventricular systolic dysfunction is similar to that seen in acute pressure overload. LV failure may be due to decreased preload, ventricular interdependence, myocardial ischemia, compression by the lungs or other unknown factors.

H5

Oral Presentation: 1621 - 1633
Poster Presentation: 1415 - 1530

NEUROLOGICAL SYMPTOMS AFTER GLOSSOPHARYNGEAL INSUFFLATION (LUNGPACKING) IN BREATH-HOLD DIVERS SUGGESTING CEREBRAL ARTERIAL GAS EMBOLISM

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BACKGROUND: Glossopharyngeal Insufflation (GI, lungpacking) is used by apnea divers to over inflate the lungs prior to diving and as a stretching maneuver for the chest. This technique can increase the transpulmonary pressure to around 7-8 kPa, suggesting a risk of pulmonary barotrauma.

MATERIALS AND METHODS: Reports of neurological symptoms were collected among elite breath-hold divers who had performed GI. To avoid decompression illness, no deep diving cases were included, neither were cases of loss of consciousness (LOC) or loss of motor control.

RESULTS: Diver one performed GI to measure his lung volume. After that maneuver he suddenly had problem to speak clearly and to find words for 3 minutes. He also experienced weakness in the right arm and double vision for about 5 minutes.

Diver two reports using GI as usual in preparation for a 100 m dynamic swim. After swimming about 35m he gradually loses the ability to move, and is assisted by his safety diver. He can hear and see (blurry) but not move or talk for 5 minutes. Within 8 minutes he was able to speak again and the paralysis went away over the following hour. He reported feeling weak and nauseous for the rest of that day.

Diver three reports packing for a static apnea. After 5 min (a short duration for this diver) he aborted the dive due to an uncomfortable feeling. Approx 1 min after end of the dive he experienced a central scotoma of both eyes: He describes that about 1/3 of the visual field was extremely blurred but not completely dark. Symptoms disappeared gradually over 5 hours. He also had a long lasting nausea.

CONCLUSIONS: These neurological signs and symptoms are different from transient hypoxia reported in extended breath holding or packing. DCI was not possible. The symptomatology suggests cerebral arterial gas embolism.

H6

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

CEREBRAL OXYGENATION AND NEUROLOGICAL PROBLEMS DURING PROLONGED BREATH-HOLDS

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BACKGROUND: Competitive breath holding (Static Apnea) is practiced in swimming pools around the world. Neurological problems such as loss of motor control (called "Samba") are sometimes seen during training and competition. Noninvasive near-infrared spectroscopy has been used to monitor cerebral hypoxia in different hypoxic conditions (1,2) but, to date, there are no data on cerebral oximetry in competitive breath-hold divers. This study looks at cerebral oximetry during hypoxia induced by prolonged breath holding, and its relationship to neurological signs and symptoms.

MATERIALS AND METHODS: After 2 warm-up breath-holds, four competitive breath-hold divers (one female and 3 males) performed up to 3 prolonged breath-holds at large lung volumes, with (wet) and without face immersion (dry) in cool water. Regional brain hemoglobin oxygen saturation was recorded from each side of the diver's forehead (R and L) using near-infrared spectroscopy (Invos 5100, Somanetics), while neurological sign and symptoms were recorded.

RESULTS: Duration of breath-holds in the 4 divers ranged from 176 to 366 s and from 173 to 366 s, in dry and wet condition respectively. No difference was seen in rate of cerebral oxygen desaturation between dry and wet breath-holds. Facial twitching and 2 episodes of fainting were noted at following levels of cerebral oxygenation: 0% R and 33% L and; 45%R and 51%L; 37%R and 40%L.

CONCLUSIONS: This study suggests that neurological signs and symptoms during breath holding occur when cerebral oxygen saturation falls below 45%. However, the effects of carbon dioxide in the arterial blood and immersion of the diver's body on near-infrared spectroscopy need to studied, before the use of this monitor can be advocated to prevent neurological problems during breath-holding.

References

1) Hadolt I, Litscher G. Noninvasive assessment of cerebral oxygenation during high altitude trekking in the Nepal Himalayas (2850-5600 m). Neurol Res 2003; 25:183-8.
2) Pollard V et al. Validation in volunteers of a near-infrared spectroscope for monitoring brain oxygenation in vivo. Anesth Analg 1996; 82:269-77.

H7

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

FLUOROSCOPIC STUDY OF GLOSSOPHARYNGEAL INSUFFLATION AND EXSUFFLATION

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BACKGROUND: Glossopharyngeal breathing can be used to inhale air above total lung capacity (Glossopharyngeal Insufflation, GI; also known as lung packing) or to exhale air below residual volume (Glossopharyngeal Exsufflation, GE). GI maneuvers are employed by competitive breath-hold divers to increase both diving depth and duration: a larger initial lung volume (achieved with GI before a dive) increases both oxygen stores and the depth at which dangerous compression of the chest occurs. Instead, GE is used to draw air from compressed lungs into the pharynx, for pressure equalization in the middle ear at depth. GI was studied in post-polio patients with cineradiography (1), but no fluoroscopic images of the diaphragm were obtained and no fluoro study of GE has ever been done.

MATERIALS AND METHODS: Fluoroscopy was used for video swallow assessment of anatomy and function of the pharynx, and for assessment of diaphragmatic motion during both GI and GE maneuvers performed by 4 competitive breath-hold divers (1 female and 3 males). Video swallow was performed with and without barium contrast.

RESULTS: Fluoroscopy revealed lateral pharyngeal pouches in 1 of the divers, similar to those seen in long-time trumpet players. Both GI and GE maneuvers resulted in simulation of ingestion in the oropharyngeal region and detailed fluoroscopic documentation will be provided at the meeting. During GI, marked hypermotility of the diaphragm was demonstrated, with its progressive flattening and eventual inversion. Flat, inverted diaphragms are typically seen in patients with COPD.

CONCLUSIONS: This is the first fluoroscopic study GE maneuvers and of diaphragmatic motion during GI. Pharyngeal pouches and inversion of the diaphragm can result from GI.

References:
1. Ardran et al. Br J Radiol 1959; 32: 322-8.

H8

Oral Presentation: 1633 - 1645
Poster Presentation: 1415 - 1530

APPLICATION OF THE PARETO PRINCIPLE TO RECREATIONAL DIVING DEATHS

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BACKGROUND: The Pareto principle states that for many phenomena, a few vital causes are responsible for most failures, and thus, failures can be effectively reduced by minimizing these causes. We applied this principle to identification of possible causes (or associations) in diving deaths.

MATERIALS AND METHODS: For each of 974 recreational diving deaths collected by DAN from 1992-2003, we attempted to identify an event sequence that included a trigger (the earliest adverse event, e.g., insufficient gas), harmful action (HA, an adverse event immediately preceding the disabling event, e.g., emergency ascent), disabling event (DE, e.g., arterial gas embolism (AGE)), and cause of death (COD, e.g., drowning). COD and DE were ascertained from possible causes listed in medical examiner reports (MER). When more then one possible cause was mentioned, the earliest was defined as the DE.

RESULTS: In the absence of other causes in MER, drowning was the COD in 70% of 862 cases where COD could be identified, but since drowning can result from DE that lead to incapacitation or unconsciousness, we concluded that DE was more informative than COD. Of 602 cases for which DE could be identified, drowning was assigned in 32%, AGE in 29%, and cardiac incidents in 26%. Other DEs were rare and ascribed to trauma (6%), decompression sickness (3%), loss of consciousness (2%), and inappropriate gas (2%). Drowning, AGE, and cardiac incidents had characteristic HA and triggers. In drowning, 79% of HA and 72% of triggers involved entrapment or insufficient gas. In AGE, 96% of HA involved emergency ascent while 83% of triggers included insufficient gas or equipment trouble. Cardiac incidents were seldom preceded by identifiable HA or triggers.

CONCLUSIONS: According to the Pareto principal, interventions that decreased entrapment, insufficient gas, emergency ascent, and equipment problems would have the greatest impact on reducing diving deaths.

H9

Oral Presentation: 1633 - 1645
Poster Presentation: 1415 - 1530

STATISTICAL VALIDATION OF THE PARETO PRINCIPLE AS APPLIED TO RECREATIONAL DIVING DEATHS

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BACKGROUND: An abstract at this meeting reported application of the Pareto principle to recreational diving fatalities (1). The Pareto principle assumes association, if not causality, between failures and possible causes but does so without statistical support. We tested the statistical association of harmful actions (HA) and triggers identified in (1) as well as other factors previously suspected of association with the disabling events (DE): drowning, arterial gas embolism (AGE), and cardiac incidents.

MATERIALS AND METHODS: We defined binary outcome variables having a value of one for a particular DE and a value of zero for all other DEs and applied multivariate logistic regression to assess the association of triggers, HA, and various possible contributing factors for each DE according to the odds ratio (OR). This identified factors associated with one DE in contrast to all other DEs.

RESULTS: Drowning was associated with entrapment (OR≥30), insufficient gas (OR=16), drysuit diving (OR=4.4), cold diving (OR=4), diving alone (OR=2.8), basic certification (OR=2.4), and being female (OR=2.3). AGE was associated with emergency ascent (OR≥30). Cardiac incidents were associated with a history of cardiovascular disease (OR≥30) and increasing age (OR=2.1 per 10 years of age). Insufficient gas was not associated with AGE although it had been identified by Pareto analysis (1). This was a consequence of contrasting AGE with all other DEs (including drowning) since insufficient gas was more common in pure drowning (78 cases) than in AGE (56 cases).

CONCLUSIONS: With the exception of insufficient gas in AGE, regression analysis supported the Pareto analysis and also identified contributing factors for specific DE. In addition to the conclusions of (1), diving deaths might also be decreased by screening older divers for cardiovascular disease.

1. Denoble PJ, et al. Application of the Pareto principle to recreational diving deaths. 2007 UHMS Meeting.

H10

Oral Presentation: 1645 - 1700
Poster Presentation: 1415 - 1530

FATALITIES IN DIVERS USING RE-BREATHERS

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BACKGROUND: The number of diving fatalities involving re-breathing diving apparatus (RDA, closed and semi-closed) is small but increasing based on data collected by DAN. We review these data below.

MATERIALS AND METHODS: We searched the DAN database for RDA fatalities during 1998-2006. Because follow-up was possible for US and Canadian cases, more information was available for these than for international cases. Cases were evaluated for triggers, harmful actions (HA), disabling events (DE) as described elsewhere at this meeting (1) and for equipment failure or procedural errors.

RESULTS: Worldwide RDA deaths in DAN data increased from 6 in 1998 to 16 in 2006. There were 24 US and Canadian deaths and 54 deaths involving 24 other nationalities. US and Canadian RDA deaths increased from 1% of all US and Canadian fatalities in 1998 to 4% in 2004. Triggers were identified in 34 cases including 9 insufficient gas and 13 equipment problems. HA were identified in 29 cases including 10 emergency ascents, 7 insufficient gas, and 6 inappropriate gas. DEs were identified in 26 cases including 13 hypoxia, 7 air embolism, and 3 seizures. There was insufficient information to evaluate equipment failure or procedural errors in 42 cases. RDA failures were identified in 9 cases and RDA procedural errors in 21 cases. There were 6 non-RDA equipment failures and 10 non-RDA procedural errors. (Multiple failures or errors occurred in some cases.)

CONCLUSIONS: In RDA fatalities, insufficient gas and emergency ascent appeared less common than in open-circuit fatalities (1), but equipment problems and inappropriate gas appeared more common for RDA. For RDA cases, RDA failures and procedural errors were more common than non-RDA failures and errors, but more than half the RDA cases had too little information for assessment.

1) Denoble PJ. Application of the Pareto principle to recreational diving deaths. 2007 UHMS Meeting.

H11

ABSTRACT WITHDRAWN

H12

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

WHAT CAN THE MEDICAL COMMUNITY DO FOR TECHNICAL DIVERS?

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BACKGROUND: The Internet assists the growth of information sharing and communication of divers worldwide. In preparation for the DAN Technical Diving Symposium 2008, we wanted to facilitate communication between the technical divers and diving researchers. We requested information from technical divers on research needed to improve their safety. A thread and poll were posted to the forum asking the question "If it were up to you, which of the following areas would you like to see the hyperbaric/medical research community focus on?"

MATERIALS AND METHODS: The Rubicon Foundation requested the assistance of The Deco Stop (TDS), an Internet forum of technical divers from around the world. The TDS forum has 13,140 members and receives 3,000 visits per day. TDS software is vBulletin Version 3.6.1 (Jelsoft Enterprises Ltd. Pangbourne, UK). The poll was set up by forum moderators to allow members to vote for one category, listed below. The associated thread was used to discuss these specific topics as well as any others not included in the poll.

RESULTS: There were 255 members that elected to vote in the poll over the first 60 days. Votes were distributed as: Decompression Theory 110 (43.14%), Diver Health 43 (16.86%), Post-Mortem Accident Analysis 41 (16.08%), Oxygen Toxicity (CNS & Pulmonary) 28 (10.98%), Gas Narcosis 17 (6.67%), Basic Sciences 5 (1.96%), High Pressure Nervous Syndrome 4 (1.57%), Recompression Therapy 4 (1.57%), Thermal Stress 3 (1.18%).

CONCLUSIONS: This clarifies interests and risks incurred by technical divers recreationally and the potential use of these divers in further research. The thread and poll have remained open so that more opinions and comments could be collected in the future. The months of December through March have been historically lower participation months on the forum.

H13

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

DRUGS DOWNED DIVERS DID

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BACKGROUND: Few studies have defined the potential interaction of medications with the physiological processes which occur while diving. In part, we often do not know to what extent and which medications might be used. This study was designed to assess the scope and nature of medication usage in a population of recreational divers.

MATERIALS AND METHODS: A review of patient records for all divers treated at our facility between the years 2000-2006 was conducted to ascertain how many had been using drugs/medications at the time of their accident and to identify those specific substances. The percentage of cases using meds as well as the total number of different drugs was determined. Once identified, the medications were grouped according to their classification as outlined in the Physician's Desk Reference and the reasons for which they had been prescribed in each case. The number of cases and percentages for each drug classification was then assessed. No attempt was made to correlate the use of any specific drug type as a putative factor leading to the injury.

RESULTS: Two hundred seventy-eight cases had been treated within the study period of which 92 (33%) had been using at least one drug at the time of accident. Some used multiple meds. 123 different medications had been used.

Table 1. Number and percent cases by drug category (n=278)

Drug category	Number of cases	Percent of cases
Psychotherapeutics	28	10%
Antihypertensives	25	8.9%
NSAIDS	24	8.6%
Antihistamines	18	6.4%
Hormones	17	6.1%
GI agents	14	5%
Bronchodilators	11	3.9%
Steroids	11	3.9%
Antibiotics	10	3.5%
Analgesics (non-narcotic)	9	3.2%
Antilipemics	7	2.5%
Diuretics	5	1.7%
Antiglycemics	4	1.4%
Narcotics	4	1.4%
Anti-seizure meds	4	1.4%
Migraine preps	4	1.4%
Urinary tract preps	4	1.4%
Anti-motion sickness meds	4	1.4%
Anti-coagulants	2	0.7%
Miscellaneous	10	3.5%

CONCLUSIONS: A substantial proportion of injured divers in this study were taking prescribed medications prior to their accident. Further evaluation to assess the effects of these medicines under hyperbaric conditions are needed. Some of these drugs were administered for conditions which have been deemed as contraindications to diving.

H14

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

INCIDENCE OF MIDDLE EAR BAROTRAUMA FOLLOWING 10-METRE BOUNCE DIVES FOR NAVAL DIVER SELECTION

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BACKGROUND: Chamber bounce dives are used by some navies as a screening tool for diver-selection. In our unit, middle ear barotrauma from bounce dives contributes to attrition during selection. To date, there is no published literature on incidence of barotrauma in bounce dives, or on the relationship of failed bounce dives to true Eustachian tube dysfunction.

MATERIALS AND METHODS: A prospective study was done on 183 pre-enlistees and military personnel undergoing bounce dives to determine the incidence of symptomatic and asymptomatic middle ear barotrauma, and to identify possible risk factors for barotrauma in this population. Candidates were administered a questionnaire for history of ENT-related medical conditions and a post-dive symptom questionnaire, and were examined after the dives for otoscopic signs of barotrauma. Barotrauma was defined as the presence of ear pain or fullness, or abnormal appearance of the tympanic membrane.

RESULTS: The incidence of middle ear barotrauma was 11.5%; one third of which were asymptomatic. 73.7% of those with otoscopic signs had mild (Teed 1) barotrauma, and this included all the asymptomatic cases. Most ENT-related conditions were not found to be associated with middle ear barotrauma, except for history of nose surgery, previous ear injury, and recent symptoms of sinusitis. Age and increasing compression rate were not found to be associated with barotrauma.

CONCLUSIONS: The incidence and severity of middle ear barotrauma during bounce dives are low, and cases of asymptomatic barotrauma were all mild. However, some barotrauma could be attributed to poor autoinflation technique in these first time divers. Detailed instruction in autoinflation techniques, or practice dives before the selection bounce dive, could minimize the rate of attrition due to poor technique. Follow up studies should be done to standardize compression rates for selection bounce dives and to establish their effectiveness as a selection tool.

H15

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

CONJUNCTIVITIS OUTBREAK AMONG HEALTH CARE PROVIDERS WHILE SCUBA DIVING - A CASE REPORT

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BACKGROUND: Conjunctivitis is a highly virulent and contagious disease. We report a recent outbreak amongst recreational divers at a resort in the South Pacific. A medical conference attended by a total of twenty-six persons was convened at a Fijian resort. All were reported healthy certified divers in shape to dive. The group was comprised of health care providers, along with spouses / significant others. Two persons were listed as a "non-divers".

CASE REPORTS: Two dive boats were made available to the group. A maximum of twelve divers were placed on one boat while the balance were on the other. Equipment on the boats was stored according to type. Masks were stored in a communal container. On the morning of day #3, a diver awoke with right eye pain and a foreign body sensation without having any known trauma or contact lens wear. Physical exam revealed moderate tearing, scleral injection, mild lid edema and small amounts of pus at the medical canthus. Cases #2 and 3 were reported shortly thereafter. The owners/operators of the resort were notified immediately. Requests were made for bleach and detergent to be supplied to each dive boat for the cleaning of masks. Additionally, a request was made to obtain up to twenty unit doses of ophthalmic antibiotics. Ultimately, eleven individuals were inflicted. Multiple pharmacies were contacted by the hotel operator. Fifteen unit doses of antibiotic drops and ointment were procured. A follow-up email survey reported that all cases had resolved within one week with no significant sequelae.

CONCLUSIONS: Diving is a hazardous activity above and below the surface. Proper maintenance of equipment, awareness of dangerous environments and preparation for medical problems can make for safer and more enjoyable diving.

H16

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

GASTRIC RUPTURE IN A DIVER DUE TO RAPID ASCENT

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BACKGROUND: Stomach rupture due to barotrauma is a rare event.

CASE REPORT: A 50 year-old, experienced male SCUBA diver developed gastric rupture due to rapid ascent from a depth of 25m. After surfacing, he immediately developed breathing problems and abdominal pain. He was brought to the local hospital. Due to sustained discomfort and a SpO2 not exceeding 91% he was transferred to the regional hyperbaric center by air ambulance. The air trip was uneventful. The diagnosis was made due to the presence of pneumoperitoneum on a routine chest x-ray taken on admittance. On surgery, a 1.5 cm rupture of the lesser curvature was found and sutured.

CONCLUSIONS: Rupture of the stomach during diving is an extremely rare event. Less than 20 cases have been described since 1969. The rupture typically occurs at the lesser gastric curvature, probably due to a thin muscular layer and fewer mucosal folds, making it less elastic. Increased air volume in the stomach causes gastric distension and closes the esophagogastric junction, thus blocking the release of air through the mouth.

H17

Oral Presentation: N/A
Poster Presentation: 1415 - 1530

THE ABSENCE OF MEMORY DISTURBANCE IN DEEP SEA SATURATION DIVERS

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BACKGROUND: Memory disturbance is a major concern in Norwegian saturation divers. Although many studies have been made to elucidate neuropsychological sequelae due to deep sea saturation diving, it remains unresolved whether or not deep sea saturation diving brings a permanent adverse effect on memory function. Moreover, the possibility of transient deterioration of memory function due to saturation diving has not been investigated until now. In the present study, memory function was measured before and after simulated deep-sea saturation dives in order to detect not only long-term but also short-term effects on memory function.

MATERIALS AND METHODS: Subjects were 21 male professional divers (aged 30-40 years) who participated in saturation dives greater than 400 msw; they previously had various saturation diving experience (maximal depth: 60 to 440 msw; years of experience: two to 14 years). Memory function was measured by a computerized test named STM-COMET. This test analyzes three aspects of memory function, i.e., short-term memory, long-term memory and working memory; moreover, this test has six sets of different contents, thus enabling repetitive measurements without the learning effect. At first, the subjects were tested one week before the saturation dives. Then they were tested three times after the dives: four hours, one week and two weeks after the completion of decompression.

RESULTS: The overall evaluation of memory function at the pre-dive measurement was slightly better than that of an age-matched control group, although the difference was not statistically significant. In addition, there was no correlation between the evaluation scores and saturation diving careers. The overall evaluation immediately after the decompression was almost the same as that of the pre-dive measurement, and it remained stable throughout the post-decompression measurements.

CONCLUSIONS: This study indicates that deep-sea saturation diving itself causes neither long-term disturbance nor short-term change on memory function provided that both compression and decompression are properly performed.

Session J: Diving Physiology and Cellular Mechanisms

J1 (President's Competition)
Oral Presentation: 0915 - 0927
Poster Presentation: 1045 – 1200

HIGH PRESSURE EFFECTS ON SPIKE GENERATION BY ISOLATED NMDA RECEPTOR SYNAPSE MAY ONLY PARTIALLY EXPLAIN CNS HYPEREXCITABILITY

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BACKGROUND: Pressure above 1.1 MPa induces in mammals and humans the high pressure neurological syndrome (HPNS). HPNS is characterized by cognitive and motor decrements associated with sleep disorders, EEG changes, tremor, and convulsions. Previous theories proposed that augmented response of the glutamatergic N-methyl-D-aspartate receptor (NMDAR) or reduced GABAergic inhibition may be involved. Recently, we have reported that isolated NMDAR synaptic response was augmented at high pressure. We now test whether this augmentation induces neuronal hyperexcitability. We studied high pressure effects on pharmacologically isolated NMDAR field excitatory postsynaptic potentials (fEPSPs) and on their efficacy in generating population spikes (PSs).

MATERIALS AND METHODS: Sprague-Dawley male rats were used. Hippocampal coronal brain slices were prepared, constantly superfused with physiological solutions, gas-saturated at normobaric pressure, and compressed up to 10.1 MPa with helium. fEPSPs and PSs were recorded from the dendritic and the somatic layers of CA1 pyramidal neurons in response to Schaefer collaterals stimulation with trains of 5 stimuli at 25 Hz.

RESULTS: Pressure caused PSs to appear earlier in the train. However, PS amplitude (-52%), frequency (-46%), and number (-40%) were decreased and PS decay time (+60%) was increased in the last 3-5 responses in the train. The reduction in late fEPSPs was associated with a decrease of the total number of PSs in the train, apparently without a change in the synaptic efficacy in eliciting PSs. Evaluation of the activation volumes (_V*, cm3/mol) for the kinetics parameters of the PS indicated slower conduction velocity (88.7 ± 10.9), rise time (79.8 ± 11.5), and decay time (131.5 ± 6.6) that suggest the contribution of modified voltage activated channels to the pressure effects.

CONCLUSIONS: These results may partially explain the neuronal hyperexcitability observed at pressure. It is postulated that significant hyperexcitability is attained at pressure only when the normal fast fEPSP (containing also AMPA receptor component) is intact.

J2 (President's Competition)
Oral Presentation: 0927 - 0939
Poster Presentation: 1045 – 1200

INVOLVEMENT OF GABAERGIC NEUROTRANSMISSION IN NEUROCHEMICAL DISTURBANCES UNDER SINGLE OR REPETITIVE NITROGEN NARCOSIS

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BACKGROUND: Nitrogen at pressure induces a neurological syndrome called nitrogen narcosis composed of motor and cognitive disturbances. Neurochemical studies in rats have demonstrated a decrease of dopamine (DA) release by neurons originating from the substantia nigra pars compacta (SNc) and projecting into the striatum, the structure involved in motor and locomotor control, during exposures to nitrogen at 3 MPa. In contrast, an increase of DA release was recorded following repetitive exposures to nitrogen narcosis. The glutamatergic input to DA cells mediated through NMDA receptors was demonstrated to be reduced for a single exposure and abolished after repetitive exposures. In another way, numerous GABAergic input to SNc modulating dopaminergic neurons could be implicated.

METHODS: Under general anesthesia, male Sprague-Dawley rats were implanted in the striatum with multifiber carbon dopamine-sensitive electrodes and guide cannulae in the SNc for drug injections. After recovery from surgery, awake free-moving rats were exposed for 2 hours up to 3MPa of nitrogen-oxygen mixture, before and after one daily exposure to 1MPa of nitrogen-oxygen, for 5 consecutive days. The effects of specific agonist (muscimol) and antagonist (gabazine) of GABAA receptor administration in the SNc were investigated to appreciate the involvement of GABAergic neurotransmission.

RESULTS: For a single exposure, muscimol counteracted significantly the nitrogen-induced DA decrease while gabazine reversed and increased it. In contrast, following repetitive exposures, gabazine remained ineffective while muscimol enhanced the nitrogen-induced DA increase.

CONCLUSIONS: The DA decrease for a single exposure to nitrogen narcosis could be explained by a facilitated GABAergic neurotransmission through sensitization of GABAA receptors located on DA cells. In the contrary, the increasing effect of repetitive exposures could result from a decrease GABAergic input to DA cells through sensitization of GABAA receptors located this time on interneurons. Thus, disinhibitory processes were suggested instead of an increase glutamatergic input.

(Grants DGA-PEA 98/0809 and MEDSUBHYP)

J3

Oral Presentation: 0939 - 0951
Poster Presentation: 1045 - 1200

REACTIVE OXYGEN AND NITROGEN SPECIES GENERATION BY HYPERBARIC STRESS IN NAœVE VERSUS EXPERIENCED DIVERS

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BACKGROUND: Reactive oxygen (ROS; O2•) and nitrogen species (RNS; NO• and ONOO-) are potent signalling molecules that regulate inflammatory response. Venous gas emboli (VGE) during decompression may elicit vascular endothelial reaction via flow disruption/injury thereby activating acute inflammatory responses. Animal models suggest that VGE may activate polymorphonuclear neutrophils (PMN) to release ROS, contributing to oxidative tissue damage and the pathogenesis of decompression sickness (DCS). The aim of this study was to compare the effects of 3 different levels of hyperbaric stress on ROS/RNS generation in experienced divers vs. naïve subjects.

MATERIALS AND METHODS: Naïve (n=10) and experienced-to-hyperbaric-stress (n=12) subjects underwent three 30-min hyperbaric stress exposures [180 kPa (18 msw); 300 kPa (30 msw); 450 kPa (45 msw)] each separated by 1 week. Blood samples were drawn pre-dive and at 20 and 60 min post-dive. PMN ROS production was quantified flow cytometrically [median fluorescence intensity (MdFI)] using DHR 123; circulating concentrations of NO• and tyrosine nitration of amino acids (N-Tyr; stable marker of ONOO-) were measured by enzyme immunoassay.

RESULTS: ROS generation was greatly enhanced in experienced divers after all three dives, with peak levels observed at 60 min post-dive 45m. Similarly, pre-dive NO• concentrations were higher in experienced vs. naïve, with maximal increases detected at post-dive 45m. Immunoreactivity of plasma N-Tyr residues in experienced divers did not change significantly from pre-dive levels (6 nM) after dives to 18m, 30m or 45m. In contrast, pre and post-dive N-Tyr levels in naïve divers were consistently higher (12 nM) after all three dives.

CONCLUSIONS: Whereas PMN ROS generation and plasma NO• levels were higher in experienced divers, their N-Tyr levels were lower than that in naïve subjects. This suggests that experienced divers may be conferred with a degree of physiological adaptation to the inflammatory response.

J4

Oral Presentation: 0951 - 1003
Poster Presentation: 1045 - 1200

HEAT SHOCK PROTEIN 70 IS UPREGULATED IN BLOOD LEUKOCYTES FROM EXPERIENCED DIVERS IN RESPONSE TO REPETITIVE HYPERBARIC STRESS

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BACKGROUND: Heat shock proteins (HSPs) are upregulated in blood leukocytes following exposure to various physiological stressors, including hyperthermia, exercise, and hypoxia. Limited human studies indicate that acute hyperbaric stress enhances HSP70 expression and animal data suggest that prior induction of HSP70 may be protective against decompression sickness (DCS). However, the effect of repeated hyperbaric stress on HSP70 expression has not been investigated in humans. The aim of this study was to examine the impact of 3 consecutive days of hyperbaric stress on intracellular (i)HSP70 expression in human leukocyte subsets.

MATERIALS AND METHODS: Eight experienced male divers (21-55 yr) underwent 3 dry simulated dives to 450 kPa (45 msw) for 35 min in a hyperbaric chamber over a 3-d period. Venous blood samples were drawn under basal conditions pre-dive and immediately after exposure (post-dive). Multi-color flow cytometry was used to quantify spontaneous and in vitro heat-shock (42 ºC, 1h) induced iHSP70 expression by lymphocytes, monocytes and neutrophils; results are expressed as the % and median fluorescence intensity (MdFI) of each subset.

RESULTS: Compared to pre-dive levels, iHSP70 expression was incrementally upregulated after repeated hyperbaric exposures, with peak increases ($p < .001$) observed in monocytes and neutrophils post-dive-3. Hyperbaric stress elicited 3- and 7-fold increases ($p < .001$) in the spontaneous % of monocytes and neutrophils expressing iHSP70, respectively. Corresponding increases in iHSP70 MdFI by neutrophils (14.4 ± 0.3 to 25.0 ± 3.0; $p < .01$) and monocytes (9.9 ± 0.2 to 16.4 ± 1.1; $p < .01$) were observed post-dive-3. Relative to spontaneous levels, heat shock augmented pre-dive leukocyte iHSP70 expression and further enhanced post-dive iHSP70 by monocytes and neutrophils.

CONCLUSIONS: This study demonstrates that HSP70 expression is upregulated in humans exposed to repetitive episodes of hyperbaric stress. The results suggest that HSP70 induction is a cellular adaptation to recurrent diving, which may contribute to diving acclimatization and a reduced susceptibility to DCS in individuals undergoing chronic hyperbaric stress.

J5

Oral Presentation: 1003 - 1015
Poster Presentation: 1045 - 1200

THE EVALUATION OF OXIDATIVE STRESS AND ANTIOXIDANT STATUS FOLLOWING REPEATED HYPERBARIC OXYGEN IN PATIENTS WITH DECOMPRESSION ILLNESS

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BACKGROUND: It has been suggested that hyperbaric oxygen (HBO) causes oxidative stress through the production of reactive oxygen species. Some patients with decompression illness (DCI) need repeated HBO treatments, which lead to concerns about an accumulation of oxidative stress. The aim of this study was to determine whether two sessions of HBO increased lipid peroxide and attenuate antioxidant capability.

MATERIALS AND METHODS: Nine DCI patients (M6, F3, mean age 36.6±1.8 and range 29-43 yr) were exposed to two sessions of U.S. Navy Treatment Table 6 (TT6) at an interval of 3 days. Venous blood was collected immediately before and after the 1st and 2nd HBO treatment. Reactive Oxygen Metabolites (ROM) and Biological Antioxidant Potential (BAP) in serum were measured as indexes of oxidative stress and antioxidant capability, respectively. We also measured uric acid (UA) as an antioxidant in serum.

RESULTS: The results are described in the table below. No changes in ROM were observed. BAP significantly increased after the 1st and after 2nd HBO compared with before the 1st HBO. UA was not affected.

	Before 1st	After 1st	Before 2nd	After 2nd
ROM (CARR. U.)	286±9	282±10	279±14	275±9
BAP (μ mol/l)	2305±73	2467±46 *	2404±112	2501±87 *
UA (mg/dl)	6.0±0.5	6.1±0.5	6.1±0.4	5.8±0.4

mean±SE., n=9, One-way Repeated-Measures ANOVA followed by Dunnett's test
* $P < 0.05$ vs. Before 1st HBO

CONCLUSIONS: Exposures to two sessions of TT6 did not cause oxidative stress. Antioxidant capability was increased in the serum after each HBO treatment, which might indicate a compensation for oxidative stress induced by HBO.

J6 (President's Competition)
Oral Presentation: 1015 - 1030
Poster Presentation: 1045 - 1200

EFFECT OF INCREASED RESPIRATORY RESISTANCE ON CARBON DIOXIDE LEVELS AND HEMODYNAMICS IN THE SUBMERGED EXERCISING DIVER

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BACKGROUND: During diving, hypercapnia can cause progressive impairment of mental performance and exercise capacity. This study examined the effect of varying levels of respiratory resistance on work of breathing/volume (WOB/V), peak-to-peak mouthpiece pressures (Pm pk-pk), cardiac output (CO), and arterial PCO2 (PaCO2).

MATERIALS AND METHODS: After institutional approval and informed consent volunteers were studied during moderate prone exercise while immersed in thermoneutral water with various levels of breathing resistance at the surface and at simulated depth of 122 feet of seawater (fsw) breathing air. Twenty subjects were studied without external breathing resistance (Z); 6 had added resistance, which was either inspiratory (I) or both inspiratory and expiratory (IE). Each subject was instrumented with ECG and radial and pulmonary artery catheters. For each resistance, measurements of inspiratory/expiratory flow rates and pressures, CO (Fick) and PaCO2 were made during the last minute of a 6 minute exercise.

RESULTS: VO2 during exercise was 2.34±0.33 L/min (mean ± SD). During Z Pm pk-pk was 6.8±2.2 cmH2O. During I or IE, Pm pk-pk ranged from 17.7 to 53 cmH2O and WOB/V from 1.46 to 4.49 J/L. CO remained unchanged despite varying resistances (17.40±2.14 L/min). PaCO2 during surface exercise was 33.7±4.9 mmHg; during Z at depth it was 46.4±5.9 mmHg ($P<0.0005$). During IE at the highest level of resistance PaCO2 was 50.9±5.9 mmHg. Mean arterial pressure trended slightly upward with increased resistance while arterial rate trended slightly downward (P NS).

CONCLUSIONS: With external breathing resistances that have been reported to be acceptable (Warkander, et al. Bio Res 19:427-45, 1992.), moderate hypercapnia does occur in the exercising diver without significantly affecting CO, MAP, or HR.

J7

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

COMPARISON OF END-TIDAL VERSUS ARTERIAL MEASURES OF CARBON DIOXIDE DURING IMMERSED EXERCISE AT SURFACE AND DEPTH

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BACKGROUND: Arterial CO_2 (P_aCO_2) is typically estimated through non-invasive measures of expired gases. The relationship between end-tidal CO_2 ($P_{ET}CO_2$) and P_aCO_2 has been characterized during dry exercise, but not during underwater exercise. The integrated effects of hydrostatic pressure, increased gas density, underwater breathing apparatus resistances, and increased respiratory deadspace may alter the relationship. The purpose of this work was to compare simultaneous measures of $P_{ET}CO_2$ and P_aCO_2 during underwater exercise near the surface and at depth.

MATERIALS AND METHODS: A system was designed and constructed to study fully immersed subjects exercising at various depths. Breathing gas, static lung load and inspired and expired breathing resistance could all be manipulated. A radial artery catheter was placed prior to the experimental trial for blood collection. A mass spectrometer (Perkins-Elmer MGA1100) was used for breath-by-breath analysis (sample tubing length 10.4 m, 0.86 mm ID; system rise time [10-90%] 230 msec). Subjects completed six minute bouts of fully submerged, prone exercise at the surface and at a chamber pressure equivalent to 37 msw (122 fsw). Blood and expired gas samples were collected during steady rate exercise at up to near-maximal aerobic capacity intensity with varying PO_2, static lung load and imposed inspiratory and expiratory resistances. Paired underwater measures were used for correlational analyses.

RESULTS: A total of 122 paired measures were available from 34 subject-trials. Overall, P_aCO_2 and $P_{ET}CO_2$ during immersed exercise were strongly correlated ($r=0.851$; $y = 0.7406x + 12.243$; $x=P_aCO_2$). The correlations weakened slightly when separated into surface and depth subgroups (0.787 [$y = 0.7556x + 11.609$] and 0.701 [$y = 0.7087x + 13.781$], respectively).

CONCLUSIONS: Simultaneous measurement of P_aCO_2 and $P_{ET}CO_2$ indicated a generally high degree of correlation despite manipulations in exercise intensity, PO_2, static lung load and imposed inspiratory and expiratory resistance.

FUNDING: NAVSEA contract #N61331-03-C-0015.

J8

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

THE EFFECT OF STATIC LUNG LOAD ON HEMODYNAMICS AND GAS EXCHANGE DURING PRONE IMMERSED EXERCISE AT 122 FSW

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BACKGROUND: Static lung load (SLL) is the difference between mouthpiece pressure and lung centroid pressure. A previous investigation of 3 subjects at 190 fsw revealed that positive SLL increased expiratory reserve volume (Thalmann ED et al. Undersea Biomed Res 1979;6:259). We hypothesized that +SLL would increase respiratory deadspace and augment hypercapnia.

MATERIALS AND METHODS: After institutional approval and informed consent 10 volunteers were studied during prone exercise while immersed in thermoneutral water at a simulated depth of 122 fsw breathing air. Each subject was instrumented with ECG and radial and pulmonary artery catheters. Cardiac output was calculated using the Fick method. Measurements were obtained during SLL 0, (0SLL), +10 cmH2O (+SLL) and -10 cmH2O (-SLL) in random order.

RESULTS: Measurements are shown in the tables below (mean±SD).

Condition	VO2	PaO2	PaCO2	VE	VD/VT	HR	CO
	L/min)	(mmHg)	(mmHg)	(L/min)		(bpm)	(L/min)
SLL0	2.3±0.5	610±61	44±7	61.2±12.1	.27±.07	141±21	17.7±2.4
SLL+	2.4±0.6	608±36	46±3	65.1±12.4	.32±.07	144±18	18.2±2.3
SLL-	2.3±0.6	606±55	45±5	61.6±8.3	.27±.08	141±19	17.6±1.9

CONCLUSIONS: During immersed prone exercise, a static lung load of ±10 cmH2O did not significantly affect arterial PCO2, respiratory deadspace, cardiac output, heart rate or stroke volume.

J9

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

CHANGES OF IMMUNE FUNCTION IN RATS AFTER 60-METER AIR SIMULATED DIVES

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BACKGROUND: Hyperbaric conditions were found to have immunological effects, but the precise action and underlying etiology are still ambiguous. We studied the effects of deep air dives on the immune response in rats and the underlying mechanisms were discussed.

MATERIALS AND METHODS: Adult Sprague-Dawley rats were exposed to 700 kPa air for 60 min, twice daily for 3 days. The subsets of lymphocytes in peripheral blood and spleen, interleukin-2 (IL-2) in plasma, the responses of splenic lymphocytes to concanavalin A (ConA) and the state of oxidative stress were determined 1, 3 and 5 days after exposures. Serum concentrations of adrenocorticotropic hormone (ACTH) and corticosterone were also measured before and during 3 days exposures. Rats exposed to 147 kPa oxygen or 700 kPa normoxic nitrogen (21 kPa oxygen + 679 kPa nitrogen) were taken as control groups.

RESULTS: Peripheral lymphocytes and CD3+ and CD4+CD3+ subsets in peripheral blood and spleen, plasma IL-2 level and the responses of splenic lymphocytes to ConA all decreased, and antioxidant enzymes activities and the concentration of reduced glutathione both decreased while the level of malondialdehyde increased after hyperbaric air exposures. All changes returned to control levels in 3-5 days. Similar changes were observed after exposures to 147 kPa oxygen but not to normoxic nitrogen. Plasma levels of ACTH and corticosterone increased after 1 exposure and recovered to normal levels after 3 exposures in rats treated with either hyperbaric or normobaric air. Pretreatment of the animals with N-acetylcysteine, a potent free radical scavenger and antioxidant, attenuated the effects of hyperbaric air on the immune and antioxidant systems.

CONCLUSIONS: These results suggest that repetitive, 60 m, simulated air dives had immunosuppressive effects on rats, which was associated with oxidative stress induced by the high partial pressure of oxygen in breathing mixture.

J10

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

THE RELATIONSHIP OF SICKLE CELL TRAIT AND OTHER HEMOGLOBINOPATHIES ON SCUBA DIVING SAFETY IN CARIBBEAN DIVERS

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BACKGROUND: There is little objective information regarding the relationship between sickle cell trait (SCT) and other hemoglobinopathies and diver safety. However, the current teaching and general consensus among most diving medicine physicians is that these disorders disqualify one from diving. The aim of this study is to elucidate the correlation between SCT and other blood dyscrasias and the risk of decompression sickness (DCS); we hypothesize that there will be no increased risk of DCS with a history of SCT or other hemoglobinopathy.

MATERIALS AND METHODS: A questionnaire was devised to obtain self-reported information from scuba divers who actively work as a Dive Master or Instructor at Caribbean dive centers. The questionnaire was sent to multiple diving agencies (via e-mail as well as standard postage) located throughout the Caribbean. Responses will be collected via e-mail and standard mail. The incidence and prevalence of DCS will be determined in divers with and without SCT and other blood dyscrasias.

RESULTS: Thirty-three responses were received. Of the responses, 22 were Caucasian, 4 were Latin American, 4 were Black, 1 was Native American, 1 was Asian, and 1 declined to state his race. Of the respondents, 1 had sickle cell trait, 14 did not, and 18 didn't know if they had sickle cell trait. The person who reported a positive sickle cell trait was of European descent; he reported no diving related injuries. Of the rest of the respondents, 4 had a history of ear barotrauma, 1 had the skin bends, and 1 had vertigo. There were no reported cases of decompression sickness.

CONCLUSIONS: Our conclusions are pending further evaluation of the results from the questionnaires.

J11

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

RESPIRATORY MUSCLE TRAINING ENHANCES SWIMMING AND RESPIRATORY PERFORMANCE AT DEPTH

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BACKGROUND: Respiratory muscle fatigue is known to shorten the time sub-maximal exercise can be performed and the endurance can be improved by respiratory muscle training. Although respiratory muscle training has been shown to improve divers' swimming endurance at 4 fsw its effectiveness at greater depths, where the respiratory work due to the increased trans-thoracic pressure, gas density and breathing gear is greater, has not been studied. This study tested the hypothesis that resistance respiratory muscle training (RRMT) will improve respiratory function and swimming endurance in divers at 55 fsw (2.67 ATA).

MATERIALS AND METHODS: Nine male subjects (25.9 ± 6.8 years) performed vital capacity maneuvers every 30 seconds against 50 cmH2O, 30 minutes/day, 5 days/ week, for 4 weeks. Subjects swam against a pre-determined load (70% max) until exhausted. Maximal inspiratory (PImax) and expiratory (PEmax) pressures (indicators of respiratory muscle strength) were measured immediately following the swims pre- and post-RRMT.

RESULTS: The latter measurement suggests that, at comparable swim duration, the respiratory muscles were less fatigued following RRMT and ventilation was lower during the swims. Lower ventilation was achieved through decreases in breathing frequency following RRMT. The ventilatory changes following RRMT helped to increase the swimming time to exhaustion by ~60% (p=0.016).

CONCLUSIONS: These results suggest respiratory muscle fatigue limits swimming endurance at depth and the increase in swimming time may be the result of reduced work of breathing or improved respiratory muscle performance.

J12

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

CHANGES IN CARDIAC AUTONOMIC NERVOUS FUNCTION AND STRESS HORMONES DURING HELIOX SATURATION DIVES TO 4.5Mpa

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BACKGROUND: It is well known that hyperbaric bradycardia is an obvious concern regarding autonomic cardiovascular function due to hyperoxia associated with saturation diving. Saturation diving places mental stress on divers, therefore, a sympathetic nervous function is activated. Thus, we studied the functional changes of autonomic nerve and stress hormones during saturation diving.

MATERIALS AND METHODS: Heliox dry saturation dives to 4.5 MPa (440 msw) were conducted three times using six healthy divers each in 2004, 2005, and 2006. Heart rate (HR), systolic and diastolic arterial pressure (SAP, DAP), and salivary cortisol and cromogranin A (CgA) of 18 divers were measured in a horizontal supine position at 14 junctures of time during five different dive periods: pre-dive (control), compression, saturation (bottom), decompression, and post-dive. High- and low-frequency power spectra (HF, LF) and the ratio of LF/HF were calculated from 5-min R-R intervals of ECG under a respiration rate controlled at 15 breaths/min.

RESULTS: Although HF, an index of cardiac parasympathetic activity, showed a significant increase during the compression period, HR, LF/HF, SBP, and DBP did not show significant changes compared with the pre-dive control values. While HF decreased, HR and LF/HF increased during the decompression and post-dive periods. While salivary cortisol showed a significant decrease during the post-dive period, salivary CgA showed a significant increase after one week from the start of the post-dive period.

CONCLUSIONS: The present study, with a comparatively large sample size, indicates that the cardiac parasympathetic nervous system is the primary modulator of hyperbaric bradycardia and is clearly manifested in the compression period. Tachycardia was observed during the decompression and post-dive periods probably due to the dominant cardiac sympathetic nervous system. Most of these post-dive phenomena continued for at least two weeks after the return to normobaric daily living. Responses in salivary cortisol and CgA do not quite collaborate each other during the post-dive period.

J13

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

CHANGE OF SERUM FREE RADICALS AND ANTIOXIDANT POTENTIAL IN REBREATHER DIVERS

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BACKGROUND: No study exists on the estimated risk from oxidative stress induced by rebreather diving activities, although some observations suggest that inhaled oxygen under hyperbaric treatment increase oxidative stress on living body. This study intended to evaluate oxidative stress and antioxidant potential of divers during rebreather diving activity, and to estimate the effect of reactive oxygen and antioxidant potential.

MATERIALS AND METHODS: The subjects were 10 healthy rebreather divers. Diving profile is depth of 30m for 30 min; total diving time was 60 minutes including 10 min of descending time and 20 min of decompression time. Subjects were equipped with the closed circuit apparatus keeping PO2 as 1.3ATA (constant). Subjects were asked to swim about 1200m underwater for 60 min. Blood samples were collected from divers' forearm vein before and after diving. Immediately after collecting the samples, a portable free radical and antioxidant potential determination device called FRAS(r) (Free Radical Analytical System) was used to measure the reactive oxygen metabolites (ROM) and the biological antioxidant potential (BAP).

RESULTS: ROM, which is the indexes of evaluating reactive oxygen species, had no significant difference (before: 284.5 ± 49.9 CARR.U, after: 284.5 ± 51.2 CARR.U.) (ROM x Hct/43; before: 294.8 ± 48.4 CARR.U, after: 289.5 ± 50.6 CARR.U.). BAP, which indicate antioxidant potential, significantly increased 10.7% after diving (before: 2221.6 ± 466.5 mol/l, after: 2458.4 ± 363.5 mol/l) ($P<0.05$).

CONCLUSIONS: In this study, it was confirmed that there was a time frame when serum BAP increased in rebreather diving, which suggests that antioxidant potential would be induced from some tissues.

J14

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

MILD DYSPNEA AFTER SCUBA DIVING: BLOOD GAS ANALYSIS

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BACKGROUND: The manifestation of dyspnea, which arises after diving and is called "Chokes", is serious. We sometimes see mild dyspnea patients. In this study, we wanted to analyze the mild dyspnea mechanism after diving.

MATERIALS AND METHODS: Our subjects were chosen from patients with dyspnea after diving between 2002 and 2006. There were 8 male and 13 female, with a mean age of 33.1 years. Arterial blood was taken from the patients before treatment for initial diagnosis. The standard value was calculated from the regression equation of Mellengaard. PaO2 was classified into 3 groups: excess, standard and low. Then, PaCO2 was analyzed, and the mechanism was analogized by these results. After treatments we examined the blood gas analysises in the PaO2 low group 6 patients.

RESULTS: Patients' PaO2 before treatment were excess: 7, standard: 7, and low; 7. No patient presented with 70mmHg or less. In the PaO2 excess group, 2 patients had low PaCO2, and the other 5 patients' PaCO2 levels were normal. All standard group patients had standard levels of PaCO2. In the PaO2 low group, 1 patient's PaCO2 level was in the excess level and 3 patients were in the low level. 6 PaO2 low group patients' blood gas had normalized on average, 26 days after the onset of manifestation.

CONCLUSIONS: It can be estimated that there are various factors from this result in the cause of mild dyspnea after diving. Psychiatric problems which caused hyperventilation might be the reason for this. Exists of mechanical failures were indicated, because the PaO2 had improved later. Since "chokes" are considered a serious manifestation, theses cases are difficult to be diagnosed as chokes. However we think that these mechanisms were the same. There were various reasons: psychiatric and/or a mechanism similar to a chokes, why patients felt dyspnea after diving.

J15

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

EFFECTS OF ENDOTOXIN (LPS) ON RATS SUBJECTED TO DECOMPRESSION

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BACKGROUND: Decompression sickness has been shown to produce lung permeability edema due in part to inflammatory mediator release in experimental models. Rats delivered low doses of endotoxin have been shown to reduce lung permeability edema following toxic oxygen exposures. We evaluated the effects of low dose endotoxin administration to rats undergoing hyperbaric decompression.

MATERIALS AND METHODS: Male Sprague-Dawley rats, acclimated to a 12-hour light/dark schedule were injected through a catheter inserted into the jugular vein with 0 (saline) or 5 mg/kg of the endotoxin, lipopolysaccharide from E. Coli. The rats were divided into 12 separate groups consisting of non-decompressed controls and those exposed to compression to 683.29 kPa for 60 minutes and decompression after pre-inoculation with endotoxin by 24, 48 or 72 hours. Post decompression, all groups were observed for gross signs of DCS, and evaluated for pulmonary edema, arterial, pleural and bronchoalveolar lavage protein, differential and white blood cell counts and inflammatory mediator levels (thromboxane B2 and leukotriene E4). Statistics: ANOVA, Fisher's test.

RESULTS: Rats pretreated with endotoxin had reduced extravascular lung water, bronchoalveolar lavage protein, arterial thromboxane B2 and Leukotriene E4 levels (except 24 hrs post injection) and bronchoalveolar lavage Leukotriene E4 levels (to a lesser degree thromboxane B2) compared with controls receiving saline. Changes were also noted in the arterial and bronchoalveolar lavage white cell counts and neutrophils.

CONCLUSIONS: The results indicate some similarities with other studies showing protective effects of endotoxin against permeability edema and its causes in the lungs of affected animals.

J16

Oral Presentation: N/A
Poster Presentation: 1045 - 1200

RETURN TO DIVING AFTER BLEOMYCIN THERAPY - CASE REPORT AND REVIEW

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BACKGROUND: Patients treated with bleomycin may develop pulmonary fibrosis or be sensitized to pulmonary oxygen toxicity. Multiple authors have expressed opinions in the medical literature that patients should not resume diving after bleomycin therapy. A 36 year-old U.S. Navy diver successfully treated for Hodgkin's lymphoma with chemotherapy, including bleomycin, and radiation therapy, desired to resume his career. We critically reviewed the literature, sought expert advice, and formulated a plan to allow his return to diving with careful evaluation.

MATERIALS AND METHODS: Review of literature revealed that prevailing opinion against oxygen exposure was based on a small number of case reports with significant confounding variables, casting some doubt on the strength of evidence. We had concerns regarding the risk of oxygen toxicity if he were to require hyperbaric oxygen therapy (HBOT) for decompression sickness, but one recent case series of 11 patients receiving HBOT after bleomycin without problems provided reassuring evidence. Our patient was evaluated with sequential pulmonary function testing (PFT), including spirometry and diffusion capacity for carbon monoxide (DLCO), beginning with baseline tests prior to and 6 months after completion of bleomycin therapy. He was then exposed to graduated levels of hyperbaric air at up to 60 fsw in a dry chamber and in wet dives. His PFT showed no change from baseline after all exposures and he experienced no pulmonary symptoms.

RESULTS: The patient was allowed to resume U.S. Navy diving. He subsequently participated in multiple routine and experimental diving operations. During participation in an experimental dive series he experienced DCS, which was successfully treated with HBOT (U.S. Navy Treatment Table 6). PFT after treatment and one week later showed no abnormality.

CONCLUSIONS: A patient resumed diving after treatment with bleomycin without pulmonary problems. Under some circumstances, it may be reasonable to allow carefully selected patients to resume diving after bleomycin therapy.

SESSION K: HBO2 Science and Cellular Mechanisms

K1

Oral Presentation: 1045 - 1057
Poster Presentation: 0915 - 1030

MECHANISMS OF EXTENSION OF HBO2 TOLERANCE BY INTERMITTENT AIR BREAKS

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BACKGROUND: Intermittent exposure to air is used as a protective strategy against hyperbaric O2 (HBO2) toxicity. Little is known about optimal intermittent exposure schedules and the mechanism of protection.

MATERIAL AND METHODS: One group of rats was exposed continuously to 2.8 ATA O2 until death. Other groups were exposed to 30, 60, 120 or 180 min intervals of HBO2 with different numbers of intermittent 20 min air breaks (1-12 breaks). After the final break, animals were exposed to HBO2 until death. In a separate experiment, animals were sacrificed before terminal exposure and lung tissue was collected for analysis of different gene expression.

RESULTS: In all intermittent exposure schedules, the maximum O2 survival time was significantly longer, approximately 11 h compared with 7-8 h in the continuous exposure group. The number of air breaks required for developing tolerance varied with the length of the HBO2 interval. However, total HBO2 time required for tolerance formation was the same, 6 h in all intermittent groups (12 breaks in 30 min schedule, 6 breaks in 60 min schedule and 3 breaks in 120 min intermittent schedule). After reaching maximum, the survival time started to decrease, indicating a turning point in HBO2 exposure, from tolerance to toxicity. Continuous exposure to HBO2 resulted in an increase in lung protein nitration as a marker of toxic peroxynitrite formation. The mechanism of this increase involves activation of inducible NOS (iNOS). Both the increase in protein nitration and iNOS activation was eliminated by intermittent air breaks.

CONCLUSIONS: Results show that: a) threshold duration of HBO2 exposure is required for tolerance formation by intermittency, b) tolerance is formed within a time "window" of HBO2 exposure, and c) intermittent air breaks inhibit iNOS activation and increase in protein nitration.

(Supported by ONR Award No: N0001406WR20022)

K2

Oral Presentation: 1057 - 1109
Poster Presentation: 0915 - 1030

LONG TERM FOLLOW UP FOR HYPERBARIC OXYGEN TREATMENT OF OSTEORADIONECROSIS OF THE MANDIBLE

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INTRODUCTION: HBO_2 is frequently given to patients who have received radiotherapy after head and neck cancers to treat symptomatic osteonecrosis and to prevent complications when surgery is required in the irradiated field. We examined our experience in 105 patients collected over a 10-year period.

MATERIALS AND METHODS: After IRB approval, a database search identified 105 HBO_2-ORN patients treated from 4/1998 to 11/2005. Case details, treatment and immediate and long-term outcomes were obtained from the chamber database, the Duke medical record, and telephone calls to the individual patients. 62 patients received HBO_2 for symptomatic ORN (exposed bone) and 29 received HBO_2 to prevent complications following proposed surgery in the irradiated field.

RESULTS:

	Symptomatic ORN	**Preventive HBO2**	**sig**
Radiation dose (mean cGy)	6942	8087	NS
Time, radiation to first symptoms (mean, months)	37.7	N/A	
Immediate response = healed	35 of 64 (58%)	N/A	
Immediate response = improved	21 of 64 (35%)	N/A	
At follow-up remained healed or improved	29 of 39 (74%)	16 of 30 (76%)	NS
Cases of ORN relapse from best status	25 of 64 (39%)	7 of 30 (23%)	NS
Months to ORN relapse, mean (95%CI)	62.6 (40.9, 84.3)	72.8 (56.6, 87.7)	P= 0.03 (log rank)

Original cancer	**Mouth-palate**	**Tongue**	**Tonsil**	**Other**	**sig**
ORN relapsed	16 (57%)	7 (28%)	7 (39%)	1 (5%)	p=.003
Months to ORN relapse, mean (95%CI)	50.0 (20.2, 80.7)	60.9 (43.6, 78.2)	37.2 (.0, 77.4)	79.5 (59.5, 98.8	p=.042 (log rank)
original cancer recurrence	3 (10%)	3 (12%)	2 (10%)	1 (5%)	NS
New cancer (%)	4 (12%)	1 (3%)	1 (5%)	1 (4.8%)	NS

SUMMARY: Adjunctive HBO_2 treatment healed or improved 93% of all symptomatic ORN cases. This benefit is sustained in 74% of symptomatic and 76% of preventive cases with follow-up. Mouth-palate and tonsil cases relapsed sooner.

K3

Oral Presentation: 1109 - 1121
Poster Presentation: 0915 - 1030

NEURONAL NOS AND GLUTAMATE DECARBOXYLASE S-NITROSYLATION BEFORE OXYGEN SEIZURES

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BACKGROUND: Glutamic acid decarboxylase (GAD) is inhibited by HBO2, but the inhibitory mechanisms and their effect on the pathogenesis of oxygen seizures are unknown. Using rats, we have found that HBO2-stimulated NO production inhibits GAD activity by S-nitrosylation. Here, mice lacking eNOS or nNOS were used to examine isoform-specific contributions to brain NO production in protein S-nitrosylation of GAD-65 in HBO2.

MATERIALS AND METHODS: Two series of experiments were conducted. First, anesthetized C57BL/6 wild type (WT) and eNOS-/- or nNOS-/- mice were exposed to HBO2 at 5 ATA for 60 min. NO metabolites (NOx), an indicator of brain NO bioactivity, and 3-nitrotyrosine (3-NT), a marker of peroxynitrite (ONOO-), were measured in striatum by microdialysis coupled with NO-chemiluminescence or HPLC-ED. Second, awake WT and nNOS-/- mice were exposed to 4 ATA HBO2 for 60 min and brain homogenates assayed by the Biotin-switch method in which cysteine and S-nitrosylated cysteine were derivitized by MMTS and biotin-HPDP, respectively. Western blot was performed with streptavidin immunoprecipitated proteins using an antibody to GAD-65 (rabbit polyclonal IgG). Total GAD activity was assayed fluorometrically.

RESULTS: HBO2 increased NOx and 3-NT during the HBO2 exposures in WT and eNOS-/- mice. In contrast, striatal NOx and 3-NTyr did not change significantly in nNOS-/- mice, and seizure latency was extended. Endogenous S-nitrosylation of GAD-65 was detectable at low levels in brain protein of WT mice and were substantially increased at 0 and 60 min after HBO2. In nNOS-/- mice, GAD-65 S-nitrosylation was reduced. S-nitrosylation of GAD-65 protein was associated with inhibition of total GAD activity in WT mice.

CONCLUSIONS: Our data show that: 1) nNOS-derived NO generates the bulk of brain NOx and ONOO-, and 2) HBO2-stimulated neuronal NO production inhibits GAD-65 activity by S-nitrosylation that contributes to an excitatory-inhibitory imbalance, which predisposes to HBO2-induced seizures.

(Supported by the Office Naval Research)

K4

Oral Presentation: 1121 - 1133
Poster Presentation: 0915 - 1030

CONGESTIVE HEART FAILURE AND HBO2T: BRAIN-TYPE ATRIAL NATRIURETIC PEPTIDE MONITORING

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BACKGROUND: Patients receiving HBO2T often have a history of cardiac disease and impaired left ventricular function. Oxygen, a known arterial vasoconstrictor, can increase peripheral vascular resistance and increase left ventricular strain, and potentially precipitating an episode of acute pulmonary edema. Cautious use of HBO2 in patients with congestive heart failure (CHF) is currently recommended. We used serum brain-type natriuretic peptide (sBNP) to monitor ventricular stain in CHF patients during their exposure to the HBO2 environment.

MATERIALS AND METHODS: Patients with a past medical history of CHF or left ventricular dysfunction as evidenced by a left-ventricular ejection fraction (LVEF) ≤ 35% were defined as high-cardiac risk at the initiation of HBO2T. Serum BNP was assayed by micro-particle enzymatic immunoassay (normal range = 0-99 pg/mL). Sequential, high-risk patients during a 8 month time period had sBNP levels determined prior to the initial HBO2T session (baseline) and again after 20-30 hyperbaric exposures.

RESULTS: Five high-risk patients were identified who had at least two sBNP measurements performed. All patients had a positive history of CHF. No episodes of cardiac decompensation or acute pulmonary edema were observed during treatment period. The mean baseline sBNP = 693±650 pg/mL and after 20-30 HBO2 treatments a decrease to 488±325 pg/mL was observed, $p < 0.05$. Four of the five patients experienced a decrease in sBNP levels during HBO2 treatments, mean decrease = -489 pg/mL.

CONCLUSIONS: A small series of patients deemed high risk for adverse cardiac events associated with HBO2T showed no evidence for increased left ventricular strain during HBO2T as reflected by stable or declining sBNP levels during the course of 20-30 HBO2 treatments. Continued cautious application of HBO2T is recommended in any patient with known myocardial dysfunction. The potential risks and benefits must always be weighed on an individual basis by both physician and patient.

K5

Oral Presentation: 1133 - 1145
Poster Presentation: 0915 - 1030

HYPERBARIC OXYGEN ATTENUATE THE CARDIAC NEURAL DYSFUNTION IN STREPTOZOTOCIN INDUCED DIABETIC RATS

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BACKGROUND: Diabetic autonomic neuropathy is the most important contributing factor of diabetic foot ulceration and co-morbid conditions. Effective treatment of autonomic neuropathy in patients with diabetes mellitus is rare. Our previous publication demonstrated that the cardiac neural dysfunction in diabetic foot patients would be attenuated by well-controlled hyperbaric oxygen therapy. The specific aim is to establish an animal model of diabetic cardiac autonomic neuropathy and validate the therapeutic effect of hyperbaric oxygen in attenuating the autonomic neuropathy in diabetic rats.

MATERIALS AND METHODS: We measured the daily heart rate variability of 32 streptozotocin (60 mg/kg, ip) induced diabetic rats during the duration of hyperbaric oxygen therapy, 3 ATA, 60 minutes, 10 dives. Frequency-domain analysis of telemetric measured R-R intervals was applied to quantify the parameters of heart rate variably. High frequency power (HF) was regarded as the vagal modulation of heart rate. Low frequency power (LF) was referred to the overall autonomic nervous function. Ratio of LF to HF (LF/HF) was regarded as the sympathetic modulation.

RESULTS: Hyperglycemia and glucosuria are evident in the experimental animals. The LF and HF of heart rate variability analysis were significantly increased after the initiation of hyperbaric oxygen therapy. The LF/HF was significantly decreased simultaneously.

CONCLUSIONS: This study demonstrates that the attenuation of diabetic cardiac neural dysfunction can be achieved by using hyperbaric oxygenation. The restoration of autonomic nervous function in diabetic rats is mainly derived from the increases of the vagal modulation and the balance between sympathetic and parasympathetic nervous functions. The findings are compatible with that in diabetic foot patients.

K6

Oral Presentation: 1145 - 1200
Poster Presentation: 0915 - 1030

INHIBITION OF NEUTROPHIL Beta-2 INTEGRINS BY HYPEROXIA: SPECIFICITY AND MECHANISM

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BACKGROUND: Exposure to hyperbaric oxygen (HBO2) at pressures of at least 2.8 atmospheres absolute (ATA) O2 for 45 minutes inhibits the ability of circulating neutrophils to adhere to target tissues. This is due to inhibition of activation-dependent beta-2 (B-2) integrin molecules on the cell surface and it has been demonstrated in both animals and humans. Inhibition of neutrophil B-2 integrins has been directly linked to the benefit of HBO2 treatment in numerous animal models, but the mechanism remains unclear. The goal of this study is to determine the biochemical basis for HBO2-mediated B-2 integrin inhibition.

MATERIALS AND METHODS: Wild type and myeloperoxidase-deficient knock-out (MPO-KO) mice were exposed to HBO2, and blood collected for cell and biochemical analysis. S-nitrosylation of proteins was detected using the biotin-switch assay.

RESULTS: HBO2 caused inhibition of wild type neutrophil B-2 integrin-specific adhesion to fibrinogen-coated plates. This was not observed with circulating monocytes from the same animals; nor was it observed with neutrophils from MPO-KO mice. Nitric oxide synthase activity was required for integrin inhibition by HBO2, indicating a role for reactive nitrogen species. We have tentatively identified three cytoskeletal proteins in HBO2-exposed neutrophils that undergo reversible S-nitrosylation in response to HBO2.

CONCLUSIONS: We conclude that myeloperoxidase in primary granules is responsible for generating reactive species that inhibit cytoskeletal control over B-2 integrins when neutrophils are exposed to hyperoxia.

K7

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

THE EFFECT OF HBO TREATMENT ON BROWN RECLUSE SPIDER VENOM INTOXICATION IN VITRO

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BACKGROUND: Brown recluse spider (Loxosceles recluse) bites can, in some people, cause cellulitis. Case reports suggest that HBO treatment may be useful at reducing the extent of injury though the mechanism of action that is unknown. The venom is complex and composed of numerous protein components. We hypothesize that the venom invokes a pro-inflammatory cascade that is interrupted by HBO treatment.

MATERIAL AND METHODS: A murine macrophage cell line, RAW 264.7, was exposed to brown recluse spider venom (BRSV) 40 nanograms per milliliter final concentration, and then treated once a day with HBO 3.0 ATA 90 minutes for up to 3 days. Relative expression of pro-inflammatory genes was measured with rt-PCR. More than 15 genes were evaluated. Changes relative to control greater than 2-fold are considered to be significant. The lot of BRSV used BRSV used was obtained from Texas spiders and has been previously been shown to produce significant cellulitis in rabbits following subcutaneous injection of microgram quantities.

RESULTS: Exposure to BRSV alone did not induce expression of any pro-inflammatory genes. In contrast, HBO treatment, by itself, induced erythropoietin (3.7-fold), IL-1 beta (2.3-fold) and IL-15 (6-fold). Exposure to BRSV followed by treatment with HBO produced gene induction data similar to that observed following HBO treatment alone.

CONCLUSIONS: These results demonstrate that this cell line is unresponsive to BRSV at least with regard to the genes evaluated. In contrast several genes were up-regulated by exposure to HBO suggesting that the cell line is responsive to increased pO2. Some of the most important components of BRSV are lipases (sphingomylinase D) and proteases, and thus macrophages may be particularly resistant to BRSV because of their own copious production of similar enzymes.

K8

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

OXYGEN-REGULATED VEGF LEVELS IN OVARIAN CANCER CELLS

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BACKGROUND: Human tumor cells cultured at pO2=20 kPa are tested as whole-cell vaccines for tumor immunotherapy, but their relevance for hypoxic tumors in situ and their responsiveness to hyperbaric oxygen therapy are unclear. To determine if ovarian cancer (OvCa) cells respond to hypoxia and hyperoxia, we studied the expression of vascular endothelial growth factor (VEGF), a hallmark of OvCa, as a function of pO2.

MATERIALS AND METHODS: We grew human OvCa cells OV17, OV167 or OV207 for three days in 20% fetal bovine serum at pO2=20 kPa until 80% confluent. Then we cultured them at pO2=1 kPa, 20 kPa or 90 kPa for up to 72 h while quantifying proliferation and secreted VEGF121+VEGF165 by ELISA and intracellular hypoxia-inducible factor 1 (HIF-1) by Western blotting.

RESULTS: VEGF concentration increased with time in the media of OvCa cells at all pO2 values ($p<0.01$). While normoxic cells doubled twice over three days, VEGF secretion per cell per hour dropped ($p=0.02$). Hypoxia enhanced the rate of VEGF secretion in all cells. Hyperoxia abolished proliferation ($p=0.0008$), but unexpectedly boosted VEGF secretion ($p=0.0258$). We compared HIF-1 levels in normoxic cells and cells cultured in hypoxia or hyperoxia for 18 to 24 hours; HIF-1 levels in hypoxic cells were higher than in normoxic. Interestingly, hyperoxic cells also expressed high HIF-1 levels paralleling high VEGF secretion.

CONCLUSIONS: Adherent OvCa cells respond both to hypoxia and hyperoxia by elevated levels of HIF-1 and VEGF. As this elevation was prominent in subconfluent growth-arrested hyperoxic cells, it is possible that proliferation and/or contact inhibition diminish HIF-1 levels. These findings support the hypothesis that whole-cell vaccines should be prepared under pO2 akin to that in situ. The findings of high HIF-1 levels in hyperoxic and subconfluent cells necessitate further studies of the underlying mechanism of HIF-1 stabilization.

K9

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

EFFECT OF HYPERBARIC OXYGENATION ON EXPERIMENTAL COLITIS IN RATS

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BACKGROUND: Hyperbaric oxygenation (HBO) has been suggested as a beneficial treatment for patients with inflammatory bowel disease. Our previous study demonstrated that HBO treatment ameliorated indomethacin-induced intestinal ulceration (Dig Dis Sci 51:1426-33, 2006). In this study, we have further evaluated the effects of HBO using a rat model of Dextran Sulfate Sodium (DSS) induced ulcerative colitis.

MATERIALS AND METHODS: 48 male Sprague-Dawley rats divided into 4 groups. Colitis was induced by DSS for 3 days followed by tap water. Group 1: control received only tap water. Group 2: received DSS. Group 3: received DSS followed by HBO treatment until day 8. Group 4: received DSS followed by HBO treatment until day 12. In each group, 6 rats were sacrificed at day 8 and the remaining 6 were sacrificed at day 12. Blood and distal colon were collected for analysis.

RESULTS: Control MPO activity was 3.24. MPO activity was significantly increased by the induction of DSS at day 8 and gradually decreased at 12 days (27.91 and 10.72, respectively). However, MPO activity was significantly increased after treatment with HBO at day 8 and 12 (45.78 and 70.10, respectively) compared to DSS alone. IL-1 Beta concentrations were also increased by DSS induction (148.67 pg/g of tissue) compared to control (117.25). Like MPO activity, HBO treatment further increased tissue IL-1 Beta at day 8 and 12. There was no change in plasma IL-1 Beta level with and without HBO treatment. Tissue and plasma TNF-alpha levels were undetectable at day 8 and 12.

CONCLUSIONS: Our data suggests that in this study group, HBO treatment has no demonstrable positive effect on DSS-induced ulcerative colitis in rats. In fact, elevation of tissue MPO activity and IL-1B concentrations after HBO treatment may indicate a greater level of inflammation in DSS-induced colitis. Clearly, more studies and investigations are needed.

K10

Oral Presentation: N/A
Poster Presentation: 0915 - 1030

PREVENTION AND SUPPRESSION OF PYROGENIC FEVER IN RABBITS BY HYPERBARIC OXYGEN

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BACKGROUND: Current investigation was to determine whether hyperbaric oxygen has an effect on both overproduction of circulating tumor necrosis factor-alpha and fever following intravenous administration of lipopolysaccharide in rabbits.

MATERIALS AND METHODS: The effects of hyperbaric oxygen (100% oxygen at 253 kPa) and normal air (8% oxygen at 101 kPa) on both the core temperature and serum levels of tumor necrosis factor-a were assessed in unanesthetized rabbits in response to lipopolysaccharide. Intravenous administration of lipopolysaccharide (0.5-10 mcg/kg) induced dose-related increased levels of both core temperature and serum tumor necrosis factor-alpha.

RESULTS: Both the febrile responses and overproduction of circulating TNF-alpha could also be suppressed by hyperbaric oxygen and, to some extent hyperbaric air (8% oxygen at 253 kPa), adopted "0" or "60" minutes after an intravenous dose of lipopolysaccharide. Pretreatment with hyperbaric oxygen once a day for consecutive 7 days significantly reduced the lipopolysaccharide-induced overproduction of circulating TNF-alpha as well as fever.

CONCLUSIONS: This study provides the first evidence that hyperbaric oxygen can be used as a prophylactic agent as well as a therapeutic agent for pyrogenic fever. Hyperbaric oxygen therapy could be considered as a possible alternative to conventional antipyretics as well as antibiotics.

Session L: Clinical HBO2 and Ischemia Treatment

L1

Oral Presentation: 1315 - 1327
Poster Presentation: 1445 - 1600

DIRECT EFFECT OF CARBON MONOXIDE ON THE NERVOUS SYSTEM CELLS

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BACKGROUND: Carbon monoxide (CO) toxicity is the result of a combination of tissue hypoxia and direct CO-mediated damage at a cellular level, because not all the signs and symptoms after CO inhalation can be explained only by the formation of carboxyhemoglobin. To investigate the mechanism of the direct CO-mediated damage, cell growth and intracellular signaling of the nervous system cells was observed.

MATERIALS AND METHODS: DBTRG human glioblastoma cells, rat embryo primary nerve cells, and PC-12 rat pheochromocytoma cells were used. The cells were exposed to either air (control group) or 1000 ppm CO in air (CO-exposed group) for 6, 12, 24, and 48 hours in a sealed chamber. Cell growth and viability was measured by a mitochondrial activity-based MTT assay. Neurite outgrowth after stimulation with nerve growth factor (NGF) was evaluated with a phase contrast microscope. The activation of p44/42 mitogen-activated protein kinase (MAPK) was examined by Western blot analysis.

RESULTS: DBTRG cells were very resistant to CO stress and cell viability was not changed after 1000 ppm CO exposure for 48 hours. In contrast, primary nerve cells and PC-12 cells were sensitive to CO and almost of these cells died in 12 hours after 1000 ppm CO exposure. In response to NGF, PC-12 cells revealed obvious neurite outgrowth. However, after exposure to CO (1000 ppm for 12 hours), most cells stopped growing and became round. After stimulation on the CO-exposed PC-12 cells with NGF, p44/42 MAPK phosphorylation was rapidly down-regulated after 60 min; whereas control cells maintained very active MAPK phosphorylation at 60 to 120 min after NGF stimulation.

CONCLUSIONS: Glial cells were very resistant to the CO stress. However, without hypoxia, CO exhibited a direct effect on nerve cells and PC-12 cells and suppressed the cell growth and viability. After CO exposure, PC-12 cells showed down-regulated phosphorylation of p44/42 MAPK. Therefore, the activation of p44/42 MAPK may be involved in the mechanism of the direct CO-mediated damage.

L2

Oral Presentation: 1327 - 1339
Poster Presentation: 1445 - 1600

HYPERBARIC OXYGEN THERAPY IN CYCLOPHOSPHAMIDE-INDUCED ACUTE HAEMORRHAGIC CYSTITIS: REPORT OF SIX CASES

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BACKGROUND: There are few reports of hyperbaric oxygen (HBO) for cyclophosphamide-induced haemorrhagic cystitis (CHC). Six cases are presented.

CASE REPORTS: An 82 year old male with chronic myeloma presented with CHC requiring 35 units transfusion. During 38 HBO; his haematuria ceased and he was discharged with an indwelling catheter for long-standing prostate problems. He remained well until a short terminal illness 19 months later.

A 65 year old female with Churg-Strauss Syndrome presented with CHC requiring 18 units transfusion. She also had alpha-1 antitrypsin deficiency with severe emphysema and was a high risk for pulmonary barotrauma. After 26 HBO, haematuria was mild. At three months, she had occasional mild haematuria, similar to her pre-cyclophosphamide state.

A 64 year old female suffering from systemic lupus erythematosis (SLE), cirrhosis and portal hypertension presented in acute urinary retention with haemoglobin 63 g.l-1. She required 17 units transfusion. During 28 HBO, her haematuria settled, and at three months she remained free of haematuria.

A 40 year old male with Wagener's granulomatosis presented with CHC which settled with 20 HBO. He remained free of further haematuria over more than two years follow-up.

A 19 year old male developed CHC following bone marrow transplantation for acute myelocytic leukaemia. Haematuria settled during 30 daily HBO, and he remained well 11 months later.

A 15 year old female with antiphospholipid syndrome, secondary SLE and bilateral renal vein thromboses on anticoagulation presented with CHC. She also had a history of bilateral spontaneous pneumothoraces. During 30 HBO her haematuria ceased, and remained so at one-year follow-up.

CONCLUSIONS: With the underlying pathologies and CHC, these patients present management challenges for HBO. All six patients failed to respond to conventional therapy over weeks or months, but responded to HBO with cessation of haematuria. We contend HBO should now be regarded as the treatment of choice for CHC.

L3

Oral Presentation: N/A
Poster Presentation: 1445 - 1600

FRACTIONATED STEREOTACTIC RADIOTHERAPY USING GAMMA UNIT AFTER HYPERBARIC OXYGENATION ON RECURRENT HIGH-GRADE GLIOMAS

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BACKGROUND: To reduce complications and to enhance the radiation effect to hypoxic cells of high-grade gliomas, we performed noninvasive fractionated stereotactic radiotherapy (FSRT) using a Gamma unit combined with hyperbaric oxygen (HBO) therapy for the treatment of recurrent disease.

PATIENTS & METHODS: Twenty-five consecutive patients who had previously received radiotherapy with chemotherapy for recurrent high-grade gliomas, including 14 patients with anaplastic astrocytoma (AA) and 11 with glioblastoma multiforme (GBM), underwent gamma FSRT immediately after HBO therapy (2.5 atmospheres absolute for 60 minutes). The Gamma FSRT was repeatedly performed using a relocatable head cast. Median tumor volume was 8.7 cc (range, 1.7-159.3 cc), and the median total radiation dose was 22 Gy (range, 18-27 Gy) to the tumor margin in 8 fractions.

RESULTS: Actuarial median survival time after FSRT was 19 months for patients with AA and 11 months for patients with GBM, which was significantly different ($p = 0.012$, log-rank test). Two patients underwent subsequent second FSRT for regional or remote recurrence. Seven patients (28%) underwent subsequent craniotomies and resections at a mean of 8.4 months after FSRT treatment, and 4 of them had radiation effects without viable cells and remained alive for 50 to 78 months.

CONCLUSIONS: Gamma FSRT after HBO therapy appears to confer a survival benefit for patients with recurrent high-grade gliomas and warrants further investigation.

L4

Oral Presentation: 1339 - 1351
Poster Presentation: 1445 - 1600

HYPERBARIC OXYGEN IN LOWER LIMB TRAUMA (HOLLT): DESIGNING A RANDOMIZED CONTROLLED MULTI-CENTRE STUDY

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BACKGROUND: Crush injury and acute traumatic ischaemia are considered indications for HBO by many in the hyperbaric field. This is supported by animal models but most human research is uncontrolled and the randomized trial frequently quoted (Bouachour et al 1996) is difficult to interpret as there is no information on important outcomes such as fracture union, wound infection, osteomyelitis or long term disability. Given the practical difficulties of treating trauma patients with HBO it is hardly surprising that there is very little use of HBO for trauma.

MATERIALS AND METHODS: We conducted a randomized double blinded pilot study of early HBO in open tibial fracture with severe soft tissue injury. 17 patients were enrolled over 18 months. We have used this experience to design an international multi-centre randomized controlled trial.

RESULTS: HOLLT plans enrolment of 250 patients with Gustilo 3 open tibial fracture who will be randomized within 24 hours of injury to receive 12 HBO sessions over 8 days or not, in addition to normal trauma care. The study is "open label" based upon logistics, cost and avoidance of detriment from transporting control patients. Follow up will continue for two years. We have drawn upon Best Practice guidelines for clinical trials plus experts in trauma research and clinical trials design. Collaborating centers are necessarily limited to those with suitably designed and located chambers at trauma centers. Enrolments have commenced in Melbourne, Australia and ethics approvals have been received or are in process at a number of European and United States centers.

CONCLUSIONS: Acute phase trauma research is difficult as a result of injury heterogeneity, acuity and the complex and busy logistics of early management. HBO in this environment can be difficult but is feasible with good facilities and experienced teams. We will welcome additional collaborators.

L5

Oral Presentation: 1351 - 1403
Poster Presentation: 1445 - 1600

IDENTIFICATION OF THE EARLY TIME WINDOW POST STROKE FOR HYPERBARIC OXYGEN EFFICACY IN THE TREATMENT OF ACUTE STROKE: A RETROSPECTIVE STATISTICAL ANALYSIS

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BACKGROUND: FDA approved treatment for acute stroke is IV Tissue Plasminogen Activator (rt-PA) within 3 hours post stroke. Rusyniak, et al. (1) and Nighoghossian, et al. (2) examine Hyperbaric Oxygen (HBO2) treatment for acute stroke in the 5 to 24 hour period post stroke with non-conclusive efficacy. To compare the efficacy of HBO2 for treatment of acute stroke in an earlier time window, we conducted a retrospective statistical analysis of the Heyman, Saltzman, Whalen (3) study of 22 HBO2 treated stroke patients with 13 patients in the 1 to 5 hour post stroke category. Stroke improvement found occurred within minutes of HBO2 application--never longer than 30 minutes.

MATERIALS AND METHODS: For our analysis we examined those patients who received HBO2 treatment (3) within 7 hours post stroke. An exploratory logistic regression analysis examining the influence of time-post-stroke, time-in-chamber, and dose of HBO2 (range 2.02 ata to 3.04 ata) was conducted.

RESULTS: Only time-post-stroke was a significant influence for recovery, with each passing hour decreasing the chance of at least partial transient recovery by 62%, Odds Ratio: 0.38 (95% CI: 0.15 - 0.95), p = 0.039. In the 1 to 5 hour group of 13 patients, 9 (41% of 22) had recovery or recovery with relapse. This represented 69% (+/- 25% SE) of this time frame. Only 2 of the 9 had permanent recovery. Past 6 hours post stroke, only 1 patient (11% +/- 21% SE) had partial recovery with relapse. The other 8 past 6 hours had no recovery at all.

CONCLUSIONS: A multi-center randomized controlled study of HBO2 treatment of acute stroke is needed. First 3 hours post stroke HBO2 administration has the most promise for efficacy and improvement of tPA therapy. HBO2 may also prove to be a useful challenge pre-tPA administration to assess the risk benefit ratio for giving tPA.

REFERENCES:
1. Rusyniak DE, et al. STROKE 34:571-574. 2003.
2. Nighoghossian N, et al. STROKE 26:1369-1372. 1995.
3. Heyman A, et al. CIRCULATION 33&34:II20-II27. 1966.

L6 (President's Competition)
Oral Presentation: 1403 - 1430
Poster Presentation: 1445 - 1600

HYPERBARIC OXYGEN PRECONDITIONING COST-EFFECTIVELY IMPROVES MYOCARDIAL FUNCTION & CLINICAL OUTCOME FOLLOWING ISCHEMIC REPERFUSION INJURY

Yogaratnam JZ[1,2], Laden G[3], Bennette S[4], Riggs C[4], Hong H[4], Gower S[4], Evans P[4], Smith RO[4], Saleh A[4], Guvendik L[1], Cowen M[1], Cale A[1], Griffin S[1]
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BACKGROUND: This study assessed the effects of HBO preconditioning, on myocardial function, clinical and economic outcome post ischemic reperfusion injury (IRI).

MATERIALS AND METHODS: This randomised control study of patients having coronary artery bypass graft (CABG) surgery using cardiopulmonary bypass (CPB), consisted of 40 and 41 patients in Groups A (Control) and B (HBO), respectively. HBO preconditioning started 4 hours prior to CABG for 90 minutes at 2.4 ATA using 100% oxygen. Pulmonary artery catheters were used to obtain haemodynamic measurements post induction, 5 minutes, 2, 4, 8, 12 and 24hours post CPB. Patient Analysis & Tracking System (PATS) was used to obtain clinical outcomes post CABG.

RESULTS: Prior CPB, Group B had lower pulmonary vascular resistance (PVR) ($p = 0.03$). Post CPB, Group B had increased stroke volume (SV) ($p = 0.01$), left ventricular stroke work (LVSW) ($p = 0.005$) and left ventricular stroke work index (LVSWI) ($p = 0.02$). Cardiac output (CO) post CPB was higher in Group B, but not significantly. ($p=0.06$). Intra-operatively, Group B had a 39.2% reduction in intra-operative blood loss. Post CABG, Group B had a reduction in blood loss (11.2%), blood transfusion (12.7%), low cardiac output syndrome (10.4%), inotorope use (8%), atrial fibrillation (AF) (11%), pulmonary complications (12.7%) and wound infections (7.6%). While Group A had neurological (2.5%) and renal (5%) complications, Group B had none. Both groups had similar post CABG gastro-intestinal complication. Post CABG, patients in Group B had 24minutes and 36minutes longer mechanical ventilation and intubation time, respectively, but spent 6 hours less in the ICU, saving US$570.57 per patient, US$96.51 per saved ICU hour, making a total savings of US$19,399.10.

CONCLUSIONS: HBO preconditioning prior to IRI improves myocardial function post CABG. It reduces PVR thus indicating increased pulmonary vascular flow. Furthermore it decreases of post CABG complications and shortens ICU recovery time thus saving cost.

L7 (President's Competition)
Oral Presentation: 1403 - 1430
Poster Presentation: 1445 - 1600

THE CARDIOPROTECTIVE EFFECTS OF HYPERBARIC OXYGEN PRECONDITIONING PRIOR TO ISCHEMIC REPERFUSION INJURY INVOLVES A SYNERGISTIC LINK BETWEEN eNOS & sICAM-1

Yogaratnam JZ[1,3,4], Laden G[2], Madden LA[3], Guvendik L[1], Cowen M[1], Greenman M[3], Seymour AM[3], Cale A[1], Griffin S[1]
[1]Department of Cardiothoracic Surgery, Castle Hill Hospital; [2]North of England Hyperbaric & Medical Services, Classic Hospital; [3]Clinical Bioscience Institute, Wolfson Building; and [4]Department of Biological Sciences, University of Hull, UK

BACKGROUND: This study examined the effects of HBO preconditioning, on soluble intercellular cell adhesion molecule (sICAM)-1 and myocardial endothelial nitric oxide synthase (eNOS) in a human model of ischemic reperfusion injury (IRI).

MATERIALS AND METHODS: This randomized control study of coronary artery bypass graft (CABG) surgery patients, involving cardiopulmonary bypass (CPB), consisted of Group A (n=40, Control) and B (n=41, HBO). HBO preconditioning started 4 hours before CABG for 90 minutes at 2.4 ATA using 100% oxygen. Blood was sampled pre HBO (all patients), post HBO (Group B), 5minutes after onset of CPB, 5minutes post IRI, 2 and 24hours post CPB. Right atrial biopsies were sampled post induction, 5minutes after onset of CPB, 5minutes post IRI, and 5minutes post CPB. Blood serum and atrial protein extracts were analyzed using quantitative ELISA for sICAM-1, and eNOS. Haemodynamics were measured post induction, 5minutes, 2, 4, 8, 12 and 24hours post CPB.

RESULTS: Post HBO, sICAM-1 increased. Post IRI, Group B's sICAM-1 increased ($p = 0.03$). Group B's sICAM-1 2hours post CPB positively correlated with LVSWI 4hours post CPB ($p=0.02$). Group B's eNOS post induction (i.e. post HBO) was higher. Group B's eNOS decreased greater between induction and onset of CPB. During IRI, Group A's eNOS decreased while Group B's increased. Following IRI, eNOS decreased in both groups but remained higher in Group B. Group B's eNOS at the onset of CPB positively correlated with PVR ($p=0.03$) and PVRI ($P=0.01$) 2hours post CPB. Group B's eNOS post IRI correlated positively with LVSW ($p=0.05$) and LVSWI ($p=0.006$) 4 hours post CPB and, negatively with PVRI ($p=0.02$) 24hours post CPB.

CONCLUSIONS: HBO preconditioning prior to CABG and IRI increased myocardial eNOS and sICAM-1. This is was associated with enhanced myocardial function and pulmonary vascular flow. This suggests a synergistic link between myocardial eNOS expression, sICAM-1 and cardioprotection in this model.

L8 (President's Competition)
Oral Presentation: 1403 - 1430
Poster Presentation: 1445 - 1600

HYPERBARIC OXYGEN PRECONDITIONING PROMOTES CARDIOPROTECTION FOLLOWING ISCHEMIC REPERFUSION INJURY BY IMPROVING MYOCARDIAL FUNCTION, LIMITING NECROSIS & ENHANCING THE INDUCTION OF HSP72

Yogaratnam JZ[1,3,4], Laden G[2], Madden LA[3], Guvendik L[1], Cowen M[1], Greenman M[3], Seymour AM[3], Cale A[1], Griffin S[1]
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BACKGROUND: Ischemic reperfusion injury (IRI) occurs during coronary artery bypass graft surgery (CABG). While hyperbaric oxygen (HBO) post IRI is known to limit myocardial damage, this study clinically assessed the cardioprotective effects of HBO prior to IRI i.e. HBO preconditioning, during CABG.

MATERIALS AND METHODS: This randomized control study of patients having CABG using cardiopulmonary bypass (CPB) consisted of 40 and 41 patients in Groups A (Control Group) and B (HBO Group), respectively. HBO preconditioning occurred 4 hours prior to CABG for 90 minutes at 2.4 ATA using 100% oxygen. Venous blood was taken pre HBO, 5 minutes after onset of CPB, 5 minutes post IRI, 2 and 24 hours post CPB. Right atrial biopsies were taken post induction, 5 minutes after onset of CPB, 5 minutes post IRI, and 5 minutes post CPB. Blood sera and biopsies protein extracts were analyzed using a quantitative sandwich ELISA for Troponin-T, and Hsp72. Haemodynamic measurements, using a pulmonary artery catheter, were taken post induction, 5 minutes, 2, 4, 8, 12 and 24 hours post CPB.

RESULTS: Post CPB, Group B showed significantly greater increases in stroke volume (SV) ($p = 0.01$), left ventricular stroke work (LVSW) ($p = 0.005$) and left ventricular stroke work index (LVSWI) ($p = 0.02$). Myocardial Hsp72 ($p=0.09$) and serum Troponin-T ($p=0.7$) were not statistically different between the groups. However following IRI, Hsp72 decreased in Group A but increased in Group B and there was a smaller rise in the quantity of serum Troponin-T in Group B.

CONCLUSIONS: HBO preconditioning prior to IRI improves myocardial SV, LVSW, and LVSWI. It preserves the myocardium by limiting myocardial necrosis and the release of Troponin-T. Furthermore, it enhances the synthesis of myocardial Hsp72 following IRI, suggesting that it is capable of inducing myocardial protective mechanisms leading to protein repair and improved function following IRI.

L9 (President's Competition)
Oral Presentation: 1403 - 1430
Poster Presentation: 1445 - 1600

THE KINETICS OF THE SELECTIN GROUP OF ADHESION MOLECULES FOLLOWING HYPERBARIC OXYGEN PRECONDITIONING IMPROVE MYOCARDIAL FUNCTION & PULMONARY FLOW IN A HUMAN MODEL OF ISCHEMIC REPERFUSION INJURY

Yogaratnam JZ[1,3,4], Laden G[2], Madden LA[3], Guvendik L[1], Cowen M[1], Greenman M[3], Seymour AM[3], Cale A[1], Griffin S[1]
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BACKGROUND: To assess the effects of hyperbaric oxygen (HBO) preconditioning on the kinetics of soluble selectin in a human model of ischemic reperfusion injury (IRI).

METHODS: This randomized control study of coronary artery bypass graft (CABG) surgery patients, involving cardiopulmonary bypass (CPB), consisted of Group A (n=40, Control) and B (n=41, HBO). HBO preconditioning started 4 hours before CABG for 90 minutes at 2.4 ATA using 100% oxygen. Blood was sampled pre HBO (all patients), post HBO (Group B only), 5minutes after onset of CPB, 5minutes post IRI, 2 and 24hours post CPB. sPSGL-1, sP-Selectin and sE-Selectin were analyzed using quantitative sandwich ELISA. Haemodynamics were measured post induction, 5minutes, 2, 4, 8, 12 and 24hours post CPB.

RESULTS: Post HBO, sPSGL-1 increased (p=0.03). Intra and post-operatively, Group B's sPSGL-1 remained higher. Group B's sPSGL-1 after onset of CPB correlated positively with SV (p=0.02), CO (p=0.02), LVSW (p=0.003) and LVSWI (p=0.002) 4hours post CPB. Group B's, sPSGL-1 post IRI correlated positively with LVSW (p=0.02) and LVSWI (p=0.006) 4hours post CPB and, negatively with PVR (p=0.03) 24hours post CPB. Post HBO, intra and post-operatively, sP-Selectin was higher in Group B but during IRI it decreased in Group B and increased in Group A. Group B's post IRI sP-Selectin correlated negatively (p=0.02) with SV and positively with PVR (p=0.003) 12hours post CPB. Group A's sP-Selectin post IRI positively correlated (p=0.004) with intraoperatively blood loss. Post HBO, sE-Selectin decreased. Pre-HBO to the onset of CPB, sE-Selectin increased significantly in Group B but not in Group A (p=0.02). Following IRI, sE-Selectin remained higher in Group B (p=0.02). 24hours post CPB, sE-Selectin positively correlated with SV (p=0.04) and LVSWI (p=0.02).

CONCLUSIONS: We conclude that HBO preconditioning affected the kinetics of soluble selectin in a manner that leads to improved myocardial function and pulmonary flow following IRI and CABG.

L10

Oral Presentation: N/A
Poster Presentation: 1445 - 1600

QUALITY OF LIFE IMPROVED AFTER HYPERBARIC OXYGEN THERAPY FOR LATE RADIATION EFFECT INJURIES INDUCED BY RADIATED BRACHIAL PLEXUS

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BACKGROUND: Radiation-induced brachial plexopathy (RIBP) is a problematic complication of radiotherapy. Hyperbaric oxygen therapy is effective for some radiation damage, current data suggests it does not reverse or slow the effects of radiation-induced brachial plexopathy.

CASE REPORT: 47 y/o right-hand dominated female with right supraclavicular Hodgkin's lymphoma was diagnosed and treated with chemotherapy in 1973. A right axillary recurrence in 1975 was treated with chemotherapy and radiation. A T-cell-rich B cell lymphoma on her right arm in 2004 was treated with three cycles of CHOP/Rituxan chemotherapy followed by radiation therapy (XRT) of 3000 cGy. Following XRT she developed numbness of right arm with progressively worsening subjective coolness, weakness and decreased range of motion. On exam, her grip strength diminished (1-2/5) on the right with ataxia and inability to write her name legibly. A trial of pentoxifylline showed minimal improvement. Finally, she was treated with HBO2 (2.4 ATA for 90 minutes x 58 treatments).

RESULTS: Patient had marked improvement in strength, decrease in numbness, and regained ability to sign her name legibly.

CONCLUSIONS: After treating this patient with HBO2, she had remarkable changes in strength and coordination, which resulted in return to normal daily activities. This is at odds with Pritchard, et al, that there is no reliable evidence to support the use of HBO2 therapy to slow or reverse RIBP.

L11 (President's Competition)
Oral Presentation: N/A
Poster Presentation: 1445 - 1600

ISOLATED PERIPHERAL CN VII AND PHRENIC NERVE PALSIES FOLLOWING OXYGEN-ENRICHED THERAPEUTIC AIR SATURATION DECOMPRESSION: A CASE REPORT

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BACKGROUND: Decompression Illness is a protean disease with varied presentations, often making diagnosis difficult and treatment complicated. Traditional teaching has held that neurological DCS is primarily spinal, and isolated peripheral nerve lesions are uncommon. We report a case of a commercial diver who developed peripheral nerve DCI following a chamber dive with oxygen-enriched therapeutic air saturation decompression.

CASE REPORT: A 26 year old male commercial diver was compressed to 186 fsw in a DDC to aid another diver with severe CNS DCI. Prolonged CPR necessitated oxygen-enriched Miller air sat decompression for the diver and physician. Psychosocial issues and patient concern of oxygen toxicity led to decreases in treatment gas periods, confrontations over control of treatment/deco, refusal of treatment of right face paresthesias that developed at shallow depths, and obscuring of signs and symptoms of CN VII and phrenic nerve palsies that developed 2-3 hours after surfacing.

RESULTS: After a five hour surface interval the diver was recompressed with 4 lower pressure-tailing treatments. Facial paralysis resolved in two weeks. Phrenic nerve paralysis persisted, but was symptomatically improved.

CONCLUSIONS: A deep extreme exposure chamber dive with vigorous physical exertion at depth resulted in DCS in two peripheral nerves, despite oxygen-enriched air sat decompression. Case management was suboptimal due to complicated psychosocial problems. Physician patience and persistence led to successful diagnosis and resolution of one nerve palsy with low pressure tailing treatments and time.

L12 (President's Competition)
Oral Presentation: N/A
Poster Presentation: 1445 - 1600

ACUTE CARBON MONOXIDE POISONING FROM VOLITIONAL HOOKAH SMOKE INHALATION

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BACKGROUND: Tobacco dependence remains the leading preventable cause of death and disease worldwide. Its epidemic use continues to thrive in various forms, including the emergence and increasing popularity of the hookah water pipe in the United States. The hookah pipe, although widely considered "safe" by the general public, delivers 36 times more tar, 15 times more carbon monoxide and 70% more nicotine than a single cigarette.

CASE REPORT: A 32 year old male smoker was emergently referred to our facility for evaluation of symptomatic carbon monoxide toxicity. He had been at a local hookah café prior to arrival, and had been smoking from a hookah water pipe for 90 minutes. He developed symptoms of acute dizziness and collapsed twice without a loss of consciousness. Upon arrival, the emergency medicine physicians determined that his neurological and physical examinations were normal. His venous carboxyhemoglobin level was 28.8%. He was treated with 100% oxygen via non-rebreather mask for 4 hours and then referred for hyperbaric medicine consultation. A detailed neurological assessment was performed, (Mini Mental Status Exam was 29/30). Additionally, he had a failed sharpened Romberg, and delayed trails B on neurological battery test. He was immediately treated with hyperbaric oxygen therapy and serially reassessed at 48 hours and 14 days.

RESULTS: Following hyperbaric oxygen therapy, the patient subjectively felt greatly improved. He reported a greater ease of breathing, and improved mentation. Additionally, his neurological exam normalized. On follow up, he was feeling back to his normal self, and his close peers confirmed a return to his baseline functioning. No further treatment required.

CONCLUSIONS: This case identifies that acute carbon monoxide poisoning can occur from volitional hookah use.

L13

Oral Presentation: N/A
Poster Presentation: 1445 - 1600

HYPERBARIC OXYGEN THERAPY (HBO) FOR IDIOPATHIC SUDDEN DEAFNESS ON SCALED OUT CASES

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BACKGROUND: Idiopathic sudden deafness occurs unilaterally and spontaneous healing is often ensued. Although the scaled out cases in audiogram are rare, the prognosis is supposedly poor even treated by corticosteroids and/or HBO with few reports.

MATERIALS AND METHODS: Grade 4 deafness (over 90dB at five frequencies from 250 to 4000 Hz) of 94 cases (21%) past 15 years were selected from idiopathic sudden deafness of 542 cases excluding recurrent progressive deafness or mumps viral infection. When more than three frequencies were scaled out (over 100db), "total deafness" of 62 cases was defined, while when one or two frequencies were scaled out, " intense deafness" of 32 cases was defined. HBO (2.0~2.8 ATA=60min.) was performed five days a week for average 19.9 days±6.8 along with predonisolone and/or PGE1.

RESULTS: Overall improvement of hearing in grade 4 deafness was average 21.7 dB±19.7 including 30 cases (32%) of " unchanged". "Total deafness" obtained average 18.3 dB including 42% of "unchanged", while "intense deafness" obtained average 28.1 dB including 16% of "unchanged". For those younger than 39 years old, 32 cases gained average 25.9 dB including 31% of "unchanged" , while for those older than 40 years old, 62 cases gained average 19.0 dB including 32% of "unchanged". Hearing improvement was remarkable in the younger age group when HBO was initiated within a week. When HBO was initiated by seventh day after onset, hearing was improved to average 24.4 dB (44 cases), 8th ~14th day average 25.0 dB (36 cases), 15th ~ 21st average 15.8 dB (8 cases), after 22nd average 2.1 dB (6 cases). After termination of HBO, hearing was only improved to average 4.9 dB±12.0 (33 cases) in 2 ~ 6 months.

CONCLUSIONS: Approximately one third of "scaled out" cases were not responded to HBO even if HBO was initiated early. Although not related to the age, more the grade of "scaled out" was severe, or the later HBO was initiated, the percent of non-responders were increased.

L14

ABSTRACT WITHDRAWN

L15

Oral Presentation: N/A
Poster Presentation: 1445 - 1600

HYPERBARIC OXYGEN THERAPY USED TO TREAT INTRACTABLE ANEMIA DUE TO RADIATION INDUCED ESOPHAGITIS AND GASTRITIS

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BACKGROUND: Hyperbaric Oxygen Therapy is approved for treating delayed radiation soft tissue injury. Head and neck soft tissue necrosis, cystitis, proctitis, and enteritis caused by radiation therapy are approved indications for HBOT according to UHMS Hyperbaric Oxygen Therapy 1999 Committee Report. The following is a case report of HBOT used to successfully resolve refractory bleeding due to radiation induced esophagitis and gastritis.

CASE REPORT: Diagnosed with gastric adenocarcinoma, the patient underwent partial esophagogastrectomy, followed by chemotherapy and radiation therapy. Six months after completing radiation therapy, patient developed shortness of breath and generalized weakness which were attributed to anemia. Endoscopy revealed active bleeding and inflammation in residual esophagus and stomach. Despite repeated endoscopic cauterization, patient continued to have symptomatic bleeding. He was transfused a total of 7 units of blood in 34 days with no response in hematocrit. Patient underwent 40 treatments of hyperbaric oxygen. Each treatment consisted of breathing oxygen at 2.4 atm for three 30 minute periods separated by 5-minute air breaks. Patient's response to therapy was assessed by monitoring symptoms, hematocrit, and repeat endoscopy.

RESULTS: Hematocrit stabilized with patient requiring no additional transfusions after 3rd hyperbaric treatment and reached normal range by the 28th treatment. Repeat endoscopic exam after 30 treatments of HBOT demonstrated marked improvement in both esophageal and gastric mucosa. Minimal bleeding was still detected, and patient was given additional 10 treatments. The patient has not had recurrence of gastrointestinal bleeding, anemia, or cancer for the last 18 months.

CONCLUSIONS: HBOT is effective therapy for delayed radiation sequelae. In addition to head and neck soft tissue necrosis, cystitis, proctitis, and enteritis, HBOT should also be considered in the event of other radiation induced soft tissue injuries such as esophagitis and gastritis.

L16

Oral Presentation: N/A
Poster Presentation: 1445 - 1600

CEREBRAL AIR-GAS EMBOLISM DUE TO REMOVAL OF QUINTON CATHETER

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BACKGROUND: Hyperbaric oxygen therapy is well established as definitive therapy for air-gas embolism. Air-gas embolism is typically associated with exposure to rapid atmospheric changes that occur diving underwater or flying, but can also occur iatrogenically. The following is a case study of radio-graphically proven air-gas embolism causing cardiac arrest following removal of a Quinton catheter.

CASE PRESENTATION: After undergoing hemodialysis, a Quinton catheter was removed from right internal jugular vein since patient's AV graft was demonstrated to be reliably functioning. Shortly after removal of the catheter, the 58 year old male patient complained of "not feeling well". Within 10 minutes of catheter removal, he lost consciousness. He was noted to have no pulse and received 8-10 minutes of CPR. Patient lost both bowel and bladder continence, and he was confused when he first regained consciousness. Subsequently, sensorium cleared rapidly, but patient was noted to have the residual neurologic deficits persisting approximately one hour after the event. He had decreased sensation to soft touch in stocking distribution in left lower extremity and abnormally slow alternating movements with both hands. CT scan of brain demonstrated air embolism in cavernous sinuses, sellar and suprasellar regions, and superior sagittal sinus. The patient was treated with hyperbaric oxygen utilizing the Navy Treatment Table VI.

RESULTS: Following treatment with hyperbaric oxygen, sensorium remained clear and all neurologic deficits resolved. Repeat CT of the brain demonstrated resolution of air gas embolism.

CONCLUSIONS: With increased utilization and development of intravascular devices and procedures, the risk for iatrogenic air-gas embolism is likely to increase. A high index of suspicion for the entity should be maintained in the face sudden cardiovascular or neurologic changes in patients recently undergoing intravascular procedures since prognosis is excellent if hyperbaric therapy is instituted in a timely manner.

L17

Oral Presentation: N/A
Poster Presentation: 1445 - 1600

ACUTE PERIPHERAL ISCHEMIA FROM HEPARIN INDUCED THROMBOCYTOPENIA: TREATMENT WITH HYPERBARIC OXYGEN THERAPY

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BACKGROUND: Acute Traumatic Peripheral Ischemia is a recognized indication for Hyperbaric Treatment. Heparin Induced Thrombocytopenia (HIT) is a serious complication of heparin therapy. 20% of these patients will have an acute thrombotic event with mortality as high as 30%, and limb loss from acute ischemia at 20 to 30%.

PATIENT HISTORY: The patient is a 58 year old Caucasian female with a history of type 2 diabetes, hypertension, and hyperlipidemia. She underwent suprasellar resection of a pituitary adenoma and developed HIT. Her immediate postoperative course was complicated by popliteal venous thrombosis, line infection and bacteremia. She developed an acute ischemic event in the left forefoot. Angiography revealed no evidence of peripheral arterial disease or proximal vein thrombosis. The diagnosis of venous limb gangrene and acute peripheral ischemia from HIT was made. She was started on intravenous argatroban (anticoagulation) and referred for urgent hyperbaric treatments.

CLINICAL COURSE: Hyperbaric treatment was a 45 fsw /90 minutes oxygen table. Hyperbaric TcPO2 showed values over 1000 mmHg at the knee, 500 mmHg above the midfoot, and 64 mmHg in the zone of ischemia. After 10 hyperbaric treatments, her foot had stabilized and a transmetatarsal amputation was planned. The argatroban was stopped, but before surgery could be performed she developed acute thrombotic events in both upper extremities. The argatroban was restarted and she resumed hyperbaric therapy. She had a total of 23 treatments with near complete resolution of the ischemia. No amputation was required.

CONCLUSIONS: While the underlying cause was different, the mechanism of this event appears to be the same as that of Acute Traumatic Peripheral Ischemia and responded to hyperbaric therapy. Further patient study is suggested for the use of hyperbaric oxygen as a possible treatment to prevent limb loss from HIT.

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