



UNDERSEA & HYPERBARIC MEDICAL SOCIETY

Raising the quality of practice one member at a time



2017 Annual Scientific Meeting



June 29 – July 1

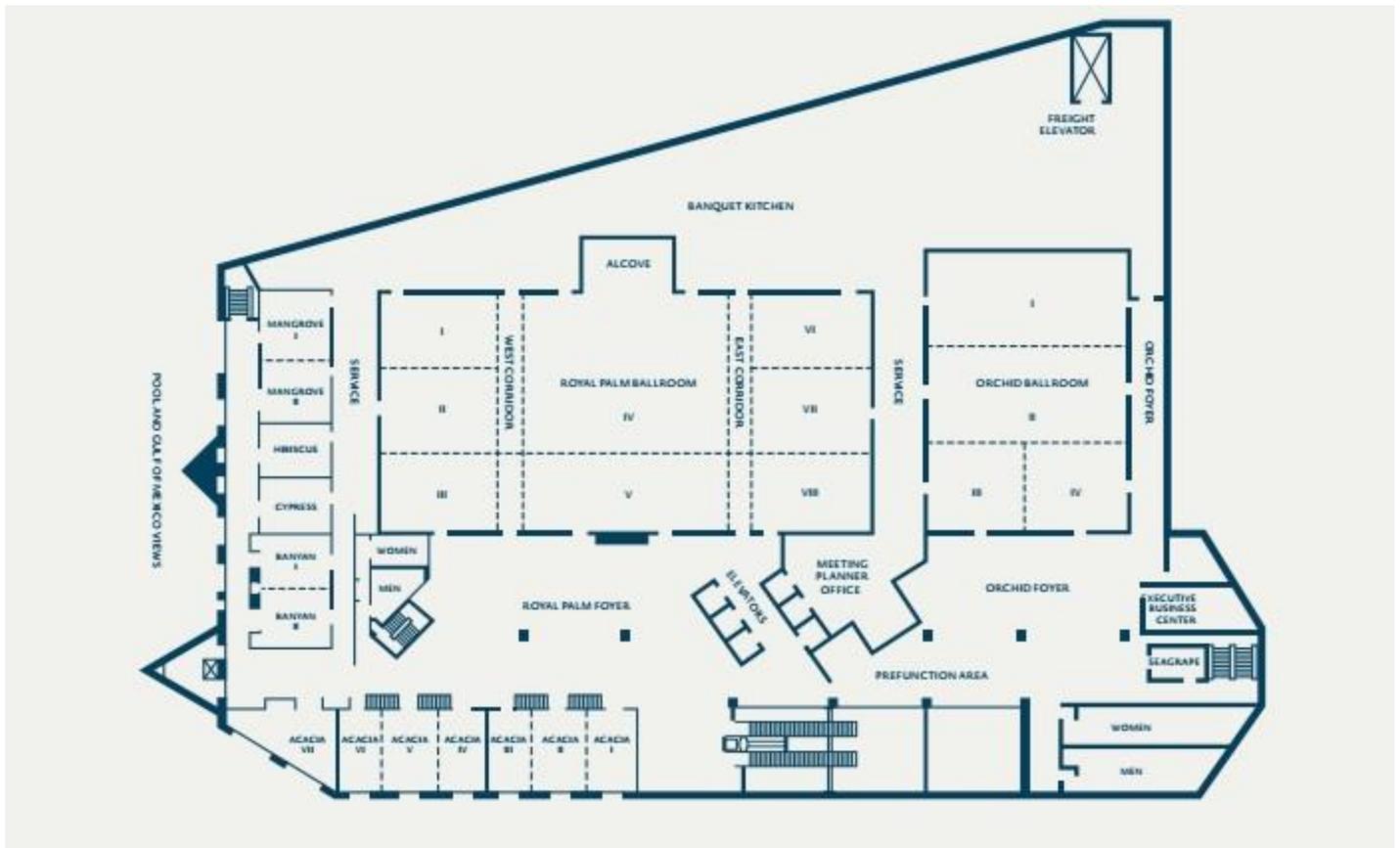
Pre-courses: June 28 / Post-course: July 2



Wound Care
Education
Partners



NAPLES GRANDE BEACH RESORT, NAPLES, FLORIDA



Wednesday, June 28:

- How to Prepare for Accreditation: **Royal Palm Ballroom I**
- Hyperbaric Oxygen Safety: Clinical and Technical Issues: **Royal Palm Ballroom II**
- Management of DCI in the Field and Development of Best Practice: **Royal Palm Ballroom III**
- **Welcome Reception: Mangrove Pool side**

Thursday, June 29:

- Exhibits: **Orchid Ballroom**
- Posters: **Royal Palm Foyer**
- General Session: **Royal Palm IV-VIII**
- Non-Physician Breakout Session: **Royal Palm I-III**

Friday, June 30:

- Exhibits: **Orchid Ballroom**
- Posters: **Royal Palm Foyer**
- General Session: **Royal Palm IV-VIII**

Saturday, July 1:

- Exhibits: **Orchid Ballroom**
- Posters: **Royal Palm Foyer**
- General Session: **Royal Palm IV-VIII**

Sunday, July 2:

- Reimbursement Rollercoaster: **Acacia 4-6**
- Surveyor Training: **Acacia 1-3**

TABLE OF CONTENTS

Subject	Page No.
UHMS Committee Leadership Listing	4
Schedules	
Pre-Courses.....	5-6
Non-Physician Breakout Track.....	6-7
General Session	7-8
Abstract Schedule	8-15
Post-Courses	16
Committee Meetings	17-18
Continuing Education	19-20
Evaluation / MOC Credit Information.....	21
Disclosures	22-26
Exhibitors	27-29
SESSIONS/ABSTRACTS	
THURSDAY GENERAL SESSION.....	30-55
PRESIDENT’S ADDRESS.....	31
PLENARY: “The History of the Undersea and Hyperbaric Medical Society (1967-2017)”	32-33
SESSION A: Diving/Decompression Illness: Theory & Mechanisms.....	34-44
LAMBERTSEN MEMORIAL LECTURE: “Arterial Gas Embolism”	45-46
SESSION B: HBO ₂ Therapy Mechanisms.....	47-54
PLENARY: “HBO ₂ for Mild Traumatic Brain Injury”	55
FRIDAY GENERAL SESSION	56-104
EXECUTIVE DIRECTOR’S ADDRESS	57
PLENARY: “An update on the UHMS Clinical Practice Guidelines”.....	58
SESSION C: Clinical HBO ₂ Therapy	59-79
KINDWALL MEMORIAL LECTURE: “Beams and Bars: Radiation Oncology and Hyperbaric Medicine, an Inseparable Story, Past, Present and Future”	80-82
SESSION D: Diving & Decompression Illness.....	83-103
PLENARY: “Emergency and Critical Care Hyperbaric Medicine: A Lost Art”	104
SATURDAY GENERAL SESSION	105-147
PLENARY: “International Perspectives on Hyperbaric Oxygen Therapy”	106-107
SESSION E: HBO ₂ Therapy, Chambers & Equipment	108-125
PLENARY: “New Pearls of Wisdom in the Diving and Hyperbaric Medicine Literature”	126
SESSION F: Clinical and Diving-Related HBO ₂ Therapy	127-146
PLENARY: “A Futurist’s Guide to Undersea and Hyperbaric Medicine: Where will we be in another 50 years?”	147
Author Abstract Index.....	148-150
2018 Annual Meeting: Save the Date	150

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Sociedade Brasileira de Medicina Hiperbárica (SBMH)
Società Italiana di Medicina Subacquea ed Iperbarica (SIMSI)
South Pacific Underwater Medicine Society (SPUMS)

SCHEDULES

PRE-COURSES: WEDNESDAY, JUNE 28

Pre-Course: How to Prepare for Accreditation	
TIME	
8:00-8:15	Welcome/Introductions
8:15-9:45	Why Accredit Clinical Hyperbaric Facilities?
9:45-10:00	<i>Break</i>
10:00-11:30	Why Accredit Clinical Hyperbaric Facilities? Con't
11:30-12:00	Hyperbaric Facility Accreditation Program Design (I)
12:00-1:00	<i>Lunch</i>
1:00-1:45	Hyperbaric Facility Accreditation Program Design (II)
1:45-2:30	Physician Issues
2:30-2:45	<i>Break</i>
2:45-3:30	Nursing Issues
3:30-3:45	Technical Issues

Pre-Course: Hyperbaric Oxygen Safety: Clinical and Technical Issues	
TIME	
8:00-8:15	Welcome/Introductions
8:15-9:15	Thirty Years of Critical Care in the Monoplace Risk Assessment Through Interactive Case Discussion Panel Discussion
9:15-10:15	Risk Assessment Through Interactive Case Discussion Panel Discussion Break
10:15-10:30	<i>Break</i>
10:30-10:50	Hyperbaric Adverse Events: 2012-2015
10:50-11:10	Code Silver / Active Shooter
11:10-11:30	The Importance of Completing Checklists to Ensure Safe Patient Care
11:30-12:00	Panel Q&A from the morning session
12:00-1:00	<i>Lunch</i>
1:00-1:50	Material selection for hyperbaric use – past and present: Part I
1:50-2:45	Material selection for hyperbaric

Pre-Course: Pre-hospital Management of Decompression Illness: Towards Development of Definitive Modern Guidelines	
TIME	
8:30-9:00	Welcome/Introductions
9:00-9:45	Presentations of decompression illness and diagnostic pearls
9:45-10:15	Discussion: Q/A
10:15-10:35	<i>Break</i>
10:35-11:20	First aid strategies for decompression illness and the evidence underpinning them
11:20-11:50	Discussion: Q/A
11:50-12:20	Common pitfalls when divers present to hospitals or doctors without expertise in diving medicine
12:20-12:35	Discussion: Q/A
12:35-1:30	<i>Lunch</i>
1:30-2:15	Remote triage of the possible decompression illness case by diving medicine experts
2:15-2:45	Discussion: Q/A

			use – past and present: Part II		
3:45-4:15	Organizational Planning	2:45-3:00	<i>Break</i>	2:45-3:15	Transporting a diver with decompression illness and the effect of increasing delay to recompression on outcome
4:15-4:30	Discussion/Questions	3:00-3:30	Understanding static electricity	3:15-3:35	<i>Break</i>
4:30	<i>Adjourn</i>	3:30-4:00	Understanding flammability testing	3:35-4:05	Discussion: Q/A
		4:00-4:45	Material selection: Putting new information into practice	4:05-4:50	The controversial issue of in-water recompression
		4:45-5:15	Panel Q & A from the afternoon session	4:50-5:20	Discussion: Q/A
		5:15-5:30	Closing/Questions	5:20-5:35	Closing remarks
6:00-8:00	Welcome Reception	6:00-8:00	Welcome Reception	6:00-8:00	Welcome Reception

NON-PHYSICIAN BREAKOUT TRACK: THURSDAY, JUNE 29

TIME		
8:00-8:30	President's Address (General Session Room: Palm 4-8)	Enoch Huang, MD
	NON-Physician Track Kick-Off	
8:30-8:40	Welcome & Introductions	Matt Schweyer, CHT
8:40-9:00	UHMS Associates Update	Gus Gustavson, RN
9:00-9:20	BNA Update	Gus Gustavson, RN
9:20-9:30	Q & A	
9:30-10:00	<i>Break/Exhibits</i>	<i>Break/Exhibits</i>
10:00-10:20	Calculating Hyperbaric Treatment Pressure while at Altitude	Philip Schell
10:20-10:40	Building a Hyperbaric Emergency Preparedness Program: Meeting the Needs of Employee Readiness and Certification	Andrew Melnyczenko
10:40-11:00	Achievement Recognition Scholarship Abstract: One Puzzle Solved	Nituna Phillips
11:00-11:20	Successful Treatment of a Patient with a Left Ventricular Assist Device with Hyperbaric Oxygen at 2.4 ATA	Marc Pullis
11:20-11:40	Hyperbaric Oxygen Therapy and the Deaf Patient	M. Ansley Evans

11:40-12:00	Complex Zygodactyly Release with Post-op Complications on a 32year-old female	Lise Crapella
12:00-1:00	Lunch	Lunch
1:00-2:00	Lambertsen Keynote: "Arterial Gas Embolism" (General Session Room: Palm 4-8)	Tom Neuman, MD
2:00-2:20	Computers in the multi-place chamber environment	Bill Gearhart, CHT
2:20-2:40	Hyperbaric Oxygen for Chronic Anal Fissures: Case Report and Discussion	Judy Ptak
2:40-3:00	Q & A	
3:00-3:30	Break	Break
3:30-4:00	Ask the Experts	Schweyer/Gustavson

GENERAL SESSION: THURSDAY, JUNE 29 – SATURDAY, JULY 1

	Thursday, June 29 General Session Royal Palm 4-8	Friday, June 30 General Session Royal Palm 4-8	Saturday, July 1 General Session Royal Palm 4-8
7:00-8:00	Continental Breakfast/Exhibits	Continental Breakfast/Exhibits	Continental Breakfast/Exhibits
8:00-8:30	Welcome to Florida's Paradise Coast of Naples, Marco Island & the Everglades Mr. Jack Wert, Executive Director, Florida's Paradise Coast CVB 8:00-8:10	Executive Director's Address: John Peters	Plenary Session: "International Perspectives on Hyperbaric Oxygen Therapy" Gerardo Bosco, MD, Mahito Kawashima, MD & Folke Lind, MD
	President's Address: Enoch Huang, MD		
8:30-9:30	Plenary Session: "The History of the Undersea and Hyperbaric Medical Society (1967-2017)" Richard Moon, MD & Peter Bennett, PhD	Plenary Session: "An update on the UHMS Clinical Practice Guidelines" John Feldmeier, DO & Jaleh Mansouri, MD	
9:30-10:00	BREAK/EXHIBITS Posters open to view at leisure	BREAK/EXHIBITS Posters open to view at leisure	BREAK/EXHIBITS Posters open to view at leisure
10:00-11:15	Session A: Diving / Decompression Illness: Theory & Mechanisms	Session C: Clinical HBO2 Therapy	Session E: HBO2 Therapy, Chambers, and Equipment
11:15-11:37	Poster Session 1	Poster Session 5	
11:37-12:00	Poster Session 2	Poster Session 6	

12:00-1:00	Lunch Posters open to view at leisure	Lunch Posters open to view at leisure	Lunch Posters open to view at leisure
1:00-2:00	Lambertsen Keynote: "Arterial Gas Embolism" Tom Neuman, MD	Kindwall Keynote: "Beams and Bars: Radiation Oncology and Hyperbaric Medicine, An Inseparable Story, Past, Present and Future" John Feldmeier, DO	"New Pearls of Wisdom in the Diving and Hyperbaric Medicine Literature" Daniel Popa, MD & Mark Binkley, MD
2:00-3:15	Session B: HBO2 Therapy Mechanisms	Session D: Diving and Decompression Illness	Session F: Clinical and Diving-Related HBO2 Therapy
3:15-3:45	Break/Exhibits Posters open to view at leisure	Break/Exhibits Posters open to view at leisure	Break/Exhibits Posters open to view at leisure
3:45-4:07	Poster Session 3	Poster Session 7	Poster Session 11
4:07-4:30	Poster Session 4	Poster Session 8	Poster Session 12
4:30-5:30	Plenary Session: "HBO2 for mild traumatic brain injury" Lindell Weaver, MD	Plenary Session: "Emergency and Critical Care Hyperbaric Medicine: A Lost Art" Ian Grover, MD & Peter Witucki, MD	Plenary Session: "A Futurist's Guide to Undersea and Hyperbaric Medicine: Where will we be in another 50 years?" Simon Mitchell, MD & Stephen Thom, MD
5:30-6:00		UHMS Business Meeting	
6:00-7:00	Dine Around Naples 6pm-11:00pm Transportation provided by Florida's Paradise Coast CVB	Exhibitor Wine & Cheese Reception	
7:00-9:00	Past President's Dinner		Awards Banquet (separate fee)
9:00-10:00			
10:00-12:00			After Party (separate fee)

THURSDAY, JUNE 29

SESSION A: Diving / Decompression Illness: Theory & Mechanisms

Oral Presentation: 10:00 – 11:12

Poster Session 1: 11:15-11:37

Poster Session 2: 11:37 – 12:00

Oral Presentation: 10:00 - 10:12 Poster Session 2: 11:37 - 12:00	A 1	Carbon dioxide levels common in diving stimulate neutrophils to produce microparticles containing pro-inflammatory interleukin-1β Thom SR, Bhopale VM, Yang M
Oral Presentation: 10:12 - 10:24 Poster Session 2: 11:37 - 12:00	A 2	Modeling HPNS: the molecular dynamics approach Bliznyuk A, Grossman Y, Moskovitz Y
Oral Presentation: 10:24 - 10:36 Poster Session 2: 11:37 - 12:00	A 3	Hyperbaric oxygen inhibits interleukin-1β production and joint inflammation following provocative decompression Thom SR, Yu K, Bhopale VM, Yang M
Oral Presentation: 10:36 - 10:48 Poster Session 2: 11:37 - 12:00	A 4	Fast, near optimal iso-risk ascent profile algorithm for air and enriched air dives Howle LE, Murphy FG, King AE
Oral Presentation: 10:48 - 11:00 Poster Session 2: 11:37 - 12:00	A 5	Evidence of inheritable determinants of decompression sickness in rats Lautridou J, Buzzacott P, Belhomme M, Dugrenot E, Lafère P, Balestra C, Guerrero F.
Oral Presentation: 11:00 - 11:12 Poster Session 2: 11:37 - 12:00	A 6	Probabilistic models for predicting the incidence and onset time of DCS after scoring marginal DCS cases as non-events Murphy FG, Swingler AJ, Gerth WA, Howle LE
Oral Presentation: n/a Poster Session 1: 11:15 - 11:37	A 7	Decompression sickness onset time bimodality is not related to dive type or severity King AE, Murphy FG, Howle LE
Oral Presentation: n/a Poster Session 1: 11:15 - 11:37	A 8	Decompression sickness manifestations in the uw sheep model after “drop-out” decompression from a 24-hour hyperbaric exposure at 33 and 45 fsw Sobakin AS, Lehner CE, Gendron-Fitzpatrick AP, Eldridge MW
Oral Presentation: n/a Poster Session 1: 11:15 - 11:37	A 9	Effects of ketogenic diet in divers breathing enriched air nitrox Bosco G, Rizzato A, Quartesan S, Camporesi E, Mangar D, Paganini M, Cenci L, Malacrida S, Mrakic-Sposta S, Moretti S, Paoli A
Oral Presentation: n/a Poster Session 1: 11:15 - 11:37	A 10	Helicopter vibration measurements and simulator development Grabau P, Blake DF, Brown LH, Huppertz G, Cooksley D, Aitken P

SESSION B: HBO₂ Therapy Mechanisms

Oral Presentation: 2:00 – 3:15

Poster Session 3: 3:45 – 4:07

Poster Session 4: 4:07 – 4:30

Oral Presentation: 2:00 - 2:12 Poster Session 3: 3:45 - 4:07	B 1	Hyperbaric and high-oxygen environments reduce circulating inflammatory cells, convert infiltrated macrophage phenotype, and activate satellites cell following skeletal muscle contusion in rats Oyaizu T, Enomoto M, Horie M, Yagishita K
Oral Presentation: 2:12 - 2:24 Poster Session 3: 3:45 - 4:07	B 2	Hyperbaric oxygen activates mitochondrial biogenesis in skeletal muscle Alvarez Villela M, Dunworth SA, Kraft BD, Harlan N, Natoli, MJ, Parker CK, Schinazi EA, Piantadosi CA, Moon RE
Oral Presentation: 2:24 - 2:36 Poster Session 3: 3:45 - 4:07	B 3	Hyperbaric oxygen treatment reduces mortality and suppresses acute hepatic inflammation in a model of septic peritonitis Halbach JL, Hawisher D, Wang A, Cauvi DM, Rosales J, Reyes T, Bickler S, De Maio, A and Perdrizet GA
Oral Presentation: 2:36 - 2:48 Poster Session 3: 3:45 - 4:07	B 4	The effects of HBO₂ after long-duration and moderate-intensity exercise on fatigue: A single-blind, cross-over randomized trial Yagishita K, Enomoto M, Shimoda M, Horie M, Oyaidu T, Okawa A
Oral Presentation: 2:48 - 3:00 Poster Session 3: 3:45 - 4:07	B 5	Doppler ultrasound imaging of in situ human kidney stones in hyperbaric conditions Simon JC, Dunmire B, Cunitz BW, Sapozhnikov OA, Thiel J, Kramer CC, Courtney TC, Bailey MR, Holm JR
Oral Presentation: 3:00 - 3:15 Poster Session 3: 3:45 - 4:07	B 6	The effect of hyperbaric oxygen on the mitochondrial metabolism of human renal cells in culture Ozcan D, Hightower LE, Perdrizet GA, Giardina C
Oral Presentation: n/a Poster Session 3: 3:45 - 4:07	B 7	Inflammatory hypoxia a common barrier to oxygen delivery to tissues Perdrizet GA

FRIDAY, JUNE 30

SESSION C: Clinical HBO₂ Therapy

Oral Presentation: 10:00 – 11:12

Poster Session 5: 11:15-11:37

Poster Session 6: 11:37 – 12:00

Oral Presentation: 10:00 - 10:12 Poster Session 6: 11:37 - 12:00	C 1	Carbon monoxide exposure and timely hyperbaric oxygen therapy Sharma D, Heyboer M, Muruganatham K, Wojcik S
Oral Presentation: 10:12 - 10:24 Poster Session 6: 11:37 - 12:00	C 2	Hyperbaric oxygen therapy is safe and effective for hospitalized ulcerative colitis patients suffering from moderate-severe flares: A multi-center, randomized, double-blind, sham-controlled trial Dulai PS, Buckley JC, Raffals LE, Swoger JM, Claus PL, O'Toole K, Ptak JA, Gleeson MW, Widjaja CE, Adler JM, Patel N, Skinner LA, Haren SP, Goldby-Reffner K, Thompson KD, Knight R, Chang JT, Siegel CA

Oral Presentation: 10:24 - 10:36 Poster Session 6: 11:37 - 12:00	C 3	Iatrogenic arterial gas embolism case series treated with hyperbaric oxygen DuBose CR, Hendriksen SM, Westgard BC, Walter JW, Masters TC, Orwig DM, Logue CJ
Oral Presentation: 10:36 – 10:48 Poster Session 6: 11:37 - 12:00	C 4	Eyetracker outcomes in a randomized trial of hyperbaric oxygen or sham in participants with persistent post-concussive symptoms Lindblad AS, Weaver LK, Wetzell P, Mulatya C, Wilson SH, Kannan MA, Villamar Z
Oral Presentation: 10:48 – 11:00 Poster Session 6: 11:37 - 12:00	C 5	A randomized trial of hyperbaric oxygen in us service members with post-concussive symptoms Weaver LK, Wilson SH, Lindblad AS, Churchill S, Deru K, Price R, Williams C, Orrison WW, Walker J, Meehan A, Mirow S, and the BIMA study team
Oral Presentation: 11:00 - 11:12 Poster Session 6: 11:37 - 12:00	C 6	Case series of frostbite injury treated with hyperbaric oxygen and prospectively evaluated with cutaneous microangiography (LUNA) Orwig D, Masters T, Hendriksen S, Logue C
Poster Session 6: 11:37 - 12:00	C 7	Adherence to intervention and follow-up in a randomized clinical trial of hyperbaric oxygen sessions versus sham Lindblad AS, Wilson SH, Weaver LK, Churchill S, Deru K
Poster Session 6: WITHDREW	C 8	Case report: Hyperbaric oxygen treatment for non-healing above-knee amputation Olson M, Byrne JL
Poster Session 6: 11:37 - 12:00	C 9	Innovative therapeutic strategies in the treatment of refractory osteomyelitis Kawashima M, Kawashima M, Tamura H, Yamaguchi T
Poster Session 6: 11:37 - 12:00	C 10	Dose dependent effects of hyperbaric oxygen therapy in children with autism spectrum disorder Colls N, Slade J, Williams B
Poster Session 5: 11:15 - 11:37	C 11	The role of hyperbaric oxygen in the treatment of calciphylaxis Marosek NJ, Skrukud BM, Bock FA, Millman MP
Poster Session 5: 11:15 - 11:37	C 12	Hyperbaric oxygen therapy used to manage suspected chemotherapy induced hemorrhagic cystitis Habana CE, Vishwakarma M, Claus P
Poster Session 5: 11:15 - 11:37	C 13	HBO₂ and severe Crohn's disease: case report Borges HLL, Souza LC, Paz MA, Meurer R
Poster Session 5: 11:15 - 11:37	C 14	Hyperbaric oxygen treatment for refractory hemorrhagic cystitis after cyclophosphamide therapy. Case report and review of reported cases German DS, McLennan GP, Gildehaus AJ, Hezel LM
Poster Session 5: 11:15 - 11:37	C 15	Cerebral arterial gas embolism in a patient with hypoplastic left heart syndrome treated with emergent hyperbaric oxygen: Case report Binkley M, Kelly MP, Hardy K
Poster Session 5: 11:15 - 11:37	C 16	Maxillary osteoradionecrosis and flap reconstruction successfully treated with adjunctive hyperbaric oxygen therapy Sharma D, Jennings S, Morgan M, Santiago W, Tatum S, Heyboer M
Poster Session 5: 11:15 - 11:37	C 17	Treating with hyperbaric oxygen therapy for necrotizing fasciitis Yamaguchi T, Kawashima M, Kawashima M, Tamura H, Nagayoshi I, Motoyama T, Furue Y, Sasaki T, Watanabe Y, Goto T, Takao K, Miyata K
Poster Session 5: 11:15 - 11:37	C 18	Effect of repetitive sessions of hyperbaric oxygen on patients with delayed neurological sequelae after acute carbon monoxide poisoning: Two case reports Choi S, Oh SH, Kim H, Lee DI

Poster Session 5: 11:15 - 11:37	C 19	Hyperbaric oxygen therapy for the treatment of radiation-induced vaginal necrosis Johnson-Arbor K
Poster Session 5: 11:15 - 11:37	C 20	Failed flap successfully treated with hyperbaric oxygen Sharma D, Jennings S, Morgan M, Santiago W, Gonzalez L, Heyboer M

SESSION D: Diving and Decompression Illness

Oral Presentation: 2:00 – 3:15

Poster Session 7: 3:45 – 4:07

Poster Session 8: 4:07 – 4:30

Oral Presentation: 2:00 - 2:12 Poster Session 8: 4:07 - 4:30	D 1	Epidemiology of morbidity and mortality in US and Canadian recreational scuba diving Buzzacott PL, Schiller D, Crain J, Marshall S, Denoble PJ.
Oral Presentation: 2:12 - 2:24 Poster Session 8: 4:07 - 4:30	D 2	Is recurrent decompression a risk factor for altitude DCI? A case series of F/A 18 pilots Landry D, Apicella A, Savaser D, Witucki P
Poster Session 8: 4:07 - 4:30	D 3	A mixed model to predict high daily diving frequency among artisanal fishermen in Mexico Chin W, Huchim O, Ninokawa S, Joo E, Huey L, Ramachandran M
Poster Session 8: 4:07 - 4:30	D 4	Understanding the distribution of daily diving frequency among small-scale artisanal fishermen Chin W, Huchim O, Joo E, Lee T, Moon K, Ramachandran M, Ninokawa S
Poster Session 8: 4:07 - 4:30	D 5	Understanding the distribution of dives completed per day completed by small-scale fishermen over a four-year period Chin W, Huchim O, Ninokawa S, Ramachandran M, Joo E
Oral Presentation: 2:48 - 3:00 Poster Session 8: 4:07 - 4:30	D 6	Flying after diving: Is a 24 hours surface interval appropriate advice for consecutive multiday diving? St Leger Dowse M, Shaw S, Smerdon G
Oral Presentation: 3:00 - 3:12 Poster Session 8: 4:07 - 4:30	D 7	Project Poseidon: Medical requirements for establishing a seaspace station Whelan H, Renaldo C, Guined J, Dituri J
Poster Session 8: 4:07 - 4:30	D 8	Hyperbaric oxygen treatment of decompression sickness: Case reports from Louisiana State University Undersea and Hyperbaric Medicine Fellowship Program Shamitko G, Hickey B, Pavelites J, Murphy-Lavoie H, LeGros TL
Poster Session 8: 4:07 - 4:30	D 9	Diving related injuries in Swedish working divers in relation to gender, age, work ability, stress and underwater work hours Hagberg M
Poster Session 8: 4:07 - 4:30	D 10	Acral peeling skin syndrome (APSS) in a recreational diver Chimiak JM, Dolens B, Nochetto M, Buzzacott P
Poster Session 7: 3:45 - 4:07	D 11	How many fishermen divers recognized signs and symptoms of decompression illness but did not seek medical attention in Yucatan Rivera N, Huchim O, Chin W, Mendez N
Poster Session 7: 3:45 - 4:07	D 12	A case of decompression sickness in a surface-supplied air dive caused by rapid ascent after facial blunt trauma struck by weight of ascent line Oh SH, Kang HD, Jung SK, Yang WS, Lee YJ

Poster Session 7: 3:45 - 4:07	D 13	Delayed diagnosed of spinal cord decompression illness: A case report Niizeki Y, Kojima Y, Oyaizu T, Enomoto M, Horie M, Suzuki S, Yagishita K
Poster Session 7: 3:45 - 4:07	D 14	Process to consider fitness to dive in a working diver with insulin-dependent diabetes: A reference case description Hagberg M
Poster Session 7: 3:45 - 4:07	D 15	Trailing hyperbaric oxygen treatments for inner ear decompression sickness Sharma D, Jennings S, Morgan M, Santiago W, Mariani P, Heyboer M
Poster Session 7: WITHDREW	D 16	Decompression illness: Clinical aspects of 100 consecutive cases treated in a single hyperbaric unit Eshita IR
Poster Session 7: 3:45 - 4:07	D 17	Posterior reversible encephalopathy and thoracic myelopathy following decompression illness Conrad EC, Kelly MP
Poster Session 7: 3:45 - 4:07	D 18	Decompression sickness in divers after altitude exposure and treatment with hyperbaric oxygen (HBO₂) Thurman RT, Weaver LK, Deru K
Poster Session 7: 3:45 - 4:07	D 19	How should we evaluate cardiac risk in the older asymptomatic scuba diver? DuBose CR, Hendriksen SM, Westgard BC, Walter JW, Masters TC, Orwig DM, Logue CJ
Poster Session 7: 3:45 - 4:07	D 20	Articular pain among fishermen divers from Yucatán, comparative cross sectional Rivera N, Lezama G, López F, Ramayo V, Mendez N

SATURDAY, JULY 1

SESSION E: HBO₂ Therapy, Chambers, and Equipment

Oral Presentation: 10:00 – 11:12

Poster Session 9: 11:15-11:37

Poster Session 10: 11:37 – 12:00

Oral Presentation: 10:00 - 10:12 Poster Session 10: 11:37 - 12:00	E 1	Monoplace hyperbaric chamber atmosphere oxygen concentration during patient treatment sessions Koumandakis G, Weaver LK, Deru K, Bell J
Oral Presentation: 10:12 - 10:24 Poster Session 10: 11:37 - 12:00	E 2	Improvements in teamwork, care quality, and patient safety through the implementation of an emergent hyperbaric treatment checklist Omodt S, Westgaard B, Walter J, Masters T, Hendriksen S, Logue C
Oral Presentation: 10:24 - 10:36 Poster Session 10: 11:37 - 12:00	E 3	Hyperbaric oxygen therapy (HBO₂) prepayment audit: discrepancies between noridian reviewers and the community standard of care Huey L, Joo E, Fang S, Chin W, Sprau S
Oral Presentation: 10:36 - 10:48 Poster Session 10: 11:37 - 12:00	E 4	Performance of the Uni-Vent Eagle™ Model 754 ventilator under hyperbaric conditions Popa DA, Waterhouse L, Duchnick JJ, Witucki PJ
Oral Presentation: 10:48 - 11:00 Poster Session 10: 11:37 - 12:00	E 5	The effect of compression rate and slope on the incidence of Eustachian tube dysfunction and middle ear barotrauma: a phase i prospective quasi-experimental study Varughese L, O'Neill OJ, Marker J, Perez L, Smykowski E, Coronel JC, Dayya D
Oral Presentation: 11:00 - 11:12 Poster Session 10:	E 6	Critical thinking – inside of the box: establishing best practice in the hyperbaric medicine clinic through in situ simulation Marosek N, Klein B, Melnychenko A, Higgins J, Balgeman J, Harms H

11:37 - 12:00		
Poster Session 10: 11:37 - 12:00	E 7	The Vortran® Automatic Resuscitator: A pilot study at depth and altitude Siegel MW
Poster Session 10: 11:37 - 12:00	E 8	Successful treatment of a patient with a left ventricular assist device with hyperbaric oxygen at 2.4 ATA Pullis MK, Orwig DM, Hendriksen SM, Masters TC, Westgard BC, Walter JW, Dubose CR, Logue CJ
Poster Session 9: 11:15 - 11:37	E 9	Allocation concealment in a blinded, randomized trial of hyperbaric oxygen for post-concussive symptoms Churchill S, Weaver LK, Wilson SH, Lindblad AS, Deru K
Poster Session 9: 11:15 - 11:37	E 10	Adverse events (AEs) in a blinded, randomized trial of hyperbaric oxygen (HBO₂) for post-concussive symptoms Churchill S, Weaver LK, Wilson SH, Lindblad AS, Deru K
Poster Session 9: 11:15 - 11:37	E 11	Building a hyperbaric emergency preparedness program: Meeting the needs of employee readiness and certification Melnyczenko A, McManimon V, Higgins J, Balgeman J, Marosek N
Poster Session 9: WITHDREW	E 12	Early termination of hyperbaric oxygen therapy Samimi F, Chivate J
Poster Session 1: Thursday, June 29: 11:15 - 11:37	E 13	Expectant management of bilateral pneumothoraces while treating severe carbon monoxide poisoning in a mechanically ventilated trauma patient Sward D, Sethuraman K, Rosenthal R
Poster Session 9: 11:15 - 11:37	E 14	Programmable ventriculo-peritoneal shunt use under hyperbaric conditions Johnson-Arbor K, Evans K, Hutson C, Barry R
Poster Session 9: 11:15 - 11:37	E 15	Calculating hyperbaric treatment pressure while at altitude Schell P, Lindsey C
Poster Session 9: 11:15 - 11:37	E 16	Hyperbaric oxygen therapy and the deaf patient Evans M, Johnson-Arbor K, Kulkarni N
Poster Session 9: 11:15 - 11:37	E 17	Type III decompression sickness: failure of a home built hyperbaric chamber Kathmann B, Pavelites J, Shamiko G, Siegel M, Murphy-Lavoie H, LeGros TL

SESSION F: Clinical and Diving-Related HBO₂ Therapy

Oral Presentation: 2:00 – 3:15

Poster Session 11: 3:45 – 4:07

Poster Session 12: 4:07 – 4:30

Oral Presentation: 2:00 - 2:12 Poster Session 12: 4:07 - 4:30	F 1	Hyperbaric oxygen therapy in the treatment of complex regional pain syndrome (CPRS). Zanon V, Vezzani G, Camporesi EM, Bosco G
Oral Presentation: 2:12 - 2:24 Poster Session 12: 4:07 - 4:30	F 2	Magnetic resonance imaging (MRI) after hyperbaric oxygen treatment for osteonecrosis of the knee (ONK) Vezzani G, Manelli D, Rao N, Dalvi PH, Camporesi EM, Bosco G
Oral Presentation: 2:24 - 2:36 Poster Session 12: 4:07 - 4:30	F 3	Radiographic and clinical response to hyperbaric oxygen therapy in symptomatic brain tumor survivors with ischemic radiation vasculopathy Arenson EB, Morin C, Snively S, Vernon W
Oral Presentation: 2:36 - 2:48 Poster Session 12:	F 4	Compressed gas diving fatalities in the province of QUEBEC: 1986-2015 Pollock NW, Buteau D

4:07 - 4:30		
Oral Presentation: 2:48 - 3:00 Poster Session 12: 4:07 - 4:30	F 5	Hyperbaric oxygen therapy for the prevention of arterial gas embolism in food grade hydrogen peroxide ingestion Hendriksen SM, Menth NL, Westgard BC, Cole JB, Walter JW, Masters TC, Logue CJ
Oral Presentation: 3:00 - 3:15 Poster Session 12: 4:07 - 4:30	F 6	Best practice guidelines and algorithm established for treatment and referral of patients with diabetic foot ulcers. Gwilliam AM, Critz D, Gustavson RB
Poster Session 12: 4:07 - 4:30	F 7	Dropped gallstones present with chronic fistula seven years after laparoscopic cholecystectomy Cui B, Thurman R, Tettleback W, Freiberger J
Poster Session 12: 4:07 - 4:30	F 8	Hyperbaric oxygen for chronic anal fissures: Case report and discussion Ptak JA, Reetz SB, Buckley JC
Poster Session 12: 4:07 - 4:30	F 9	Improved homonymous hemianopia with hyperbaric oxygen therapy Kelly JK, Slade JB
Poster Session 11: 3:45 - 4:07	F 10	Traumatic optic neuropathy treated with hyperbaric oxygen therapy and steroids Sethuraman K, Sward D, Rosenthal R, Shulman M, Alexander J
Poster Session 11: 3:45 - 4:07	F 11	Complex zygodactyly release with post-op complications on a 32year-old female Crapella L, Havriliak D, Lally R, Johnson T, Martinez C, Butler G
Poster Session 11: 3:45 - 4:07	F 12	Issues with self-injection of cosmetic fillers Henderson R, Reilly DA, Cooper JS
Poster Session 11: 3:45 - 4:07	F 13	One puzzle solved Phillips N, Evans M, Johnson-Arbor K
Poster Session 11: 3:45 - 4:07	F 14	The use of mafenide acetate (Sulfamylon) under hyperbaric conditions: Case report and literature review Johnson-Arbor K, Attinger C
Poster Session 11: 3:45 - 4:07	F 15	The use of hyperbaric oxygen therapy for skin necrosis after liposuction Johnson-Arbor K, Evans K, Sher S
Poster Session 11: 3:45 - 4:07	F 16	Reticulocytosis after hyperbaric treatments in a Jehovah's Witness patient with acute blood loss anemia Johnson-Arbor K, Evans M, Verstraete R
Poster Session 11: 3:45 - 4:07	F 17	Stability of preserved hearing and cochlear implant function following multiple scuba dives Zeitler DM, Almosnino G, Holm JR
Poster Session 11: 3:45 - 4:07	F 18	Hyperbaric oxygen therapy for complications of elective cosmetic surgery Johnson-Arbor K, Attinger C, Evans K
Poster Session 11: 3:45 - 4:07	F 19	Class B chamber critical care - A case report of severe carbon monoxide poisoning and gastrointestinal bleeding DuBose KD, Hanley ME

POST COURSES: SUNDAY, JULY 2

	Sunday, July 2
TIME	Post Course: The Reimbursement Rollercoaster: Provider & Facility Update
	Acacia 4-6
0800-0820	Introduction with short version of MACRA, PQRS/MIPS transition 6 months in, Registry update
0820-0900	The Future of Payment: ACO and PCMH – what they are, why we are being “nudged” to develop them, and are they the future health care models
0900-0930	Understanding MAC LCDs, regional monitoring and preparing for compliance
0930-1015	Risk assessment for reimbursement, scoring and necessary documentation
1015-1030	Break
1030-1100	Audits – how to prepare, prevent and/or respond - pre-authorization vs. pre-payment review
1100-1130	Billing compliance, facility and professional coding (modifiers, CCI edits, bundling and other management headaches)
1130-1200	Panel Q&A from the morning session, Moderator: Marc Robins Wrap-up
12:00	ADJOURN

	Sunday, July 2
TIME	Surveyor Training (must contact Tom Workman)
	Acacia 1-3
8:00-10:30	Training
10:30-1045	Break
10:45-12:00	Training
12:00-1:00	Lunch
1:00-3:00	Training
3:00-3:15	Break
3:15-5:00	Training

COMMITTEE MEETING SCHEDULE

	TUESDAY JUNE 27	WEDNESDAY JUNE 28			THURSDAY JUNE 29			FRIDAY JUNE 30				SATURDAY JULY 1		
	BANYON 1-2	ACACIA 2	ACACIA 5	MANGROVE 1	ACACIA 2	ACACIA 5	MANGROVE 1	BANYON 1-2	ACACIA 2	ACACIA 5	MANGROVE 1	ACACIA 2	ACACIA 5	MANGROVE 1
7:00-7:30						Safety Committee 7:00-8:00		NBDHMT Breakfast 7:00-8:00						
7:30-8:00														
8:00-8:30									NBDHMT Board Meeting 8:00- 12:00					
8:30-9:00				CHT/CHRN STUDY HALL 8:30-10:30									Management of DCI Pre- course Proceedings meeting (Mitchell) 8:00-11:30	
9:00-9:30														
9:30-10:00														
10:00-10:30		MOC Committee 10:00- 11:00				Accreditati on Council Meeting 10:00- 12:00								Diving Committee 10:00-12:00
10:30-11:00				CHT/CHRN EXAM 10:30-12:30										
11:00-11:30							ACEP UHM Section Meeting 11:00-12:00							
11:30-12:00														
12:00-1:00					Associate Luncheon			GME Committee 12:00-1:15						CPG Committ ee 12:00- 1:00
1:00-1:30		ABPM EXAM: 1:00-4:00				Specialty ED & QUARC Team Meeting: 1:00-3:00								
1:30-2:00	ACCME Conf Call: 1:30-3:00								Surveyor Refresher Training Course 1:00-3:00	Safety Sub- committee Work Group: 1:00-5:00		Chapter President's Committee 1:00-2:00		

2:00-2:30							Management of DCI Pre-course Proceedings meeting (Mitchell): 2:00-5:45			QUARC Committee Meeting: 2:00-3:30	Member-ship Committee 2:00-3:00			
2:30-3:00														
3:00-3:30			Editorial Board Meeting 3:00-5:00			Education Committee 3:00-5:00			BNA General Meeting: 3:00-4:00			ACHM Board Meeting 3:00-5:00		
3:30-4:00										Publication Committee: 3:30-4:30				
4:00-4:30	UHMS Board of Directors (private meeting) 4:00-11:00													
4:30-5:00		HBO Therapy Committee 4:45-7:45												
5:00-5:30														
5:30-6:00			Associate's Council Meeting: 5:30-7:30								Specialty Council Meeting (Claus): Private Meeting: 5:00-7:00			
6:30-7:00							BNA Board Meeting: 6:30-							
7:00-7:30														
7:30-8:00														
8:00-8:30														
8:30-9:00														
9:00-on														

Overall Goal of the UHMS Annual Scientific Meeting

The primary goal of the Undersea and Hyperbaric Medical Society ASM is to provide a forum for professional scientific growth and development to 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 with past and present leaders of the Society, and to become active in societal affairs.

CONTINUING EDUCATION

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

Designation Statements:

- **2017 Annual Scientific Meeting: June 28-July 1:**
The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of **18** AMA PRA Category 1 Credit(s)[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.
- **Pre-hospital Management of Decompression Illness: Towards Development of Definitive Modern Guideline: Wednesday, June 28**
The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of **7.5** AMA PRA Category 1 Credit(s)[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.
- **How to Prepare for Accreditation: Wednesday, June 28:**
The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of **7.5** AMA PRA Category 1 Credit(s)[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.
- **Hyperbaric Oxygen Safety: Clinical and Technical Issues: Wednesday, June 28:**
The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of **8** AMA PRA Category 1 Credit(s)[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.
- **The Reimbursement Rollercoaster-Provider & Facility Update: Sunday, July 2:**
The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of **4.25** AMA PRA Category 1 Credit(s)[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.
- **Poster Session Credits - Online:** You will be sent an email with a coupon code to access this on our courses website. The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of **23** AMA PRA Category 1 Credit(s)[™]. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Nursing CEU: Licenses Types Approved: Advanced Registered Nurse Practitioner; Clinical Nurse Specialist; Licensed Practical Nurse; Registered Nurse; Certified Nursing Assistant; Respiratory Care Practitioner Critical Care; Respiratory Care Practitioner Non-Critical Care; Registered Respiratory Therapist; Certified Respiratory Therapist

- **2017 Annual Scientific Meeting: June 28-July 1:** is approved by the Florida Board of Registered Nursing Provider #50-10881. Credit hours approved **18**.
- **Pre-hospital Management of Decompression Illness: Towards Development of Definitive Modern Guideline: Wednesday, June 28:** is approved by the Florida Board of Registered Nursing Provider #50-10881. Credit hours approved **7.5**.
- **How to Prepare for Accreditation: Wednesday, June 28:** is approved by the Florida Board of Registered Nursing Provider #50-10881. Credit hours approved **7.5**.

- **Hyperbaric Oxygen Safety: Clinical and Technical Issues: Wednesday, June 28:** is approved by the Florida Board of Registered Nursing Provider #50-10881. Credit hours approved **8**.
- **The Reimbursement Rollercoaster-Provider & Facility Update: Sunday, July 2:** is approved by the Florida Board of Registered Nursing Provider #50-10881. Credit hours approved **4.5**.
- **Poster Session Credits - Online:** is approved by the Florida Board of Registered Nursing Provider #50-10881. Credit hours approved **23**.

NBDHMT:

- **2017 Annual Scientific Meeting: June 28-July 1:** This live activity is approved for **18** Category A credit hours by National Board of Diving and Hyperbaric Medical Technology, 9 Medical Park, Suite 330, Columbia, South Carolina 29203.
- **Pre-hospital Management of Decompression Illness: Towards Development of Definitive Modern Guideline: Wednesday, June 28:** This live activity is approved for **7.5** of DMT recertification credit hours by National Board of Diving and Hyperbaric Medical Technology, 9 Medical Park, Suite 330, Columbia, South Carolina 29203. (NBDHMT does not recognize this course for CHT/CHRN Category A or B credits).
- **How to Prepare for Accreditation: Wednesday, June 28:** This live activity is approved for **7.5** Category A credit hours by National Board of Diving and Hyperbaric Medical Technology, 9 Medical Park, Suite 330, Columbia, South Carolina 29203.
- **Hyperbaric Oxygen Safety: Clinical and Technical Issues: Wednesday, June 28:** This live activity is approved for **8** Category A credit hours by National Board of Diving and Hyperbaric Medical Technology, 9 Medical Park, Suite 330, Columbia, South Carolina 29203.
- **The Reimbursement Rollercoaster-Provider & Facility Update: Sunday, July 2:** This live activity is approved for **4.25** Category A credit hours by National Board of Diving and Hyperbaric Medical Technology, 9 Medical Park, Suite 330, Columbia, South Carolina 29203.
- **Poster Session Credits - Online:** This live activity is approved for **23** Category A credit hours by National Board of Diving and Hyperbaric Medical Technology, 9 Medical Park, Suite 330, Columbia, South Carolina 29203.

Full Disclosure Statement: All faculty members and planners participating in continuing medical education activities sponsored by Undersea and Hyperbaric Medical Society are expected to disclose to the participants any relevant financial relationships with commercial interests. Full disclosure of faculty and planner relevant financial relationships will be made at the activity.

Disclaimer: The information provided at this CME activity is for Continuing Medical Education purposes only. The lecture content, statements or opinions expressed however, do not necessarily represent those of the Undersea and Hyperbaric Medical Society.

EVALUATION LINKS

In an effort to “GO GREEN” and improve the efficiency in evaluating our CME Program, we now offer the evaluation form online. A hard-copy evaluation form can be provided upon request. Thank you for supporting our efforts to help reduce our carbon footprint. The evaluation link will also be emailed to you once the meeting is over.

2017 Annual Scientific Meeting: June 28-July 1 (Includes Non-Physician Track):

<https://www.uhms.org/asm17evaluation>

Online Poster Sessions: <https://www.courses-uhms.org/2017-asm-poster-sessions>

Pre-hospital Management of Decompression Illness: Towards Development of Definitive Modern Guideline:

Wednesday, June 28: <https://www.uhms.org/eval-dci-pre-course>

How to Prepare for Accreditation: Wednesday, June 28:

<https://www.uhms.org/eval-accreditation-pre-course>

Hyperbaric Oxygen Safety: Clinical and Technical Issues: Wednesday, June 28:

<https://www.uhms.org/eval-safety-pre-course>

The Reimbursement Rollercoaster-Provider & Facility Update: Sunday, July 2:

<https://www.uhms.org/eval-reimbursement-post-course>

MAINTENANCE OF CERTIFICATION (MOC):

2017 Annual Scientific Meeting: June 28-July 1: “MOC ABPM: This activity has been approved by the American Board of Preventive Medicine for up to **23** MOC credits. Claiming ABPM MOC credit is appropriate for those who are ABPM diplomates:

Keynote/Plenary MOC: <https://www.uhms.org/asm-2017-keynote-plenary-moc>

The Online Poster Session Credits will all be used as your MOC – please be sure to mark that you need MOC credits: <https://www.courses-uhms.org/2017-asm-poster-sessions>

Pre-hospital Management of Decompression Illness: Towards Development of Definitive Modern Guideline:

Wednesday, June 28: MOC ABPM: This activity has been approved by the American Board of Preventive Medicine for up to **4** MOC credits. Claiming ABPM MOC credit is appropriate for those who are ABPM diplomates:

<https://www.uhms.org/moc-dci-pre-course>

How to Prepare for Accreditation: Wednesday, June 28: MOC ABPM: This activity has been approved by the American Board of Preventive Medicine for up to **7** MOC credits. Claiming ABPM MOC credit is appropriate for those who are ABPM diplomates:

<https://www.uhms.org/moc-accreditation-pre-course>

Hyperbaric Oxygen Safety: Clinical and Technical Issues: Wednesday, June 28: MOC ABPM: This activity has been approved by the American Board of Preventive Medicine for up to **6.25** MOC credits. Claiming ABPM MOC credit is appropriate for those who are ABPM diplomates: <https://www.uhms.org/moc-safety-pre-course>

The Reimbursement Rollercoaster-Provider & Facility Update: Sunday, July 2: MOC ABPM: This activity has been approved by the American Board of Preventive Medicine for up to **4** MOC credits. Claiming ABPM MOC credit is appropriate for those who are ABPM diplomates: <https://www.uhms.org/moc-reimbursement-post-course>

For ABPM Requirements for Maintenance of Certification (MOC) please visit their website: https://www.theabpm.org/moc/index_moc.cfm.

General Disclosure to Participants of Relevant Relationships with Commercial Interests
UHMS Annual Scientific Meeting
June 29-July 1, 2017

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Enoch Huang, MD	Planner	Novadaq	Speakers Bureau
Peter Buzzcott, PhD	A5/D1: abstract Presenter	Divers Alert Network, a not-for-profit that insures recreational divers	Employment/Consultant

Name of Commercial Supporter	Amount of Monetary Commercial Support	In-Kind (List what was provided)
Sechrist	\$6500	Financial
Sechrist	\$0	Satchels
Wound Care Education Partners	\$1000	Financial
NBDHMT	\$500	Financial
Serena Group	\$1000	Financial

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Signature of Activity
Director/Coordinator

Stacy Rupert

Date: June 1, 2017

General Disclosure to Participants of Relevant Relationships with Commercial Interests
Pre-hospital Management of Decompression Illness: Towards Development of Definitive Modern Guidelines
Wednesday, June 28th

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Frank Butler	Planner	DSO Medical Consultants - provides consultation on medicolegal issues pertaining to the treatment of diving illnesses.	Consultant

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Divers Alert Network	\$21,000 (Travel/Lodging Reimb)	

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General Disclosure to Participants of Relevant Relationships with Commercial Interests
How to Prepare for Accreditation
Wednesday, June 28th

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General Disclosure to Participants of Relevant Relationships with Commercial Interests
Hyperbaric Oxygen Safety: Clinical and Technical Issues
Wednesday, June 28th

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Date: June 1, 2017

General Disclosure to Participants of Relevant Relationships with Commercial Interests
The Reimbursement Rollercoaster-Provider & Facility Update
Wednesday, June 28th

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Marc Robins	Planner	KCI	Speakers Bureau

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American Board of Preventive Medicine, Chicago, IL: TABLE # 3: The American Board of Preventive Medicine, Incorporated (ABPM) is a member board of the American Board of Medical Specialties. ABPM originated from recommendations of a joint committee comprised of representatives from the Section of Preventive and Industrial Medicine and Public Health of the American Medical Association and the Committee on Professional Education of American Public Health Association. www.theabpm.org

Anacapa Technologies, Inc, San Dimas, CA: TABLE # 12: Anacapa Technologies, Inc. is a market leader and innovator in the formulation of antiseptic wound care products. Our offering has been expanded to serve the veterinarian. Our manufacturing site is in San Dimas, California. <http://anacapa-tech.net/>

Baromedical Nurses Association, Gotha, FL: TABLE # 1: The *BNA* provides nurses with a professional organization in order to maintain and promote the status and standards of practice in hyperbaric nursing. <http://www.hyperbaricnurses.org/>

Best Publishing Company, Palm Beach Gardens, FL: BOOTH # 1: Best Publishing Company was founded in 1966 and has become the largest and one of the most respected publishers of educational books on diving, wound care, and hyperbaric medicine. We produce educational books along with professional periodicals such as the *Wound Care & Hyperbaric Medicine Magazine*, a peer reviewed quarterly publication that covers all aspects of wound care, diving medicine, and hyperbaric oxygen therapy (HBOT). We also produce the *Wound Care & Hyperbaric Medicine Calendar* that promotes diving, wound care, and hyperbaric education courses worldwide. www.bestpub.com

Feel Good Inc., Orlando, FL: BOOTH # 13: We are the premier leading worldwide distributor of TENS Stimulators with **over 10 years' experience!** Our FDA class II cleared medical devices use electrical pulses for the stimulation of muscles. These portable and compact electrical TENS Stimulators are a breakthrough in the compact medical device industry. <https://www.feelgoodinc.org>

Fink Engineering, PTY, LTD, Warana, Australia: TABLE # 7: Fink Engineering Pty Ltd (a subsidiary of Fink International) was established in Victoria, Australia in 1987 to provide engineering design and consultancy to the offshore oil and diving industries. We have developed a world class set of Rectangular Hyperbaric Chamber Systems that are just beginning to be appreciated overseas as evidenced by systems shipped to New Zealand, Singapore, Canada and our recently completed projects in the USA. www.fink.com.au

Hydrospace Group Inc., Claremont, CA: Booth # 6: Hydrospace Group is dedicated to providing cost effective, innovative, high precision and reliable solutions for components, systems and vehicles designed to work underwater, from 20 to 20,000 feet. The dedication is rooted in the realization that the future will continue to demand new tools and methods to increase subsea productivity. These solutions will inherently combine a wide range of manned and unmanned technologies that need to work in concert. The harsh nature of this environment across the globe's oceans demands the highest levels of performance to achieve safety and reliability that will ensure commercial viability. <http://hydrospacegroup.com/>

International ATMO, Inc., San Antonio, TX: TABLE # 2: International ATMO, Inc. is one of the oldest continuous providers of hyperbaric medicine education services including hyperbaric consulting, hyperbaric safety training, hyperbaric oxygen treatment, wound center consulting, wound care education and wound center management. International ATMO's continuing education courses in hyperbaric medicine, wound center management, wound care center education and safety training attract an international attendance of physicians, nurses, and technicians annually. The Hyperbaric Medicine Team Training Course is the original UHMS-Designated Introductory Course in Hyperbaric Medicine that meets the requirements of all Medicare Intermediaries. We also offer various hyperbaric education books, wound care center books as well as books from NFPA and UHMS. www.hyperbaricmedicine.com

Pan-America Hyperbarics, Inc., Richardson, TX: TABLE # 10: 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

Perry Baromedical, Riviera Beach, FL: TABLE # 5: Perry Baromedical is the only company in the world which designs, manufactures, installs and services monoplace, dualplace and multiplace hyperbaric chambers. We provide the highest quality product, and are focused on assisting hospitals with a comprehensive Hyperbaric Oxygen Therapy department. For further information visit our website at www.perrybaromedical.com or call us at 561-840-0395. www.perrybaromedical.com

Phelps Memorial Hospital Center, Sleepy Hollow, NY: TABLE # 9: Now part of Northwell Health™, Phelps Memorial Hospital Center is dedicated to: improving the health of the community we serve; sustaining an environment of excellence where medical, social and rehabilitative services are delivered proficiently, efficiently and effectively. <https://phelpshospital.org/>

Reimers Systems Division of PCCI, Inc., Alexandria, VA: BOOTH # 2: 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

Sea-Long Medical Systems, Waxahachie, TX: TABLE # 8: Sea-Long Medical Systems is now under new ownership. Their commitment is to deliver an unprecedented level of service. Their hyperbaric accessory department is being expanded to include zone valve boxes, high/low alarm panels, cryogenic hoses and check valves, passive vaporizers, automatic and semi-automatic oxygen manifolds, ground strap testers, chamber ground test kits, and a complete line of 100% cotton, no-pocket, hyperbaric scrubs...to list a few items. If you know of products they can offer that would be of benefit to you, please contact them. www.sea-long.com

Sechrist Industries, Anaheim, CA: BOOTH # 5: 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.sechristusa.com

UHMS Fellowship Program: TABLE #4: Fellowship training in Undersea and Hyperbaric Medicine recognizes special commitment and expertise in Undersea and/or Hyperbaric Medicine. In the United States, those eligible for Fellowship training must be Board Certified in Undersea and Hyperbaric Medicine by a Board sanctioned by the American Board of Medical Specialties (ABMS) and must be in active practice in undersea and/or hyperbaric medicine. <https://www.uhms.org/education/credentialing/fellowship-programs.html>

THURSDAY, JUNE 29

PRESIDENT'S ADDRESS

Enoch Huang, MD

8:00 AM – 8:30 AM



ABOUT THE LECTURE:

The annual President's address will present a "State of the Society" review of the activities of the UHMS, focusing on the activities of the most recent year as well as the challenges and initiatives of the future.

PLENARY:
**“The History of the Undersea and Hyperbaric Medical Society
(1967-2017)”**

Richard Moon, MD & Peter Bennett, PhD

8:30 AM – 9:30 AM



**Richard
Moon, MD**



**Peter
Bennett, PhD**

The beginnings of the Undersea Medical Society (UMS) came as a result of an informal discussion in 1966 at a meeting of the Aerospace Medical Association. The meeting was at the Sands Hotel in Las Vegas on April 20, 1966, between six scientists who shared a common interest in diving medicine. Drs. Chris Lambertsen, Bob Workman, Ed Beckman, Walter Mazzone, Earl Ninow and Jack Kinsey later became founders of the Undersea Medical Society, with Chris Lambertsen drafting the constitution and officially initiating the Society the following year.

These six individuals, along with 83 others, became the charter members of the UMS, which came into being a year later on April 10, 1967. Initially a section of the Aerospace Medical Association the UMS became a separate society in 1974. The first annual meeting was held in 1968 at the Americana Hotel, Bal Harbour, Florida. Of note, a congratulatory telegram was sent from Vice President Hubert Humphrey, who had a major interest in the oceans, to the first President of the Society, Dr. Chris Lambertsen. The following year the meeting was held in San Francisco. A tradition of frugality began, with revenues for the first two years of only \$2,620 – of which only about half was spent. The Associates became an important addition to the Society in 1975. From the start, a major aim was for the Society to be international, and indeed several of the original members were from other countries, including Denmark, Italy, Switzerland and United Kingdom, just to name a few.

There was no Society headquarters until 1973, when a permanent office was established at the Federation of American Societies for Experimental Biology (FASEB) in Bethesda, Maryland. The following year saw the first publication of the Society’s journal, *Undersea Biomedical Research*. Because of increasing interest in clinical hyperbaric medicine, in 1986 the decision was made to change the Society’s name to the Undersea & Hyperbaric Medical Society. The new name became official in 1990. In 1993 the journal began publication under its new name: *Undersea & Hyperbaric Medicine*. As of February 2017 there have been 1,789 peer-reviewed articles published in the Society’s journals. Drs. Richard Buckles, Peter Bennett, Manny Radomski, Hugh Van Liew, Tom Neuman, Claude Piantadosi, George Mychaskiw and Enrico Camporesi have served as Editor-in Chief. The Society also published the *Journal of Hyperbaric Medicine* for a short time. *Undersea Medicine: Abstracts from the Literature* was a valuable summary of the pertinent literature before the Internet. The newsletter *Pressure* began in 1972.

Since the Society’s beginning there have been 38 Presidents and five Executive Directors. Presidents initially served for one year. However, many early Presidents felt that it took at least a year to become familiar with the job, at which time the gavel had to be handed to the next person. In 1994 this was remedied when the President’s tenure was extended to two years. The first of five Executive Directors was Chuck Shilling, a former U.S. Navy diving medical officer involved in rescue of survivors of the submarine *USS Squalus* in 1939. He served 13 years in that position and has been followed by Leon “Lee” Greenbaum, Don Chandler, Peter Bennett and John Peters. In 1996 the Society purchased a building of its own and moved from FASEB to Kensington, Maryland. The Society made a significant

profit when the building was sold in 2005. Temporary quarters were held in Dunkirk, Maryland, until the retirement of Mr. Chandler in 2007 when the office was moved to Durham, North Carolina under the direction of Dr. Bennett. Today the UHMS headquarters is located in North Palm Beach, Florida, where it moved when John Peters assumed the position of Executive Director in July 2014.

The Society has played a crucial role in defining appropriate conditions for treatment with hyperbaric oxygen and promoting ethical use of this modality. The Hyperbaric Oxygen Committee Report, with guidelines for treatment, has become a national standard, accepted by government agencies and private insurance companies. CME accreditation is provided by the UHMS for coursework. Chamber certification was started under the guidance of Tom Workman. The UHMS aggressively and successfully pursued physician certification in Undersea & Hyperbaric Medicine under the auspices of the American Board of Medical Specialties.

In order to keep the specialty current the Society has successfully lobbied third-party payers to maintain reimbursement, as well as set guidelines for appropriate practice. Several Society honorary awards have been created. One in particular, a Fellowship in Undersea & Hyperbaric Medicine, has been created as an honor bestowed upon exceptional physicians and scientists.

There are currently 2,274 members, including 1,160 Regular Members, 942 Associate Members and 172 others (Corporate Members, Honorary and Student Members). The Society remains the major voice of the science and medicine of diving and its sister discipline, hyperbaric oxygen therapy.

SESSION A
DIVING & DECOMPRESSION ILLNESS:
THEORY & MECHANISMS

Moderators:

THURSDAY, JUNE 29

Oral Presentations:
10:00 AM – 11:15 AM

Poster Presentations:
Poster Session 1: 11:15 AM – 11:37 AM
Poster Session 2: 11:37 AM – 12:00 PM

A 1

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 10:00 - 10:12

POSTER PRESENTATION TIME: Poster Session 2: 11:37 - 12:00

RESIDENT COMPETITION: No

Carbon dioxide levels common in diving stimulate neutrophils to produce microparticles containing proinflammatory interleukin-1 β

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Introduction: Mild hypercapnia (CO₂ elevation by 2-4 mmHg \sim 0.3 kPa) is common during diving, and comparable to breathing \sim 0.4% (4,000 ppm) CO₂. This often occurs in submarines due to air handling issues. Blood-borne microparticles (MPs), 0.1- 1 μ m diameter vesicles, increase in response to virtually all diving activities and are correlated with decompression sickness. We hypothesized that due to enhanced carboxylation reactions CO₂ elevations will stimulate MPs production.

Materials/Methods: Neutrophils were isolated from the blood of healthy human volunteers and mice. MPs production was measured after cells were placed in buffer equilibrated with different partial pressures of CO₂. Follow-up studies were done with mice exposed to 0.1 to 1.0 % CO₂ for up to two hours.

Results: Human and murine neutrophils generate MPs with high interleukin-1 β (IL-1 β) content when incubated in buffer equilibrated with air plus 0.1 to 0.4% CO₂. This is mediated by mitochondrial reactive oxygen species production through activities of pyruvate carboxylase and phosphoenolpyruvate carboxykinase, verified by depleting enzymes in cells with small inhibitory RNA. However, CO₂ above 0.4% diminishes responses due to competing reactions seemingly related to inhibition of cytosolic malic enzyme. Activation of the so-called NLRP3 inflammasome and synthesis of IL-1 β are concomitant events linked with the biochemical mechanism for MPs production. CO₂ exposures for 30 minutes trigger MPs and IL-1 β production, lasting hours. Blood-borne MPs elevations in mice occur following the same dose-response pattern as in ex vivo neutrophil studies, and the MPs are responsible for diffuse vascular damage assessed as leakage of high-molecular weight dextran and elevation of lung wet-to-dry weight ratios.

Summary: By increasing inflammatory MPs production CO₂ may increase the propensity for decompression injuries in diving and pose a heretofore unrecognized occupational health risk.

A 2

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 10:12 - 10:24

POSTER PRESENTATION TIME: Poster Session 2: 11:37 - 12:00

RESIDENT COMPETITION: Yes

Modeling HPNS: the molecular dynamics approach

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Background: Professional divers exposed to ambient hyperbaric pressure (HP) above 1.1 MPa can develop high-pressure neurological syndrome (HPNS). The glutamate-type N-methyl-D-aspartate receptor (NMDAR) has been implicated in CNS hyperexcitability as part of HPNS. NMDARs containing different subunits exhibited different degrees of increased or decreased currents at HP [1-3]. Our previous experimental molecular approach was unsuccessful in revealing the mechanisms underlying the complex HP modulation of NMDAR activity. We suggest a new theoretical approach in order to examine the hypothesis that protein conformational changes, induced directly by HP or indirectly via protein-lipids (membrane) interactions, are responsible for NMDAR hyperexcitability at HP.

Materials/Methods: GROMACS software [4] was used to perform Molecular Dynamics simulations of NMDAR (containing GluN1-1a and GluN2B subunits) embedded in the membrane under various pressure conditions in the presence and absence of helium.

Results: Simulations explicitly show that helium causes substantial distortions in the membrane (as has been previously shown [5]) and in the NMDAR. Root mean square deviation plots indicate that pressurized helium causes protein conformational alteration. In addition, transmembrane domain, containing the pore of the receptor (responsible for ions movement across the membrane), is altered.

Conclusions: Combining preliminary analysis of the simulation and previous experimental results, one can speculate that helium at HP (and not just hydrostatic pressure per se) may alter the receptor tertiary structure via protein-lipids interactions (contrary to common predisposition). This causes changes of the receptor physiology.

1. Bliznyuk A, et al. The N-methyl-D-aspartate receptor's neglected subunit - GluN1 matters under normal and hyperbaric conditions. *Eur J Neurosci.* 2015; 42(8): 2577-2584.
2. Bliznyuk A, et al. The enigma of the dichotomic pressure response of GluN1-4a/b splice variants of NMDA receptor: experimental and statistical analyses. *Front Mol Neurosci.* 2016; 9: 40.
3. Mor A, et al. Pressure-selective modulation of NMDA receptor subtypes may reflect 3D structural differences. *Front Cell Neurosci.* 2012; 6: 37.
4. Hess B, et al. GROMACS 4: Algorithms for highly efficient, load-balanced, and scalable molecular simulation. *J Chem Theory Comput.* 2008; 4(3): 435-447.
5. Moskovitz Y, Yang H. Modelling of noble anaesthetic gases and high hydrostatic pressure effects in lipid bilayers. *Soft Matter.* 2015; 11(11): 2125-2138.

Acknowledgment: Oak Ridge Leadership Facility (OLCF) at Oak Ridge National Lab provided the access to the Titan supercomputer.

A 3

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 10:24 - 10:36

POSTER PRESENTATION TIME: Poster Session 2: 11:37 - 12:00

RESIDENT COMPETITION: No

Hyperbaric oxygen inhibits interleukin-1 β production and joint inflammation following provocative decompression

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Introduction: Joint pain is the most common manifestation of decompression sickness (DCS). Circulating proinflammatory microparticles (MPs), 0.1 – 1.0 μ m vesicles, are elevated in animals and humans after simulated or bona fide underwater diving, and are correlated with development of DCS. We hypothesized that inflammatory changes will occur in knee joints of decompressed mice, changes will correlate with MPs, and some changes can be inhibited by hyperbaric oxygen (HBO₂) (2.8 ATA for 90 minutes).

Materials/Methods: Mice were exposed for two hours to 790-kPa air and euthanized post-decompression to study blood-borne and articular changes. Some mice received HBO₂ after decompression.

Results: Whereas control mice had 747 ± 71 (SE, N=12) MPs/ μ l plasma post-decompression there were $7731 \pm 1458/\mu$ l (P<0.05) at two hours and $5897 \pm 988/\mu$ l (P<0.05) at 14.5 hours. Intra-articular changes were not evident at two hours post-decompression but at 14.5 hours, compared to control, there were increases of 4.5 ± 0.6 (P<0.05)-fold in neutrophils with no significant increase in erythrocytes (50 ± 19 vs. 51 ± 15 RBC/joint) and in synovial lining, elevations of 2.1 ± 0.2 (P<0.05)-fold in ferritin, 2.4 ± 0.2 (P<0.05)-fold in thrombospondin and 2.5 ± 0.4 (P<0.05)-fold in interleukin (IL)-1 β . Intra-MPs IL-1 β concentration was 9.5 ± 1.4 pg/million MPs in controls versus 82 ± 7 (P<0.05, N=9) at 14.5 hours post-decompression. HBO₂ inhibited decompression-associated elevations of IL-1 β in MPs and the synovium, and synovial ferritin.

Summary: Decompression-induced arthritis is abrogated by HBO₂, seemingly due to an inhibitory effect on inflammasome activation. Mechanisms for articular changes following high gas pressure may be linked to synovium-specific responses. Further work is needed to elucidate these pathophysiological events.

A 4

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 10:36 - 10:48

POSTER PRESENTATION TIME: Poster Session 2: 11:37 - 12:00

RESIDENT COMPETITION: No

Fast, near-optimal iso-risk ascent profile algorithm for air- and enriched-air dives

Howle LE^{1,2,3}, Murphy FG^{1,4}, King AE¹

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Introduction/Background: Optimal iso-risk decompression profiles can be generated by probabilistic decompression models. A decompression profile is considered to be optimal if, given an acceptable probability of decompression sickness occurring, the diver is returned to the surface in the shortest possible time. Previous work has shown that decompression schedules are not unique, thus complicating the optimization method [1]. Current algorithms for generating optimal profiles are suitable for generating decompression tables but remain too slow to be programmed into a diver-worn dive computer.

Materials/Methods: We parameterized a general ascent profile generator using a power-law function for generating near-optimal profiles using the USN93 model. This avoids the need to search over a large number of stop depth and stop times. For testing and comparison to decompression schedules generated with Navy software [1], we used several profiles covering range of depths and bottom times. All profiles used a 3.3% target probability of decompression sickness.

Results: We found that, even with the parameterized power-law ascent profile, multiple “optimal” decompression schedules were possible. That is, there are multiple profiles that reach the surface at the same time and that have the same target risk. We solved this uniqueness problem by adjoining a condition to the optimization method that favors the shallower of the decompression schedules. When we converted the piecewise continuous profile to the typical stair-stepped profile, we found little difference between the two profiles. In some cases, we were able to generate profiles with identical risk but shorter decompression times than those created with Navy software.

Summary/Conclusions: This parametrized decompression schedule generation method may allow optimization of decompression schedules in real time, thus allowing dive computers to incorporate probabilistic decompression models.

Supported by ONR Grant #N00014-13-1-0063, NAVSEA contract #N00024-13-C-4104.

1. Weathersby PK, Hays JR, Survanshi SS, Homer LD, Hart BL, Flynn ET, Bradley ME. Statistically based decompression tables II. Equal risk air diving decompression schedules. Technical report NMRI 85-17; 1985: 60; Naval Medical Research Institute. U.S Navy.

A 5

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 10:48 - 11:00

POSTER PRESENTATION TIME: Poster Session 2: 11:37 - 12:00

RESIDENT COMPETITION: No

Evidence of inheritable determinants of decompression sickness in rats

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Introduction: Decompression sickness (DCS) is a complex and poorly understood systemic disease caused by inadequate desaturation following a decrease of ambient pressure. Strong variability between individuals is observed for DCS occurrence. This raises questions concerning factors that may be involved in the interindividual variability of DCS occurrence. This study aimed to experimentally assess the existence of inheritable factors involved in DCS occurrence by selectively breeding individuals resistant to DCS from a population stock of Wistar rats.

Methods: 52 male and 52 female Wistar rats were submitted to a simulated air dive known to reliably induce about 67% DCS: Compression was performed at 100 kPa.min⁻¹ up to 1,000 kPa absolute pressure before a 45-minute stay. Decompression was performed at 100 kPa.min⁻¹ with three decompression stops: five minutes at 200 kPa, five minutes at 160 kPa and 10 minutes at 130 kPa. Animals were observed for one hour to detect DCS symptoms. Individuals without DCS were selected and bred to create a new generation, subsequently subjected to the same hyperbaric protocol. This procedure was repeated up to the third generation of rats.

Results: As reported previously, this diving profile induced 67% DCS and 33% asymptomatic rats in the founding population. DCS/asymptomatic ratio was not initially different between sexes, although males were heavier than females. In three generations, the outcome of the dive significantly changed from 33% to 67% asymptomatic rats, for both sexes. Interestingly, survival in females increased sooner than in males.

Conclusion: This study offers evidence suggesting the inheritance of DCS resistance. Future research will focus on genetic and physiological comparisons between the initial strain and the new resistant population.

A 6

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 11:00 - 11:12

POSTER PRESENTATION TIME: Poster Session 2: 11:37 - 12:00

RESIDENT COMPETITION: Yes

Probabilistic models for predicting the incidence and onset time of DCS after scoring marginal DCS cases as non-events

Murphy FG^{1,2}, Swingler AJ¹, Gerth WA², Howle LE^{1,3,4}

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Introduction/Background: Probabilistic models for predicting the incidence and onset time of decompression sickness (DCS) must be calibrated using dive data in which DCS outcomes are weighted as 1.0 if DCS occurred or 0.0 if DCS did not occur. A dive in which a DCS outcome is suspected but not treated is termed a marginal event with a conventionally assigned fractional weight of 0.1. Recent work has shown that fractionally weighting marginal events adversely impacts the quality of model calibration [1]. In the present work, we investigated the practical impact of treating marginal DCS events as non-events with 0.0 weights.

Materials/Methods: Two dive data sets, BIG292 [2] and NMRI98 [3], were used with marginal events assigned 0.0 weights. A simple exponential-exponential EE1 model was progressively enhanced by adding linear kinetics, a threshold term, and oxygen as a participating gas. Each enhancement was optimized and evaluated by Akaike information criterion to determine whether the added features were statistically justified.

Results: Linear-exponential (LE1) kinetics provided a significantly improved fit to BIG292 over EE1. The addition of oxygen as a contributor to DCS risk provided a significantly improved fit to NMRI98. LE1-predicted risks for saturation dives were not significantly impacted by the reassignment of marginal events. Because the bulk of marginal events occurred during saturation dives, risks from saturation dives are incorrectly ascribed to bounce dives when marginal events are assigned weights of 0.1.

Summary/Conclusions: Weighting marginal events as 0.0 improves the overall quality of fit. Data from marginal events should be included by a different mechanism in future work.

Supported by ONR Grant #N00014-13-1-0063 and NAVSEA contract .

1. Howle LE, et al. Marginal DCS events: their relation to decompression and use in DCS models. *J Appl Physiol* (1985); 2009 Nov; 107(5): 1539-1547.
2. Thalmann ED, et al. Improved probabilistic decompression model risk predictions using linear-exponential kinetics. *Undersea Hyperb Med*. 1997 Winter; 24(4): 255-274.
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A 7

THURSDAY, JUNE 29

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 1: 11:15 - 11:37

RESIDENT COMPETITION: Yes

Decompression sickness onset time bimodality is not related to dive type or severity

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Introduction/Background: Occurrence density functions (ODFs) illustrate the time of onset of decompression sickness (DCS) for experimental dive data. The ODF of DCS onset during or following dives recorded in the BIG292 data set is bimodal [1]. Probabilistic models used to predict the incidence of DCS generate unimodal ODFs. It has been conjectured that replicating the bimodality of the ODF would improve a model's fit to the data. In this work, we investigated the source of ODF bimodality.

Materials/Methods: ODFs of the BIG292 data set were computed using convolution and plotted for several groupings of data, including separation by dive type, institution, study age, event severity, and perceived severity index [2]. Each ODF was determined to be bimodal, unimodal or ambiguous in shape.

Results: All but one iteration of data segregation resulted in a bimodal or ambiguously shaped ODF, the latter likely due to an insufficient quantity of data for that group. It was found that dive data from trials conducted prior to 1984 yield unimodal ODFs. When examining the time of onset determination method used in each originating report, it was evident that the protocol for determining symptom onset times became consistent across institutions in 1984, where a Diving Medical Officer examined divers immediately after surfacing, and again after two hours. This protocol likely contributed to the second ODF peak.

Summary/Conclusions: A distinct source of the second ODF peak, such as differences in dive type or event severity, could not be found. Replicating the bimodal ODF shape in computational models would likely be difficult and, perhaps, meaningless, as there is no relation between dive type or event severity and DCS symptom onset time.

Supported by ONR Grant #N00014-13-1-0063, NAVSEA contract

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A 8

THURSDAY, JUNE 29

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 1: 11:15 - 11:37

RESIDENT COMPETITION: No

Decompression sickness manifestations in the uw sheep model after 'drop-out' decompression from a 24-hour hyperbaric exposure at 33 fsw and 45 fsw

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Introduction: Humans experiencing submarine or underwater habitat escape and rescue may undergo rapid "drop-out" decompression, with limb bends, central nervous system decompression sickness (CNS-DCS) and respiratory DCS (chokes). Decompressed adult sheep were used as a model of the submariner and diver to determine what might occur in humans undergoing similar "drop-outs."

Methods: Twelve adult female sheep (90.3 ± 8.5 kg SD) underwent a 24-hour hyperbaric exposure (33 fsw and 45 fsw, 1.97 to 2.33 ATA). They were decompressed at a rate 30 fsw/minute (0.91 ATA/minute) to atmospheric pressure and then observed four hour for clinical signs. With logistic regression of outcomes on log exposure pressure, we estimated the incidence of sheep decompression outcomes.

Results: All but two of the 12 decompressed sheep developed DCS: one developed CNS-DCS; two developed RDCS; 10 developed limb bends; and no lethal outcomes occurred. Logistic regression of outcomes on exposure pressure showed steep dose-responses for CNS-DCS, limb bends, RDCS, and lethal events.

sheep "drop-out" pressure, fsw	predicted incidence, %				
	DCS	CNS-DCS	limb bends	RDCS (chokes)	lethal
33	80	5.4	96	4.2	0.0
45	93	9.2	91	23	0.4

Conclusions: Decompression outcomes in sheep point to the potentially high risk from "drop-out" decompression after prolonged hyperbaric exposure at comparatively shallow depths. Those managing a submarine or habitat escape and rescue will face important operational decisions to minimize the potential loss of human lives.

Research was funded by NAVSEA/U.S. Navy.

A 9

THURSDAY, JUNE 29

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 1: 11:15 - 11:37

RESIDENT COMPETITION: No

Effects of ketogenic diet in divers breathing enriched-air nitrox

Bosco G¹, Rizzato A¹, Quartesan S¹, Campoesi E², Mangar D², Paganini M³, Cenci L¹, Malacrida S¹, Mrakic-Spota S⁴, Moretti S⁴, Paoli A¹

¹ Environmental Physiology & Medicine Lab, Department of Biomedical Sciences, University of Padova, Italy; ² TEAMHealth Research Institute, TGH, Tampa, Florida, U.S.; ³ Emergency Medicine Residency Program, University of Padova, Italy; ⁴ CNR Institute of Bioimaging and Molecular Physiology, Segrate (Milano), Italy

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Introduction: Overweight divers face a challenging activity, starting from a higher levels of circulating cytokines and oxidative stress. A ketogenic diet (KD) is described as effective in weight loss, in countering inflammation and oxidative stress, and is used in the control of drug-refractory seizures. This pilot study aimed to investigate whether KD can protect divers from oxidative stress and inflammation during immersion.

Materials/Methods: Blood and urine samples from six overweight divers were obtained: a) before (CTRL) and after a dive breathing enriched-air nitrox and performing light underwater exercise (NTRX); and b) after a dive (same conditions) performed after seven days of KD (K-NTRX). We measured urinary 8-isoprostane and 8-OH-2-deoxyguanosine to evaluate lipid peroxidation and DNA oxidative damage. Plasmatic IL-1 β , IL-6 and TNF- α levels were measured to investigate the inflammatory status.

Results: KD was successful for weight loss (3.20 ± 1.31 kg) and seemed to dampen lipid peroxidation and inflammatory biomarkers production in response to EAN diving. Indeed, levels of 8-isoprostane, IL-1 β , IL-6 at K-NTRX dive were similar to those measured at the baseline.

Conclusions: Short-term KD seems to be effective in weight loss and protective toward lipid peroxidation and inflammatory status triggered by diving.

A 10

THURSDAY, JUNE 29

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 1: 11:15 - 11:37

RESIDENT COMPETITION: No

Helicopter vibration measurements and simulator development

Grabau P¹, Blake DF^{1,2}, Brown LH³, Huppatz G⁴, Cooksley D⁵, Aitken P⁶

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Introduction: It has been suggested that the vibration caused by helicopter retrieval of scuba divers suffering from decompression sickness (DCS) may increase nitrogen bubble generation, potentially precipitating or worsening signs and symptoms. Current published helicopter vibration data are only reflective of helicopter component parts and not actual flights, with most research focusing on crew members and not patients during emergency retrievals. Helicopter vibrations are complex and difficult to generate artificially; therefore, actual flight vibration data are required to develop a model for ongoing research into retrieval of divers.

Methods: Three triaxial accelerometers were mounted under a rescue litter with a 70-kg mannequin lying supine and recorded longitudinal, lateral and vertical vibrations at the head, waist and feet during all flight modes of helicopter retrieval in a Bell 412 helicopter. Flight vibration data was analyzed and used to design the vibration simulator.

Results: The recorded maximum vertical vibration levels were: root-mean-squared (RMS) average 1.79 m/s², peak 7.49 m/s² and crest factor of 4.62 m/s². These were recorded in the approach phase of the flight. The vibration frequency range was from 3.9 to 150 Hz. The helicopter simulator consists of a rescue litter atop a vibration table, through which the vibrations are “played back” with a feedback control algorithm, allowing for high-fidelity reproduction of the actual recorded flight vibrations.

Conclusion: Recorded vertical flight vibrations are consistent with ISO2631 thresholds for “very uncomfortable” and indicate a high level of jolting. Pre-recorded real flight vibrations can now be reproduced using a vibration simulator, enabling research into the effect of vibrations on bubble generation in divers.

Acknowledgments: Funding for this research has been obtained from the Queensland Emergency Medicine Research Foundation, Townsville Hospital and Health Service, and International Divers Alert Network.

CHRISTIAN J. LAMBERTSEN, MD, DSc (Hon) MEMORIAL LECTURE
THURSDAY, JUNE 29: 1:00 pm - 2:00 pm



GUEST SPEAKER: Dr. Tom Neuman
LECTURE TITLE: “Arterial Gas Embolism”

ABOUT THE LECTURE:

Barotraumatic arterial gas embolism (AGE) can be one of the most severe injuries a diver may suffer and that a practitioner of Undersea Medicine can be summoned to treat. It is unquestionably one of the more common causes of death in the sport diving community and hence understanding of the circumstances in which it occurs, its pathophysiology, and its clinical manifestations are important to both physicians and those who support hyperbaric chambers and their operations. Barotraumatic AGE was first described in the early part of the twentieth century and has been the subject of considerable investigation since. Unfortunately, good animal models for barotraumatic gas embolism are not readily available and thus the bulk of our knowledge comes from animal experiments which can only questionably be extrapolated to humans or from observational case series; the latter often occurring in the setting of submarine escape training which differs from sport scuba divers.

This lecture will explore the history of arterial gas embolism beginning with the time period in which it was initially described as a rapidly progressive and fatal case of caisson’s disease. It will then continue to describe and examine a series of largely personal observations based upon cases that have predominantly been treated at the University of California, San Diego Hyperbaric Medicine Division of the Department of Emergency Medicine.

Rather than being a simple “stroke” secondary to air in the cerebral circulation, barotraumatic AGE is a systemic event, with measurable effects in many organ systems other than the brain, as well as a number of biochemical and hematologic changes associated with its systemic nature.

Finally, although death due to barotraumatic AGE only occurs in a small percentage of cases (estimated to be around 4%), the mechanism of sudden death caused by barotraumatic AGE has not been fully elucidated. In this lecture some thoughts on what the underlying mechanism of nearly instantaneous death secondary to barotraumatic AGE will be also presented.

ABOUT DR. NEUMAN:

Dr. Neuman was trained as a diving medical officer, he retired from the Naval Reserve with the rank of Captain. He was president of the UHMS in 1989 and past editor-in-chief of the journal Undersea and Hyperbaric Medicine. He is the co-editor of the 5th Edition of Bennett and Elliott's Physiology and Medicine of achievement. Dr. Neuman was an advisor to the National Academies of Sciences to advise NASA on the medical problems associated with colonization of the moon and the trip to Mars. Dr. Neuman is an active diver, a PADI scuba instructor. He is board certified in Internal Medicine, Pulmonary Medicine, Emergency Medicine, Undersea and Hyperbaric Medicine and Preventive Medicine. Dr. Neuman received the Albert Behnke Award for outstanding scientific contributions to the field of Undersea Medicine. He also received the Stover-Link award for contributions to diving safety and the Merrill Spencer Award for lifetime achievement. Dr. Neuman was an advisor to the National Academies of Sciences on medical problems associated with colonization of the moon and the trip to Mars. He is an active diver and a PADI scuba instructor. He is board certified in Internal Medicine, Pulmonary Medicine, Emergency Medicine, Undersea and Hyperbaric Medicine and Preventive Medicine.

CHRISTIAN J. LAMBERTSEN, MD, DSc (Hon) MEMORIAL LECTURE ABOUT DR. LAMBERTSEN



Dr. Christian J. Lambertsen received a B.S. Degree from Rutgers University in 1938 and a M.D. Degree from the University of Pennsylvania in 1943. During his medical school period, he invented and first used forms of the initial U.S. self-contained closed-circuit oxygen rebreathing apparatus, for neutral buoyancy underwater swimming and diving. As a student, he aided the early Office of Strategic Services (O.S.S.) in establishing the first cadres of U.S. military operational combat swimmers. Dr. Lambertsen became a U.S. Army medical officer on graduation from medical school in early 1943, and immediately joined the O.S.S. Maritime Unit on active duty through its period of function in World War II. He joined the University of Pennsylvania Medical Faculty in 1946, and became Professor of Pharmacology in 1952. While a faculty member he combined diving research and further underwater rebreathing equipment developments for the Army and Navy. In 1967 he served as Founding President of the Undersea Medical Society (now Undersea and Hyperbaric Medical Society.) Dr. Lambertsen is recognized by the Naval Special Warfare community as "The Father of U.S. Combat Swimming." His hand has touched every aspect of military and commercial diving. Dr. Lambertsen's active contributions to diving began during WWII and became even more progressive in the post-war period through the evolutions of the U.S. Navy Deep Submergence and Naval Special Warfare developmental programs.

SESSION B
HBO₂ THERAPY MECHANISMS

Moderators:

THURSDAY, JUNE 29

Oral Presentations:
2:00 PM – 3:15 PM

Poster Presentations:
Poster Session 3: 3:45 PM – 4:07 PM
Poster Session 4: 4:07 PM – 4:30 PM

B 1

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 2:00 - 2:12

POSTER PRESENTATION TIME: Poster Session 3: 3:45 - 4:07

RESIDENT COMPETITION: Yes

Hyperbaric and high-oxygen environments reduce circulating inflammatory cells, convert infiltrated macrophage phenotype and activate satellite cells following skeletal muscle contusion in rats

Oyaizu T, Enomoto M, Horie M, Yagishita K

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Introduction: Hyperbaric oxygen (HBO₂) treatment promotes rapid recovery from soft-tissue injuries. However, the mechanism of HBO₂ treatment on injured tissue is still unclear. It is possible that circulating inflammatory cells mediate recovery following injury. Thus, the activity of inflammatory cells following soft-tissue injury was assessed.

Materials/Methods: A muscle contusion on the calf of rats was performed by the drop-mass method. Rats then either received treatment (HBO₂) or no treatment. The HBO₂ protocol consisted of 2.5 ATA 100% oxygen for 120 minutes. HBO₂ was performed once per day for five days. Blood samples for flow cytometry analysis were collected by cardiac puncture before and three, six, 24, 48 and 72 hours after injury. Injured calf muscles were dissected one, three, five and seven days after injury and transverse sections were obtained with a cryostat. The presence of CD68 (M1: proinflammatory macrophage marker), CD163 (M2: anti-inflammatory macrophage marker), Pax7 and MyoD (a satellite cell marker) were evaluated with immunocytochemistry.

Results: The proportion of circulating CD11b-positive cells was significantly lower following HBO₂ treatment six and 24 hours after injury. Peak infiltration of CD68-positive cells into the injury site occurred two days earlier in the HBO₂ group. CD163-positive cells in the HBO₂ group was greatly increased at three, five and seven days. In the HBO₂ group, the number of Pax7+MyoD- quiescent satellite cells in the injured muscle was significantly higher at three and five days. The number of Pax7+MyoD+ proliferating satellite cells was significantly higher at one and three days; the number of Pax7-MyoD+ differentiated satellite cells was significantly higher at one, three and five days.

Conclusions: The current findings indicate that HBO₂ significantly reduces circulating inflammatory cells and leads to macrophage conversion from M1 to M2 macrophages. The anti-inflammatory effect of HBO₂ enhances satellite cell proliferation and differentiation in contused rat skeletal muscle, thereby leading to muscle recovery.

B 2

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 2:12 - 2:24

POSTER PRESENTATION TIME: Poster Session 3: 3:45 - 4:07

RESIDENT COMPETITION: yes

Hyperbaric oxygen activates mitochondrial biogenesis in skeletal muscle

Alvarez Vilella M, Dunworth SA, Kraft BD, Harlan N, Natoli, MJ, Parker CK, Schinazi EA, Piantadosi CA, Moon RE; Duke Center for Hyperbaric Medicine and Environmental Physiology, Duke University School of Medicine, Durham, NC 27710

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Background: In eukaryotes, mitochondrial biogenesis is regulated through a coordinated transcription program of nuclear and mitochondrial encoded genes. This program can be activated by oxidative stress leading to NOS induction, a pathway integrated by the nuclear transcription factor co-activator PGC1a.

We postulated that, through ROS generation, hyperbaric oxygen could trigger the mitochondrial biogenetic program in the cell and increase the skeletal muscle's oxidative capacity.

Methods: Twelve, recreationally active healthy subjects (mean VO_{2peak} =39.5 mL/kg/min) were randomized to a high-intensity interval training program (HIIT) in a hyperbaric oxygen (HBO_2) environment (PiO_2 =1.4 atm) or a normobaric air environment (PiO_2 =0.21 atm).

Contralateral vastus lateralis muscle biopsies and maximum exercise tests at a simulated high-altitude of 15,000 feet ($pbar$ =429mmHg, PiO_2 =0.12 atm) with gas exchange analysis were performed in all subjects before and after training.

Concentrations of nuclear and mitochondrial encoded transcription factors and proteins, as well as mtDNA copy numbers were measured in the obtained muscle biopsies. Results were compared within and between groups using repeated measures two-way ANOVA with post-hoc Fisher's LSD test.

Results: Compared to the normobaric air group, the HBO_2 -trained subjects exhibited significantly higher levels of PGC1a, MFN1 and GLUT-4 as well as a trend toward higher copy numbers of MtDNA. These findings did not correspond with a higher altitude VO_{2peak} increase in the HBO_2 -trained group (mean increase in VO_{2peak} 5.6mL/kg/min versus 5.3 mL/kg/min in the HBO_2 and air groups respectively, P =non-significant).

PGC1-a

Level	Number	Mean	Std Dev	Std Err		
				Mean	Lower 95%	Upper 95%
Air	6	2.73943	0.735323	0.30019	1.9678	3.5111
HBO	6	4.41438	0.837142	0.34176	3.5359	5.2929

MFN1

Level	Number	Mean	Std Dev	Std Err		
				Mean	Lower 95%	Upper 95%
Air	6	1.50190	0.260193	0.10622	1.2288	1.7750
HBO	6	2.16457	0.427087	0.17436	1.7164	2.6128

GLUT4

Level	Number	Mean	Std Dev	Std Err		
				Mean	Lower 95%	Upper 95%
Air	6	1.68607	0.271813	0.11097	1.4008	1.9713
HBO	6	2.35657	0.436009	0.17800	1.8990	2.8141

Conclusions: Our results point toward an HBO_2 -induced activation of the mitochondrial repair program and insulin sensitization in humans. These findings help to further elucidate the mechanisms of action underlying hyperbaric oxygen therapy, and open the possibility for the investigation of new therapeutic applications.

B 3

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 2:24 - 2:36

POSTER PRESENTATION TIME: Poster Session 3: 3:45 - 4:07

RESIDENT COMPETITION: No

Hyperbaric oxygen treatment reduces mortality and suppresses acute hepatic inflammation in a model of septic peritonitis

Halbach JL, Hawisher D, Wang A, Cauvi DM, Rosales J, Reyes T, Bickler S, De Maio A, Perdrizet GA
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Background: Hyperbaric oxygen (HBO₂) therapy reduces acute inflammation in many pathologic settings and can increase survival in animal models of sepsis. The liver contributes to the pathogenesis of the multiple organ dysfunction syndrome during sepsis. We tested the hypothesis that HBO₂ will suppress acute hepatic inflammation in murine septic peritonitis.

Methods: Adult, male CD-1 outbred mice were subjected to cecal ligation and puncture (CLP) to induce peritonitis and sepsis using a UCSD-Animal Care and Use Committee approved protocol. Animals were randomly assigned to no treatment (CLP) or CLP + HBO₂ (2.4 ATA x 60 minutes) administered by one of three treatment algorithms; at one hour, at one and six hours hrs, or at one, six and 21 hours after CLP. Sham control animals underwent laparotomy only. Mortality was determined at 72 hours. Levels of inflammatory cytokine mRNAs (TNF α , IL-6 and IL-10) were measured in liver tissue by standard qRT-PCR assay at three hours following CLP versus CLP + HBO₂. Bacterial numbers were determined from the peritoneal cavity and blood at six hours following CLP versus CLP + HBO₂. Survival rates and bacterial counts were compared between groups and significance defined at $P \leq 0.05$.

Results: Survival rates were 12% in the CLP versus 52% for CLP + HBO₂ group, $P < 0.02$. Additional HBO₂ sessions at 6 and 21 hrs did not significantly change survival rates versus one HBO₂ session. Increased survival was associated with suppression of TNF α , IL-6 and IL-10 mRNA in liver tissue. Bacterial counts were not different in blood or peritoneum in any group.

Conclusion: HBO₂ therapy improved survival and suppressed acute hepatic inflammatory gene expression while having no effect on bacterial numbers in the peritoneal cavity or bloodstream during septic peritonitis.

B 4

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 2:36 - 2:48

POSTER PRESENTATION TIME: Poster Session 3: 3:45 - 4:07

RESIDENT COMPETITION: No

The effects of HBO₂ after long-duration and moderate-intensity exercise on fatigue: a single-blind, cross-over randomized trial

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Introduction: Hyperbaric oxygen (HBO₂) therapy has recently been used to treat patients with soft-tissue injuries including joint sprain, muscle contusion and muscle strain. In addition, HBO₂ was reported to have an effect on reduction of muscle fatigue from repetitive ankle joint exercises. However, the effects of HBO₂ on fatigue are still controversial. In this study, we performed a double-blind, crossover randomized study applied with HBO₂ and air (1.2 ATA) after long-duration and moderate-intensity exercise, and evaluated the effects of HBO₂ on physiological parameters.

Subjects/Methods: Nine athletic university students (average age 21.3 years) were enrolled and underwent long-duration and moderate-intensity exercise (60-minute periods using an exercise bike to 75% HRmax). The subjects underwent HBO₂ (2.5 ATA for 60 minutes, for a total of 90 minutes including compression and decompression) and air intervention (1.2 ATA for 80 minutes, 90 minutes in total) in the double-blind crossover randomized mode. Blood sampling, measurement of fatigue (visual analog scale, VAS) and two-dimensional mood scale (TDMS) were performed before and after exercise, immediately after interventions, 1.5 hours after interventions and 24 hours later.

Results: There were no statistically significant differences between the groups in the blood sampling data, including: white blood cell, C-reactive protein, creatinine kinase, lactate, myoglobin, T-cell, CD4/CD8, and natural killer cells. Whole-body fatigue was significantly reduced immediately after HBO₂ (48.4 points to 28.7) compared to air (43.2 points to 37.9) based on the VAS (P<0.05). The feeling of amenity was significantly improved 24 hours later based on TDMS (P<0.05).

Discussions: This study showed that HBO₂ after long-duration and moderate-intensity exercise may have effects on fatigue. This study was well designed, but the statistically significant differences between the groups were observed mainly in the subjective evaluation. More study is necessary to clarify the effects of HBO₂ on fatigue.

B 5

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 2:48 - 3:00

POSTER PRESENTATION TIME: Poster Session 3: 3:45 - 4:07

RESIDENT COMPETITION: No

Doppler ultrasound imaging of in situ human kidney stones in hyperbaric conditions

Simon JC¹, Dunmire B², Cunitz BW², Sapozhnikov OA^{2,3}, Thiel J², Kramer CC⁴, Courtney TC⁴, Bailey MR², Holm JR⁴

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Introduction/Background: Hyperbaric pressures of 3-100 atmospheres absolute (ATA) have been shown to reduce the color Doppler ultrasound “twinkling artifact” on ex vivo human kidney stones, leading to the hypothesis that surface crevice microbubbles cause twinkling. However, it is unclear whether stable microbubbles can exist on the surface of kidney stones in the human body. For the first time, we imaged kidney stones of human subjects inside a hyperbaric chamber to determine whether stable microbubbles exist as measured by the ultrasound twinkling artifact.

Materials/Methods: Seven human subjects with kidney stones known to twinkle were imaged with a programmable ultrasound system outside the chamber with the ultrasound probe, ultrasound technician, inside attendant, and subject inside the chamber. Subjects breathed ambient air while exposed to a maximum pressure of 4 ATA except for a scheduled decompression stop at 1.6 ATA when subjects breathed pure oxygen. Twinkling was quantified as the Doppler power for two-minute intervals before pressurization (baseline), at 4 ATA, at 1.6 ATA, and after pressurization. A paired t-test was used to determine statistical significance ($P < 0.05$).

Results: Preliminary results from four subjects show no change in twinkling at 4 ATA compared to baseline levels (Doppler power ratio mean and standard deviation: 0.94 ± 0.39 ; $P = 0.30$). However, a statistically significant increase in twinkling was observed when subjects breathed pure oxygen during the decompression stop at 1.6 ATA compared to baseline levels (ratio: 1.84 ± 0.49 ; $P = 0.046$). At the end of the study with subjects once again breathing ambient air, twinkling was similar to what was initially observed (ratio: 1.07 ± 0.29 ; $P = 0.44$).

Summary/Conclusions: The increase in twinkling associated with breathing pure oxygen supports the crevice microbubble hypothesis. As with ex vivo kidney stones, higher pressures than explored in this study may be needed to reduce twinkling on in situ stones, but altering gas composition may enhance twinkling.

Acknowledgment: Work supported by the National Space Biomedical Research Institute through NASA NCC 9-58 and NIH grant DK043881.

B 6

THURSDAY, JUNE 29

ORAL PRESENTATION TIME: 3:00 - 3:15

POSTER PRESENTATION TIME: Poster Session 3: 3:45 - 4:07

RESIDENT COMPETITION: No

The effect of hyperbaric oxygen on the mitochondrial metabolism of human renal cells in culture

Ozcan D, Hightower LE, Perdrizet GA, Giardina C

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Background: Type 2 diabetes mellitus leads to cellular stress and tissue damage that can ultimately result in kidney failure. In our previous work, hyperbaric oxygen (HBO₂) therapy effectively suppressed renal injury in a mouse model of diabetes mellitus. We wish to determine what effect HBO₂ has on mitochondrial metabolism using a human kidney cell line (HK-2, proximal renal tubular epithelium; ATCC CRL-2190) model.

Methods: Cultured HK-2 cells were exposed to hyperbaric oxygen at 2.4 ATA for 120 minutes for a single session. Samples were then transferred to the SeaHorse XF analyzer (SeaHorse Biosciences) either immediately following HBO₂ (T0) or 24 hours later (T24). Mitochondrial respiration/oxygen consumption and glycolytic flux were simultaneously measured. Data was compared between the pretreated baseline cells with the post HBO₂-treated cells at T0 and T24 using the Students t-test with significance set at P ≤ 0.05.

Results: Exposure to HBO₂ decreased the rate of oxygen consumption and increased the rate of glycolysis compared to rates in untreated control HK-2 cells. These changes were similar at T0 and T24 time points following HBO₂.

Conclusion: HBO₂ treatment of a human renal cell in culture reduced oxygen consumption (oxidative phosphorylation) and increased glycolysis. This metabolic pattern is typical of cells exposed to stressful conditions. This metabolic change may reflect an adaptive response to reduce total levels of reactive oxygen species (ROS) within the cellular microenvironments and thereby attenuate cell damage and death. Attenuation of pathologic ROS production may be one mechanism of the observed therapeutic benefit of HBO₂ in the setting of inflammation and hypoxia.

B 7

THURSDAY, JUNE 29

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 3: 3:45 - 4:07

RESIDENT COMPETITION: No

Inflammatory hypoxia a common barrier to oxygen delivery to tissues

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Background: A wide array of chronically diseased tissues can be characterized by inflammatory hypoxia (IH). Reversal of IH through the administration of hyperbaric oxygen will break this vicious cycle and may normalize tissue responses and repair.

Methods: Hypothesis generation. Previous work in humans will be reviewed to demonstrate that IH exists in a human model of acute, self-resolving inflammation: the tuberculin reaction (TR) [1].

Results: The data (N=20; 5 weak, 15 strong TR) demonstrate that strong reactors rapidly develop tissue hypoxia accompanied by a paradoxical increase in microvascular hemoglobin-oxygen saturation and a reduction in oxygen extraction (OE) and oxygen consumption (OC). The authors conclude that IH induces a type of “protective regulation” that is similar to what others have termed “*oxygen conformance, cytopathic hypoxia or dysoxia*” to explain the apparent neglect of hypoxic tissues to increase the extraction of oxygen from hemoglobin. Yet, by providing 100% inspired oxygen (1 atmosphere) at specific time points (24, 48, 72, 96 hours) during the TR, OC (mL of O₂/kg/min) is increased from 3.5 and plateaus at 6.0, suggesting adequate oxygenation. However, a trial of hyperbaric oxygen (2.0 ATA) results in a further and marked increase in OC from 4.5 to 12.

Conclusion: Early time points during dermal inflammation rapidly establish a condition of IH in humans. IH does not induce tissue neglect of oxygen but rather demonstrates an oxygen deficit that can be met only through effective tissue reoxygenation using increased partial pressures of oxygen dissolved in plasma. Reoxygenation of compromised tissues must occur before successful treatment of these common and diverse chronic diseases can be expected.

1. Abbot NC, et al. Effect of hyperoxia at 1 and 2 ATA on hypoxia and hypercapnia in human skin during experimental inflammation. *J Appl Physiol.* 1994(77):767-773.

PLENARY:
“HBO₂ for Mild Traumatic Brain Injury”
Lindell Weaver, MD
4:30 – 5:30 PM



ABOUT THE LECTURE:

This presentation will discuss hyperbaric oxygen for mild traumatic brain injury, presenting an overview published Department of Defense-sponsored clinical trials about this question, along with presenting new results from the “Brain Injury and Mechanisms of Action of hyperbaric oxygen for persistent post-concussive symptoms after mild TBI (BIMA)” randomized trial.

FRIDAY, JUNE 30

“EXECUTIVE DIRECTOR’S ADDRESS”

John Peters, FACHE

8:00 AM – 8:30 AM



ABOUT THE LECTURE:

Organizational performance improvement (OPI) has been the keystone for the UHMS’s operations plan over the past three years. OPI leads to an organization’s sustainability.

We’re also using OPI to elevate the UHMS to be a high-performing organization and the below graphic represents the methodology we employ to move the needle positively.



The UHMS Executive Director will detail the organization’s progress over the past 3 years to include a department-by-department review highlighting transformation.

While the UHMS is celebrating its 50th anniversary in 2017, the leadership and governance teams are busily planning and implementing process that results in the UHMS being sustainable for its next fifty (50) years.

PLENARY:
“An update on the UHMS Clinical Practice Guidelines”
John Feldmeier, DO & Jaleh Mansouri, MD
8:30 – 9:30 AM



John Feldmeier, DO



Jaleh Mansouri, MD

ABOUT THE LECTURE:

About this Lecture: Drs. John Feldmeier and Jaleh Mansouri will present an update on the CPG (Clinical Practice Guideline) Project. There are currently three active committees working to develop and publish CPG's for indications approved by the UHMS (Undersea and Hyperbaric Medical Society) for hyperbaric oxygen therapy. The disorders under review are carbon monoxide poisoning, compromised flaps and grafts, and late radiation tissue injuries (LRTI). The GRADE methodology will also be discussed in this context, especially in regard to how it allows for semiquantitative analysis of the available literature by assignment of values for RCTs (randomized controlled trials) and observational studies using predetermined criteria.

The delayed progress in completing the work of these committees is due to several challenges. The project is both labor-intensive and requires the effort of committee members who are volunteers. The body of literature requiring review is quite large, and there is also a relative lack of RCT's in each of these areas. Nevertheless, it is our hope that with the completion of each CPG area, the experience gained will propel and accelerate the process in developing future CPGs for the remaining indications of hyperbaric oxygen therapy.

SESSION C
CLINICAL HBO₂ THERAPY

Moderators:

FRIDAY, JUNE 30

Oral Presentations:
10:00 AM – 11:15 AM

Poster Presentations:
Poster Session 5: 11:15 AM – 11:37 AM
Poster Session 6: 11:37 AM – 12:00 PM

C 1

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 10:00 - 10:12

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION: Yes

Carbon monoxide exposure and timely hyperbaric oxygen therapy

Sharma D, Heyboer M, Muruganantham K, Wojcik S

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Introduction: Hyperbaric oxygen (HBO₂) therapy is used to treat carbon monoxide (CO) poisoning. It blunts ischemia-reperfusion injury in addition to rapidly eliminating CO, clinically decreasing the incidence of neurocognitive sequelae. HBO₂ is best administered within six hours of ED arrival for maximum benefit. A limited number of HBO₂ 24/7 facilities for emergent conditions makes it difficult to achieve this target. This study more than doubles the number of cases previously presented as preliminary data in 2015.

Materials/Methods: A retrospective chart review of 89 patients transferred for HBO₂ treatment from October 1, 2010. through February 5, 2017. for CO poisoning to a facility providing 24/7 HBO₂.

Results: Patients with a median CO level of 26 were transferred primarily by ground (86.5%) from a median distance of 89.5 miles. The cause of CO poisoning in 57% of cases was from residential exposure. In 75% of the cases contact with hyperbaric medicine was made within approximately two hours of ED presentation. However, transfer to the HBO₂ hospital took almost four hours. Only 35% of the patients received HBO₂ within the six-hour window. Patients from a median distance of 87 miles received HBO₂ within six hours while patients with a median distance of 96 miles received HBO₂ six hours after the event. Of patients transported by ground, 50% were treated outside the six-hour window and were 94 miles or farther from the HBO₂ hospital.

Summary: This study clearly demonstrates that a continuing decrease in 24/7 HBO₂ facilities is putting patients with moderate to severe CO poisoning at risk. Improvement needs to be made in timely identification of CO exposure and more immediate contact with HBO₂ facilities to reduce the delay to treatment. In addition, this study suggests more patients may benefit from air transport when at distances greater than 90 miles.

C 2

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 10:12 - 10:24

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION: No

Hyperbaric oxygen therapy is safe and effective for hospitalized ulcerative colitis patients suffering from moderate to severe flares: a multicenter, randomized, double-blind, sham-controlled trial

Dulai PS, Buckey JC, Raffals LE, Swoger JM, Claus PL, O'Toole K, Ptak JA, Gleeson MW, Widjaja CE, Adler JM, Patel N, Skinner LA, Haren SP, Goldby-Reffner K, Thompson KD, Knight R, Chang JT, Siegel CA

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Introduction/Background: Hyperbaric oxygen (HBO₂) therapy markedly increases tissue oxygen delivery and case series suggest a potential therapeutic benefit for ulcerative colitis (UC). We investigated HBO₂ as an adjunct to steroids for patients hospitalized for moderate to severe UC flares.

Materials/Methods: UC patients hospitalized for moderate to severe flares (Mayo score ≥ 6 , endoscopic subscore ≥ 2) were randomized across three sites to either steroids + daily HBO₂ (2.4 ATA @ 100% oxygen, 90 minutes, 10 sessions) or steroids + daily sham hyperbaric air (1.2 ATA @ 21% oxygen, 90 minutes, 10 sessions). The treating medical team and gastroenterologist performing study assessments were blinded to study assignment. The primary outcome was the clinical remission at Study Day 5 (partial Mayo score ≤ 2 with no subscore > 1). Secondary outcomes were: clinical response (reduction in partial Mayo score ≥ 2 ; rectal bleeding subscore of 0-1); and progression to second-line therapy (colectomy, anti-TNF therapy, cyclosporine).

Results: 18 patients (10 HBO₂ sessions, 8 sham) were randomized and treated. The study met its primary endpoint of clinical remission at Study Day 5 for HBO₂ versus sham (50% vs. 0%, $P=0.04$). Response to HBO₂ was observed as early as Day 3 (60% vs. 13%, $P=0.07$), and a significantly higher proportion of HBO₂ patients achieved Day 10 response (80% vs. 25%, $P=0.05$) and remission (50% vs. 0%, $P=0.04$). HBO₂ patients less often required progression to 2nd line therapy (10% vs. 63%, $P=0.04$) or colectomy specifically (0% vs. 38%, $P=0.07$) while hospitalized. There were no adverse events.

Summary/Conclusions: HBO₂ used adjunctively with steroids for hospitalized UC patients resulted in higher rates of response and remission, and a reduction in rates of colectomy or progression to second-line therapy while hospitalized. HBO₂ is safe and well tolerated. Further randomized trials are needed to confirm our findings.

C 3

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 10:24 - 10:36

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION: Yes

Iatrogenic arterial gas embolism case series treated with hyperbaric oxygen

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Introduction/Background: Iatrogenic air gas embolism (AGE) is a rare but significant medical complication that can occur in patients undergoing invasive procedures. Typical presentation of its occurrence can include sudden cardiac, neurologic or pulmonary abnormalities. The definitive treatment for AGE is hyperbaric oxygen (HBO₂) therapy. Most of these patients will be critically ill and require ICU level of care while undergoing HBO₂. Currently, there are few programs in the country with chambers that are able to manage such a condition, and decreased time to treatment may improve outcomes.

Materials/Methods: This is a retrospective review of patients who were diagnosed with iatrogenic air gas embolism from 2000 to 2017 who were treated with HBO₂ at Hennepin County Medical Center in Minneapolis, Minnesota. Records of demographic data, indications for HBO₂, time to chamber and clinical outcome were included in this study.

Results: 38 patients were identified; seven excluded due to insufficient data. Of the 31 patients, 17 (55%) improved with treatment while 14 (45%) had no change or a poor clinical outcome. Twelve of the 14 patients who had poor outcomes were transferred from outside facilities and had experienced longer periods of time prior to initiation of HBO₂. Five of these patients did not survive their injury and nine had no change in symptoms from treatment.

Conclusions: HBO₂ continues to be the definitive treatment for AGE. In our preliminary results, faster time to treatment showed a trend to more favorable outcomes in patients who suffered from iatrogenic AGE. Transferring patients from outside facilities can be time-consuming, and if more HBO₂ chambers were equipped for emergency care, patient outcomes could improve.

C 4

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 10:36 - 10:48

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION: No

Eyetracker outcomes in a randomized trial of hyperbaric oxygen or sham in participants with persistent post-concussive symptoms

Lindblad AS¹, Weaver LK^{2,3}, Wetzel P⁴, Mulatya C¹, Wilson SH¹, Kannan MA⁴, Villamar Z⁴

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Introduction: Eye movements may offer a sensitive method to detect abnormalities and measure response to intervention in mild traumatic brain injury (mTBI).

Methods: The Brain Injury and Mechanisms of Action of Hyperbaric Oxygen for Persistent Post-Concussive Symptoms after Mild Traumatic Brain Injury Study (BIMA) randomized 71 participants to either 40 daily sessions of hyperbaric oxygen or sham. A companion normative population study enrolled 75 participants. An eye-tracking system (EyeLink II, SR Research, Ottawa, Canada) was used to measure eye movements at baseline, 13 weeks and six months. Left and right eye movements were recorded for up to 34 parameters for 11 tracking tasks including both saccadic and smooth pursuit. Results were considered significant if t-tests for at least one eye was significant at $P < 0.001$ and the contralateral eye at $P < 0.02$ as confirmatory evidence to adjust for multiple testing.

Results: Of the 34 test parameters measured, all but five during the circular task, four during the horizontal ramp task, and 13 during the reading task showed significantly worse performance in the BIMA population compared to the normal population. On average, BIMA participants read fewer lines than normative participants (44.3 vs. 47.8 lines, $P = 0.04$), averaged more fixations (6.9 vs. 6.1, $P = 0.004$) and more regressions per line (3.8 vs. 3.1, $P = 0.0002$). At 13 weeks and six months, BIMA participants shifted toward the normal population distribution for the circular and horizontal ramp tasks. The reading task continued to suggest abnormalities, with no differences between the hyperbaric and sham arms.

Conclusions: Circular, horizontal ramp, and reading tasks were the most sensitive in differentiating between the normative and BIMA participants, suggesting potentially greater vulnerability of the smooth pursuit system to mTBI compared to the saccadic system. Hyperbaric oxygen did not result in a significant improvement compared to sham.

C 5

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 10:48 - 11:00

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION: No

A randomized trial of hyperbaric oxygen in U.S. service members with post-concussive symptoms

Weaver LK^{1,2}, Wilson SH³, Lindblad AS³, Churchill S¹, Deru K¹, Price R⁴, Williams C⁵, Orrison WW⁵, Walker J⁵, Meehan A⁵, Mirow S^{2,5} and the BIMA study team

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Introduction: In prior Department of Defense studies participants with persistent post-concussive symptoms after mild traumatic brain injury exposed to hyperbaric oxygen (HBO₂) or sham chamber sessions reported improvement regardless of allocation.

Methods: In this exploratory, double-blind, sham-controlled trial of HBO₂ for military personnel with persistent post-concussive symptoms, 71 randomized participants received 40 60-minute HBO₂ (1.5 atmospheres absolute, N=36) or sham chamber sessions (air, 1.2 atmospheres absolute, N=35). At baseline, 35 participants (49%) met post-traumatic stress disorder (PTSD) criteria. Outcomes included post-concussive symptoms, quality of life, neuropsychological, neurological, electroencephalography, sleep, audiology/vestibular, autonomic, visual, neuroimaging, and laboratory testing, at baseline, 13 weeks (shortly post-intervention), and six months, plus 12-month symptom questionnaires.

Results: By the Neurobehavioral Symptom Inventory, the HBO₂ group had improved 13-week scores compared to sham (HBO₂ mean change -3.6 points, sham mean change +3.9 points, P=0.03). In participants with PTSD, change with HBO₂ was more pronounced (-8.6 points vs. +4.8 points with sham, P=0.02). Rivermead Post-Concussion Symptom Questionnaire RPQ-3 improved with HBO₂ compared to sham (mean change difference -1.5, P=0.01). The PTSD Checklist-Civilian version scores also improved in the HBO₂ group, and more so in the subgroup with PTSD. Improvements regressed at six and 12 months. HBO₂ improved some cognitive processing speed and sleep measures. Participants with PTSD receiving HBO₂ had improved sensory organization test scores and reduced vestibular complaints at 13 weeks. Participants without PTSD had improved anger control with HBO₂. Most measures independent of patient reports did not change over time or did not change in a way that consistently favored one intervention over another.

Conclusions: By 13 weeks, HBO₂ improved post-concussive and PTSD symptoms, cognitive processing speed, sleep quality, and vestibular symptoms, most dramatically in those with PTSD. However, most changes did not persist to six to 12 months. For military personnel, additional HBO₂ studies are warranted.

C 6

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 11:00 - 11:12

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION: Yes

Case series of frostbite injury treated with hyperbaric oxygen and prospectively evaluated with cutaneous microangiography (LUNA)

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Introduction: Hyperbaric oxygen is a treatment option for frostbite injury if there is evidence of peripheral limb ischemia. At our institution, we evaluate ischemia by performing a technetium bone scan. We then use microangiography (LUNA) to score clinically at-risk tissue. In this prospective partially blinded study, 14 patients received initial and repeat LUNA of the involved extremities and were treated with daily hyperbaric oxygen therapy for 10 total treatments. We quantified perfusion deficits of the extremities on the LUNA using the Hennepin Frostbite Score. To our knowledge this is one of the largest case series of frostbite patients treated with hyperbaric oxygen.

Results: Thirty-three extremities showed bone deficit on initial bone scan. A total of 21 extremities showed deficits on LUNA at some point during the treatment course. Of the extremities that had deficit on LUNA, the average improvement in the Hennepin Score was 4.4% by the end of hyperbaric treatments. A total of 13 extremities (62%) improved based on LUNA scoring during the course of HBO₂, and five extremities (23%) worsened. Seven extremities had amputations, and one extremity will likely get an amputation in the near future. A high Hennepin Score corresponded to a higher likelihood of amputation.

Conclusion: A majority of the extremities with radiographic deficits demonstrated objective improvement by the end of the hyperbaric course. LUNA provided a valuable objective measurement in monitoring this population. The frostbite injuries that are worse on initial presentation (higher Hennepin Score) tended to do worse. At this point, it is unclear if hyperbaric oxygen improved outcomes in frostbite injuries. In our series, improvement was most evident for less severe frostbite injuries. Further studies randomizing patients to hyperbaric oxygen for frostbite injury are planned to address this.

C 7

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION: No

Adherence to intervention and follow-up in a randomized clinical trial of hyperbaric oxygen sessions versus sham

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Introduction: Adherence to treatment and follow-up visits are important comparators of data quality in studies testing hyperbaric oxygen for treatment of post concussive symptoms following mild traumatic brain injury. The American Academy of Neurology suggests cautiously interpreting studies with less than 80% adherence.

Methods: The BIMA* study randomized 71 participants from three sites to 40 one-hour sessions of hyperbaric oxygen (>99% oxygen, 1.5 ATA, N=36) or sham (air, 1.2 ATA, N=35) over 12 weeks. In-person follow-up visits occurred at 13 weeks and six months, and telephone or on-line questionnaire completion occurred at 12 months post-randomization. A protocol amendment adding 24- and 36-month follow-up and requiring re-consent was approved two years after enrollment initiation and after 58% of participants had completed the 12-month follow-up.

Results: A total of 29 HBO₂ participants (81%) and 30 sham participants (86%) completed 40 chamber sessions. Six HBO₂ participants (17%) and three sham participants (9%) completed 20-39 sessions. One HBO₂ participant (3%) and two sham participants (6%) completed fewer than 20 sessions. Scheduling difficulty was the predominant reason for completing fewer than 40 sessions (five of 11 participants). A total of 36 HBO₂ participants (100%) and 34 sham participants (97%) completed 13-week follow-up; 35 HBO₂ participants (97%) and 32 sham participants (91%) completed six-month follow-up; 36 HBO₂ participants (100%) and 32 sham participants (91%) completed 12-month follow-up; 42 participants (59%) consented to extended follow-up [25 HBO₂ participants (69%); 17 sham participants (49%)]. The primary reason for consent failure was inability to contact the participant.

Conclusions: BIMA had excellent intervention and follow-up adherence through 12 months. Re-consent for extended follow-up at 24 and 36 months resulted in high loss to follow-up rates, which may have been avoided if the extended follow-up had been included as part of the original design and consent.

* BIMA is the Brain Injury and Mechanisms of Action of Hyperbaric Oxygen (HBO₂) for Persistent Post-Concussive Symptoms after Mild Traumatic Brain Injury (mTBI) (BIMA) Study

C 8

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: WITHDREW

RESIDENT COMPETITION: No

Case report: Hyperbaric oxygen treatment for non-healing above-knee amputation

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WITHDREW

C 9

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION:

Innovative therapeutic strategies in the treatment of refractory osteomyelitis

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Introduction: Suppurative osteomyelitis is an inflammatory disease of the bone marrow, cortical bone or periosteum caused by bacterial infection. Even presently with the development of antibiotics, some cases become refractory from multidrug-resistant bacteria. The first clinical report using HBO₂ to treat osteomyelitis was done by Slack in 1965. Currently HBO₂ has become a standard/recommended treatment for osteomyelitis in many countries and hyperbaric medicine societies.

Methods: Between 1981 and 2016 we treated 773 osteomyelitis cases with HBO₂, using 2.0 ATA for 60 minutes per day. We obtained good results, even if we treated them with the administration of antibiotics plus HBO₂ conservatively. If patients did not show sufficient improvement, we suggested closed irrigation therapy, also a standard treatment for infectious disease of the bones and joints.

Results: 508 of the patients (65.7%) were treated conservatively, and the other 265 cases (34.3%) were treated surgically in addition to having HBO₂. A total of 481 cases (94.7%) from the conservatively treated group did not have recurring symptoms; 251 cases (94.7%) additionally treated with irrigation therapy never had recurring symptoms.

Conclusion: Since 2009, we have been using "ozone nano-bubble water (ONW)," which has a sterilizing effect against various bacteria and viruses for closed irrigation therapy. It contains ozone bubbles approximately 10-100 nm in diameter, 8.8 x 10⁸ particles/mm³ in 0.9% NaCl water. The features of ONW include sterilization for various kinds of bacteria and viruses, even multidrug-resistant bacteria. Moreover ONW does not damage normal tissue and continues to dissolve more than a year in the water. It is used in various fields – e.g. medical, engineering, agriculture, environmental purification or food processing – and various other advantages have been reported.

C 10

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 6: 11:37 - 12:00

RESIDENT COMPETITION: Yes

Dose-dependent effects of hyperbaric oxygen therapy in children with autism spectrum disorder

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Introduction: This paper reviews research on the potential benefit for children with autistic spectrum disorder (ASD) after hyperbaric oxygen (HBO₂) therapy. HBO₂ involves placing patients in a pressurized chamber, allowing respiratory exchange of gases at supra-atmospheric pressures. Sessions last one to two hours, occurring daily with spans from weeks to months. HBO₂ has well-established benefits in treating numerous conditions, including decompression sickness, gas emboli, and chronic wounds. The field has potential for expansion into different conditions/diagnoses. This review attempts to bring together the data in regard to potential benefit in children with ASD.

Materials/Methods: A meta-analysis was performed of six prospective clinical trials providing dose-specific outcomes using two ratings scales: 1.3 atm/24-25% oxygen and 1.5 atm/100% oxygen. While different behavioral rating scales were used, there was enough overlap in both the Autism Treatment Evaluation Checklist (ATEC) and the Aberrant Behavior Checklist (ABC) at placebo for comparison. The mean change in total ATEC and ABC scores with 95% confidence interval (CI) were evaluated using a DerSimonian and Laird random effects model.

Results: Neither hyperbaric treatment scale demonstrated statistically significant improvement over placebo; however, both scales demonstrated elevated changes in behavior for higher dose treatment. Treatment at 1.5 atm/100% oxygen showed ABC gains of 17.1 (95% CI 12.4-21.8) and in ATEC gains of 14.1 (95% CI 2.1-26.1). Treatment at 1.3 atm/24-25% oxygen showed ABC gains of 7.5 (95% CI 1.2-13.8) and in ATEC gains of 8.6 (95% CI 2.4-14.7).

Summary/Conclusions: Meta-analysis confirms randomized controlled trial findings that treatment at 1.3 atm/24-25% oxygen does not improve autism behavior over placebo. The presence of greater behavioral gains across two rating scales for treatment with 1.5 atm 100%/oxygen suggests a biologically plausible dose-response effect for HBO₂ in autism treatment. Further studies are needed to determine the possible extent of this benefit as well as development of a protocol for optimal depth, oxygen content, and duration of therapy.

The views expressed in this material are those of the authors, and do not reflect the official policy or position of the U.S. Government, the Department of Defense, or the Department of the Air Force.

C 11

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: No

The role of hyperbaric oxygen in the treatment of calciphylaxis

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Introduction/Background: Calciphylaxis lesions are extremely painful violaceous indurated necrotic skin and adipose lesions due to arteriolar media calcification and intimal endothelial fibrosis and thrombosis. Risk factors include end-stage renal failure requiring dialysis (up to 4.5% incidence), obesity, female sex, hyperparathyroidism, hypercoagulable states (including warfarin use), diabetes, and malignancy. Mortality ranges from 43% at six months to 77% at five years; death is typically from sepsis.

Materials/Methods: Our patient is a 60-year-old woman with systemic lupus erythematosus, poorly controlled insulin-treated diabetes, hypertension, peripheral arterial disease, body mass index of 41, prior single parathyroidectomy for hyperparathyroidism, who is hemodialysis-dependent due to renal failure secondary to lupus nephritis and diabetes.

She developed a painful abdominal wall lesion which progressed to a necrotic wound over six months. Deep tissue biopsy confirmed calciphylaxis. Antiphospholipid antibodies, cryoglobulins, protein S and C, antithrombin, and lupus anticoagulant were normal/negative. Mildly elevated fibrinogen, D-dimer, alkaline phosphatase, parathyroid hormone level 210 pg/mL, phosphorus 5.1 mg/dL, and mildly decreased calcium 7.6 mg/dL, were noted.

Her treatment included excisional surgical wound debridement and negative-pressure wound therapy, 12.5 grams sodium thiosulfate intravenous three times weekly, clopidogrel, low-dose aspirin, and sevelamir and cinacalcet to optimize her calcium, phosphorus and vitamin D status. Dialysis frequency was increased to five times weekly. She received hyperbaric oxygen therapy (HBO₂); 40 sessions at 2.0 ATA, 85 minutes each.

Results: The patient achieved full wound healing with these treatment strategies.

Summary/Conclusions: Noting the significant mortality and morbidity of calciphylaxis, we recommend a multimodality calciphylaxis treatment approach, including HBO₂. HBO₂ promotes wound healing through angiogenesis, fibroblast proliferation and oxygen-dependent neutrophil bactericidal action. Per An, et al., the therapeutic response in HBO₂ calciphylaxis lesions ranges up to 58%. Per McCarthy, et al., surgical excisional wound debridement and subtotal parathyroidectomy, when indicated, are effective treatments.

C 12

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: Yes

Hyperbaric oxygen therapy used to manage suspected chemotherapy- induced hemorrhagic cystitis

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Introduction: Hemorrhagic cystitis (HC) is a serious clinical problem that occurs after pelvic radiation, chemotherapy or both. Patients undergoing bone marrow transplant are at risk for hemorrhagic cystitis due to either the direct effects of chemotherapy or activation of inactive viruses in the kidney, ureter or bladder. We report on this case in which a patient's HC is thought to be in part secondary to the chemotherapy and reactivation of BK virus infection of the bladder. Hyperbaric oxygen (HBO₂) therapy was successfully delivered and resolved the symptoms of HC.

Case history: A 17-year-old female underwent unrelated donor bone marrow transplant in August 2014 following treatment and high-dose chemotherapy, which included cyclophosphamide, for chronic myeloid leukemia (CML). Despite remaining in morphologic and cytogenetic remission, she developed significant transfusion-dependent HC with urinary clots and associated pain considered to be urinary BK infection. Patient subsequently underwent intravenous treatment for BK infection. Continuous bladder irrigation therapy failed to control her hematuria. A total of 20 planned sessions of HBO₂ treatment in a monoplace chamber was initiated. Protocol included using 2.0 ATA 100% oxygen for 85 minutes with two five-minute air breaks. Symptoms improved by her seventh HBO₂ session, with no hematuria upon completion.

Discussion: HC can result from damage to the transitional epithelium and blood vessels of the bladder by toxins, pathogens, radiation, medications or illness. Affected patients may develop asymptomatic microscopic hematuria, or in this case, gross hematuria with clots. Those who underwent chemotherapy are often immunocompromised and are at high risk of acquiring bacterial and viral infections, such as BK virus, which may further aggravate HC. HBO₂ has been shown to promote the reduction of local edema, improve fibroblast activity, and enhance healing of the friable bladder tissues related to suspect chemotherapy-induced HC and associated symptoms.

C 13

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: No

HBO₂ and severe Crohn's disease: case report

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Introduction: We present a case of a female patient with severe Crohn's disease (CD), with multiple perineal fistulas and use of corticosteroids and immunosuppressive drugs in high doses. There was no improvement in symptoms despite adequate therapy. After HBO₂ the patient achieved significant clinical improvement, with wound closure and decreased doses of medication.

Case Report: A 27-year-old female had a history of diarrhea and hematochezia starting in 2009. After several hospital admissions – due to the permanence of symptoms associated with severe weight loss – she was referred to a proctologist in August 2009. She was diagnosed with Crohn's disease, confirmed by biopsy, and started on corticosteroids and immunosuppressant drugs.

In December 2009, she presented with severe intestinal obstruction, undergoing the first surgical procedure and colostomy. In May 2010, a colostomy reversal was performed, and drug regimen was altered to azathioprine + prednisolone 80 mg.

In 2013, despite the drug regimen update, she showed no improvement. Her condition evolved to include an abdominal fistula in 2014 and a rectovaginal fistula in 2015. She was given antibiotics in an attempt to avoid further surgical procedures.

In December 2015, she underwent an extensive fistulectomy and referred for HBO₂. In March 2016, at the initial examination, there were two large wounds – a paravaginal and an intergluteal – both presenting with abundant exudates and secretions. She showed a satisfactory response with associated HBO₂ + corticosteroids + immunosuppressants at high doses.

Results: After 20 HBO₂ sessions, she was able to feed herself properly and showed substantial reduction in the amount of secretions. She experiences total remission of intestinal symptoms and complete wound closure. Currently, she is under a low-dose immunosuppressant and no corticosteroids, and has resumed her daily living activities symptom-free.

Conclusion: HBO₂ can be used to control both systemic and inflammatory activities of Crohn's disease.

C 14

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: No

Hyperbaric oxygen treatment for refractory hemorrhagic cystitis after cyclophosphamide therapy: case report and review of reported cases

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Introduction: Cyclophosphamide is a chemotherapeutic agent used in several different malignancies and autoimmune diseases. Its metabolite, acrolein, excreted in urine, can result in uroepithelial damage including the bladder with resultant hematuria. Hematuria is generally mild but can result in intractable bleeding in up to 40% of patients. This requires blood transfusions along with traditional conservative measures. Hyperbaric oxygen treatments have been utilized with success to treat these patients.

Materials/Methods: We report a case of a young woman with systemic lupus erythematosus and cyclophosphamide treatments who developed symptomatic unresponsive hematuria. An extensive literature review was performed with Ovid Gateway up to 2017. Only patients treated with cyclophosphamide and hematuria were included in the review.

Results: Hematuria was treated with a course of 60 hyperbaric oxygen treatments at 2.4 ATA, 90 minutes, single 10-minute air break in a Sechrist monoplace hyperbaric chamber. The patient experienced resolution of hematuria and symptoms. No recurrence was noted for more than six months. Fifteen previous cases were found. Hyperbaric oxygen treatments resolved hematuria in nearly all cases, with varying lengths of follow up.

Summary/Conclusion: Macroscopic hematuria in our patient developed and rapidly progressed, requiring several hospitalizations and blood transfusions. Symptoms were unresponsive to cessation of cyclophosphamide treatments and to conservative efforts, from hydration to external diversion. A course of hyperbaric oxygen treatments were completed, with resolution of hematuria and no further need for intervention for more than six months. Previous reports in the literature noted similar success with hyperbaric oxygen treatments. We recommend hyperbaric oxygen treatments in patients who received cyclophosphamide with subsequent intractable hematuria, with the expectation of resolution of symptoms and hematuria.

C 15

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: Yes

Cerebral arterial gas embolism in a patient with hypoplastic left heart syndrome treated with emergent hyperbaric oxygen: case report

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Case report: A 30-year-old female with a history of seizure disorder and hypoplastic left heart syndrome treated with a Norwood procedure in 1986 followed by a modified non-fenestrated Fontan (left SVC to IVC to pulmonary arteries) with a known small baffle leak. On day of presentation, patient went to an outpatient infusion center for chemotherapy infusion, but was found to be thrombocytopenic. She was started on a platelet transfusion. Near the conclusion of the transfusion, she became unresponsive with perioral cyanosis, rightward gaze and a left facial droop. She was transferred to the Emergency Department at 16:49. Initial concern was for seizure versus cerebrovascular accident. An emergent non-contrast head CT revealed intracranial air in the right MCA distribution. Patient was brought to the hyperbaric chamber, and a hyperbaric treatment started at 21:05. Patient was treated with a U.S. Navy Table 6 in a multiplace chamber, with no extensions. Ten minutes into the treatment patient became more alert and spontaneously began asking questions. The following day she was treated with a U.S. Navy Table 5. Patient had repeat CT of the head, showing resolution of intracerebral gas and small areas of ischemia in right frontal lobe and right caudate. On hospital Day 5, neurologic exam was documented as normal, with 5/5 strength and no residual deficits. Treating the patient was a concern because patient has a single ventricle, in which the pulmonary artery is connected directly to the vena cava. There is very little data regarding the effects of HBO₂ therapy on single-ventricle physiology. There are only two case reports of three pediatric patients treated with HBO₂ for CAGE in a similar setting [1, 2]. In these cases, the patients had improvements in their symptoms following HBO₂ therapy. These cases and ours indicate HBO₂ is feasible and indicated for CAGE in patients with cyanotic congenital heart disease.

1. [LeDez KM](#), [Zbitnew G](#). Hyperbaric treatment of cerebral air embolism in an infant with cyanotic congenital heart disease. [Can J Anaesth](#). 2005 Apr; 52(4): 403-408.

2. Newcomb A, Frawley G, Fock A, Bennett M, d'Udekem Y. [Hyperbaric oxygenation in the management of cerebral arterial gas embolism during cavopulmonary connection surgery](#). [J Cardiothorac Vasc Anesth](#). 2008 Aug; 22(4): 576-580.

C 16

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: Yes

Maxillary osteoradionecrosis and flap reconstruction successfully treated with adjunctive hyperbaric oxygen therapy

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Introduction: We report a case of osteoradionecrosis of the maxilla that responded favorably to operative debridement, reconstructive surgery and adjunctive hyperbaric oxygen (HBO₂) therapy.

Materials/Methods: The patient is a 60-year-old male with a past medical history pertinent for squamous cell carcinoma of the upper lip/gingiva. He was treated with anterior maxillectomy, local and radical neck dissection, and reconstruction of anterior maxilla with iliac bone graft, then followed with post-operative radiation therapy. Patient developed osteoradionecrosis (ORN) of the maxilla, oral-nasal fistulas, and exposed hardware with post-operative breakdown of reconstruction site within three months following radiotherapy. Patient was referred to hyperbaric medicine.

The patient received tympanostomy tubes bilaterally by ENT to avoid barotrauma in the setting of difficulty with ear equalization prior to starting HBO₂.

The patient received 40 HBO₂ treatments initially, at 2.5 ATA for 90 minutes, in addition to operative debridement and antibiotics. Infected hardware and non-viable bone were successfully removed. An upper lip/nose reconstruction was performed with staged flap surgeries interspersed with 10 post-operative HBO₂ treatments after each procedure. The patient received a total of 70 HBO₂ treatments.

Results: At his five-month ENT office visit the patient continued to do well, with resolution of the ORN, resolved oral-nasal fistulas and healed flaps. He is currently awaiting further reconstructive surgeries for upper lip flap revision.

Summary: Our patient benefitted from adjunctive HBO₂ in the treatment of maxillary ORN with fistulas, requiring staged reconstructive flap surgeries.

The use of HBO₂ as an adjunctive therapy for treatment of ORN mandible is well documented. It is believed to benefit less common maxillary ORN also but has less published data. This case supports the continued use of adjunctive HBO₂ in the treatment of ORN maxilla.

C 17

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: No

Treating with hyperbaric oxygen therapy for necrotizing fasciitis

Yamaguchi T, Kawashima M, Kawashima M, Tamura H, Nagayoshi I, Motoyama T, Furue Y, Sasaki T, Watanabe Y, Goto T, Takao K, Miyata K

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Introduction: Necrotizing fasciitis is characterized as rapidly widespread necrosis of the subcutaneous tissue and fascia due to a toxin-producing bacterial infection. If sepsis occurs it is potentially fatal. Early surgical debridement and antibiotic administration are the basic treatments. Hyperbaric oxygen (HBO₂) therapy given adjunctively is effective.

Materials/Methods: We treated 21 cases of necrotizing fasciitis from 1981 to January 2016. All were treated with HBO₂ in addition to the basic treatment. The Laboratory Risk Indication of Necrotizing Fasciitis (LRINEC) score ranged 1-10; average was 5.8. Bacteria was detected as follows: Staphylococcus aureus in 11 cases; α -Streptococcus in five cases; β -Streptococcus in five cases (Group A: four cases, Group B: one case); E. coli in two cases. HBO₂ was performed at 2.8 ATA for the first three days and at 2.0 ATA from the fourth day for 60 minutes.

Results: 21 cases had 22 infected parts: 13 were cured/improved without amputation. An upper arm amputation and above-the-knee amputation was done in one case. There were finger amputations in two cases and toe amputation in one case. Unfortunately, Kawashima Orthopaedic Hospital could not treat four cases requiring advanced integrated care. When their condition worsened, these patients were moved to another hospital. Patients with necrotizing fasciitis are often immunocompromised, as they often have diabetes, cancer or liver disease. Out of 21 patients, 11 cases had diabetes and/or liver dysfunction; four cases had fatal systemic toxic conditions. Three of the latter four cases also had serious diabetes and/or liver dysfunction.

Conclusion/Summary: Since 2009 we have been using "ozone nano-bubble water (ONW)" for washing wounds. It contains ozone bubbles of approximately 10-100 nm in diameter, 8×10^8 particles/mm³ in 0.9% NaCl water. The features of ONW are include sterilization for various kinds of bacteria and viruses – even multidrug-resistant bacteria. Moreover, ONW does not damage normal tissue and keeps dissolving more than a year in the water. It is used in various fields such as medical, engineering, agriculture, environmental purification or food processing, and various advantages have been reported.

C 18

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: No

Effect of repetitive sessions of hyperbaric oxygen on patients with delayed neurological sequelae after acute carbon monoxide poisoning: two case reports

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Introduction: Delayed neurological sequelae (DNS) is relatively a common complication after acute carbon monoxide poisoning. As DNS is considered classic pathophysiology of carboxyhemoglobin-induced hypoxia, hyperbaric oxygen (HBO₂) therapy is currently well supported for acute CO poisoning. However, even though various kinds of treatments for DNS have been introduced, definitive treatment for DNS has not been available for this potentially life-threatening disorder. We report on two patients who recovered from DNS due to acute CO poisoning after they underwent repetitive HBO₂ treatments.

Materials/Methods: A 35-year-old male and 52-year-old male developed DNS approximately four weeks after acute carbon monoxide poisoning. They showed slow responses to all kinds of external stimulations, impaired concentration, cognitive dysfunction, comprehension difficulties, limb rigidity, and urinary and bowel incontinence at the onset of DNS development. Emergent MRIs showed demyelination and inflammation in the deep white matter of both patients. The patients underwent 20 sessions of HBO₂. Repetitive HBO₂ consisted of 2.5 ATA for 90 minutes, once a day for 20 days. After treatment with multiple sessions of HBO₂, both patients showed near-complete recovery from both physical and neurological signs and symptoms of DNS. The follow-up MRI also showed a remarkable improvement of demyelination and inflammation in both patients' deep white matter.

Conclusion/Summary: Future control studies are needed to evaluate the effectiveness of repetitive hyperbaric oxygen therapy in patients who develop DNS.

C 19

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: No

Hyperbaric oxygen therapy for the treatment of radiation-induced vaginal necrosis

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Introduction: Vaginal necrosis is a rarely reported but disabling complication of pelvic radiation therapy. We describe the successful use of hyperbaric oxygen (HBO₂) therapy in the treatment of a patient with vaginal necrosis.

Case Report: A 61-year-old female with a history of squamous cell vaginal cancer treated one year previously with chemotherapy and external beam radiation therapy (7000 cGy) developed severe and progressive pelvic pain. She reported that she was unable to achieve a seated position due to the pain, and she required inpatient hospitalization due to her decreased mobility and pain medication requirements. Exam under anesthesia revealed perineal destruction and cavitation from the vagina to the right ischiorectal fossa, consistent with vaginal necrosis. Biopsies were negative for recurrent malignancy. The patient was referred for HBO₂ therapy, but initiation of treatments was delayed due to the development of a rectovaginal fistula which required sigmoid colostomy. The patient eventually completed 60 daily HBO₂ treatments (2.5 ATA, 90 minutes at 100% O₂ with five-minute air breaks x2), after which she reported resolution of her pain. She was also able to maintain a seated position and ambulate with a walker, although she was deconditioned from months of lying on her side. After rehabilitation, she was able to return home and live independently.

Discussion: Vaginal necrosis occurs months after the completion of pelvic radiation therapy, and is traditionally characterized by pelvic pain which is worsened by sitting. Vaginal consolidation gradually occurs, with eventual vaginal obliteration. Our patient experienced pain relief and increased mobility after receiving HBO₂ for this condition, which was indicative of an improved quality of life.

Conclusion: The diagnosis of vaginal necrosis should be considered in patients who previously received pelvic radiation, who are now unable to sit. Hyperbaric oxygen therapy should be considered for the treatment of radiation-induced vaginal necrosis.

C 20

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 5: 11:15 - 11:37

RESIDENT COMPETITION: Yes

Failed flap successfully treated with hyperbaric oxygen

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Introduction: This is the case of a patient who suffered consecutive failed flaps for above-the-knee amputation (AKA) that responded favorably to adjunctive hyperbaric oxygen therapy.

Materials/Methods: A 46-year-old female with a past medical history pertinent for lupus, arterial insufficiency and hypercoagulability underwent bilateral AKA due to ischemic limbs. Her ischemia was a result of severe arterial insufficiency due to hypercoagulability. Postoperatively her bilateral AKA myocutaneous flaps failed, with resulting necrosis and surgical wound dehiscence. Patient underwent revision, but subsequent flaps failed again. At imminent risk of bilateral hip disarticulation and associated mortality, the patient was referred to hyperbaric medicine for evaluation. Patient had necrotic tissue with exposed femur at time of consultation.

Transcutaneous oximetry (TcPO₂) at room air was 18 mmHg (right), 1 mmHg (left) consistent with critical limb ischemia. TcPO₂ 1 ATA 100% oxygen challenge was non-predictive at 29 mmHg (right), 19 mmHg (left). TcPO₂ values at 2.0 ATA 100% oxygen were >200 mmHg bilaterally and predictive of response to HBO₂.

The patient was treated with HBO₂ at 2.0 ATA for 90 minutes for a total of 38 treatments in conjunction with further operative surgical debridement and negative-pressure wound therapy.

Results: There was demonstrable improvement in wound bed health/granulation tissue, decreased wound depth, and wound contracture. Patient was able to be discharged to a rehabilitation facility and subsequently to home, with superficial wounds. She follows in the wound care center and has continued to show improvement.

Summary: This case demonstrates the benefit of adjunctive HBO₂ in the treatment of an ischemic wound after failed flap. It further demonstrates the use of TcPO₂ for patient selection and treatment decision-making. The use of HBO₂ has been largely evidenced through animal studies and clinical case series as an adjunctive treatment for ischemic compromised flaps to promote survival of the tissue.

ERIC P. KINDWALL, MD MEMORIAL LECTURE
FRIDAY, JUNE 30: 1:00 pm - 2:00 pm



GUEST SPEAKER: DR. JOHN FELDMEIER
LECTURE TITLE: “Beams and Bars: Radiation Oncology and Hyperbaric Medicine, An Inseparable Story, Past, Present and Future”

ABOUT THE LECTURE:

On the occasion of the 50th Anniversary of the UHMS, this presentation will look to the past, present and future to discuss the historic and ongoing inextricable relationship between hyperbaric oxygen and radiation therapy. This relationship predates the founding of our society by at least 12 years, at which time a brave and inspired clinician and scientist named Churchill-Davidson first irradiated patients in a monoplace chamber at pressure. This brave study was based on firm and still-valid biologic principles established by Gray and Tomlinson a few years earlier: Namely, well-oxygenated tumors are as much as three times more sensitive to radiation cell kill than are hypoxic tumors. For a number of reasons, simultaneous radiation and hyperbaric oxygen are not clinically employed at this time even though retrospective reviews of these studies have shown statistically enhanced local tumor control.

For the latter decades of the last century and so far in the 21st century, the interaction between the two disciplines has been primarily the application of hyperbaric oxygen to treat or prevent delayed radiation injuries. The pioneering work of Robert Marx DDS, and his colleagues, initially at Wilford Hall USAF Medical Center and continuing to this day at the University of Miami, has established the rationale, designed a successful clinical protocol and reported the results in employing hyperbaric oxygen as an adjunct in the management and prevention of mandibular osteoradionecrosis. As the experience mounted and biologic principles were described, hyperbaric oxygen was applied to the treatment at many soft tissue and organ sites, including the rectum and bladder. We owe a debt of gratitude to Mr. Dick Clarke and the Baromedical Research Foundation for giving us a well-designed randomized controlled trial that supports HBO2 for delayed proctitis. The application of HBO2 has been so successful in radiation injury that at many centers it is the most common indication for treatment, and at several prominent centers, patients with radiation damage constitute more than 50% of those receiving treatment. Clinical dilemmas do arise when patients are found to have active malignancy or are undergoing chemotherapy. Recently some, especially our colleagues in Japan, have begun again to look at hyperbaric oxygen as a radiation sensitizer, employing and sequencing the two therapies in such a way that the dangers of explosive decompression and the resistance of staff to slowing throughput in a busy radiation center have been removed.

As for the future, there remains a wealth of unexplored and potentially even broader combined applications of the two therapies. A possible role for hyperbaric oxygen in hastening the resolution of severe acute consequences of cancer treatment has recently been reported. There is no reason not to consider and study hyperbaric oxygen as an enhancer of cytotoxic chemotherapeutic agents, many of which mimic radiation in their mechanism of action. Additional refinements of hyperbaric oxygen as a radiosensitizer show promise, including infused and implanted radioisotopes. In my mind, perhaps the most exciting potential future application would be the prophylactic application of hyperbaric oxygen in irradiated patients who are unknowingly at increased risk for complications due to inherent idiosyncratic sensitivities. In order to apply this concept to its full potential, reliable predictive biochemical or imaging

assays will need to be developed so that intervention can take place before the expression of these serious consequences of treatment.

In summary, the fields of hyperbaric oxygen and radiation oncology have been closely related for more years than our society has existed. Previously, hyperbaric oxygen was investigated as the most powerful and safest radiation sensitizer. Currently, hyperbaric oxygen plays a key role in managing and preventing late complications. For the future, the studies of radiosensitization need to be revisited and refined to include cytotoxic drugs and novel ways to enhance radiation antitumor effect without the problems and dangers experienced nearly 60 years ago. The development of predictive assays for delayed radiation injury may allow intervention with hyperbaric oxygen even prior to the manifestation of those complications.

ABOUT DR. FELDMEIER:

A 1970 graduate of Duquesne University in Pittsburgh with a B.S. in Physics, Dr. Feldmeier initially served as a meteorologist in the USAF Weather Service until 1975. He received his D.O. degree from The Philadelphia College of Osteopathic Medicine in 1979 with USAF sponsorship and completed residency training in Radiation Oncology at the University of Texas Health Science Center at San Antonio, Texas in 1985. He received a fellowship certificate from the USAF Hyperbaric Medicine Fellowship Training Program at Brooks Air Force Base in San Antonio, Texas and was a staff physician there from 1980 to 1982. Dr. Feldmeier then served as the Chief of Radiation Oncology from 1985 to 1987 and ultimately simultaneously Chairman of the Hyperbaric Medicine Department at Wright-Patterson Air Force Base Medical Center in Dayton, Ohio. He returned to the University of Texas Health Science Center as faculty in 1987 and ultimately became Chief of Radiation Oncology there. He was also the Radiation Oncology Residency Program Director there before leaving to join the faculty at Wayne State University from 1992 until 1997. He became Division Chief and Clinical Chief of Radiation Oncology at Grace Hospital in Detroit, Michigan in 1993. In 1997 he joined the University of Toledo Medical Center (previously known as Medical College of Ohio) and served as Department Chairman of Radiation Oncology there until his retirement from that position in 2013. He was named Professor Emeritus upon his retirement.

Dr. Feldmeier has authored numerous publications in both radiation oncology and hyperbaric medicine. He has been the editor of the Undersea & Hyperbaric Medical Society (UHMS) Hyperbaric Oxygen Therapy Committee Report which provided the rationale for the UHMS Accepted Indications for HBO2. He served a review editor of the UHMS scientific journal, Undersea and Hyperbaric Medicine. He is a Fellow of Undersea and Hyperbaric Medicine and continues on the UHMS Board of Directors as Past-President of the UHMS. He currently co-chairs the UHMS Research Committee. He is a Fellow of the American College of Radiation Oncology. He has been recognized as one of "The Best Doctors in America" until his retirement beginning in 2007. He is a consultant to International ATMO. He is the only physician board certified in both Radiation Oncology and Undersea and Hyperbaric Medicine.

ERIC P. KINDWALL, MD MEMORIAL LECTURE

ABOUT DR. KINDWALL



Dr. Kindwall is known by many as the "Father of Hyperbaric Medicine." Whether you knew him personally or simply by reputation, we have all benefited from his efforts, passion, wisdom, knowledge, energy and vision. Dr. Kindwall has played a great role in growing and shaping the specialty of Undersea and Hyperbaric Medicine. He was likewise instrumental in molding the UHMS into what it is today. Dr. Kindwall began diving in 1950. He cultivated his interest in the field and during the Vietnam War served as the Assistant Director of the U.S. Navy School of Submarine Medicine. He also was the Senior Officer responsible for the Diving Medicine Program. In 1969, after leaving the Navy, Dr. Kindwall became Chief of the Department of Hyperbaric Medicine at St. Luke's

Medical Center, Milwaukee, Wis. Shortly after the Undersea Medical Society was created in the mid-1960s, Dr. Kindwall identified the need for standardized education in the field. He created the UMS Education and Standards Committee to help elevate course content and ensure instructor competence. This committee later became our Education Committee. When the AMA initiated its Continuing Medical Education program, Dr. Kindwall persuaded the organization to recognize the UMS as a grantor of CME credits. In 1972, Dr. Kindwall felt that the Society's members would benefit from improved communication. He created our first newsletter and was named editor. Dr. Kindwall chose the name Pressure because clinical hyperbaric medicine was rapidly developing. Even though the UHMS had not yet incorporated "Hyperbaric" into the Society's name, he wanted a title for the newsletter that would encompass all who worked with increased atmospheric pressure. He stated: "The Society's goal then, as it is now, is to serve all who deal with the effects of increased barometric pressure." That same year, Dr. Kindwall recognized the need to have a relationship with Medicare to help provide insight on reputable clinical management. The UMS followed this lead, and a Medicare Panel was created. The recommendations were presented to the U.S. Public Health Service. The challenge was that no reliable hyperbaric medicine clinical guidelines were available that addressed appropriate applications of Hyperbaric Medicine. To remedy this deficit, the UMS Executive Committee created an Ad Hoc Committee on hyperbaric oxygen therapy. Dr. Kindwall was named Chair. The committee created the first Hyperbaric Oxygen Therapy Committee Report. Again, this text was published 10 years before the UHMS incorporated "Hyperbaric" into its name. The report was sent to HCFA and the Blues and became their source document for reimbursement. Dr. Kindwall updated the text two more times and thus was the Editor and Chair of the Committee and text for three of its 12 editions. Dr. Kindwall later worked to expand the available information on the specialty by creating one of the first complete texts on the field. He created Hyperbaric Medicine Practice in 1994 and later updated and revised his text two more times. The Society's first journal, Hyperbaric Oxygen Review, has also been influenced by Dr. Kindwall. His love for research and education was clear: He became the initial editor, creating a journal that at first consisted of review articles and one original contribution. Over the years, it has grown to one full of original research. Dr. Kindwall's presence is felt in so many of the UHMS' activities and initiatives. Much of what we all take for granted – what is just "there" and "available" – has his touch and influence. Some of us have been blessed to have had a closer impact by Dr. Kindwall's life, but I think that I can easily say that each of us has been influenced in some way.

SESSION D
DIVING AND DECOMPRESSION ILLNESS

Moderators:

FRIDAY, JUNE 30

Oral Presentations:

2:00 PM – 3:15 PM

Poster Presentations:

Poster Session 7: 3:45 PM – 4:07 PM

Poster Session 8: 4:07 PM – 4:30 PM

D 1

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 2:00 - 2:12

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: No

Epidemiology of morbidity and mortality in U.S. and Canadian recreational scuba diving

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Introduction: Scuba diving is a popular recreational pursuit enjoyed by millions of divers worldwide. This study investigates morbidity and mortality suffered by divers in the United States and Canada.

Methods: The National Electronic Surveillance System (NEISS) and Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP) were searched for scuba diving injuries. The Divers Alert Network (DAN) diving fatality database was searched for deaths, and Sports and Fitness Industry Association (SFIA) estimates for diving were obtained from annual surveys.

Results: In the United States there were an estimated 1,394 emergency room (ER) presentations annually for scuba-related injuries. The majority (80%) were treated and released, or released without treatment. Fewer than 1% were dead on arrival or died in the ER. There were an estimated 306,174,386 dives made by U.S. residents from 2006-2015, and concurrently there were 563 recreational diving deaths, a fatality rate among U.S. recreational divers of 0.18 per 10⁵ dives and 1.8 per 10⁵ diver-years. There were 658 diving deaths in the United States from 2006-2015 and 13,943 ER presentations for scuba injuries, a rate of 47.2 deaths per 1,000 ER presentations. There were 98 cases of scuba-related injuries identified in the CHIRPP data. The prevalence of scuba-related injuries for patients aged 0-17 years was 1.5 per 10⁵ cases, and the prevalence of scuba related-injuries to patients 18-62 years per was 16.5 per 10⁵ cases.

Conclusion: In Canada and the United States only one out of every 10,000 ER presentations is due to a scuba-related injury. That there are 47 deaths for every 1,000 ER presentations speaks to the relatively unforgiving environment in which scuba diving takes place. At 1.8 deaths per million recreational dives, mortality in scuba diving is nonetheless relatively low. As with calls to the DAN Emergency Hotline, barotrauma and DCS were the most common injuries seen at the ER.

D 2

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 2:12 - 2:24

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: Yes

Is recurrent decompression a risk factor for altitude DCI?

A case series of F/A 18 pilots

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Background: Altitude decompression illness (DCI) is a recognized clinical entity. Two main mechanisms are thought to occur. The first is decompression sickness, when pilots are exposed to altitude and pre-existing tissue nitrogen becomes supersaturated relative to ground exposure – akin to divers experiencing nitrogen bubble formation on ascent. The second is arterial gas embolism following pulmonary barotrauma, due to rapid pressure fluctuations. Given the rarity of DCI in modern aircraft, much of the literature is derived from hypobaric chambers where the decompression stresses are extreme and often coexist with hypoxemia.

Methods: Our objective was to describe a case series of altitude decompression illness occurring in military pilots evaluated at our institution. We retrospectively reviewed hyperbaric records for 60-foot tables from December 2011-2016. Altitude-related exposures were included; all others were excluded.

Results: All pilots were flying the Legacy F/A-18 aircraft. Nine of 12 cases (75%) of altitude DCI cases had multiple sudden decompression/recompression events during flight. Three of 12 (25%) had a single sudden decompression. Reported decompressions ranged from 12,000-35,000 feet of cabin altitude, with a median of 18,000. It is generally agreed that 18,000 feet of altitude is the threshold at which DCS becomes a concern. Oxygen breathing during flight was inconsistent. Symptom onset ranged from immediate until four hours post-flight. Symptoms included joint pain, paresthesia, ataxia and cognitive deficits. All patients were treated with hyperbaric oxygen within eight hours of symptom onset. All patients experienced complete resolution of their symptoms. Two of 12 experienced recurrent symptoms and were retreated, with resolution.

Conclusions: Pressure fluctuations during flight may provoke DCI even at altitudes below 18,000 feet. Recurrent decompressions without ground interval may potentiate DCI. Pilots should be encouraged to consult a flight surgeon after any abnormal pressure fluctuation events. Additional oxygen breathing by pilots may mitigate DCI in at-risk aircraft.

D 3

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: No

A mixed model to predict high daily diving frequency among artisanal fishermen in Mexico

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Introduction: Small-scale artisanal fishermen from the Yucatán Peninsula dive for subsistence using hookah dive systems. We attempted to understand the data structure that would best predict the high daily diving frequency of three or more dives among these fishermen, as well as identify the predictors that would have the highest correlation with this outcome.

Methods: Data inputs from dive recorders were converted to single line-by-line outputs via a subroutine in RStudio. Using a series of formulas in Microsoft Excel, we classified a pair of subsequent dives with a surface interval shorter than 10 minutes as a single dive. We then truncated the database to return the maximum number of dives per day for each diver. We used a nested model (mixed-effect logistic regression (MELOGIT) and mixed effect Poisson distribution (MEPOISSON) to predict the outcome of three or more dives per day with the following parameters: day of the week (DOW); month of the year (M); lag between diving dates (LAG); and total bottom time – TBT₁ and TBT₂– and mean depth – FSW₁ and FSW₂– for subsequent dives.

Results;

model	N _{obs}	N _{groups}	observations per group			N _{parameters}	parameter contrast	
			number of dives per fisherman				not significant	significant
			min	average	max			
MEPOISSON	599	17	2	35	81	7	DOW M LAG FSW ₁ FSW ₂	TBT ₁ TBT ₂
MELOGIT	590	17	2	35	81	7	DOW	M TBT ₁ TBT ₂ FSW ₁ FSW ₂ LAG

Conclusion: Fishermen completed three or more dives in fewer than 12% of all their respective diving days. The depths and durations of their first and second dives were strong predictors of whether or not a fisherman would conduct a third dive: Completing longer first and second dives lowered the probability of conducting a third dive. Longer lags between diving days (i.e., days without diving) also predicted the outcome of three or more dives per day.

D 4

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: No

Understanding the distribution of daily diving frequency among small-scale artisanal fishermen

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Introduction: Small-scale artisanal fishermen from the Yucatán Peninsula dive for subsistence using hookah dive systems. We wanted to understand whether the month of diving was related to the number of days when fishermen made three or more dives per day.

Methods: We collected dive profiles of 17 consenting fishermen over a five-year period, from 2012 to 2016. Dive profiles were recorded using Sensus Ultra dive recorders (ReefNet Inc[®]) with an accuracy of +/- 1 foot of seawater. Output from the recorders was converted to single line-by-line outputs via a subroutine in RStudio. We used a Pearson chi-squared test of independence to test the relationship between the categorical variable of month and a binary categorical variable of daily dive frequency: one to two dives versus three or more dives.

Results:

month	1-2 dives/day	=>3 dives/day	Total
Jan	49	6	55
Feb	49	5	54
Mar	4	1	5
Apr	17	3	20
May	62	8	70
Jun	22	0	22
Jul	353	40	393
Aug	349	27	376
Sep	299	20	319
Oct	209	10	219
Nov	145	6	151
Dec	151	9	160
Total	1,709	135	1,844

Pearson $\chi^2(11, N=1,844) = 18.6242, P=0.068$

Discussion: Fishermen made dives most during the months of July to December, the lobster-harvesting season. Capture techniques used to harvest lobster might explain why the fishermen conducted more dives during these months. Fishermen capture single lobsters by hand as opposed to nets or boxes. Fishermen conducted yo-yo diving patterns, with some dives resulting in no capture. This meant that more dives had to be completed in an effort to meet capture needs. The frequency of completing three or more dives daily has increased over the years analyzed. One possible explanation of this trend is the growth in global market demand for lobster.

D 5

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: No

Understanding the distribution of dives completed per day by small-scale fishermen over a four-year period

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Introduction: Small-scale artisanal fishermen from the Yucatan Peninsula dive for subsistence. Fishermen utilize hookah dive systems to breathe compressed air. We wanted to understand if the distribution of dives per year and day was constant across a four-year period.

Methods: Dive profiles were recorded using Sensus Ultra dive recorders (ReefNet[®] Inc), with an accuracy of +/- 1 foot output from recorders were prepared via a subroutine in RStudio. Data inputs from dive recorder were converted to single line-by-line outputs. We used a chi-square goodness-of-fit test to compare the four-year distribution of when fishermen conducted three or more dives per day versus one to two dives day (7% to 93% of time). We compared these percentages over each individual year among 17 fishermen divers.

Results:

year	outcome variable (dives/day)	expected	observed	χ^2	P
2013	1-2	495	505	3.03	0.0819
	3+	37	27		
2014	1-2	556	539	7.55	0.006
	3+	42	59		
2015	1-2	498	492	0.88	0.347
	3+	38	43		
2016	1-2	123	126	1.22	0.269
	3+	9	6		

Discussion: The number of dives per day that each fisherman performs is not equally distributed across years, months or days of the week. In 2013, there were fewer recorded days of three or more dives than would be expected if the data set were equally distributed. In 2014 and 2015, this trend was reversed, and there were more recorded days of three or more dives than would be expected if the data set were equally distributed by year. This indicates that as time progresses, the fishermen are performing more days of three or more dives than is expected. The reason for this trend is unknown.

D 6

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 2:48 - 3:00

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: No

Flying after diving: Is a 24-hour surface interval appropriate advice for consecutive multiday diving days?

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Introduction: Dive vacations that involve commercial air travel expose the diver to decreased atmospheric pressure and decreased partial pressures of oxygen (ppO₂) during flight. Any onset of decompression illness (DCI) during flight potentiates diversion of the aircraft to expedite recompression. Onset of symptoms may also occur post-flight, and some divers will board a plane even when symptoms are evident pre-flight. For sport divers a surface interval (SI) \geq 24 hours before flying is advised, whereas commercial pilots generally observe up to 48 hours and take depth of dives into consideration. This study observed the frequency and nature of symptoms in divers who had flown after consecutive multiday days.

Methods: An anonymous online survey was publicized through diving exhibitions and social media. Data included diver/diving demographics; signs and symptoms of DCI before, during, and after flight home; details of the last two dives; SI before the flight; free text; and flight information.

Results: Data from 316 divers were examined (69% male, 31% female) age range 17-75 (median age 49). Divers recorded 4,356 dives in the week preceding the flight, range 1-36 (median 14). Overall 54/316 (17%) respondents reported a SI of less than the recommended 24 hours.

Of the respondents 15 boarded a plane regardless of symptoms associated with DCI; and an additional 18 respondents developed symptoms during (nine) or after (nine) the flight. A SI of \geq 24 hours had been observed by 14/18. A total of 11/33 divers subsequently sought help and were diagnosed and treated for DCI.

Free text showed a lack of understanding of the consequences of altered pressure and gas environments during flight on a diver previously exposed to an intense period of consecutive multiday days.

Conclusion: These data suggest that 24 hours is not an appropriate SI for all divers, particularly in the context of consecutive, multiday/day diving.

D 7

FRIDAY, JUNE 30

ORAL PRESENTATION TIME: 3:00 - 3:12

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: No

Project Poseidon: Medical requirements for establishing a seospace station

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Knowledge of the oceans is more than a matter of curiosity. Our very survival may hinge upon it.

~ President John F. Kennedy, Jr., March 1961, message to Congress

Introduction: Project Poseidon is a proposed 100-day undersea multidisciplinary research expedition organized by the SeaSpace Exploration & Research Society. The International Board of Undersea Medicine (IBUM) and other skilled physicians were consulted to establish requirements for this record-setting endeavor. The expedition's proof-of-concept mission centers around long-duration undersea habitation and serves to reignite interest in exploration of the ocean. It serves as a springboard for the long-term vision of establishing a permanent human presence in the ocean.

Methods: A systematic review of existing literature was performed by IBUM physicians, a Saturation Diving Officer, past and present commercial saturation divers, along with multiple U.S. Navy Master divers. A total of 34 papers were reviewed and discussed along numerous external resources.

Results: The team's consensus is that the following conditions should disqualify a candidate: acute disease, chronic serious otitis, otitis media, perforated tympanic membrane, significant nasal/pharyngeal respiratory obstruction, chronic sinusitis, inability to equalize pressure, asthma and PFO. Additionally, the following tests should be administered: pulmonary function, dental fitness, X-rays (chest and long bone), hearing, heart disease, arrhythmias and drug screening. Any prescribed medications should be noted for contraindications. Consideration should be placed on psychiatric evaluation and temperament for extended-duration missions. A high standard of physical and mental health is required for this type of diving. Physicians should identify anything that could distract divers and cause them to ignore their own or other's safety.

Conclusion: The scientific/academic community faces a cost-prohibitive barrier for development of a habitat to explore/work in the ocean. Project Poseidon is a balanced contribution to research, education and outreach that bridges the present gap and makes it possible to perform research, open new fields of scientific discovery and inspire a generation to explore. The involvement of qualified physicians knowledgeable in saturation diving and hyperbaric medicine will add to the safety of the endeavor.

D 8

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: Yes

Hyperbaric oxygen treatment of decompression sickness: case reports from Louisiana State University Undersea and Hyperbaric Medicine Fellowship Program

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Background: The risk of decompression illness is sometimes minimized by recreational diving groups. Decompression illness (DCI) is an omnipresent concern for those subjected to higher-than-atmospheric pressures. This includes both recreational and commercial underwater diving, as well as those receiving hyperbaric oxygen (HBO₂) therapy for wound healing. Symptoms can range from minor skin or joint findings to severe paralysis, spinal cord injury, pulmonary edema, and death. The authors present a series of five case reports outlining recent decompression injury experiences treated at the LSU post-graduate medical training program in Undersea and Hyperbaric Medicine.

Methods: Five emergent decompression injuries treated at WJMC were summarized by treating LSU UHM Fellows and reviewed by attending physicians.

Results: Five cases of decompression illness are presented, each with varying degrees of neurologic disability. Cases 1 and 2 were injured recreational divers in Mexico who were diving “safe profiles” and sustained significant paralysis and mental status changes. After delayed presentation for treatment at West Jefferson Medical Center these injuries resolved. Case 3 highlights a potential iatrogenic injury involving unilateral blindness during routine wound treatment with hyperbaric oxygen therapy. Blindness resolved after continued therapy with hyperbaric oxygen therapy. Case 4 is a recreational diver from Zanzibar with a previously unknown pulmonary bleb who was injured during a routine dive, with delayed resolution after treatment. Case 5 is a local “hell diver” spearfisherman, who routinely practices unsafe diving profiles. He was injured after exceeding decompression limits but recovered fully after prompt treatment.

Conclusion: The wide variety of serious decompression illness presented here does not support the widely advertised assertion that “diving is as safe as bowling.” Four of five cases in this presentation were “undeserved” (unexplained) hits and underscores the need for better preventive measures and continued research in DCI.

D 9

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: No

Diving-related injuries in Swedish working divers in relation to gender, age, work ability, stress and underwater work hours

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Aim: To explore diving-related injuries among different categories of working divers in Sweden in relation to gender, age, work ability, stress and underwater work hours.

Method: Working divers in Sweden were invited to answer a web-based questionnaire about health, diving experience and suggestions for improving safety at work. Study group – number answer/number invited: rescue divers (at fire departments): 155/368; Coastguard 39/78; Navy 66/214; scientific 63/163; construction 13/20; diving instructors CMAS 253/397; PADI 73/111. Total 662/1,351. Diving-related injuries were defined as symptoms of decompression illness and impairment of hearing after dives as a worker during the previous year. The work ability score was used as an index where 0 is no work ability and 10 is work ability as best. Stress was a single question valid to Maslach Burnout Inventory.

Results: In bivariate analyses, diving injuries was related to underwater work hours, stress and negatively to work ability and age. There was no relation to gender. In a multivariate regression with the variables the work ability was not a significant factor.

Conclusion/Discussion: The strongest relation for diving injuries was for underwater working hours being one quantity of work demands. Age was negatively related to injuries, which may be due to healthy worker selection and/or experience. The perceived stress may be due to work demands and control, which may be an indicator for increased risk for injuries.

D 10

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 8: 4:07 - 4:30

RESIDENT COMPETITION: No

Acral peeling skin syndrome (APSS) in a recreational diver

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Introduction: The exact cause of dive-related skin problems can be elusive [1, 2]. A syndrome named “diver’s hand” has been described in saturation divers [3] but not recreational divers.

Methods: A 39-year-old diver (over 3000 dives) with no skin problems who has been diving for five years. After eight uneventful months as a professional underwater photographer, she recalled contact with a chemical stain remover that irritated her hands and kept her out of the water for two weeks [4]. Since then, any prolonged period of diving started with rash on her forearms/ankles that responded to Benadryl initially but eventually progressed to erythema, pruritus, hardening/swelling, pain with distal paresthesia. The peeling began and did not stop for several months. She remains an avid diver who endures this process with each dive vacation two to three times/year. She typically makes four to five dives/day (60 minutes each) for three to four days before onset. Unsuccessful measures include using a drysuit with cotton-lined dry gloves and boots, varying dive locations, applying topical cortisone and Vaseline under gloves while sleeping. Freshwater swimming pools, tanning (solar), hot tubs, snorkeling, coldwater diving exposure are not considered causal.

Results: A large differential that included tinea manum, dermatitis, monoclonal gammopathy, vasculopathy, solar irritation, microangiopathy, APSS and exfoliative keratolysis was entertained. Investigations ruled out all but APSS, which has a strong association with heat, friction, humidity and exposure to water, and trauma [5]. With increased decompression stress secondary to her robust dive schedule, the impact of venous gas emboli on impaired dermal attachments between stratum corneum and granulosum is unknown but intriguing.

Conclusion: Exfoliation of the hand and feet after three to four days of robust diving days is consistent with APSS. Skin biopsy and DNA testing for the TGM5 mutation may help confirm the diagnosis. Treatment and association with diver’s hand should be further studied.

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D 11

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: Yes

How many fishermen divers recognized signs and symptoms of decompression illness but did not seek medical attention in Yucatán?

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Introduction: Intensive diving is undertaken periodically for fishing in Yucatán coastal communities. Decompression events are common among fishermen divers, but as fishermen are accustomed to dive daily during lobster or sea cucumber seasons, fishermen might not always recognize decompression sickness or they may underestimate the severity of their signs and symptoms. In other cases, divers might even consider omitting their treatment at the hyperbaric program due to the cost. In this retrospective study our aim was to describe whether fishermen asked for medical attention at the hyperbaric program every time they experienced and recognized a decompression event.

Materials/Methods: In this cross-sectional study, we developed interviews and medical history of 214 fishermen divers from four fishing communities of Yucatán and reviewed their clinical records at the hyperbaric program. We developed a chi-squared test to compare the proportion of untreated decompressions events among divers with or without medical insurance.

Results: We obtained descriptive statistics and identified the main reasons for not treating. From the 214 divers, fishermen recalled 404 decompressions: 343 (85%) were treated at the hyperbaric program, while 61(15%) remained untreated. Additionally, one tympanic perforation due to a dysbarism also remained untreated to date. Fishermen without medical insurance affiliation had significantly higher numbers of untreated decompression events. The main reasons for not seeking treatment in a timely manner were: a) not having medical affiliation; b) the costs related with the treatment; c) fishermen planned to dive again during the following 24 hours. Five of the fishermen who made dives after their decompression event said they had recovered from muscular pain after using NSAIDs and subsequent diving, while 55% still experienced pain as the main sequelae.

Conclusions: At least 15% of the participating fishermen did not receive treatment at the hyperbaric program. While some fishermen noted resolution of their symptoms, others still experienced sequelae.

D 12

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: Yes

A case of decompression sickness in a surface-supplied air dive caused by rapid ascent after facial blunt trauma struck by weight of ascent line

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Introduction: We report a rare case of a patient with a decompression sickness developed from rapid ascent due to facial blunt trauma; He had ascended from a depth of 30 meters seawater after being struck by a weight on the ascent line.

Case presentation: A 45-year-old fisherman diver was transported to our emergency department by emergency fire service. He had been harvesting marine products using surface-supplied compressed air dive. As he was finishing his work at 30 meters of seawater, his forehead was struck by a weight on the ascent line when it was thrown by the tender on the boat. His face mask was broken and he ascended rapidly. During the drive to a nearby clinic to treat his forehead wound, he experienced no symptoms. But on arrival at that place, he complained of generalized weakness and shortness of breath; his mentation then changed to drowsy.

Initial examinations in our emergency department showed the diver to have a drowsy mental status with relatively stable vital signs. There was a laceration wound on his right eyebrow about 3 cm length. However, we noted a huge areas of cutis marmorata on his trunk and both. A brain CT scan showed no abnormal findings. The abdominopelvic CT scan showed intravascular gas collections along the course of venous systems in the peritoneal cavity, including the mesenteric, hepatic and pancreatic vessels and the inferior vena cava.

Along with vigorous fluid therapy, hyperbaric oxygen therapy was given using U.S. Navy Treatment Table 6A. Cutis marmorata disappeared, and the patient responded well to the therapy. On the follow up abdominopelvic CT scan, there was no remnant gas in the peritoneal cavity nor any ischemic change in the bowel wall. He returned his work after three weeks per the recommendations of the U.S. Navy Diving Manual.

Conclusion: This is a rare case of a decompression sickness developed from rapid ascent after facial blunt trauma struck by a weight on the ascent line.

D 13

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: No

Delayed diagnosis of spinal cord decompression illness: a case report

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Introduction: Diagnosing whether neurological symptoms after diving result from decompression illness (DCI) or nerve compression is difficult, and delayed recompression treatment is controversial. We report a patient with spinal cord DCI who responded to delayed treatment after a difficult diagnostic process.

Materials/Methods: A 70-year-old recreational diver experienced high nitrogen loading because of repetitive and decompression diving, as well as problems making a safety stop. Immediately after diving, he experienced dysesthesia of the lower limbs and muscle weakness of the upper limbs. Problems with balance and handwriting, and bladder and bowel dysfunction occurred gradually. At several other hospitals, he was suspected of having spondylotic myelopathy but could not be definitively diagnosed; therefore, he visited our hospital two months after symptom onset. We diagnosed spinal cord DCI with posterior column dysfunction and prescribed recompression treatment.

Results: Symptoms before treatment (69 days after symptom onset) included: Romberg test: positive; one-legged standing: impossible; manual muscle testing: 4 in the right tibialis anterior and extensor hallucis longus; grip power: right 14 kg, left 20 kg; and hypesthesia in both lower extremities.

At last follow-up (after the following treatments – 210 days after symptom onset: nine treatments with U.S. Navy Treatment Table 6 ; 11 treatments with U.S. Navy Treatment Table 9; and 10 short table treatments (0.15 MPa, 60 minutes), findings included: Romberg test: negative; one-legged standing with eyes closed: unstable; manual muscle testing: all 5; and hypesthesia: resolved.

Summary: A late first visit, gradually worsened symptoms, and cervical nerve compression on magnetic resonance images made diagnosing our patient difficult. We diagnosed DCI because of nitrogen loading, symptom onset immediately after ascending, and response to treatment. DCI must be suspected in cases of neurological symptoms after diving, and delayed treatment should be considered. Recompression treatment two months after diving was effective in our patient with spinal cord DCI and a difficult diagnosis.

D 14

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: No

Process to consider fitness to dive in a working diver with insulin-dependent diabetes: a reference case description

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Introduction/Background: The European Diving Technology Committee book on medical assessment of working divers 2004 (Wendling, et al.) states: "Once diabetes is diagnosed in a working diver, an automatic disqualification may seem wise, but is no longer acceptable."

Questions: Is a working diver (a scientific diver) who was diagnosed with insulin-dependent diabetes mellitus (IDDM) after working diver certification fit to dive? What requirement on limitation of work tasks has to be reported to the employer (work ability)? What special requirement for the fitness-to-dive (FTD) examination has to be put on the physician?

Materials/Methods: We arranged communications between several qualified scientific experts in Sweden in diving medicine, diabetology and diving, as well as a physician at The Swedish Work Environment Authority. The scientific experts exchanged several mailings to reach best agreement with current views and scientific literature.

Results: We did not reach consensus, but a majority of experts consented to the following statements. Restrictions on work tasks and diving procedure were sent to the employer as well as requirements of the FTD examination.

Conclusions:

1. The IDDM diver must dive together with another working diver. May be employed only in physical light underwater work: guidance, observation, photographic documentation, collection of bottom samples.
2. When NN (the scientific diver) has insulin-dependent diabetes mellitus diving and underwater work should be conducted according to published guidelines for IDDM divers, and the dive team should be informed of the condition.
3. Requirements for FTD: The diabetic diver should be assessed annually by a diving medicine physician; HbA1c must be in the range 45-55 mmol/mol; last HbA1c test must have been no later than three months prior; diver must never have had diabetes or insulin coma, nor diabetic ketoacidosis (DKA) the last two years; diver must adhere to monitoring of diabetes with regular visits, four blood tests per day or CGM (continuous glucose monitoring), and presence of adrenergic symptoms at low blood sugar; diver must have no complications of diabetes.

D 15

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: Yes

Trailing hyperbaric oxygen treatments for inner ear decompression sickness

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Introduction: This is a case of inner ear decompression sickness (DCS) treated favorably with trailing hyperbaric oxygen (HBO₂) treatments.

Materials/ Methods: A 67-year-old male presented to our hyperbaric facility for evaluation after initial treatment and discharge from an outside hospital.

The patient was a certified dive instructor with 1,000+ dives and no previous decompression events. He presented to the outside hospital with symptoms of vertigo, nausea, vomiting and inability to walk that began within 15 minutes after the second dive of the day. The first wreck dive was to approximately 80 feet for 30 minutes, followed by surface interval of 90 minutes. The second dive was to approximately 100 feet, exact dive time unknown. The dive computer was not available.

The patient received a U.S. Navy Treatment Table (TT) 6 with improvement in symptoms. This was followed by TT6 and TT5 over a three-day period at the outside hospital. He reported improvement in vertigo, although with continuing gait imbalance. CT imaging showed no acute abnormalities. The patient was referred to us from the outside hospital upon discharge for persistent vertigo and instability. Our neurological exam was pertinent for right-sided nystagmus, wide-based unsteady gait, and severely impaired Romberg test results.

The patient received three daily HBO₂ TT5 treatments followed by seven more daily trailing treatments at 2.0 ATA for 120 minutes each, over 10 days. Gradual resolution was noted in vertigo and nystagmus, with improvement in sharpened Romberg from 1 to 5 seconds (left), severely impaired to four seconds (right), and completion of 10 tandem steps.

Results: The patient had resolution of vertigo, no nystagmus, a sharpened Romberg 15+ seconds (left) and 30+ seconds (right), and completed 15+ tandem steps at the six-week follow-up visit to our Hyperbaric Clinic .

Summary: We document a case of the successful use of more than a week of trailing HBO₂ treatments for inner ear DCS with complete symptom resolution.

D 16

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: WITHDREW

RESIDENT COMPETITION: Yes

Decompression illness: clinical aspects of 100 consecutive cases treated in a single hyperbaric unit

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WITHDREW

D 17

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: No

Posterior reversible encephalopathy and thoracic myelopathy following decompression illness

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Case report: A 24-year-old man was diving and ascended rapidly from 80 feet. Upon surfacing he developed dyspnea and inability to move or speak. He was assisted to the boat and received oxygen, regaining mobility and speech after 10 minutes. En route to hospital he developed a one-minute generalized tonic-clonic seizure. In the ED, the diver was tachycardic to 120, hypertensive at 154/84 mmHg, and hypoxic at 95% on a non-rebreather. Neuro exam revealed: confusion, slowness to answer questions, CN 2-12 intact but sensation diminished LLE, intact vibration and pinprick, 2+ reflexes, intact proprioception, normal heel-to-shin, no dyssynergia, motor grossly intact, but gait/Romberg/sharpened Romberg test was not done. Head CT was negative. He was immediately taken to the hyperbaric chamber and underwent a U.S. Navy Treatment Table 6 with extensions and showed moderate improvement.

Next day he reported left leg weakness, numbness, and stool incontinence. Examination showed weakness of the left hip, knee and ankle (4+/5). Sensation was reduced on the right foot, and the left plantar response was extensor. MRI of the cervical and thoracic spine (Figure 1A) revealed T2 prolongation at T4-T8 levels. Brain BRI (Figures 2A-C) demonstrated T2 prolongation in the right cerebellum, left>right frontoparietal region. Hyperintense lesions were apparent on diffusion coefficient (ADC) sequence. He received six additional hyperbaric treatments. After treatments he was ambulatory, with no incontinence, with residual left leg weakness and altered sensation. He was discharged for physical/occupational rehabilitation.

At the three-month follow-up, left leg weakness and numbness had resolved, legs were at full strength with diminished pinprick sensation over right shin and dorsal foot. His gait was normal. Follow-up MRI of the brain, cervical and thoracic spine demonstrated complete resolution (Figures 1B and 2D-F).

Discussion: Decompression illness (DCI) results from an abrupt change in environmental pressure. Our patient's clinical and radiographic thoracic myelopathy is a common presentation in neurologic DCI [1-3]. His cerebral presentation and radiographic findings suggest posterior reversible encephalopathy syndrome (PRES). Clinically he experienced seizure and altered mental status. Radiographically his MRI showed cerebral white matter-predominant T2 hyperintensities with facilitated diffusion. Finally, he had complete resolution of clinical, radiographic cerebral findings [4]. The pathophysiology of cerebral DCI remains poorly understood, but one proposed mechanism is that gas bubbles mechanically injure vascular endothelium, causing vasogenic edema [3, 5]. This proposed mechanism supports one of the leading hypotheses of PRES as being mediated by increased vascular permeability and edema [4]. Decompression illness serves as a novel example of how cerebral endothelial dysfunction may lead to PRES.

References and images will be on poster.

D 18

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: Yes

Decompression sickness in divers after altitude exposure and treatment with hyperbaric oxygen (HBO₂)

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Introduction: Increased altitude exposure after diving can worsen or provoke decompression sickness (DCS). We describe divers evaluated/treated for DCS after altitude exposure.

Methods: By retrospective review (1987-2016), we identified 29 divers evaluated/treated for DCS after altitude exposure from 168 divers seen at two hyperbaric facilities.

Results: A total of 15 divers were male; mean age was 37±12 years (range 17-64); 20 (69%) made dives in tropical locations. The divers completed a mean of six dives (range 1- 28) over three days (range 1- 13). Twenty divers had provocative dive profiles: 13 missed decompression obligations, eight rapid ascent, two inadequate surface intervals, one post-dive exercise. With altitude excursion (22 aircraft, seven vehicle), all experienced DCS symptoms and received HBO₂.

	post-dive symptoms, received HBO ₂ (N=4)	post-dive symptoms, received surface O ₂ (N=3)	post-dive symptoms, no treatment (N=14)	no post-dive symptoms (N=8)
post-dive symptoms	pain-3 itching-1 weakness-1 numbness-4 dizziness-1 fatigue-2 vision-1 headache-1 difficulty breathing-1 nausea/vomiting-1 muscle twitching-1 personality-1	pain-3 itching-1 numbness-1 fatigue-1 headache-2 personality-1	pain-6 rash-2 numbness-4 dizziness-3 unconsciousness-1 fatigue-6 vision-1 headache-3 nausea/vomiting-1 personality-1	none
dive-to-altitude interval (hours)	56±28 <72 hours-1	36±24 <72 hours-2	36±21 <72 hours-11	22±16 <24 hours-4
altitude symptoms	pain-3 itching-1 weakness-1 numbness-1 dizziness-1 fatigue-1 headache-1 personality-1	pain-1 weakness-1 numbness-2 fatigue-1 headache-2	pain-11 rash-1 itching-1 weakness-1 numbness-7 dizziness-3 fatigue-4 headache-5 nausea/vomiting-1	pain-6 numbness-4 difficulty breathing-1 nausea/vomiting-1
dive to HBO ₂ interval (days)	7±25 (range 3-13)	5±3 (range 3-9)	6±3 (range 2-13)	3±2 (range 1-5)
HBO ₂ sessions	7±5 (range 2-13) TT6-2 Other-2	3±2 (range 1-5) TT6-1 TT6+Other-2	3±5 (range 1-19) TT6-8 TT6+Other-6	2±1 (range 1-5) TT6-6 TT6+Other-2
symptom resolution	total-0 partial-4	total-2 partial-1	total-7 partial-6 none-1	total-4 partial-4
sequelae	neurocognitive-4 weakness-1 fatigue-1	neurocognitive-1	neurocognitive-3 pain-2 numbness-3 headache-1 personality-1	pain-3 weakness-1 numbness-1

Conclusions: Some divers identified in this limited review experienced DCS after surface intervals conforming to current guidance. HBO₂ may provide benefit to divers with DCS after altitude excursion.

D 19

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: Yes

How should we evaluate cardiac risk in the older asymptomatic scuba diver?

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Introduction/Background: Currently there are no requirements or standards for recreational scuba divers to undergo routine or preventative evaluation for fitness to dive after they have obtained their scuba certification. Cardiac disease is a leading trigger of a diver-related injury and a leading cause of diver-related fatalities.

Case: A 60-year-old male presented for a return to dive physical evaluation after suffering from decompression illness several months prior. After his evaluation, it was determined that the patient should be sent for cardiac screening due to his age. He ultimately was found to have an abnormal Bruce Protocol stress test. This eventually led to further cardiac workup and intervention with cardiac stenting. Several months after his initial stenting, he returned for further stenting due to cardiac symptoms with exertion for a total of four stents. He ultimately plans to return to scuba diving but is interested in optimizing his health and reducing his risk for scuba-related injury.

Summary/Conclusions: The number of individuals who are becoming scuba-certified continues to increase; the number of older drivers will continue to increase as the sport becomes more popular and more adaptable with increasing technology. Our aging scuba population is at increased risk for cardiac complications during diving. This is an issue that will continue to present itself and, as a specialty, we should work to implement routine evaluation of older age individuals who wish to continue to scuba dive.

D 20

FRIDAY, JUNE 30

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 7: 3:45 - 4:07

RESIDENT COMPETITION: Yes

Articular pain among fishermen divers from Yucatán, a comparative cross-sectional

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Introduction: Diving is one of the activities most practiced by the fishermen of Chicxulub, Yucatán. The capture of species with high commercial value, such as sea cucumber and Caribbean spiny lobster, make it attractive, particularly when the fishermen depend on the practice. The illnesses related to this practice are diverse but include articular pains associated with dysbaric osteonecrosis, an ailment directly related to the time of diving as well as dive characteristics.

Methods: In this cross-sectional study we developed interviews and physical examinations to identify articular pain unrelated to osteoarthritis, rheumatoid arthritis or other degenerative arthritis. We excluded patients with antecedents of chikungunya. Obtaining that the odds of articular pain were significantly higher among divers when compared with non-diver fishermen, we developed a post-hoc goodness-of-fit test.

Results: From the 44 fishermen, 14 were divers. Mean age of the divers was 44 (Confidence Interval 95% 22-44). Among the 30 non-divers, the mean age was 57 (Confidence Interval 95% 26-80). Articular pain was higher among divers when compared with no divers ($P < 0.05$).

Conclusions: Even when non-diving fishermen were significantly older (and articular pain among general population is associated with age) odds for articular pain were higher among divers.

PLENARY:
“Emergency and Critical Care Hyperbaric Medicine: A Lost Art”
Ian Grover, MD & Peter Witucki, MD
4:30 PM – 5:30 PM



Ian Grover, MD



Peter Witucki, MD

ABOUT THE LECTURE:

Our discussion this afternoon will focus on the vanishing critical care capable hyperbaric facilities that are available 24 hours a day, 7 days a week here in the United States. What are the factors that lead to this crisis, and how severe is the shortage of available emergent hyperbaric facilities? We will also look at options to try and reverse this alarming trend as well as the staffing and equipment requirements for running a 24/7 critical care capable hyperbaric facility.

SATURDAY, JULY 1

PLENARY:
“International Perspectives on Hyperbaric Oxygen Therapy”
Gerardo Bosco, MD; Mahito Kawashima, MD & Folke Lind, MD
8:00 AM – 9:30 AM



**Gerardo
Bosco, MD**



**Mahito
Kawashima, MD**



**Folke
Lind, MD**

ABOUT THE LECTURE:

Currently, the Undersea and Hyperbaric Medical Society has approved hyperbaric oxygen (HBO₂) therapy for 14 different diseases. Indeed, HBO₂ has been demonstrated in several clinical studies to enhance the body's innate ability to repair, to regenerate and to be a useful adjunct therapy for many chronic and acute conditions. To date HBO₂ therapy indications are still under investigation to clarify molecular and clinical mechanisms as per bone diseases (edema, necrosis and infections).

Innovative therapeutic strategies in the treatment of femoral head necrosis: Bosco

The University of Padua is widely committed to hyperbaric medicine both in training and research. In particular, the department of Biomedical Science has established a second-level master “Diving and Hyperbaric Medicine” course addressed to graduates in medicine and surgery and a higher education course in “Technical and Health Management in Diving and Hyperbaric Chamber Environment.” The main objective of the master course is to train a specific professional profile: from directly providing appropriate medical care to patients, to the capability to direct the medical direction or the clinical activities management in a diving and hyperbaric medicine unit. The aim of the higher education course is to improve technical, health care and managerial skills in technicians and nurses. Both masters and higher education courses program include seminars utilizing real working scenarios of underwater and hyperbaric conditions to enhance expertise.

Clinical and basic research on diving and hyperbaric medicine is performed in our department, with particular attention on the efficacy of HBO₂ in osteonecrosis (ON), wound infections and healing. Our studies aim to point out possible molecular mechanisms involved in tissue regeneration (especially bone) promoted by HBO₂ treatment. Recently we published a retrospective study where we demonstrated evidence of the efficacy of hyperbaric oxygen treatment in 217 patients with avascular necrosis of the femoral head (ANFH) (144 men and 73 women, mean age 53.8, FICAT stages I-II-III) for four consecutive years. Enrolled patients were treated with 90 HBO₂ sessions (compressed oxygen for 82 minutes at 2.5 ATA) over 12 months; conditions were evaluated by MRI and Visual Analogue Scale (VAS) pain scores. Data showed that HBO₂ significantly alleviated joint pain, improved joint structure in patients at all stages and such improvements remain substantially unchanged for approximately four years. Hip surgery was not necessary in most patients with Stages I and II and in almost half the patients with Stage III FICAT scores.

In another recent work we tried to discern possible molecular mechanisms underpinning the effectiveness of HBO₂ therapy in ANFH. We monitored serum RANKL and osteoprotegerin (OPG) of 23 ANFH patients (FICAT I-II-III) treated with two sequential series of HBO₂ (60 total sessions). Interestingly, we found that OPG concentration significantly increased at the 15th session, suggesting an anti-osteoclastic activity of the therapy. This hypothesis was further supported by the finding that proinflammatory cytokines plasmatic levels (IL1 β , IL-6, TNF α) are modulated in response to HBO₂

therapy and that this modulation may inhibit osteoclast activation and differentiation. These findings contributed to the recent acceptance of avascular necrosis of the femoral head by the European Committee for Hyperbaric Medicine as indication for treatment with HBO₂ by the consensus conference of Lille (ECHM, May 2016).

Our most recent challenge is an effort to use hyperbaric oxygenation in regenerative medicine. We aim to understand if and how HBO₂ may a) accelerate the efficacy of adipose-derived stem cells (ADSCs) differentiation into bone or endothelial cells precursor; and b) enhance the probability of success in tissue-engineered implants.

Innovative therapeutic strategies in the treatment of refractory osteomyelitis: Kawashima

Suppurative osteomyelitis is an inflammatory disease of the bone marrow, cortical bone or periosteum caused by bacterial infection. Even with the development of antibiotics, some cases become refractory from multiresistant bacteria. The first clinical report on the use of hyperbaric oxygen therapy to treat osteomyelitis was done by Slack in 1965. Presently, HBO₂ therapy has become a standard/recommendatory treatment for osteomyelitis in many countries and hyperbaric medicine societies. We have treated 773 osteomyelitis cases with HBO₂ therapy between 1981 and 2016. Patients were treated at 2.0 ATA for 60 minutes per day. We obtained good results even if we treated them with the administration of antibiotics plus conservative HBO₂.

If patients did not show sufficient improvement, we suggested closed irrigation therapy, which is also a standard treatment for bone and joint infectious disease. 508 (65.7%) were treated conservatively and the other 265 cases (34.3%) were treated surgically in addition to undergoing HBO₂ treatment. 481 cases (94.7%) from the conservatively treated group did not have recurring symptoms. 251 cases (94.7%) treated with irrigation therapy also had no recurring symptoms. Since 2009, we have used "ozone nano-bubble water (ONW)," which has a sterilizing effect against various bacteria and viruses for the closed irrigation therapy. It contains ozone bubbles approximately 10nm-100nm in diameter, 8.8x10⁸ particles/mm³ in 0.9% NaCl water. The features of ONW include sterilization for various kinds of bacteria and viruses, even multiresistant bacteria. Moreover, ONW does not damage the normal tissue and keeps dissolving in water more than a year. It is used in various fields – e.g., medical, engineering, agriculture, environmental purification or food processing, and various other advantages have been reported.

Innovative therapeutic strategies in the treatment neurosurgical infections: Lind

Central nervous system (CNS) infections in or adjacent to the brain or spinal cord are rare but grave medical challenges, often leading to instant and repetitive surgical interventions and intense long-term antibiotic treatment. Karolinska University hospital has two decades of experience using adjunctive hyperbaric oxygen (HBO₂) therapy to help cure such acute or subacute spontaneous, post-traumatic or postoperative infections. HBO₂ shows promising clinical results in these acute life-threatening brain abscesses as well as in cranial or spinal biofilm infections resilient to conventional antimicrobial therapy. It is safe. It is an alternative to standard surgical removal of infected bone flaps, acrylic flaps and other foreign material. It improves outcomes in our patient population and can probably reduce overall costs. It is especially useful in more complex infections involving multiple risk factors, such as radiotherapy, multiple reoperations and antibiotic-resistant microorganisms.

SESSION E
HBO₂ THERAPY, CHAMBERS,
AND EQUIPMENT

Moderators:

SATURDAY, JULY 1

Oral Presentations:
10:00 AM – 11:15 AM

Poster Presentations:
Poster Session 9: 11:15 AM – 11:37 AM
Poster Session 10: 11:37 AM – 12:00 PM

E 1

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 10:00 - 10:12

POSTER PRESENTATION TIME: Poster Session 10: 11:37 - 12:00

RESIDENT COMPETITION: No

Monoplace hyperbaric chamber atmosphere oxygen concentration during patient treatment sessions

Koumandakis G^{1,2} Weaver LK^{1,2,3} Deru K^{1,2} Bell J^{1,2}

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Introduction: In monoplace hyperbaric chambers, the chamber atmosphere oxygen concentration increases over time, but the increase may vary from session to session.

Methods: Using a benchtop oxygen analyzer (905P, Quantek Instruments, Grafton, MA) (range 0-100% oxygen, resolution 0.1%, accuracy $\pm 1\%$), we measured chamber oxygen concentration during patient treatment sessions provided in two hyperbaric oxygen chambers (Sechrist 3200). A gas-sampling catheter was clipped to patient's chest and passed through the chamber door to the analyzer. Oxygen concentration was measured every 10 seconds for the duration of the treatment. The analyzers were spanned weekly.

Results: Over six months we collected data from 114 patient treatment sessions: 77 sessions provided in Chamber #1 and 37 in Chamber #2. Patients were compressed at 2 psi/minute from 0.85 ATA to 2.0 ATA, over 10 minutes and remained at pressure for 90 minutes (110 minutes door to door). Chamber flow rates were set to 350 lpm unless rarely increased for patient comfort.

	Chamber #1	Chamber #2
sessions measured	77	37
chamber oxygen concentration at 2.0 ATA (10 minutes), mean \pm 1SD (range)	90.2 \pm 2.6% (85.6%-96.9%)	96.6 \pm 1.5% (92.0%-99.6%)
mean time to reach 90% oxygen	10.2 \pm 2.0 minutes (range 6-15 minutes)	5.2 \pm 0.9 minutes (range 4-9 minutes)
mean time to reach 95% oxygen	19.9 \pm 7.8 minutes (range 8-49 minutes)	8.8 \pm 4.1 minutes (range 6-27 minutes)
mean minutes spent at <98% oxygen	42.6 \pm 14.0 minutes (range 13-92 minutes) Not reached in 6 sessions (8%)	35.6 \pm 31.9 minutes (range 8-119 minutes) Not reached in 4 sessions (11%)

Conclusions: The chamber atmosphere oxygen concentration at any given point in the treatment varied slightly between chambers and by session. Further work is required to determine whether chamber selection, patient size, gas flow, supply pressure, and catheter placement may contribute to this variability.

E 2

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 10:12 - 10:24

POSTER PRESENTATION TIME: Poster Session 10: 11:37 - 12:00

RESIDENT COMPETITION: No

Improvements in teamwork, care quality and patient safety through the implementation of an emergent hyperbaric treatment checklist

Omodt S, Westgaard B, Walter J, Masters T, Hendriksen S, Logue C

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Background: A consistent team approach to emergent hyperbaric therapy is essential to patient safety and quality care. Evidence suggests that instituting a uniform safety checklist can improve communication, delineate clear roles and responsibilities and ensure consistent care delivery in an emergent center. The process by which we instituted a uniform safety checklist at our hyperbaric facility demonstrates both the importance of leadership and staff engagement in the process as well as the potential operational improvements to be gained.

Methods: Through routine review several gaps in emergent care quality were identified at our hyperbaric facility. In response we developed a role-based checklist to be completed prior to pressurization for each emergent hyperbaric treatment. To ensure completeness and develop both employee engagement with and adherence to the process, the checklist was developed with input from all members of our interdisciplinary hyperbaric medical treatment team, including technicians, nurses, physicians and respiratory therapists. We reviewed checklist adherence and treatment outcomes for a one-year period.

Results: Review of our data revealed 100% (N=225) adherence to checklist completion by all team members, though 40% (N=90) were missing one of four signatures. After implementation, we were able to start treatments an average of 14 minutes earlier (32 minutes vs. 46 minutes). Only one instance of variation in care was noted over the year after checklist implementation. In subsequent informal interviews, all staff noted that improvements had been made in teamwork, quality and safety through the checklist process, thereafter prompting ongoing checklist review as part of our internal quality assurance.

Conclusions: By delineating clear roles and responsibilities, a uniform safety checklist can improve the consistency, efficiency and safety of emergent hyperbaric medical care.

E 3

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 10:24 - 10:36

POSTER PRESENTATION TIME: Poster Session 10: 11:37 - 12:00

RESIDENT COMPETITION: No

Hyperbaric oxygen therapy (HBO₂) prepayment audit: discrepancies between Noridian reviewers and the community standard of care

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Introduction/Background: The U.S. federal government has identified a high incidence of fraud and abuse in the practice of HBO₂. From January 2015 to September 2016, Noridian, a Medicare Administrative Contractor (MAC), conducted a prepayment review of HBO₂ provided at the UCLA Medical Center.

Methods: A database was created to analyze the review findings. Denial reasons were evaluated to build appeal cases, with additional medical records, supporting literature and rebuttal letter from the treating physician(s). An interdepartmental workflow was established to standardize the appeal process, and a Kaizen event identified workflow opportunities to improve clinical documentation.

Results: Up to 78% of claims submitted to Medicare were reviewed. In 58% of total denied claims, reviewers required bone biopsy, culture, MRI or X-ray to confirm diagnoses like osteomyelitis. However, community standard is to accept exposed bone with a high index of clinical suspicion by the treating physician. For many diagnoses in addition to diabetic foot ulcers (DFU), reviewers required 30 days of no measurable improvement (31%) prior to HBO₂. After the second appeal, MAC reviewers frequently overturned these cases, confirming these criteria apply only to DFU. Similarly, osteoradionecrosis denials citing lack of exposed bone (20%) were overturned after second appeal when it was indicated that a CT scan sufficiently demonstrated osteoradionecrosis. Claims for soft-tissue radionecrosis and osteoradionecrosis were denied if dental surgery was planned (9%), but usually reversed by explaining they are indications nonetheless.

There were often discrepancies between the community standard of care and Noridian's initial denial reasons. The likelihood of overturn was four times higher after the second appeal than the first.

Discussion: Healthcare providers should work with policymakers to help devise legislation that would grant protection for patients and providers undergoing prepayment review so as to minimize financial burden on individuals and impact on quality of patient care.

E 4

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 10:36 - 10:48

POSTER PRESENTATION TIME: Poster Session 10: 11:37 - 12:00

RESIDENT COMPETITION: Yes

Performance of the Uni-Vent Eagle™ Model 754 ventilator under hyperbaric conditions

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Introduction/Background: Occasionally, critically ill patients requiring mechanical ventilation also require hyperbaric oxygen (HBO₂) therapy. Though ventilators designed for HBO₂ are now commercially available, some institutions use ventilators that were available prior to the advent of these hyperbaric specific units. One such ventilator is the Uni-Vent™ model 754, which has been shown to be an adequate replacement in HBO₂ for non-electric ventilators. However, its performance could benefit from more complete characterization along with investigation of concerns of oxygen leaks in the vent housing, which poses a fire risk.

Materials/Methods: A Uni-Vent™ Eagle model 754 was investigated at 1.0, 2., and 2.8 ATA in assist-control mode using a Michigan Instruments test lung (compliance set to 0.05 L/cmH₂O) and 100% O₂. Tidal volumes ranged from 100-700mL, in 100mL increments for one minute intervals. Delivered volumes, peak pressures and the oxygen percent within the chamber and within the ventilator (using a custom drilled port) were recorded. At each depth, three different respiratory rates were investigated (12, 20, and 30 breaths/minute). The I:E ratio at 12 and 20 br/min was held to 1:2, while at 30 br/min it was held to 1:1.

Results: At 2.4 and 2.8 ATA, the ventilator delivered less volume than at 1.0 ATA. At the respiratory rate of 30 br/min, however, breath stacking was seen above 300 mL at all depths but was blunted at both 2.4 and 2.8 ATA. Peak pressures increased with both respiratory rate and breath stacking at depth. O₂ levels did not rise in the housing during our investigation.

Summary/Conclusions: Hyperbaric conditions cause decreased delivered tidal volumes in a dose-dependent fashion. Peak pressures increased with respiratory rate, which was blunted at depth except with breath stacking. The Uni-Vent™ Eagle model 754 performed safely and effectively at depth but requires spirometric analysis to correctly program desired ventilator settings.

E 5

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 10:48 - 11:00

POSTER PRESENTATION TIME: Poster Session 10: 11:37 - 12:00

RESIDENT COMPETITION: Yes

The effect of compression rate and slope on the incidence of Eustachian tube dysfunction and middle ear barotrauma: a phase I prospective quasi-experimental study

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Introduction: Eustachian tube dysfunction (ETD) and middle ear barotrauma (MEB) are the most reported complications during hyperbaric oxygen treatment. Despite this, there is no standardized rate of compression (ROC) shown to decrease its occurrence. The incidence shows significant variation across various prospective and retrospective studies. Teaching appropriate ear equalization techniques and concomitant patient disease may play a role in successful or unsuccessful compression. Certain data show the ROC might influence ETD and MEB. Our study was formulated in an attempt to find an optimal ROC that might reduce ETD and MEB.

Methods: Data was collected prospectively on 2,807 patient treatments. We randomly assigned four different ROCs using two variables – time (10 vs. 15 minutes) and slope (linear vs. non-linear) – in a repetitive and consecutive protocol throughout the study period. We recorded any patient or inside observer (IO) requiring a stop during compression. Patients requiring stops were evaluated post-treatment for the presence of ETD, MEB or both. All findings were compared to our standard 10-minute linear ROC (reference). Otoscopic findings were graded using both the Teed and O'Neill grading systems for ETD and MEB. The evaluation of the tympanic membrane was accomplished with video otoscopy to capture baseline photos and repeated to evaluate any patient requiring a stop. Data were analyzed using basic statistical methods.

Results: When comparing the different rates of compression, there was a decreased tendency for ETD and MEB in patients compressed using a 15-minute linear schedule. Results are statistically significant.

Conclusion: The use of a 15-minute linear compression schedule is associated with a reduced risk for ETD and MEB during elective hyperbaric oxygen treatments in a Class A chamber.

E 6

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 11:00 - 11:12

POSTER PRESENTATION TIME: Poster Session 10: 11:37 - 12:00

RESIDENT COMPETITION: No

Critical thinking inside the box: establishing best practice in the hyperbaric medicine clinic through in situ simulation

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Introduction/Background: What team actions are essential in response to a patient discovered to be in cardiac arrest at 2.0 ATA? How are these actions coordinated among multidisciplinary team members, separated by undefiable physical laws? What actions may or may not be performed by the inside attendant during the 90 seconds required for the multiplace hyperbaric chamber to rapidly decompress? How do we understand best practice management of cardiac arrest in the hyperbaric medicine clinic?

Hyperbaric oxygen (HBO₂) therapy is administered in a pressurized environment that imposes limitations on conventional life support response. HBO₂ team members must think critically and prioritize interventions that optimize patient survival and minimize the potential for pressure-related injury to staff.

Materials/Methods: A multidisciplinary simulation exercise, supported in situ by the simulation center of this large tertiary academic medical center in the Midwest, afforded opportunity to understand the complex problem of the unresponsive patient in the multiplace hyperbaric chamber. Two scenarios were developed and learning objectives defined that would promote knowledge acquisition and demonstrate competency in executing hyperbaric medicine clinic emergency procedures. The authenticity of the simulation was enhanced through participation of the medical emergency response stakeholders.

Results: The hands-on application of basic life support in the context of the hyperbaric care environment was universally agreed to be a positive experience among the 19 respondents to a post-exercise survey. Of primary value, respondents reported enhancement in their level of preparedness for a medical emergency response in the multiplace hyperbaric chamber.

Summary/Conclusions: The Hyperbaric Medicine Clinic is leveraging the in situ simulation experience to establish best practice. Environment of care improvements and procedural guideline revisions are the early products of the simulation exercise.

E 7

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 10: 11:37 - 12:00

RESIDENT COMPETITION: Yes

The Vortran[®] automatic resuscitator: a pilot study at depth and altitude

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Introduction: The Vortran[®] Automatic Resuscitator (VAR[®]) is a single-use mechanical ventilator that may have potential for use in critical care. However, treatment of critically ill patients, such as dive or altitude injuries, is often performed under conditions that deviate from normobaric pressure and which may negatively affect the functioning of medical devices. In this study, the performance of the VAR[®] was tested to assess its utility as a mechanical ventilator under hyperbaric and hypobaric conditions.

Methods: The VAR[®] was tested under hyperbaric pressures in dry hyperbaric chambers, hypobaric pressures in a vacuum chamber, and normobaric pressures while ventilating a Siemens 190 Test Lung. Driving pressure for mechanical cycling of the device was provided by standard hospital oxygen or air at 55 psi. PIP, PEEP, RR, IT, ET and I:E ratios were recorded for three manufacturer standard PIP settings and a target RR of 12 bpm using an electronic airway pressure monitor (APM) and an analog spirometer.

Results: *Normobaric pressure:* For all three PIP settings, all measurements did not fluctuate significantly once the desired RR was set. However, at the lowest PIP setting of 15-25 mmH₂O, adjustment of the VAR[®]'s controls were needed to maintain target RR.

Hyperbaric pressure: The VAR[®] was not able to function at ambient pressures >1.85 ATA at a PIP setting of 25-35 mmH₂O and failed at much lower ambient pressures at the low- and high end of PIP settings when the VAR[®]'s controls were not able to be constantly adjusted.

Hypobaric pressure: A VAR[®] PIP setting of 15-25 mmH₂O was unable to maintain ventilation under hypobaric conditions ≤ 0.95 ATA. However, with PIP settings of 25-45 mmH₂O, cycling of the VAR[®] was maintained with adequate ventilation parameters.

Summary: The VAR[®] was not able to maintain adequate ventilation in a hyperbaric environment above 1.50 to 1.85 ATA. However, the VAR[®] could maintain ventilation at an ambient pressure up to 2.4 ATA with continuous adjustment, an ambient pressure that is still generally non-therapeutic for dive injuries. With a PIP setting of 25 to 45 mmH₂O, adequate ventilation was maintained at altitude pressures tested to 6,046 feet.

E 8

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 10: 11:37 - 12:00

RESIDENT COMPETITION: No

Successful treatment of a patient with a left ventricular assist device with hyperbaric oxygen at 2.4 ATA

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Introduction/Background: Patients with a left ventricular assist device (LVAD) are not commonly treated with hyperbaric oxygen (HBO₂) due to the risk of fire and device failure. We report a case of a patient with radiation cystitis successfully treated with HBO₂. There is only one previous abstract of a similar case in the literature – by the UCSD in 2010. However, the patient was treated using the lithium-ion 14V battery packs which are now restricted by the NFPA.

EB is an 81-year-old male with a history of prostate cancer status post radiation who presented for HBO₂ for radiation cystitis that required blood transfusions, bladder fulguration and placement of bilateral nephrostomy tubes.

Materials/Methods: The LVAD is typically powered by two 14V lithium-ion (li-ion) battery packs and another 11V li-ion battery in the Pocket Controller (PC). We removed all li-ion batteries and connected the test pump to Thoratec's new Mobile Power Unit (MPU), which consists of three non-rechargeable standard alkaline batteries and connects to 100-240V AC. The MPU was placed in a nitrogen-purge box and set to compress to 6 ATA.

Results: Prior to starting treatment, testing on the device was performed. Upon reaching 92 fsw, the PC alarmed as the softkeys auto pressed due to increased pressure. Testing to 2.4 ATA and 2.8 ATA had no effects on PC softkeys. LVAD coordinator and Bio Medical examined the pump, PC, and MPU with no damage. Nursing protocols were created to prepare the patient daily for treatment and in case of device failure.

EB completed 44 HBO₂ treatments, with no mechanical failures or complications. He had resolution of gross hematuria, and nephrostomy tubes were removed.

Summary/Conclusion: EB had an excellent outcome, with improvement in quality of life after removal of his nephrostomy tubes. Patients with LVADs can be successfully treated with HBO₂ with appropriate protocols to decrease risk.

E 9

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 9: 11:15 - 11:37

RESIDENT COMPETITION: No

Allocation concealment in a blinded, randomized trial of hyperbaric oxygen for post-concussive symptoms

Churchill S¹, Weaver LK^{1,2}, Wilson SH³, Lindblad AS³, Deru K¹

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Introduction: In randomized trials, allocation concealment (blinding) can minimize bias. We report concealment results in a randomized, double-blind clinical trial of hyperbaric oxygen (HBO₂) for persistent post-concussive symptoms (BIMA*).

Methods: BIMA randomized 71 military service members at three sites to receive forty 60-minute sessions of HBO₂ (1.5 ATA, oxygen) or sham (1.2 ATA, air) chamber sessions over 12 weeks. Participants were blind to pressure and breathing gas. At 13 weeks, participants completed a two-question written survey asking whether they thought they received HBO₂ or sham sessions and why. Blinded study staff completed a similar questionnaire for each participant.

Results: Seventy participants (99%) completed the questionnaire (HBO₂ N=36, sham N=34). Forty-one (59%) were unsure of intervention, balanced between HBO₂ (N=21) and sham (N=20) groups (HBO₂ N=36, sham N=34). Four participants in each group thought they received HBO₂, while 10 sham and 11 HBO₂ participants believed they received sham. The blind was protected (P=0.99).

Of eight participants who believed they received HBO₂, seven (three in HBO₂, four in sham) cited symptom improvement, while 15 (six in HBO₂, eight in sham) believed they received sham due to lack of symptom improvement. Of the other six participants who believed they received sham, five (three HBO₂, two sham) cited lack of in-chamber neurological symptoms, one (HBO₂) listed gas smell, and one (HBO₂) listed pressure change. One HBO₂ participant selected HBO₂ because he wore a hood in the chamber. No participant based their conclusions on interactions with chamber or study personnel.

Site principal investigators selected “not sure” for every participant. Study coordinators were unsure of allocation in 75% of participants and correctly guessed allocation in eight (12%) (P=0.74).

Conclusions: Sham pressurization protected the blind in this trial. Participants based allocation assumptions on outcome and could not discern intervention arm by pressure, smell, taste or gas flow.

* BIMA is the Brain Injury and Mechanisms of Action of Hyperbaric Oxygen (HBO₂) for Persistent Post-Concussive Symptoms after Mild Traumatic Brain Injury (mTBI) (BIMA) Study

E 10

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 9: 11:15 - 11:37

RESIDENT COMPETITION: No

Adverse events in a blinded, randomized trial of hyperbaric oxygen for post-concussive symptoms

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Introduction: We report chamber- and protocol-related AEs for participants enrolled in a randomized, double-blind clinical trial of HBO₂ for persistent post-concussive symptoms (BIMA*).

Methods: This study randomized 71 military service members at three sites to forty 60-minute sessions of HBO₂ (1.5 ATA, oxygen) or sham (1.2 ATA, air) over 12 weeks. AEs were collected at each in-person or phone study visit. A physician determined injury severity and relationship to chamber sessions/study participation. AEs through the 12-month visit are reported.

Results: Participants underwent 2,145 chamber sessions. No serious AEs (death/hospitalization) were associated with chamber sessions. Twenty-seven participants reported 61 chamber-related AEs: middle-ear barotrauma (pain or TEED>0) (16 HBO₂ participants, five sham participants), sinus barotrauma (seven HBO₂, three sham), headache (one HBO₂, two sham), dizziness/vertigo (one HBO₂, two sham), vision change (one HBO₂, one sham), somnolence (one HBO₂, one sham), dyspnea (one HBO₂), neck irritation (one sham), eye pruritis (one sham), hyperventilation (one HBO₂), and anxiety (one HBO₂). Three additional AEs were associated with the test of pressure before randomization: two middle ear and one sinus barotrauma. One HBO₂ participant discontinued intervention at 33 sessions for myopia (Snellen change 20/13 to 20/15, no change by autorefractor). Barotraumas were mild and non-limiting. No participant reported chamber claustrophobia.

Fourteen AEs were associated with the study assessment battery:

- ECG: skin irritation from pad adhesive (5)
- computed tomography: anxiety (3), infusion site extravasation (1)
- vestibular testing: dizziness (1), syncope (1), claustrophobia (1)
- blood collection: dizziness (1)
- overall assessment battery: fatigue (1)

AEs unrelated to study participation/intervention were common: 35 HBO₂ participants (97%) and 34 sham participants (97%) reported AEs between enrollment and the 12-month visit, but 353/433 recorded AEs (82%) were unrelated acute illnesses or injuries.

Conclusions: AEs in this study were rare, and chamber exposures were safe in this population. The assessment battery was well tolerated.

* BIMA is the Brain Injury and Mechanisms of Action of Hyperbaric Oxygen (HBO₂) for Persistent Post-Concussive Symptoms after Mild Traumatic Brain Injury (mTBI) (BIMA) Study

E 11

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 9: 11:15 - 11:37

RESIDENT COMPETITION: No

Building a hyperbaric emergency preparedness program: meeting the needs of employee readiness and certification

Melnyczenko A, McManimon V, Higgins J, Balgeman J, Marosek N

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Introduction/Background: The creation of a sound safety program is paramount to the success of any hyperbaric practice. National governing bodies and societies have established codes and standards that call for the establishment of safety practices, drills, and in-service education. Challenges to this effort include practice needs, patient schedules, absence of resources, and staffing limitations, among others.

Materials/Methods: During monthly meetings the Hyperbaric Safety Committee selects program topics. The scenarios are approved by the hyperbaric safety director. Twice-monthly events are planned and announced utilizing the institution's email exchange and calendar platform. Standardized handouts containing course description, learning goals, objectives and references are electronically distributed to the group in advance. A record of each event is catalogued in an institutional database of exercises. This documentation is reviewed, compiled and submitted for course review to the National Board of Diving and Hyperbaric Technology (NBDHMT) for CEU consideration.

Results: Feedback derived from an internal anonymous survey has indicated that participants in this program have a deeper appreciation for hyperbaric safety and a perceived increase in their preparedness and confidence. Review of these exercises has led to the enhancement of safety procedures and identified critical equipment needs. Access to local continuing education resources reassures staff that they can meet the NBDHMT recertification requirements.

Summary/Conclusions: Championing a culture of safety in hyperbaric medicine demands teamwork, constant vigilance and practice. Implementing this program has effectively removed barriers to specialty recertification called for by accreditation guidelines. Additionally, the performance of scenario-based exercises empowers us to respond optimally to emergent situations. We view this as a new standard that other hyperbaric programs can implement to their advantage. Doing so may very well lead to a more confident, skilled and prepared staff in the face of any emergency.

E 12

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: WITHDREW

RESIDENT COMPETITION: No

Early termination of hyperbaric oxygen therapy

Samimi F, Chivate J

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WITHDREW

E 13

Thursday, June 29

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 1: 11:15 - 11:37

RESIDENT COMPETITION: No

Expectant management of bilateral pneumothoraces while treating severe carbon monoxide poisoning in a mechanically ventilated trauma patient

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Introduction/Background: We present successful hyperbaric management of severe CO poisoning in a mechanically ventilated multisystem trauma patient with small bilateral pneumothoraces .

Materials/Methods: A previously healthy 25-year-old male jumped from a third-story apartment to escape a fire. He was intubated upon arrival for airway protection. He sustained the following injuries: second- and third-degree burns to his face, arms and hands; small bilateral pneumothoraces, left lung laceration, lung contusions; Grade 2-3 liver laceration; left hand laceration; right scapular body fracture; left posterior iliac wing fracture involving the sacro-iliac joint; smoke inhalation; CO poisoning and possible cyanide poisoning. Relevant labs: COHb 26.4%, lactate 10.6 mmol/L, arterial pH 7.18, AST 314, ALT 138, troponin 0.19 ng/mL , EtOH 189 mg/dL.

Initial resuscitation and management of traumatic injuries prevented immediate HBO₂ treatment. He received hydroxocobalamin 5g IV. Bronchoscopy showed extensive carbonaceous soot in all visualized airways. Once stabilized he was ventilated easily on VC/SIMV, PEEP of 12. His minute volumes were 9 L. Subsequent bedside chest X-ray (CXR) failed to demonstrate pneumothoraces despite pneumothoraces and lung laceration seen on CT.

Results: After consultation with critical care and the trauma surgery services, we elected to proceed cautiously with a single HBO₂ treatment (2.8 ATA x 46 minutes – our institution protocol for CO poisoning). This was approximately six hours after injury. We ventilated the patient with PC 14 cm H₂O, PEEP 12. The hyperbaric physician joined the patient and critical care hyperbaric nurse at 46 minutes and accompanied both to the surface. Total decompression time was 41 minutes; the final 10 feet at 1 foot/minute. Vital signs, physical exam and minute ventilation was monitored continuously. Equipment sufficient to perform needle decompressions or finger thoracostomies was available inside the chamber.

Summary/Conclusions: Decompression was uneventful; post-procedural CXR was negative for pneumothorax.

E 14

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 9: 11:15 - 11:37

RESIDENT COMPETITION: No

Programmable ventriculoperitoneal shunt use under hyperbaric conditions

Johnson-Arbor K, Evans K, Hutson C, Barry R

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Introduction: Although traditional ventriculoperitoneal (VP) cerebral spinal fluid (CSF) shunts appear to be safe for use under hyperbaric conditions, the use of newer, programmable VP shunts under hyperbaric conditions has not been previously explored. We present a case of a patient with a programmable VP shunt who received hyperbaric oxygen (HBO₂) therapy.

Case Report: A 54-year-old male was referred for HBO₂ due to a compromised skin flap over a synthetic cranioplasty. The patient had a history of a previous subarachnoid hemorrhage with evacuation and cranioplasty; he subsequently required multiple cranioplasty revisions. Due to a persistent complex cranial defect, he was taken to the operating room for a revision cranioplasty and flap closure. Postoperatively, the flap edges appeared dusky, and he was referred for adjunctive HBO₂. During the hyperbaric medicine evaluation, it was discovered that the patient had a Strata (Medtronic, Minneapolis, MN) programmable lumbar-peritoneal shunt. Due to unfamiliarity with the programmable shunt system, the components of the device were carefully investigated, with the assistance of the manufacturer. The patient eventually received HBO₂ treatments, which he tolerated without evidence of shunt malfunction.

Discussion: Programmable VP shunts contain a ventricular catheter, a peritoneal catheter and an adjustable valve which allows for transcutaneous CSF flow rate adjustment. Several manufacturers make programmable VP shunts; the Medtronic version contains a valve that houses a flow-regulating cobalt magnet, which is gold-plated to protect against corrosion. CSF flows freely through the valve; there is no air or battery present. Physicians can adjust the flow rate transcutaneously using a magnet held above the valve.

Conclusion: The Medtronic Strata programmable VP shunt appears to be safe for use under hyperbaric conditions. As the components of other manufacturer's programmable VP shunts may differ, these devices should be carefully investigated prior to their use in a hyperbaric environment.

E 15

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 9: 11:15 - 11:37

RESIDENT COMPETITION: Yes

Calculating hyperbaric treatment pressure while at altitude

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Introduction: Does our standard wound treatment gauge pressure of 2.0 atmospheres absolute (ATA) take into account our being at 7,000 feet in elevation? If not, what is the degree of discrepancy, and is it large enough to warrant action to correct? If the discrepancy is substantive, then in order to actually be treating patients at their prescribed treatment pressures, a compensating adjustment needs to be calculated and implemented.

Method: Standard treatment tables were consulted. We noted that 7,000 feet above sea level (our approximate altitude) the barometric pressure is 3.352 psi (or 0.228 ATA) less than the 14.7 psi (or 1 ATA) standard at sea level. This translates to a starting atmospheric pressure of 0.772 ATA, to which we add another ATA of pressure for a total treatment pressure 1.772 ATA. This was deemed large enough a deviation from our intended treatment pressure of 2 ATA (being nearly one-quarter of an atmosphere) to warrant adjustment.

An inquiry to the chamber manufacturer confirmed that they had made no adjustment to the machinery or gauges to compensate for the higher elevation.

Our concerns, along with our calculations, were submitted to “Ask the Expert” at the UHMS website and were confirmed, with the exception of a standard gauge at altitude adjustment of +0.03 ATA we had made but neglected to mention in our correspondence. The gauge at altitude adjustment was derived from consulting standard tables used to calculate adjustments to gauges calibrated at sea level but used at various altitudes.

Adding the 0.03 ATA gauge at altitude adjustment to the 0.228 of an ATA that we were deficient in from standard at sea level pressure gave us a total needed adjustment of 0.258 ATA. This meant that in order to treat patients at 2.0 ATA true, we would need to add 0.258 ATA to our gauge setting for a chamber pressure reading of 2.258 ATA. We rounded this number to 2.26 ATA for purposes of practical application. We submitted our findings and calculations to the medical director. At our behest and with his approval, the change was then implemented.

Result/Follow-up: The patients were informed of the forthcoming increase to their treatment pressure and the reason for it. Upon implementation, no disadvantageous effects were seen by the staff or reported by patients.

E 16

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 9: 11:15 - 11:37

RESIDENT COMPETITION: No

Hyperbaric oxygen therapy and the deaf patient

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Introduction: Patients with disabilities require individualized care when in the hyperbaric environment. We present the successful use of hyperbaric oxygen (HBO₂) therapy in a deaf patient.

Case report: A 34-year-old male was transferred to a tertiary care center for HBO₂ evaluation due to concern for forearm compartment syndrome. He was deaf in both ears and communicated by American Sign Language (ASL); he did not read lips. He preferred live interpreters to video interpretation services. The patient was taken to the OR for forearm exploration; he began HBO₂ treatments postoperatively. Video interpretation was utilized to communicate with the patient during his hyperbaric consultation, but in order to facilitate adequate communication during the hyperbaric treatments and dressing changes, a live interpreter was used. The patient completed five treatments at 2.5 ATA, with standard air breaks. He was eventually discharged home after skin grafting.

Discussion: Challenges involved in the care of a deaf hyperbaric patient include achieving communication and ensuring that hyperbaric orientation and treatments can be performed adequately and in a timely manner through an interpreter. Live interpreter scheduling was difficult, as this patient required treatment around a major holiday. Our patient was treated in a monoplace chamber, which allowed the interpreter to remain immediately outside the chamber throughout the treatment and communicate via ASL through the acrylic panels. Our patient also received manual cues for air breaks via the live interpreter. In a multiplace chamber, the live interpreter would likely need to lock in with the patient, as adequate sign language communication would be more difficult to achieve through a smaller acrylic portal.

Conclusion: Unique communication challenges are associated with the treatment of deaf patients under hyperbaric conditions. Hyperbaric providers should be aware of the regulations and individual needs pertaining to the use of interpreters in deaf patients.

E 17

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 9: 11:15 - 11:37

RESIDENT COMPETITION: Yes

Type III decompression sickness: failure of a home built hyperbaric chamber

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Introduction: Hyperbaric medicine is routinely used in both the inpatient and outpatient settings all throughout the country. It is generally considered a safe and effective way to treat many disease processes ranging from chronic wounds to acute gas-related emergencies. While there are many benefits associated with hyperbaric therapy, some people have tried to create hyperbaric chambers for use outside supervised clinical settings. The purpose of this case report is to highlight hyperbaric therapy by discussing the catastrophic effects that can be occurred when the proper mechanical and therapeutic indications are ignored. An explosive decompression occurs when a sudden drop in pressure occurs at a rate that is too fast for air to escape safely from the lungs. What follows is a discussion of an unfortunate patient who built a crude chamber with substandard materials, which ultimately resulted in his significant injury and death.

Case presentation: 48-year-old male was found unconscious next to a homemade hyperbaric oxygen chamber. The patient managed to crawl out of the chamber and had experienced upper and lower extremity shaking with possible eye deviation to the left. The patient was brought to the emergency department via Life Flight air ambulance. On arrival to the ED in Galveston, the patient was found to have bilateral pneumothoracics. Chest tubes were placed bilaterally, and he was admitted to MICU. Neurology, neurosurgery, cardiothoracic surgery, general surgery departments all consulted during the hospital course. The patient was transferred to West Jefferson Medical Center five days after the event and received hyperbaric therapy. Ultimately, the patient expired.

Conclusion: Hyperbaric oxygen therapy is generally accepted as safe, and it is obviously not advised that civilians attempt to build their own chambers. This patient experienced a massive arterial gas embolism that likely would have benefited from hyperbaric therapy had it been administered earlier. The patient may still have expired, but in our experience, had this patient received hyperbaric oxygen more emergently, the outcome may have been different.

PLENARY:
**“New Pearls of Wisdom in the Diving and Hyperbaric
Medicine Literature”**
Daniel Popa, MD & Mark Binkley, MD
1:00 PM – 2:00 PM



Daniel Popa, MD



Mark Binkley, MD

ABOUT THE LECTURE:

Dr. Popa will give highlights of the diving literature over the past 1-2 years including the following articles:

- **Possible central nervous system oxygen toxicity seizures among US recreational air or enriched air nitrox open circuit diving fatalities 2004-2013.** Buzzacott P, Denoble PJ. *Brain Inj.* 2017;31(3):366-369.
- **Association of microparticles and neutrophil activation with decompression sickness.** Thom SR, Bennett M, Banham ND, Chin W, Blake DF, Rosen A, Pollock NW, Madden D, Barak O, Marroni A, Balestra C, Germonpre P, Pieri M, Cialoni D, Le PN, Logue C, Lambert D, Hardy KR, Sward D, Yang M, Bhopale VB, Dujic Z. *J Appl Physiol* (1985). 2015 Sep 1;119(5):427-34.
- **The probability and severity of decompression sickness.** Howle LE, Weber PW, Hada EA, Vann RD, Denoble PJ. *PLoS One.* 2017 Mar 15;12(3)
- **Prevention and treatment of decompression sickness using training and in-water recompression among fisherman divers in Vietnam.** Blatteau JE, Pontier JM, Buzzacott P, Lambrechts K, Nguyen VM, Cavenel P, Ruffez J. *Inj Prev.* 2016 Feb;22(1):25-32.

Dr. Binkley’s lecture will be focused on recent hyperbaric medicine articles regarding hyperbaric oxygen treatment of osteonecrosis of the femoral head and the use of hyperbaric oxygen as an adjuvant therapy for umbilical cord blood stem cell transplants.

SESSION F
CLINICAL AND DIVING-RELATED
HBO₂ THERAPY

Moderators:

SATURDAY, JULY 1

Oral Presentations:
2:00 PM – 3:15 PM

Poster Presentations:
Poster Session 11: 3:45 PM – 4:07 PM
Poster Session 10: 4:07 PM – 4:30 PM

F 1

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 2:00 - 2:12

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: No

Hyperbaric oxygen therapy in the treatment of complex regional pain syndrome

Zanon V ^{1,2,5}, Vezzani G ^{2,5}, Camporesi EM ⁴, Bosco G ^{2,3}

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Introduction/Background: Complex regional pain syndrome (CPRS) is a nosological entity that has been included in the Italian indications for hyperbaric oxygen therapy since 2007 as algodystrophy.

The protocol usually applied is 2.2 ATA (223kPa) to 2.5 ATA (253 kPa) for at least 60 minutes at depth at an FiO₂=1, 30-40 treatments.

During 2015's bibliographic revision and implementation of the Italian Guide Lines to HBO₂ therapy a GRADE approach to the issue has been introduced. In turn this has indicated the need for further study of its efficacy to better weight HBO₂ use and effects in CPRS.

Materials/Methods: A single-center per-protocol retrospective study lasting 27 months took place at the Diving and Hyperbaric Medicine Unit in Brescia, Italy. The study enrolled any patient who ended the scheduled HBO₂ course during the period from January 1, 2015, through March 31, 2017.

The study comprised 124 patients (59 males, 65 females), average age of 56 at the access visit for HBO₂. Of these 78 (23%) had a single presentation in three major sites: knee (right > left), ankle/foot (right > left), and coxofemoral joint (left > right); 64.92% were idiopathic; 31.58% had a post-traumatic origin; and 3.5% were post-surgery.

After a medical assessment, the treated patients were exposed to 1 treatment/day, five days/week, [average exposure: 46.98 treatments] for 35 minutes x 2 at an FiO₂=1 and a three-minute air break, at a pressure of 2.4 ATA (242 kPa).

Results: *Complete recovery:* 65.32% (subjective feedback and clinical evaluation and MRI at three to four weeks after the treatments); *improved:* 32.26%; *unchanged:* 2.42%. No any occurrence of worsening clinical conditions were reported.

Summary/Conclusions: Hyperbaric oxygen therapy is capable of reducing edema, improving hypoxic tissue oxygenation and upregulating osteoblast production, which leads to both regeneration and structural rearrangement of the bone tissue.

F 2

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 2:12 - 2:24

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: No

Magnetic resonance imaging after hyperbaric oxygen treatment for osteonecrosis of the knee

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Introduction: Osteonecrosis of the knee (ONK) is a debilitating disease caused by temporary or permanent reduced blood flow to femoral condyles. We retrospectively reviewed patients with ONK who underwent hyperbaric oxygen therapy (HBO₂) interventions.

Methods: The severity of each patient's functional impairment was classified using the Oxford Knee Score (OKS). Certified musculoskeletal radiologists reviewed magnetic resonance imaging (MRI). These MRIs were obtained prior to HBO₂ treatment, one year after completion of HBO₂ (60 to 90 sessions), and approximately six to seven years after initiating HBO₂. HBO₂ was provided with a tight-fitting mask at 2.5 ATA for 60 continuous minutes. Commonly, patients received a first series of 30 treatments once a day for six weeks. Following a two-month break, patients received 20 more HBO₂ treatments for four weeks. Subsequently, patients received one or two more sets of 20 HBO₂ treatments, each with an approximate one-month break. These patients could receive up to 90 HBO₂ treatments over 12 months. A follow-up MRI was collected after 12 months and a third MRI was collected at a six- to seven-year follow-up. Data were analyzed by a qualified statistician (SPSS Inc., Chicago, Illinois).

Results: We studied 29 males and eight females whose (mean age = 54 years old). Patients received an average of 68 treatments over approximately three cycles.

MRI findings: Fourteen patients had three MRIs each. Initial evaluation showed one of three patterns at the femoral condyle: diffuse bone marrow edema, focal geographic abnormality with T2 hyperintense signal, or edema surrounding a focal subchondral low-signal area. On short-term follow-up (one year), 13 patients had normal femoral condyle appearance, and on long term follow-up (six to seven years), the MRI appearance was completely normal in all 14 cases.

Conclusion: Clinical improvement can be observed after only 20 treatments, but radiological improvement is not visible on MRI until the completion of 60+ treatments.

Table 1. Oxford Knee Scores throughout HBO₂ treatment (60 is normal in OKS).

	n	mean (± SD)
Baseline OKS	37	13.9 ± 10.0
OKS After 1 st cycle	37	30.2 ± 6.3
OKS After 2 nd cycle	37	59.8 ± 0.8
OKS after 3 rd cycle	28	59.8 ± 1.0

F 3

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 2:24 - 2:36

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: No

Radiographic and clinical response to hyperbaric oxygen therapy in symptomatic brain tumor survivors with ischemic radiation vasculopathy

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Introduction: Substantial evidence supports the efficacy of hyperbaric oxygen (HBO₂) therapy for radiation injury to bone and soft tissue, but there is limited information about the benefit of HBO₂ in therapeutic radiation (RT) injury to the brain [1]. Ischemic vasculopathy may occur in irradiated brain tumor survivors and degrade functionality and quality of life. These vascular changes conform anatomically to the RT field and are well demonstrated radiographically on MRI perfusion mapping.

We treated 27 irradiated symptomatic brain tumor survivors with HBO₂. Whenever possible, pre-HBO₂ assessment included neurocognitive testing and MRI perfusion mapping so that patients could serve as their own controls. Our goals were to confirm the safety of HBO₂ in this clinical setting and determine clinical and radiographic efficacy. Initially, we gave 30-40 treatments at 2.0 ATA, but once safety was confirmed, we settled on at least 60 treatments at 2.4 ATA without air breaks. This is a retrospective review of these patients.

Methods: With a mean follow-up of 12 months, range four to 31 months, three patients have died of progressive tumor (not unexpected). There were no unusual or severe side effects. No patient without progressive tumor has declined neurologically or radiographically. Seventeen patients, (68%) have demonstrated clinical and/or radiographic improvement thus far. Clinical responses include regaining sufficient spatial orientation to drive a car, ability to return to full-time work because of reduced fatigue, improved seizure control, and recovery of cognition from a near-vegetative state to prediagnosis baseline. The latter patient demonstrated dramatic improvement in vascularity to both the irradiated non-dominant brain and the non-irradiated dominant side. Responses have occurred as early as six weeks and as late as one year. Early results suggest superiority of 60 sessions at 2.4 ATA. Patients treated more than 10 years post-RT have not responded as well.

Conclusion: We conclude that HBO₂ can be given safely to patients with radiation brain injury, and that many have experienced meaningful clinical and radiographic improvement. To the best of our knowledge, this is the first time that MRI perfusion mapping has been used to demonstrate cerebral neoangiogenesis. HBO₂ deserves further study in these patients. Key questions to be addressed include: optimum number of treatments and pressure, which patients and functions are most responsive, and when is the best time to intervene.

1. Niezgoda JA, et al. Adv Skin Wound Care. 2016 Jan; 29(1): 12-19.

F 4

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 2:36 - 2:48

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: No

Compressed-gas diving fatalities in the province of Quebec: 1986-2015

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Introduction: Underwater diving is conducted for many purposes: recreational, commercial, scientific, military, public safety, and training. While diving is generally safe, both non-fatal and fatal accidents occur. Quebec is the largest province in Canada, accounting for 15% of the national land area, with almost 9,000 km (approximately 5,592 miles) of coastline and a multitude of lakes and waterways. The oversight of diving is more robust in Quebec than in any other province or territory, with all divers required to possess renewable licenses, but accidents persist.

Methods: We reviewed medical and community records to identify and evaluate compressed-gas diving fatalities occurring in Quebec between January 1986 and December 2015. Data are presented as mean±SD or median with ranges and percentages, as appropriate.

Results: We identified 58 fatalities within the 30-year period, 1.9±2.1 (0-9) annually. Full autopsies were conducted in most cases (N=54, 93%), with the majority (N=46; 84%) completed at a single facility. Victims were 35±11 (18-61) years of age; and the majority male (N=50; 86%). Certification status was established for 55 victims: 28 (51%) open-water (entry) level, seven (13%) advanced, five (9%) divemaster, and five (9%) were diving as students in various programs. Incidents occurred most commonly in ocean environments (N=18, 31%), lakes (N=11, 19%), quarries (N=10, 17%), near dams (N=7, 12%), or under ice (N=7; 12%). Problems developed at a median depth of 6 (0-60) meters (20 [1-198] feet). Drowning was the most common cause of death (N=37, 66%), followed by cardiac events (N=6, 11%), and gas embolism (N=5, 9%). Primary contributing factors were exceeding competence (N=15), recklessness (N=10), inadequate supervision (N=8), and medical health issues (N=5). Multiple contributing factors were identified in most cases.

Conclusions: Comprehensive accident review is important for hazard identification. Public dissemination of findings is critical for hazard awareness and risk reduction.

F 5

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 2:48 - 3:00

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: No

Hyperbaric oxygen therapy for the prevention of arterial gas embolism in food-grade hydrogen peroxide ingestion

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Background: Food-grade hydrogen peroxide ingestion is a relatively rare presentation that can lead to significant morbidity and mortality due to its release of vascular gas emboli as well as oxidizing and tissue-damaging effects. There are no defined guidelines at this time regarding treatment of such exposures, and providers may not be familiar with the potential complications associated with high concentration hydrogen peroxide ingestions. In this case series, we describe four patients who accidentally consumed 35% hydrogen peroxide and were treated with hyperbaric oxygen therapy.

Methods: We reviewed the medical records of four different patients who presented to our emergency department after ingestion of highly concentrated hydrogen peroxide. We compared the symptoms on presentation, initial imaging, hyperbaric oxygen treatment, post-treatment imaging and patient outcomes.

Results: Four patients were included. All patients accidentally consumed variable amounts of 35% hydrogen peroxide. Two of the four patients were critically ill and required intubation. All four patients had evidence of venous gas emboli as seen CT or ultrasound. Intubated patients were assumed to have an arterial gas embolism since an exam could not be followed. After hyperbaric oxygen therapy each patient was discharged from the hospital neurologically intact with no other associated organ injuries related to vascular gas emboli.

Conclusion: Ingestion of food-grade hydrogen peroxide may result in portal vein emboli as well as arterial gas emboli (AGE). Hyperbaric oxygen therapy is an effective treatment for vascular gas emboli related to hydrogen peroxide ingestion, including AGE. This series adds to the literature showing multiple cases with a diverse range of acuity, all with excellent results after HBO₂ therapy. Physicians should consider HBO₂ therapy for symptomatic ingestions of high concentrations of hydrogen peroxide.

F 6

SATURDAY, JULY 1

ORAL PRESENTATION TIME: 3:00 - 3:15

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: No

Best practice guidelines and algorithm established for treatment and referral of patients with diabetic foot ulcers

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Introduction: The prevalence of diabetes in the U.S. increased from 0.93% in 1958 to 7.02% in 2014 and continues to rise. In 2014, 21.9 million people had diagnosed diabetes mellitus (DM). Only 1.6 million were diagnosed in 1958 [1].

This increase in DM creates a need for programs to screen patients who will likely have complications from the disease, including: cardiovascular disease, kidney failure, visual impairment and lower-extremity conditions including amputations [2].

Problem wounds are increasing in prevalence, resulting in growing health care cost and utilization of resources; diabetic foot ulcers (DFU) account for 60% of amputations [3]. Through appropriate interventions patients can improve their quality of life (QOL) and slow or stop the cycle of destruction. There are times that this includes referral for hyperbaric oxygen (HBO₂) treatments.

Methods: Our purpose is to share clinical practice guidelines for DFU as researched and recommended by the Undersea and Hyperbaric Medical Society. Included with this research is a detailed algorithm that will guide the clinician through wound assessment, the environment of care, vascular evaluation and referrals.

- ***Wound assessment:*** includes evaluation of debridement options, infection, wound bed preparation and periwound environment.
- ***Environment of care:*** treatment of underlying infection, controlled blood sugars, nutrition, lab values, offloading and behavior modification to promote healing.
- ***Testing and vascularization:*** Transcutaneous oximetry monitoring (TCOM) provides a direct, quantitative assessment of oxygen availability to the periwound skin and an indirect measurement of periwound microcirculatory blood flow [4]. This can be a significant predictor of limb salvage.
- ***Referral guidelines:*** Compromised DFUs that have been present for longer than 30 days, classified as Wagner 3 (or higher) or show signs of ischemia. Add HBO₂ post-operatively to the standard of care to reduce the risk of major amputation and incomplete healing [3, 4].

Conclusion: As wound/hyperbaric nurses and using these guidelines, DFUs can be treated appropriately and increase the rate of healing, which improves QOL.

1. Long-term trends in Diabetes: April 2016. Retrieved from:

https://www.cdc.gov/diabetes/statistics/slides/long_term_trends.pdf

2. CDC, Diabetes Home, National Data. Retrieved from: <http://www.cdc.gov/diabetes/data/national.html>

3. Huang ET, Mansouri J, Murad MH, et al. A clinical practice guideline for the use of hyperbaric oxygen therapy in the treatment of diabetic foot ulcers. *Undersea Hyperb Med.* 2015; 42(3); 205-247.

4. Weaver LK. Ed. Undersea and Hyperbaric Medical Society, *Hyperbaric Oxygen Therapy Indications: 13th Edition.* North Palm Beach FL: Best Publishing Company, 2014: 25-38

F 7

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: Yes

Dropped gallstones present with chronic fistula seven years after laparoscopic cholecystectomy

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Introduction: Patients having wounds recalcitrant to healing despite appropriate management are commonly brought to the attention of hyperbaric medicine consultants. He or she is charged with deciding the value hyperbaric oxygen (HBO₂) therapy may offer and identifying any unresolved factors contributing to suboptimal wound healing.

Case report: A 90-year-old woman was referred for HBO₂ to optimize healing a chronic posterior subcostal wound present for three months despite treatment using standard wound care modalities. The wound, being in an unusual location and unrelated to trauma merited further evaluation. MRI revealed the presence of spilled gallstones related to a laparoscopic cholecystectomy performed seven years previously. The insidious gallstone-induced infection presented as a peritoneal-cutaneous fistula. The wound healed uneventfully following laparoscopic gallstone extraction, abscess wall debridement and peritoneal-cutaneous tract excision.

Discussion: Laparoscopic cholecystectomy is the gold standard procedure in the management of symptomatic cholelithiasis, though it is associated with an increased potential for stone spillage during gallbladder removal or extraction [1, 2, 3]. The reported incidence of spilled gallstones during laparoscopic cholecystectomy ranges between 5.7%-30% and stone-related complications occur in only 0.08%-1.46% [4, 5]. As the stones can disperse within the abdominal and pelvic regions, laparoscopic removal can be difficult [6]. Based on the relatively low incidence of complication, routine removal through a laparotomy is considered unnecessary [4, 5, 7]. Complications may not become evident for years following the procedure [5].

Conclusion: Wounds failing to show progress despite treatment with accepted standard modalities may signal the need for evaluation and additional investigation before proposing hyperbaric oxygen as an adjunct to optimize healing. This case brings into focus the potential consequences of spilled gallstones and adds to the clinical armamentarium of hyperbaric and wound care specialists evaluating both common and unusual wounds. Laparoscopic stone extraction and fistula excision were necessary for wound healing.

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F 8

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: No

Hyperbaric oxygen for chronic anal fissures: case report and discussion

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Introduction/Background: Chronic anal fissures (CAFs) often do not heal due to reduced blood flow and tissue hypoxia to the area, thought to be due to internal anal sphincter hypertonia. CAFs cause distressing symptoms of pain and bleeding for patients, which reduces their physical and emotional well-being. Standard treatments include sitz baths, topical vasodilators (e.g., nifedipine, nitroglycerin), and surgery. These are unsuccessful in some patients. Because hyperbaric oxygen (HBO₂) can increase the amount of oxygen delivered to the area with the fissure it is a reasonable choice for patients who have not responded to other therapies.

Materials/Methods: A 53-year-old female with chronic pain, spasms and bleeding from a CAF for more than two years was referred to our unit. Standard treatments had not worked. She received 34 HBO₂ treatments at 2.4 ATA for 90 minutes over seven weeks. Her symptoms were monitored by self-report and with a questionnaire specifically designed to ask about CAF symptoms (Table 1), administered at the start of HBO₂ and after treatments 10, 20 and 30.

Results: The patient reported marked improvement of her symptoms, which was reflected in her questionnaire responses (Table 1).

Table 1: CAF Questionnaire responses				
	start of HBO ₂	HBO ₂ #10	HBO ₂ #20	HBO ₂ #30
rectal bleeding with defecation	EBM	SOTT	MOTT	SOTT
rectal bleeding unrelated to defecation	AOTT	MOTT	MOTT	SOTT
rectal pain with defecation	EBM	EBM	EBM	SOTT
rectal pain unrelated to defecation	MOTT	MOTT	MOTT	SOTT
rectal spasms	MOTT	MOTT	MOTT	SOTT

EBM=Every bowel movement; AOTT = all of the time; MOTT = most of the time; SOTT = some of the time

Summary/Conclusions: HBO₂ resulted in marked improvement of CAFs in this patient. CAF should be investigated as an approved indication for HBO₂ since the major contributor to this condition is hypoxia.

F 9

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 12: 4:07 - 4:30

RESIDENT COMPETITION: Yes

Improved homonymous hemianopia with hyperbaric oxygen therapy

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Introduction/Background: Homonymous visual-field defects result from insult to the retrochiasmal visual pathway, with 17%-30% following acute stroke. Any recovery of a complete homonymous hemianopia typically occurs within the first 10 days after the ischemic event, and improvement after 10-12 weeks is negligible. Only 38%-48% of patients demonstrate any measurable improvement. No proven treatment exists for recovery of the impacted visual field.

This is a report of a 69-year-old male hospitalized for eight weeks with septic shock. He was discharged as a quadruple amputee due to necrotizing fasciitis and pressor-induced ischemia. On the day of admission the patient experienced cardiac arrest for approximately 15 minutes and was subsequently noted to have large areas of ischemic change in the occipital and parietal lobes bilaterally. Following discharge a complete left homonymous hemianopia was noted, and approximately five months after initial insult hyperbaric oxygen treatments were initiated.

Materials/Methods: The patient underwent 61 hyperbaric oxygen treatments in a multiplace chamber at 2.0 ATA for 90 minutes each. Visual field testing was performed by Humphrey Visual Field analysis. Baseline testing was performed, then after treatments 13, 31, 46 and 58 and again six months after treatment.

Results: No significant improvement in the visual fields was noted at 13 treatments, but approximately 50% improvement was demonstrated in the right eye after 30 treatments with less improvement in the left. Continued improvement was noted after 46 treatments and plateau by 58 treatments.

Summary/Conclusions: This case demonstrates significant objective improvement of a fixed neurologic deficit following an ischemic brain injury. Various hypotheses exist regarding the recovery of neurologic deficits to include collateral flow mechanisms, the zone of penumbra effect and reactivation of reversibly damaged nerve tissue. This case reveals partial recovery of a neurologic deficit through the use of hyperbaric oxygen, more than five months after the original insult.

The views expressed are those of the author and do not reflect the official views or policy of the Department of Defense or its Components.

F 10

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: No

Traumatic optic neuropathy treated with hyperbaric oxygen therapy and steroids

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Introduction: A 27-year-old healthy male presented after falling 20 feet. He suffered right distal femur fracture and non-displaced right orbital fractures with extension to the optic canal and skull base fracture through middle cranial fossa, sphenoid body and lesser wing of the sphenoid. Globes appeared intact. He denied pain on extraocular movement, flashes or floaters, but described total right vision loss. Ophthalmic examination revealed no light perception (NLP) on the right, with 20/20 vision on the left, a 4.5 mm non-reactive right pupil, 3+ afferent pupillary defect (APD), normal intraocular pressure (IOP), full motility, mild right periorbital edema/ecchymosis, normal dilated fundoscopic examination, anterior segment, normal appearance of optic nerve and macula.

Material/Methods: Given the severity of the traumatic optic neuropathy and morbidity associated with NLP vision, the patient was treated emergently with hyperbaric oxygen (U.S. Navy Dive Table 5) and high-dose steroids (solumedrol 1 gm IV daily) was initiated. On Day 2, he received two treatments at 2.4 ATA for 90 minutes. His exam after the third treatment was notable for improvement in right vision to 20/100 with 1+ APD, an inferior hemifield defect, and markedly diminished color saturation and brightness. He received three additional daily HBO₂ sessions (2.4 ATA for 120 minutes) and daily high-dose steroids. Minocycline 100 mg PO BID (by mouth twice daily) was started for potential neuroprotection on Day 2.

Results: The patient's vision improved to 20/40 after three treatments. He was discharged following six HBO₂ treatments and six days of 1 gm/day IV solumedrol followed by 1 mg/kg oral prednisone daily.

Conclusion: At the two-month follow-up, the patient's vision was 20/60+2 on the right. Humphrey Visual Field testing revealed a dense inferior hemifield defect, and optical coherence tomography of the retinal nerve fiber layer indicated significant thinning of temporal, and mild superior quadrant thinning.

F 11

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: No

Complex zygodactyly release with post-op complications on a 32year-old female

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Introduction: Syndactyly is failure of separation of the digits during early gestation. Zygodactyly occurs between the third and fourth fingers and is most common. The incidence of syndactyly ranges from one in 2,000 to one in 3,000 live births. Complex zygodactyly involves bone fusion of the affected fingers. Release surgery is almost always done in early childhood.

Case: 32year-old female who was born with bilateral complex zygodactyly underwent surgical release on the left hand at age 16. She postponed the surgery on the right hand until age 33. The patient had the release procedure using a dorsal flap for the web space and both multiple dorsal and volar v-y interdigitating advancement flaps. She developed soft-tissue infection at the surgical site seven days post-op which required IV antibiotics. Cultures were positive for group D streptococcus, and she was treated with intravenous vancomycin and ciprofloxacin. The flap deteriorated, and a section of the fingers became dusky. Hyperbaric oxygen (HBO₂) therapy was added to the treatment. The patient received 34 treatments of 90 minutes at 2.0 ATA, with two five-minute air breaks per session. Wound care utilized absorbent silver alginate. Treatments were initiated in the hospital, and the patient continued treatment as outpatient. At time of discharge from HBO₂ the wounds were healed and the patient was referred for occupational therapy.

Discussion: When choosing a plan of care for a complicated wound it is important to incorporate all available treatment modalities. HBO₂ therapy is CMS-approved and an adjunctive treatment for a limited number of diagnoses. Compromised flap is an indication for HBO₂ therapy. The patient did not know about HBO₂ and was reluctant to agree to treatments five day per week. The treatment team successfully addressed the patient's psychological and emotional needs for her to complete the treatment and have a successful outcome.

F 12

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: No

Issues with self-injection of cosmetic fillers

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Introduction: Natural and synthetic fillers have revolutionized aesthetic facial rejuvenation and soft tissue augmentation. We present a case highlighting the dangers of filler self-injection.

Case: A 37-year-old female working in a physician's office self-injected Juvederm Voluma XC around both temples. She immediately experienced left side hearing loss, blanching over the left face, and pain. Hyaluronidase, topical nitroglycerin paste and alternating cold and warm compresses were initiated. As her condition was not improving, an emergency CT angiogram was initiated. It showed occlusion of a superficial temporal artery branch. She was treated with enoxaparin, aspirin, dexamethasone, piperacillin/tazobactam and intradermal lidocaine. After six HBO₂ treatments in three days, the patient showed improvement in appearance, with markedly decreased ischemic discoloration. Her hearing returned to baseline.

Discussion: Few similar cases of acute peripheral arterial ischemia have been reported. Algorithms for treating such injuries generally neglect HBO₂. HBO₂ is efficacious in these situations by a variety of mechanisms: oxygenation of ischemic tissues, reduction of edema, amelioration of ischemic/reperfusion injury, promotion of angiogenesis and collagen maturation. The patient's resolved hearing highlights the utility of HBO₂ in sudden sensorineural hearing loss.

Our patient obtained the filler from her employer who performed such injections. Many patients are able to obtain fillers from unregulated sources. Coupled with the availability of online videos and diagrams illustrating injection, it is easy for patients to acquire and attempt self-injection of fillers.

Some have suggested an injunction on all websites selling do-it-yourself fillers and showing self-injection techniques. Others encourage tighter governmental regulations.

Conclusions: Injectors should have guidelines for using product, not only on patients but staff as well. Filler courses should include handling complications and include HBO₂ in their guidelines. Clinicians should remind patients to seek treatment from qualified clinicians. The goal of a bargain price using self-injection may quickly become expensive and disfiguring.

F 13

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: No

One puzzle solved

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Background: Adaptation to the hyperbaric environment can be difficult, especially for patients with complex medical comorbidities. We present the use of careful patient preparation in order to facilitate the use of hyperbaric oxygen (HBO₂) therapy in a pediatric patient with developmental and physical challenges.

Case report: An autistic 9-year-old female on chronic immunosuppressant therapy due to a history of liver transplantation presented to an outpatient laboratory for a routine blood draw. A self-adherent bandage was applied to the patient's ring finger after phlebotomy. When the bandage was removed two days later, the finger was noted to be purple with tissue sloughing present. Due to the patient's autism, she had been unable to voice complaints of pain; her chronic immunosuppressant use likely contributed to the skin breakdown. After surgical debridement of non-viable tissue, she was referred for HBO₂ for treatment of acute traumatic peripheral ischemia. Due to her developmental delay, interventions were implemented to facilitate HBO₂ treatments. Identification of psychological barriers, use of child life services, comprehensive gradual patient and family introduction to the hyperbaric environment, and establishment of patient-specific treatment techniques were utilized successfully. The patient completed 30 HBO₂ treatments without difficulty; complete healing of the finger was achieved.

Discussion: Avoidance of frightening words and approaching the patient on the floor at her eye level enabled development of a non-threatening rapport with the patient. Along with the use of consistent predictability (using the same chamber and staff for each treatment), this routine allowed the patient to understand what to expect in the hyperbaric environment.

Conclusion: Careful use of patient-specific techniques can facilitate the successful use of HBO₂ in challenging patients.

F 14

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: No

The use of mafenide acetate (Sulfamylon®) under hyperbaric conditions: case report and literature review

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Introduction: Mafenide acetate (Sulfamylon®) is a topical sulfonamide wound care agent. Mafenide acetate (MA) is often listed as a contraindication to hyperbaric oxygen (HBO₂) therapy administration. We present a case of uncomplicated MA use in a hyperbaric patient.

Case report: A 58-year-old female was referred for HBO₂ evaluation for treatment of a compromised split-thickness skin graft. The patient had been prescribed MA for topical wound care since all other topical therapies had resulted in wound deterioration. After careful evaluation of the literature surrounding the use of MA in the hyperbaric environment, the decision was made to proceed with HBO₂. The patient completed 40 HBO₂ treatments without complications. She subsequently underwent repeat skin grafting and achieved 100% take and full healing of her wounds.

Discussion: MA may cause metabolic acidosis and potentially affect vasomotor tone due to its inhibition of carbonic anhydrase. Previous hyperbaric texts have listed MA as being a contraindication to HBO₂ or as “incompatible with hyperbaric oxygen” because of prior research that shows that MA-induced “peripheral vasodilatation in burned animals, coupled with a central vasoconstriction induced by hyperbaric oxygen, produces results which are worse than when using either agent alone.” In the referenced article, the survival of burned, infected rats was increased when topical MA was used; when MA and HBO₂ were used, the survival rate decreased but was not statistically significant. There is no mention in the article of any vasomotor tone abnormalities in the MA or HBO₂-treated groups.

Conclusion: The use of MA and HBO₂ led to decreased survival rates in a single experimental burn wound model. There is no evidence that MA causes alterations in vasomotor tone when used under hyperbaric conditions. MA may be safe to use for topical wound care in the hyperbaric environment, especially in patients unaffected by burns.

F 15

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: No

The use of hyperbaric oxygen therapy for skin necrosis after liposuction

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Introduction: Although it is rarely encountered, skin necrosis is a known complication of liposuction. We present the case of a patient who sustained extensive skin necrosis during liposuction, who achieved wound healing with use of hyperbaric oxygen (HBO₂) therapy.

Case report: An otherwise healthy 36-year-old female underwent liposuction and fat transfer at a Dominican Republic hospital. Postoperatively, she developed near-circumferential black discoloration, consistent with ischemic necrosis, across her anterior abdomen, flanks and lower back. Topical silver sulfasalazine was prescribed for wound care of the discolored skin regions. Due to concerns for liposuction-induced acute peripheral arterial ischemia and skin necrosis, the patient was referred for HBO₂. She underwent 15 daily HBO₂ treatments (2.5 ATA, 90 minutes at 100% oxygen, five-minute air breaks x2), with resultant decrease in the size of her wounds. She was subsequently taken to the operating room for debridement and xenograft placement to the open wounds. Postoperatively, she received an additional 20 daily HBO₂ treatments, which she tolerated without complications. At the end of the second HBO₂ course, the patient's wounds were greatly smaller, with pink granulation tissue evident and no visible tissue necrosis.

Discussion: Etiologies of liposuction-associated skin necrosis include burns from the use of ultrasonic probes, as well as the use of sharp cannulae and superficial liposuction technique. Cigarette smoking is also implicated as a risk factor for skin necrosis after liposuction. HBO₂ is recommended as a treatment of liposuction-associated skin necrosis. The mechanisms of action of HBO₂, including hyperoxygenation, neovascularization and decreased reperfusion injury, result in improved oxygen delivery to the affected areas.

Conclusion: A diagnosis of skin necrosis should be considered in patients who present with cutaneous discoloration after liposuction. The use of HBO₂ in patients with liposuction-associated skin necrosis can result in improved wound healing and a superior aesthetic outcome.

F 16

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: No

Reticulocytosis after hyperbaric treatments in a Jehovah's Witness patient with acute blood loss anemia

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Introduction: While hyperbaric oxygen (HBO₂) therapy is a well-known treatment for patients who have sustained acute blood loss anemia and cannot receive blood transfusion, the changes in hematologic parameters caused by hyperbaric exposure have not been previously examined. We report a case of significant reticulocytosis in a patient who received HBO₂ for acute blood loss anemia.

Case Report: A 43-year-old female Jehovah's Witness underwent an elective CT-guided liver biopsy. During the biopsy, she became hypotensive, presumably from hemorrhage. After resuscitation with intravenous saline and dopamine, she underwent emergent right hepatic artery embolization. Before the biopsy, her hemoglobin was 10.3 g/dL; after the biopsy, her hemoglobin reached a nadir of 4.6 g/dL; she was tachycardic and complained of light-headedness and weakness. Iron and erythropoietin infusions were ordered. Daily HBO₂ (2.5 ATA x 90 minutes at 100% oxygen, with five-minute air breaks x2) was initiated six days after the biopsy, with resultant decreases in the patient's heart rate and improvements in her subjective complaints. The patient's reticulocyte count was 1.7% prior to her biopsy and 4.8% two days after the biopsy. After HBO₂ treatments were started, the reticulocyte count increased dramatically, reaching as high as 12.9%. The patient was eventually discharged from the hospital in stable condition, with a hemoglobin of 6.3g/dL.

Discussion: Inspiration of normobaric oxygen has been reported to increase hemoglobin and reticulocyte levels in healthy, non-anemic patients. The results of this case are intriguing, as it is possible that HBO₂ may also lead to stimulation of erythrocyte production in anemic patients.

Conclusion: The benefits of HBO₂ in anemic patients who are unable to receive transfusion may be greater than previously understood. Further research is needed to investigate the relationship between hyperbaric exposure and erythropoiesis in this patient population.

F 17

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: Yes

Stability of preserved hearing and cochlear implant function following multiple scuba dives

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Background: There is limited data regarding the safety of cochlear implants (CI) during exposure to barometric pressure changes associated with scuba and hyperbaric oxygen (HBO₂) therapy. While the internal components of CIs have been tested to pressures of 165 feet (6 atmospheres absolute; ATA) *ex vivo*, there are limited data on the function of CIs *in vivo* following scuba or HBO₂. Additionally, as more CI patients have preserved low-frequency hearing following surgery, it becomes increasingly important to understand how pressure changes may affect residual hearing. There is currently no data regarding the effects of barometric pressure changes on preserved low-frequency hearing after cochlear implantation. This is a concern since scuba diving could theoretically affect hearing in these patients.

Case presentation: We present a case report of a 57-year-old female who underwent successful cochlear implantation with preservation of low-frequency hearing. Ten months postoperatively she performed 20 scuba dives to depths of 92 feet (3.8 ATA).

Results: The patient had no vestibular effects during or after scuba, and had no symptoms concerning for middle ear barotrauma or inner ear decompression sickness. Audiometric testing after scuba showed no change in residual hearing. The internal receiver-stimulator of the CI was unaffected by prolonged and repeated pressures of 3.8 ATA. Additionally, the patient did not note any subjective change in the quality of the sound heard through the device following the dives.

Conclusions: This is the first report of preserved hearing after cochlear implantation being maintained following scuba, and corroborates previous literature showing that exposure to barometric pressures with a cochlear implant *in situ* is safe, without adverse effects on the implant hardware or software. Scuba diving appears safe not only with cochlear implants but also in patients with residual hearing without additional treatment.

F 18

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: No

Hyperbaric oxygen therapy for complications of elective cosmetic surgery

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Introduction: Although they are often considered to be minor procedures, elective cosmetic surgeries can result in significant complications. We describe two cases where hyperbaric oxygen (HBO₂) therapy was used as an adjunctive treatment for cosmetic surgery complications.

Case reports: *Case 1:* A 73-year-old female underwent abdominoplasty. At her one week postoperative visit, she was found to have peri-incisional duskeness and blistering. She was referred for hyperbaric medicine consultation for a compromised skin flap. Upon evaluation in the HBO₂ clinic, abdominal wall ecchymosis was noted, suggesting an underlying hematoma. After operative hematoma evacuation and debridement, HBO₂ was initiated to promote skin flap healing. The patient completed seven HBO₂ treatments. She eventually required skin grafting for definitive healing of the abdominal wall.

Case 2: A 24-year-old female developed fevers and buttock pain one week after liposuction and fat transfer to the buttocks. On her second visit to the emergency department for these complaints, a diagnosis of necrotizing soft tissue infection was established. The patient underwent incision and drainage of the affected areas; HBO₂ was administered postoperatively. The patient required multiple operative debridements, but ultimately healed well.

Discussion: Bacterial infections, including necrotizing fasciitis, represent the most common complications after liposuction. A high level of clinical suspicion is required when evaluating patients for potential HBO₂ after cosmetic surgery complications, as the patient's condition may be more severe than initially suspected. Familiarity with the typical appearance of a "compromised flap" allows the HBO₂ physician to suspect additional pathology when the patient's presentation is atypical. A multidisciplinary approach to these patients, including both plastic surgeons and HBO₂ physicians, facilitates streamlined and more effective patient care.

Conclusion: The severity of postoperative cosmetic surgery complications is not always readily apparent on initial evaluation. HBO₂ represents a useful adjunct for selected postoperative complications of cosmetic surgery.

F 19

SATURDAY, JULY 1

ORAL PRESENTATION TIME:

POSTER PRESENTATION TIME: Poster Session 11: 3:45 - 4:07

RESIDENT COMPETITION: Yes

Which came first? Carbon monoxide poisoning, full thickness burns, gastrointestinal bleeding, or myocardial infarction: a case report of monoplace hyperbaric critical care

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Introduction: Very few monoplace centers will accept critical-care patients with thermal burn issues, mechanical ventilation, IV infusions, sedation, neuromuscular blockers, blood pressure management, and transport concerns. This case describes a patient who was treated for severe carbon monoxide poisoning with a concurrent gastrointestinal bleed and a myocardial infarction. A review of the equipment used, including pretreatment protocol, monitoring, multidisciplinary team communication and risk/benefit ratio will be discussed.

Case: A 66-year-old male was found unresponsive and fire rescue determined he had carbon monoxide exposure. He had a carboxyhemoglobin level of 53 and required intubation. The patient was transported to Kent Hospital, the only 24/7 hyperbaric oxygen center between Boston and New York. Planned treatment was the Weaver Protocol. The patient also had burns on his extremities and incontinence of foul liquid stool that appeared melanotic. He was monitored clinically, and troponins were 4.168 prior to the second hyperbaric treatment. Risk-benefit ratio discussion with the family and health care team lead to the decision to complete the second hyperbaric oxygen treatment. Before the third treatment, the patient's blood pressure dropped and EKG changes suggested an anterior infarct. Re-evaluation determined risk outweighed benefit for the third treatment in the protocol. The patient was diagnosed with an upper gastrointestinal bleed, while follow-up troponins decreased and leveled off at around 3.2.

Discussion: This case shows that severe critically ill patients can be safely monitored and treated in monoplace facilities. The patient's carboxyhemoglobin level, ejection fraction, hemoglobin, blood pressure and ventilator settings all improved within the first 24 hours after just two hyperbaric oxygen treatments. We believe in order to provide more acute care and greater access for critically ill patients, it would be beneficial for all undersea and hyperbaric medicine fellow-trained physicians to be comfortable treating critically ill patients with monoplace chambers.

PLENARY:

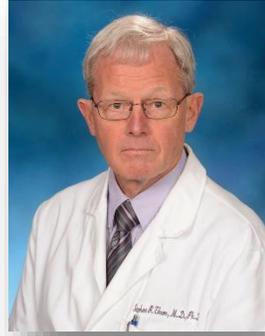
**“A Futurist’s Guide to Undersea and Hyperbaric Medicine:
Where will we be in another 50 years?”**

Simon Mitchell, MD & Stephen Thom, MD

4:30 PM – 5:30 PM



Simon Mitchell, MD



Stephen Thom, MD

ABOUT THE LECTURE:

On the occasion of the Society’s 50th anniversary we will inevitably look back over our history. It is also appropriate and fun to project forward into the future, and speculate on how the fields of diving and hyperbaric medicine may (or may not) develop, and where they will be in another 50 years. Drs. Simon Mitchell (mainly on the diving side) and Steven Thom (mainly on the hyperbaric side) will present their personal wish lists and, where relevant, their predictions for the pathophysiological, therapeutic, and engineering developments in these fields.

AUTHOR LISTING

A

Adler JM: C 2
Aitken P.: A 10
Alexander J: F 10
Almosnino G: F 17
Alvarez Villela M: B 2
Apicella A: D 2
Arenson EB: F 3
Attinger C: F 14; F 18

B

Bailey MR: B 5
Balestra C: A 5
Balgeman J: E 6; E 11
Barry R: E 14
Belhomme M: A 5
Bell J: E 1
Bhopale VM: A 1; A 3
Bickler S: B 3
BIMA study team: C 5
Binkley M: C 15
Blake DF: A 10
Bliznyuk A: A 2
Bock FA C 11
Borges HLL: C 13
Bosco G: A 9; F 1; F 2
Brown LH: A 10
Buckey JC: C 2; F 8
Buteau D: F 4
Butler G: F 11
Buzzacott P: A 5; D 1; D 10
Byrne JL: C 8

C

Camporesi EM: A 9; F 1; F 2
Cauvi DM: B 3
Cenci L: A 9
Chang JT: C 2
Chimiak JM: D 10
Chin W: D 3; D 4; D 5; D 11; E 3
Chivate J: E 12
Choi S: C 18
Churchill S: C 5; C 7; E 9; E 10
Claus P: C 12

Claus PL: C 2
Cole JB: F 5
Colls N: C 10
Conrad EC: D 17
Cooksley D: A 10
Cooper JS: F 12
Coronel JC: E 5
Courtney TC: B 5
Crain J: D 1
Crapella L: F 11
Critz D: F 6
Cui B: F 7
Cunitz BW: B 5

D

Dalvi PH: F 2
Dayya D: E 5
De Maio A: B 3
Denoble PJ: D 1
Deru K: C 5; C 7; D 18; E 1; E 9;
E 10
DI Lee DI: C 18
Dituri J: D 7
Dolens B: D 10
DuBose CR: C 3; D 19; E 8
DuBose KD: F 19
Duchnick JJ: E 4
Dugrenot E: A 5
Dulai PS: C 2
Dunmire B: B 5
Dunworth SA: B 2

E

Eldridge MW: A 8
Enomoto M: B 1; B 4; D 13
Eshita IR: D 16
Evans K: E 14; E 16; F 13; F 15;
F 16; F 18

F

Fang S: E 3
Freiberger J: F 7
Furue Y: C 17

G

Gendron-Fitzpatrick AP: A 8
German DS: C 14

Gerth WA: A 6
Giardina C: B 6
Gildehaus AJ: C 14
Gleeson MW: C 2
Goldby-Reffner K: C 2
Gonzalez L: C 20
Goto T: C 17
Grabau P: A 10
Grossman Y: A 2
Guerrero F: A 5
Guined J: D 7
Gustavson RB: F 6
Gwilliam AM: F 6

H

Habana CE: C 12
Hagberg M: D 9; D 14
Halbach JL: B 3
Hanley ME: F 19
Hardy K: C 15
Haren SP: C 2
Harlan N: B 2
Harms H: E 6
Havriliak D: F 11
Hawisher D: B 3
Henderson R: F 12
Hendriksen S: C 3; C 6; D 19; E 2;
E 8; F 5
Heyboer M: C 1; C 16; C 20; D 15
Hezel LM: C 14
Hickey B: D 8
Higgins J: E 6; E 11
Hightower LE: B 6
Holm JR: B 5; F 17
Horie M: B 1; B 4; D 13
Howle LE: A 4; A 6; A 7
Huchim O: D 3; D 4; D 5; D 11
Huey L: D 3; E 3
Huppertz G: A 10
Hutson C: E 14

J

Jennings S: C 16; C 20; D 15
Johnson T: F 11
Johnson-Arbor K: C 19; E 14;

E 16; F 13; F 14; F 15; F 16;
F 18

Joo E: D 3; D 4; D 5; E 3

Jung SK: D 12

K

Kang HD: D 12

Kannan MA: C 4

Kathmann B: E 17

Kawashima M: C 9; C 17

Kawashima M: C 9; C 17

Kelly JK: F 9

Kelly MP: C 15; D 17

Kim H: C 18

King AE: A 4; A 7

Klein B: E 6

Knight R: C 2

Kojima Y: D 13

Koumandakis G: E 1

Kraft BD: B 2

Kramer CC: B 5

Kulkarni N: E 16

L

Lafère P: A 5

Lally R: F 11

Landry D: D 2

Lautridou J: A 5

Lee T: D 4

Lee YJ: D 12

LeGros TL: D 8; E 17

Lehner CE: A 8

Lezama G: D 20

Lindblad AS: C 4; C 5; C 7; E 9;
E 10

Lindsey C: E 15

Logue CJ: C 3; C 6; D 19; E 2; E 8;
F 5

López F: D 20

M

Malacrida S: A 9

Manelli D: F 2

Mangar D: A 9

Mariani P: D 15

Marker J: E 5

Marosek N: C 11; E 6; E 11

Marshall S: D 1

Martinez C: F 11

Masters T: C 3; C 6; D 19; E 2;

E 8; F 5

McLennan GP: C 14

McManimon V: E 11

Meehan A: C 5

Melnyczenko A: E 6; E 11

Mendez N: D 11; D 20

Menth NL: F 5

Meurer R: C 13

Millman MP: C 11

Mirow S: C 5

Miyata K: C 17

Moon K: D 4

Moon RE: B 2

Moretti S: A 9

Morgan M: C 16; C 20; D 15

Morin C: F 3

Moskovitz Y: A 2

Motoyama T: C 17

Mrakic-Sposta S: A 9

Mulatya C: C 4

Murphy FG: A 4; A 6; A 7

Murphy-Lavoie H: D 8; E 17

Muruganantham K: C 1

N

Nagayoshi I: C 17

Natoli MJ: B 2

Niizeki Y: D 13

Ninokawa S: D 3; D 4; D 5

Nochetto M: D 10

O

O'Neill OJ: E 5

O'Toole K: C 2

Oh SH: C 18; D 12

Okawa A: B 4

Olson M: C 8

Omodt S: E 2

Orrison WW: C 5

Orwig D: C 3; C 6; D 19; E 8

Oyaidu T: B 1; B 4; D 13

Ozcan D: B 6

P

Paganini M: A 9

Paoli A: A 9

Parker CK: B 2

Patel N: C 2

Pavelites J: D 8; E 17

Paz MA: C 13

Perdrizet GA: B 3; B 6; B 7

Perez L: E 5

Phillips N: F 13

Piantadosi CA: B 2

Pollock NW: F 4

Popa DA: E 4

Price R: C 5

Ptak JA: C 2; F 8

Pullis MK: E 8

Q

Quartesan S: A 9

R

Raffals LE: C 2

Ramachandran M: D 3; D 4; D 5

Ramayo V: D 20

Rao N: F 2

Reetz SB: F 8

Reilly DA: F 12

Renaldo C: D 7

Reyes T: B 3

Rivera N: D 11; D 20

Rizzato A: A 9

Rosales J: B 3

Rosenthal R: E 13; F 10

S

Samimi F: E 12

Santiago W: C 16; C 20; D 15

Sapozhnikov OA: B 5

Sasaki T: C 17

Savaser D: D 2

Schell P: E 15

Schiller D: D 1

Schinazi EA: B 2

Sethuraman K: E 13; F 10

Shamitko G: D 8; E 17

Sharma D: C 1; C 16; C 20; D 15

Shaw S: D 6

Sher S: F 15

Shimoda M: B 4

Shulman M: F 10

Siegel CA: C 2

Siegel M: E 7; E 17

Simon JC: B 5

Skinner LA: C 2

Skrukrud BM C 11

Slade JB : C 10; F 9
Smerdon G: D 6
Smykowski E: E 5
Snively S: F 3
Sobakin AS: A 8
Souza LC: C 13
Sprau S: E 3
St Leger Dowse M: D 6
Suzuki S: D 13
Sward D: E 13; F 10
Swingler AJ: A 6
Swoger JM: C 2
T
Takao K: C 17
Tamura H: C 9 ; C 17
Tatum S: C 16
Tettleback W: F 7
Thiel J: B 5
Thom SR: A 1; A 3

Thompson KD: C 2
Thurman R: D 18; F 7
V
Varughese L: E 5
Vernon W: F 3
Verstraete R: F 16
Vezzani G: F 1; F 2
Villamar Z: C 4
Vishwakarma M: C 12

W
Walker J: C 5; E 2
Walter JW: C 3; D 19; E 8; F 5
Wang A: B 3
Watanabe Y: C 17
Waterhouse L: E 4
Weaver LK: C 4; C 5, C 7; D 18;
E 1, E 9; E 10
Westgaard B: E 2, C 3, D 19, E 8,
F 5

Wetzel P: C 4
Whelan H: D 7
Widjaja CE: C 2
Williams B: C 10
Williams C: C 5
Wilson SH: C 4, C 5, C 7, E 9; E 10
Witucki P: D 2, E 4
Wojcik S: C 1

Y
Yagishita K: B 1, B 4, D 13
Yamaguchi T: C 9; C 17
Yang M: A 1, A 3
Yang WS: D 12
Yu K: A 3

Z
Zanon V: F 1
Zeitler DM: F 17





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