UNDERSEA AND HYPERBARIC MEDICAL SOCIETY

Hyperbaric Medicine INDICATIONS MANUAL

15TH EDITION

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Chair and Editor

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Preface

The application of air under pressure (hyperbaric air) dates back to 1667, when Nathaniel Henshaw proposed a hypo-hyperbaric room pressurized and depressurized with an organ bellows.[1] In the nineteenth century, Simpson wrote a treatise on the use of compressed air for certain respiratory diseases.[2] The medicinal uses of oxygen were first reported by Beddoes in 1794,[3] while the first article describing adjunctive uses of hyperbaric oxygen (HBO_2) was written by Fontaine in 1879,[4] who constructed a mobile operating room that could be pressurized. He observed that pressurized patients were not as cyanotic after the use of nitrous oxide during induction of anesthesia as compared to patients anesthetized at atmospheric pressure. In addition, he noted that hernias were much easier to reduce. Around that time, the work of Paul Bert[5] and J. Lorrain-Smith[6] showed that oxygen under pressure had potentially deleterious consequences on the human body with side effects that included central nervous system and pulmonary toxicity. The efforts of Churchill-Davidson and Boerema in the 1950s and 1960s spurred the modern scientific use of clinical hyperbaric medicine.

In 1967, the Undersea Medical Society was founded by six United States Naval diving and submarine medical officers with the explicit goal of promoting diving and undersea medicine. In short order, this society expanded to include those interested in clinical hyperbaric medicine. In recognition of the dual interest by members in both diving and clinical applications of compression therapy, the society was renamed The Undersea and Hyperbaric Medical Society in 1986. It remains the leading not for profit organization dedicated to reporting scientifically and medically efficacious and relevant information pertaining to hyperbaric and undersea medicine.

In 1972, an ad hoc Medicare committee was formed to evaluate the efficacy of HBO_2 for specified medical conditions. The focus was to determine if this treatment modality showed therapeutic benefit and merited insurance coverage. The growth of the body of scientific evidence that had developed over the preceding years supported this endeavor and recognition for the field. In 1976, the Hyperbaric Oxygen Therapy Committee became a standing committee of what was then the UMS. The first Hyperbaric Oxygen Committee Report was published in 1977 and served as guidance for practitioners and scientists interested in HBO_2. The report is usually published every three to five years and was last published in 2019. Additionally, this document continues to be used by the Centers for Medicare and Medicaid Services and other third-party insurance carriers in determining payment.

The report, currently in its 15th edition, continues to grow in size and depth to reflect the evolution of the literature. Observant readers will notice that we have changed the name of the committee and manual to recognize that the specialty of hyperbaric medicine encompasses more than just the delivery of oxygen under pressure. Hyperbaric physicians evaluate complex patients for underlying conditions that lead to ischemia and hypoxia, coordinate care with specialists to help reverse or overcome these conditions, and conduct research on the effects of action of oxygen under pressure. This year, a new indication—osteonecrosis of the femoral head—has been added to our list of recognized indications for which scientific and clinical evidence supports the use of HBO_2. This edition also adds a chapter on Emerging Indications where HBO_2 may have some efficacy, but evidence is not robust enough for recognition by the committee, as well as a chapter discussing the rationale and evidence for choosing a specific dose of oxygen.

The Undersea and Hyperbaric Medical Society continues to maintain its reputation for its expertise on medicinal oxygen. With leading experts authoring chapters in their respective fields, this publication continues to provide the most current and up to date guidance and support for scientists and practitioners of hyperbaric medicine.

Enoch T. Huang, MD, MPH&TM
Editor, UHMS Hyperbaric Medicine Committee Chair

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In Memoriam:
Dr. Michael Bennett
(1956-2023)

I. Background

The Undersea and Hyperbaric Medical Society (UHMS) is an international scientific organization that was founded in 1967 to foster exchange of data on the physiology and medicine of commercial and military diving. Over the intervening years, the interests of the Society have enlarged to include clinical hyperbaric oxygen. The society has grown to over 2,000 members and has established the largest repository of diving and hyperbaric research collected in one place. Clinical information, an extensive bibliographic database of thousands of scientific papers, books, and technical reports that represent the results of over 100 years of research by military and university laboratories around the world are contained in the UHMS Schilling Library, whose holdings are now part of the Duke University Library, Durham, NC. The results of ongoing research and clinical aspects of undersea and hyperbaric medicine are reported annually at scientific meetings and in *Undersea and Hyperbaric Medicine* published quarterly. Previously the society supported two journals, *Undersea Biomedical Research* and the *Journal of Hyperbaric Medicine*. These two journals were merged in 1993 into *Undersea and Hyperbaric Medicine*.

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II. Defining the Specialty of Undersea and Hyperbaric Medicine

In the United States, the discipline of undersea & hyperbaric medicine is recognized by both the American Board of Emergency Medicine (ABEM) and the American Board of Preventive Medicine (ABPM) as warranting the status of a subspecialty under each of their specialty umbrellas. The description of this discipline in the United States and all other countries should begin with the basic scientific definition of the essential elements of hyperbaric oxygen (HBO_2). However, to understand the complexities of its appropriate practice and to recognize and condemn the unfortunate proliferation of unsafe centers and unproven practices, it is necessary to append additional explanatory paragraphs that go beyond a simple physical definition.

III. Definition of Hyperbaric Oxygen and its Safe Delivery

The definition of clinical HBO_2 is complex and often misrepresented to justify its use for unproven treatments. For this reason and to clarify misunderstandings, the UHMS Hyperbaric Medicine Committee has defined what a session of HBO_2 must include.

Hyperbaric oxygen is a medical procedure requiring a physician's prescription and oversight. All patients must have their entire body placed within a hard sided hyperbaric chamber that meets the American Society of Mechanical Engineers and Pressure Vessels for Human Occupancy (ASME-PVHO-1) code, and the National Fire Protection Association (NFPA 99) code and standards for hyperbaric chambers, at a pressure of not less than 2.0 ATA (202.65 KPa) while breathing physician prescribed medical grade oxygen for an amount of time that is typically between 90-120 minutes per treatment. Medical grade oxygen (>99.0% oxygen purity) is the only acceptable gas that should be used for therapeutic delivery of hyperbaric oxygen.[*]

During appropriate and acceptable clinical hyperbaric use, oxygen acts as a drug and is regulated by the FDA. Using Evidence Based Medicine (EBM) criteria, HBO_2 is dosed systemically by breathing medical grade oxygen under increased hyperbaric pressure, for the diagnoses described in this manual and approved by the Undersea and Hyperbaric Medical Society (UHMS)

Proven Application of Hyperbaric Oxygen (HBO_2)

The most common and acceptable clinical hyperbaric treatment pressures range between 2.0 ATA (202.65 KPa) and 3.0 ATA (303.975 KPa). The pressures used per treatment vary and are determined based on the acceptable guidelines for HBO_2 treatment found in this manual. These pressure requirements are supported by numerous publications and years of clinical practice. These standards are under constant review by the Hyperbaric Medicine Committee of the UHMS. Additionally, the UHMS Accreditation Council has established criteria for the safe and clinically appropriate delivery of HBO_2. The FDA has advised patients to preferentially seek HBO_2 at hyperbaric facilities that have achieved accreditation by the UHMS Accreditation Council. Most appropriate disorders require a series of elective HBO_2 treatments delivered daily over a period of four to eight weeks. Certain emergency conditions are treated once or over a period of a few days depending on the diagnosis. A few emergency indications will require more than one treatment per day. In certain circumstances HBO_2 represents the primary treatment modality while in others it is an adjunct to surgical or pharmacologic interventions. All patients referred for HBO_2 should be evaluated and supervised by qualified physicians with appropriate undersea and hyperbaric medicine (UHM) training that includes both evaluation and treatment. Operational staff must be properly trained and ideally certified as a hyperbaric technologist (CHT) or as a hyperbaric nurse (CHRN).

Hyperbaric Pressure

The term hyperbaric pressure is redundant. Hyper in medical terms signifies "above normal" or "increased". Baric is a term coined around 1880 that pertains to weight or pressure of the atmosphere. So hyperbaric pressure can be simply stated as "hyperbaric." Hyperbaric is defined as any atmospheric pressure above the normal pressure at sea level. Average pressure at sea level is 760 mmHg or 1 ATA (101.325 KPa). Atmospheric pressure fluctuates

[*] Medical grade oxygen should meet United States Pharmacopeia (USP) or national equivalent standard for purity

(higher or lower) depending on the weather and the altitude where the pressure is measured. This measure of pressure has a number of other equivalent values including: 0 feet of seawater (fsw), 14.7 pounds per square inch (psi), 1 atmosphere absolute (1 ATA), 1.013 Bars, 101.325 KPa, and usually 0 when using a gauge that measures pressure at sea level.

Hyperbaric Air and its Potential Unsafe Delivery

Hyperbaric air involves increasing the barometric pressure above normal atmospheric pressure while breathing air. This type of treatment was defined in the medical literature as early as 1662 and has no medical rationale when using pressures less than 2.0 ATA. The chambers delivered hyperbaric air for use as a "medical spa" as one would use a spa today; however, in the 1800s it was being used to support certain medical and surgical conditions without credible research at a time when Evidence Based Medicine (EBM) had not been developed. EBM did not become a standard until 1992 when introduced by Dr. David Sackett. The use of hyperbaric air in history was described by some physicians as having a physiologic basis, mainly when used above 2.0 ATA. Unfortunately, the use of hyperbaric air became a mainstay of many subjective treatments including the Spanish Flu, hypertension, diabetes mellitus, syphilis, and various cancer treatments that patients paid for without sound scientific proof of its efficacy. Those treatments had the added risk of patients suffering adverse effects of breathing hyperbaric air for long exposures.

Unproven Hyperbaric Treatment Often Termed Mild Hyperbaric Oxygen

Mild hyperbaric facilities have proliferated in wellness centers, spas, and even shopping center store fronts. These centers use untested and uncertified chambers that present significant fire risks as well as potential loss of life due to explosive decompressions. Mild hyperbaric facilities are now employing oxygen concentrators to enrich the breathing gas mix in the subtherapeutic chamber pressures they employ. These concentrators are mated to delivery systems (simple oronasal masks or nasal prongs) that are subject to leaks, and the intrusion of ambient gasses results in a breathing mix that is well less than 100% oxygen. Both hyperbaric chambers and oxygen concentrators are Class II medical devices. The FDA requires that both be cleared individually and together for them to be marketed in the United States. Furthermore, these mild hyperbaric centers are using chambers not meeting the standards of the ASME PVHO-1 or the NFPA. As oxygen escapes into the chamber, it creates a significantly enriched oxygen atmosphere, and when it approaches a concentration of 23.5% or higher, it may have potential catastrophic results. The presence of oxygen enhances both the intensity and rapidity of the spread of fire. Many patients purchase these chambers for their home and have no guidance to the potential catastrophic occurrences.

Mild hyperbaric facilities typically deliver sessions for an hour or less, for a spectrum of medical disorders or complaints. When the proven and accepted indications for hyperbaric oxygen are treated in these mild hyperbaric chambers, this treatment is inadequate and ineffective. Moreover, these mild hyperbaric centers treat diagnoses for which HBO_2 has not been found to be clinically effective or listed in this manual's accepted diagnoses. There is no credible evidence to support the use of mild hyperbaric oxygen for any EBM indication for hyperbaric oxygen as reported in this manual. The application of mild hyperbaric therapy for the treatment of acceptable indications can lead to severe disability or death of the patient or occupant because of inadequate treatment. Mild hyperbaric sessions are offered for many experimental indications for which there is no evidence based scientific support and usually against the healthcare advertising practices of both the Federal Trade Commission (FTC) and Federal Drug Administration (FDA). The target group for these treatments may include children with disorders such as autism, cerebral palsy, post concussive/traumatic brain injury syndromes, and near drowning with cerebral anoxia. Also targeted for treatment in mild hyperbaric centers are the elderly patients having suffered

cerebrovascular accidents (strokes) or those with cognitive decline. Since medical insurers do not reimburse for these experimental indications, patients are provided with a substantial out of pocket expense.

Hyperbaric oxygen IS

- Treatment of the entire body
- Treatment at 2.0 to 3.0 ATA
  - Inhalation of 100% oxygen at pressure
  - Treatments usually 90 to 120 minutes
- A treatment prescribed and managed by a licensed physician

Hyperbaric oxygen is NOT

- Topical application of oxygen
- Treatment at mild pressures less than 2.0 ATA
- Treatment in hyperbaric air
- Delivered by untrained and unlicensed personnel

IV. Classification of Hyperbaric Chambers

The NFPA classifies chambers according to occupancy for the purposes of establishing minimum construction and operation requirements.[1]

1. Class A – Human, multiple occupancy
2. Class B – Human, single occupancy
3. Class C – Animal, no human occupancy

Figure 1. Multiplace Chamber

Photograph courtesy of Lindell Weaver MD, of Intermountain Medical Center, Murray, Utah. Fink DL8 multiplace chamber, Fink Engineering, Melbourne, Australia.

Clinical treatments can be carried out in either a Class A (multi) or B (mono) chamber system. In a Class B system, the entire chamber is pressurized with near 100% oxygen, and the patient breathes the ambient chamber oxygen directly. A Class A system holds two or more people (patients, observers, and/or support personnel); the chamber is pressurized with compressed air while the patients breathe near 100% oxygen via masks, head hoods, or endotracheal tubes. It is important to note that Class B systems can and are pressurized with compressed air while the patients breathe near 100% oxygen via masks, head hoods, or endotracheal tubes.

Figure 2. Monoplace Chamber
Photograph courtesy of Sechrist Industries.

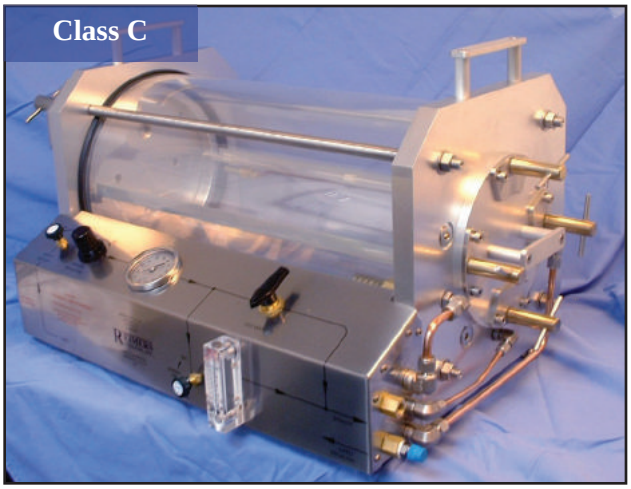

Figure 3. Animal Chamber
Photograph courtesy of Reimers Systems.

According to the UHMS definition and the determination of The Centers for Medicare and Medicaid Services (CMS) and other third-party carriers, breathing medical grade near-100% oxygen at 1 atmosphere of pressure or exposing isolated parts of the body to 100% oxygen does not constitute HBO_2 therapy. The patient must receive the oxygen by inhalation within a pressurized chamber. Current information indicates that pressurization should be to 1.4 ATA or higher.

The literature of HBO_2 began to appear during the 1930s as navies and universities around the world began studies in oxygen breathing at elevated pressures as a way to more safely decompress divers and to treat decompression sickness and arterial gas embolism. During the 1960s, HBO_2 was incorporated in standard treatment tables of the U.S. Navy. Extensive research on oxygen toxicity was undertaken to establish safe limits, overall safety, and medical and physiologic aspects of the compressed gas environment. These efforts led to a vast body of literature that underpins modern hyperbaric medicine.

In 1976, recognizing the need for meticulous scrutiny of emerging clinical applications of HBO_2, the Executive Committee of the UHMS established the Hyperbaric Oxygen Therapy (now Hyperbaric Medicine) Committee. The Committee was charged with the responsibility of continuously reviewing research and clinical data and rendering recommendations regarding clinical efficacy and safety of HBO_2. To achieve this goal, the multispecialty committee is comprised of practitioners and scientific investigators in the fields of internal medicine, infectious diseases, pharmacology, emergency medicine, general surgery, orthopedic surgery, trauma surgery, thoracic surgery, otolaryngology, oral and maxillofacial surgery, anesthesiology, pulmonology, critical care, radiation oncology and aerospace medicine.

Since 1976, the Committee has met annually to review research and clinical data. From the 28 indications for which third-party reimbursement was recommended in the 1976 and 1979 reports, the number of recognized indications has been refined to 15 in the current report. These indications are those for which in vitro and in vivo pre-clinical research data as well as extensive positive clinical experience and study have become convincing.

Evidence considered by the Committee includes sound physiologic rationale; in vivo or in vitro studies that demonstrate effectiveness; controlled animal studies, prospective controlled clinical studies; and extensive clinical experience from multiple, recognized hyperbaric medicine centers.

The Committee requires that experimental and clinical evidence submitted for the efficacy of HBO_2 treatment for a disorder be at least as convincing as that for any other currently accepted treatment modality for that disorder. Studies in progress will continue to clarify mechanisms of action, optimal oxygen dosage, duration of exposure times, frequency of treatments, and patient selection criteria. The Committee recommends third party reimbursement of HBO_2 for the disorders included in the accepted conditions category. Currently, most insurance carriers have established HBO_2 reimbursement policies.

The Committee also reviews cost effectiveness and has established guidelines for each entity. Results show that, in addition to its clinical efficacy, HBO_2 yields direct cost savings by successfully resolving a high percentage of difficult and expensive disorders, thereby minimizing prolonged hospitalization. However, the Committee recommends that each individual hyperbaric facility, whether monoplace or multiplace, establish its own charges consistent with the actual local costs of providing such service.

V. Utilization Review for Hyperbaric Oxygen

A utilization review section is presented for each recognized HBO_2 indication. It is recommended that utilization review be obtained if the number of HBO_2 treatments is to exceed the recommended number of treatments for that indication. Such review should involve discussion of the clinical case with another qualified hyperbaric medicine physician from an outside institution. If that individual agrees that additional HBO_2 is warranted, treatment may exceed the usually prescribed number of treatments.

VI. Acceptance (Addition) of New Indications for Hyperbaric Oxygen

New indications for HBO_2 are considered for acceptance at the meeting of the Hyperbaric Medicine Committee during the annual meeting of the Undersea and Hyperbaric Medical Society. This consideration can be initiated from within the Committee itself or may result in response to a written request by a non-Committee member. When a new indication is considered for acceptance, an application is completed that summarizes the in vitro, in vivo, and clinical aspects of the new indication for HBO_2 therapy. The application is presented to the committee, and a member is selected to present counter arguments to accepting each new indication. At the Annual Scientific Meeting of the UHMS, the petitioner's and opposition's arguments are presented to the Hyperbaric Medicine Committee. A consensus of the Hyperbaric Medicine Committee is required to recommend that the indication be moved into the Accepted category. If the Committee determines that a new condition merits acceptance, it makes this recommendation to the Executive Committee of the Society, which ultimately votes whether or not to recognize the new indication.

VII. List of Abbreviations

ABI	ankle-brachial index
ACGIH	American Conference of Governmental Industrial Hygienists
AGE	arterial gas embolism
AHA	American Heart Association
AKA	above knee amputation
ANAM	automated neuropsychological assessment metric
ARDS	acute respiratory distress syndrome
ATA	atmospheres absolute
ATM	atmosphere
ATP	adenosine triphosphate
AVNFH	avascular necrosis of the femoral head
BCBS	Blue Cross Blue Shield
BCVA	baseline best corrected visual acuity
bFGF	basic fibroblast growth factor
BID	two times a day
BKA	below knee amputation
BMJ	*British Medical Journal*
BP	blood pressure
BRAO	branch retinal artery occlusion
BSA	body surface area
CABG	coronary artery bypass graft
CAGE	cerebral arterial gas embolism
CaO_2	arterial content of oxygen in blood
CAT	catalase
CBC	complete blood count
CDER	Center for Drug Evaluation and Research
CDRH	Center for Devices and Radiological Health
CDSR	Cochrane Database of Systematic Reviews
CEBM	Oxford Centre for Evidence-Based Medicine
CGA	Compressed Gas Association
cGy	centigray
CI	cardiac index
CMS	Centers for Medicare and Medicaid Services
CNS	central nervous system
CO_2	carbon dioxide
COHb	carboxyhemoglobin
CO	carbon monoxide
CONSORT	Consolidated Standards of Reporting Trials
CPA	O_2 stable lecithinase-C alpha toxin
CPB	cardiopulmonary bypass
CPG	clinical practical guidelines
CRA	central retinal artery
CRAO	central retinal artery occlusion
CSF	cerebrospinal fluid
CT	computed tomography
cTnI	troponin I
CV	cardiovascular
CVA	cerebrovascular accident
CvO_2	venous content of oxygen in blood
DAI	diffuse axonal injury
dB	decibel
DCI	decompression illness
DCS	decompression sickness
DFU	diabetic foot ulcer
dL	deciliter
DM	diabetes
DO_2	oxygen delivery
EBI	evidence-based indications
EBM	evidence-based medicine
ECHM	European Committee for Hyperbaric Medicine
EKG	electrocardiogram
EMS	emergency medical services
ENT	ear, nose, and throat
eNOS	endothelial nitric oxide synthase
EPC	endothelial progenitor cells
ESR	erythrocyte sedimentation rate
ESTRO	European Society of Therapeutic Radiology and Oncology
EVA	extravehicular activities
FBF	fibroblast growth factors
FDA	Food and Drug Administration
FiO_2	fraction of inspired oxygen
FMD	flow-mediated dilation

VII. List of Abbreviations (continued)

fsw	feet of sea water
g	gram
GAS	group A *streptococcus*
GCP	good clinical practice
GCS	Glasgow Coma Scale
GI	gastrointestinal
GMCSF	granulocyte-macrophage colony stimulating factor
Gy	gray
$H2O_2$	hydrogen peroxide
HBO_2	hyperbaric oxygen
HCFA	Health Care Financing Administration
HCIO	hypochlorous acid
HCV	hepatitis C virus
Hgb	hemoglobin
HIF	hypoxia-inducible factor
HIV	human immunodeficiency virus
HODFU	hyperbaric oxygen therapy in diabetics with chronic foot ulcers
HOPPS	Hospital Outpatient Prospective Payment System
HTN	hypertension
Hz	hertz
IB	investigator's brochure
IBDQ	inflammatory bowel disease questionnaire
ICA	intracranial abscess
ICAM	intracellular adhesion molecule
ICG	indocyanine green fluorescence
ICGA	indocyanine green fluorescence angiography
ICU	intensive care unit
IDE	investigational device exemption
IL	interleukin
IM	internal medicine
IMRT	intensity-modulated radiation
IND	investigational new drug
INR	in-water recompression
IR	ischemia-reperfusion
IRB	institutional review board
ISSHL	idiopathic sudden sensorineural hearing loss
IT	intra-tympanic
ITT	intention to treat
ITS	intratympanic steroid
IU	international unit
IV	intravenous therapy
IVFA	intravenous fluorescein angiogram
IVIG	intravenous immunoglobulin
IVS	intravenous steroid
KD	ketogenic diet
kg	kilogram
kPa	kilopascal
LENT-SOMA	late effects in normal tissues subjective, objective, management, and analytic score
LDL	low density lipoprotein cholesterol
LR	lactated Ringer's solution
LRINEC	Laboratory Risk Indicator for Necrotizing Fasciitis
MACE	Military Acute Concussion Evaluation
MBC	minimum bactericidal concentration
MEB	middle ear barotrauma
MESS	mangled extremity severity score
mg	milligram
MI	myocardial infarction
MIC	minimum inhibitory concentration
mL	milliliter
mmHg	millimeters of mercury
MMP	matrix metalloproteinase
MOF	multiorgan failure
MoHC	monoplace hyperbaric chamber
MPa	megapascal
MR	magnetic resonance
MRI	magnetic resonance imaging
mRNA	messenger ribonucleic acid
MRSA	methicillin-resistant Staphylococcus aureus
MSAC	Medicare Service Advisory Committee (Australia)
msw	meters of sea water
MT	medical therapy

mTBI	mild traumatic brain injury
N_2	nitrogen
N_2O	nitrous oxide
NAC	N-acetylcysteine
NAT	nucleic acid testing
NATO	North Atlantic Treaty Organization
NBA	normobaric air
NBO_2	normobaric oxygen
NCI-PDQ	National Cancer Institute Patient Data Query
NF	nuclear factor
NFPA	National Fire Protection Association
NFST	national fire select test
NIH	National Institute of Health
NIOSH	National Institute for Occupational Safety and Health (U.S.)
NLR	neutrophil-lymphocyte ratio
NNT	number needed to treat
NO	nitric oxide
NOS	nitric oxide synthase
NRC	National Research Council of the National Academies
NSAID	nonsteroidal anti-inflammatory drug
NSF	National Science Foundation
NSTI	necrotizing soft-tissue infection
NSE	neuron-specific enolase
O_2	oxygen
ON	osteonecrosis
OOC	organ of Corti
OPG	osteoprotegerin
ORN	osteoradionecrosis
OR	odds ratio
OSHA	Occupational Safety and Health Administration
PAD	Peripheral arterial disease
PAR	percent area reduction
paO_2	arterial oxygen tension
PAOD	peripheral arterial occlusive disease
PBMC	peripheral blood monocytes
PCL-M	PTSD checklist – military version
PCS	post-concussion syndrome
PDGF	platelet derived growth factor
PDHA	post-deployment health assessment
PDPH	post-dural procedural headache
PFO	perfringolysin
PET	positron emission tomography
PG	pyoderma gangrenosum
PM	progressive myopia
PML	polymorphonuclear leukocytes
PMN	polymorphonuclear neutrophils
PMNL	polymorphonuclear leukocytes
PO_2	partial pressure of oxygen
POS	oral steroid
ppm	parts per million
PTA	pure tone average
$PtcO_2$	transcutaneous partial pressure oxygen measurement
PTCI	percutaneous transluminal coronary intervention
PT	prothrombin time
PTSD	post-traumatic stress disorder
PTT	partial prothrombin time
PVR	pulse volume recordings
QALY	quality adjusted life years
QH	every hour
RANKL	receptor activator of nuclear factor-kappa B
RBC	red blood cell
RCT	randomized controlled trial
RF	retrolental fibroplasia
RNS	reactive nitrogen species
ROS	reactive oxygen species
SARS	severe acute respiratory syndrome
SCD	sickle cell disease
SEK	Swedish kroner currency
SD	standard deviation
SGB	stellate ganglion block
SMCS	skeletal muscle compartment syndrome
SPC	stem progenitor cell
SpCO	carboxyhemoglobin saturation
SPECT	single-photon emission computed tomography

VII. List of Abbreviations (continued)

SPP	skin perfusion pressure
SSc	systemic scleroderma
SSHL	sudden sensorineural hearing loss
ST	standard therapy
TACO	transfusion associated circulatory overload
TAD	transfusion associated dyspnea
TBSA	total body surface area
TBI	traumatic brain injury
TCOM	transcutaneous oxygen measurement
$TcPO_2$	transcutaneous oxygen partial pressure
TEN	toxic epidermal necrolysis
TGF	transforming growth factor
TIMP	tissue inhibitor of metalloproteinase
TNF	tumor necrosis factor
TRALI	transfusion related acute lung injury
TRAM	transverse rectus abdominis myocutaneous
TRPV	transient receptor potential vanilloid
TTI	transfusion-transmitted infection
TWA	time weighted average
Tx	treatment
UHMS	Undersea and Hyperbaric Medical Society
UMS	Undersea Medical Society
USAF	United States Air Force
USN	United States Navy
USP	United States Pharmacopoeia
VD	vasodilator
VEGF	vascular endothelial growth factor
VGE	venous gas embolism
VLU	venous leg ulcer
VO_2	oxygen consumption
WHO	World Health Organization
WRS	word recognition score
XD	xanthine dehydrogenase
XO	xanthine oxidase

VIII. Author Biographies

Caesar A. Anderson MD, MPH, CWS

Dr. Anderson specializes in hyperbaric medicine and limb salvaging with board certification in internal medicine, undersea and hyperbaric medicine and the practice of advanced wound care. He has surgical expertise in the use of bioengineered skin substitutes and advance wound management and serves as medical director of UC San Diego Health's hyperbaric and wound care program in Encinitas. He completed a fellowship in diving and hyperbaric medicine at the University of Pennsylvania Hospital in Philadelphia and a combined residency training program in internal and preventive medicine at Yale-New Haven Hospital and Griffin Hospital in Connecticut. Dr. Anderson did his general surgery residency at the University of Connecticut and earned his medical degree from Howard University College of Medicine in Washington DC, and his master's degree in public health from Yale University School of Medicine.

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Professor Bennett is the academic head of the department of anesthesia, a senior staff specialist in diving and hyperbaric medicine at Prince of Wales Hospital, and conjoint professor in the faculty of medicine, University of New South Wales in Sydney, Australia. He graduated from the University of New South Wales in 1979 and spent his early post-graduate training at the Prince Henry/Prince of Wales Hospitals before undertaking training in anesthesia in the UK. He was medical director of the Department of Diving and Hyperbaric Medicine at POWH from 1993 to 2007.

In 2002 he was the recipient of the Behnke Award for outstanding scientific achievement from the Undersea and Hyperbaric Medical Society. He is the author of over 140 peer-reviewed publications including 15 Cochrane reviews of the evidence in diving and hyperbaric medicine. He is an executive member of the Australia and New Zealand College of Anesthetists (ANZCA) special interest group in diving and hyperbaric medicine and chair of the ANZCA DHM subcommittee responsible for the ANZCA Diploma of Advanced DHM. He is a past vice-president of the UHMS and currently the past president of SPUMS.Conjoint Professor, UNSW Medicine, University of NSW. He is also Academic Director, Wales Anesthesia, Prince of Wales Hospital, Randwick, NSW Australia.

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Jay C. Buckey, M.D.
Professor of Medicine, Geisel School of Medicine at Dartmouth
Medical Director, Center for Hyperbaric Medicine at Dartmouth-Hitchcock Medical Center

Dr. Buckey is the Medical Director of the Center for Hyperbaric Medicine at Dartmouth and has had longstanding involvement in research on the effects and uses of hyperbaric oxygen. The Dartmouth center was part of a phase I trial of hyperbaric oxygen as a radiation sensitizer for head and neck cancer, and participated in a randomized, sham-controlled trial of hyperbaric oxygen for moderately severe ulcerative colitis. The center has also completed two other clinical trials—a dose ranging trial of hyperbaric oxygen for severe ulcerative colitis, and a phase 1 trial of hyperbaric oxygen for radiosensitization of isolated brain metastases prior to stereotactic radiosurgery. Dr. Buckey also initiated and currently directs the International Multicenter Registry for Hyperbaric Oxygen Therapy, which is a consortium of hyperbaric centers that collect consistent outcome data on all patients treated with hyperbaric oxygen therapy.

Frank Butler Jr. MD, Capt, MC, USN (Ret)

Dr. Butler is a former U.S. Navy SEAL platoon commander and a pioneer in the field of ophthalmology and diving. He has been a diving medical research officer at the U.S. Navy Experimental Diving Unit where he helped to develop many of the diving techniques and procedures used by Navy SEALs today. His landmark paper, "Diving and Hyperbaric Ophthalmology," was the first comprehensive review of ocular disorders in diving and is now the standard on this topic. His 2008 paper in *Undersea and Hyperbaric Medicine* provided the first comprehensive overview of the use of HBO_2 in ocular disorders. Dr. Butler has volunteered his time as an ophthalmology consultant to UHMS and the Divers' Alert Network since 1995, providing expert advice to divers around the world. He served for three years as a member of the Board of Directors for the Undersea and Hyperbaric Medical Society. He is the Co-Chair of the UHMS Decompression Sickness and Arterial Gas Embolism Committee and is currently spearheading the Society's effort to develop evidence-based best practice guidelines to improve the treatment of these disorders. Dr. Butler has been awarded the U.S. Special Operations Command Medal by Admiral Bill McRaven and the Academy of Underwater Arts and Sciences NOGI Award for Distinguished Service to the diving community. He currently chairs the Department of Defense's Committee on Tactical Combat Casualty Care.

Enrico M. Camporesi MD, FUHM, AB

Enrico M. Camporesi MD (Milan, 1970), FUHM (2000), AB Anesthesiology (1978)
AB Undersea Medicine (2000 and 2009)
HBO Committee (1988, Chair, 1996)
Past President, UHMS (2000-2002)
Treasurer (2012-2014)
Editor in Chief, UHM (2016-present)
Emeritus Professor of Surgery, Department of Surgery, University of South Florida, Tampa, Florida
Attending Anesthesiologist, TeamHealth, Tampa General Hospital, Tampa, Florida
Director of Research, TeamHealth Research Institute
Hyperbaric Medicine Director, Memorial Hospital of Tampa
Research interest in anesthesia, respiration and exercise in extreme environments, diving medicine and hyperbaric oxygen biology

Benjamin Cherng, MBBS, MBBS (National University of Singapore), MRCP (UK)
Consultant, Department of Infectious Diseases, Singapore General Hospital
Program Director, Singhealth Infectious Diseases Residency, Singapore

Paul Cianci MD, FACS, FUHM, FACP
Director, Hyperbaric Medicine Department, Doctors Medical Center, San Pablo, CA
Director Emeritus, Department of Hyperbaric Medicine, John Muir Medical Center, Walnut Creek, CA
Director Emeritus, Department of Hyperbaric Medicine, Saint Francis Memorial Hospital, San Francisco, CA
Diplomate, American Board of Internal Medicine
Fellow, American College of Physicians
Certified by the American Board of Preventative Medicine in the subspecialty of subsea and hyperbaric medicine
Fellow, Undersea and Hyperbaric Medicine
Professor Emeritus of Internal Medicine, University of California, Davis
Past President, Undersea and Hyperbaric Medical Society
Current member of the UHMS Hyperbaric Oxygen Committee
Consultant to the DOD, NOAA, and State of California
Visiting distinguished professor, University of Texas, Houston
Director, Department of Hyperbaric Medicine, Health Science Center, University of Texas, Houston (1998–1990)

Julia Faulkner
Julia Faulkner has been the executive assistant in the Department of Hyperbaric Medicine at Doctors Medical Center, San Pablo, CA, for over 30 years. During that time, she has been an integral part of the preparation and the publishing aspects of many of the peer review papers from this group of doctors.

John J. Feldmeier DO, FACRO, FUHM
Professor Emeritus and Past Chairman, Radiation Oncology, University of Toledo Medical Center

Dr. Feldmeier is Professor Emeritus of Radiation Oncology at the University of Toledo from which he has just retired as the long-term chairman. He has been recognized as a "Best Doctor" since 2007. He is a past president of the Undersea and Hyperbaric Medical Society and recognized as an expert in applying hyperbaric oxygen to the management of radiation injuries. He is board certified in both radiation oncology and hyperbaric medicine.

Laurie Beth Gesell MD, FACEP, FUHM
System Director, Hyperbaric Medicine and Wound Care, Aurora Health Care Medical Group
Section Chair, Undersea and Hyperbaric Medicine, Aurora St. Luke's Medical Center, Milwaukee, Wisconsin

Dr. Gesell is the system director for hyperbaric medicine and wound care with Aurora Health Care Medical Group and section chair for undersea and hyperbaric medicine. She is board certified in emergency medicine and undersea and hyperbaric medicine. Dr. Gesell is a Fellow of the American College of Emergency Physicians, as well as the Undersea and Hyperbaric Medical Society. Dr. Gesell is a past president of the Undersea and Hyperbaric Medical Society, past chair of the UHMS Board of Directors, and former chair of the UHMS Hyperbaric Oxygen Therapy Committee. She currently serves as the UHMS Treasurer. Dr. Gesell also represents the medical specialty as the UHMS Delegate in the AMA House of Delegates.

VIII. Author Biographies (continued)

Dr. Georgios F. Giannakopoulos MD, PhD, FEBTS, FACS

Georgios Giannakopoulos is a consultant Traumasurgeon and Helicopter Emergency Medical Services (HEMS) physician at Amsterdam University Medical Centre and the 'Lifeliner 1' HEMS in Amsterdam, The Netherlands. He has special interest in the early prehospital and inhospital management and treatment of the severely injured patient, the operative treatment of spinal injuries, limb reconstruction after severe injury and fracture healing disorders (non-union) with special interest in fracture related infections. As a fellow of the European board of Trauma Surgery and fellow of the American College of Surgeons he is interested in surgical education and scientific research. He participates in several national and international projects and his publication list counts more than 70 peer-reviewed articles.

Catherine E. Hagan MD, MS, CDR MC (UMO) USN

Chief Medical Officer, Staff Ophthalmologist, Anterior Segment & Corneal Refractive Surgeon, Naval Hospital Jacksonville, Florida

Dr. Hagan obtained her undergraduate degree in zoology from the University of Florida and attended medical school at the University of Louisville, KY. In 2007, she became the 11th woman in U.S. history to earn the Submarine Medical Officer Qualification. Upon completion of ophthalmology residency in 2008 at the Naval Medical Center San Diego, CA, she was awarded the departments only Excellence in Research award for her support with the publication, proposal and ultimate approval of Central Retinal Artery Occlusion (CRAO) as an accepted indication for HBO_2 Therapy by the UHMS. Since residency, she has been stationed at Naval Hospital Camp LeJeune, NC, from 2008-2011 and Naval Hospital Jacksonville since 2011, where she has held multiple leadership roles such as Department Head of Ophthalmology and Refractive Surgery, Chair of Credentials Committee, Surgical Physician Advisor of Process Improvement, and Chair of the Medical Executive Committee. She is currently serving as the Chief Medical Officer of Naval Hospital Jacksonville and its five branch health clinics spanning from Key West, FL to Albany, GA. CDR Hagan continues to serve as a consultant on ocular disorders for the U.S. Navy Dive School and is an invited guest lecturer twice a year on the topic of treating CRAO with HBO_2.

Brett B. Hart MD, FUHM

Dr. Hart earned his MD from the Uniformed Services University of the Health Sciences. He completed hyperbaric medicine fellowship training at Duke University and is dual board certified in anesthesiology and undersea and hyperbaric medicine. A former U.S. Navy Undersea Medical Officer, Dr. Hart now serves as a Pharmacovigilance Medical Monitor at Emmes in Rockville, Maryland.

Marvin Heyboer III, MD, FUHM

Professor, Emergency Medicine
Division Chief, Hyperbaric Medicine & Wound Care
State University of New York, Upstate Medical University, Syracuse, NY

Marvin Heyboer III, MD is a Professor of Emergency Medicine, Division of Hyperbaric Medicine and Wound Care at SUNY Upstate Medical University in Syracuse, NY. He is Medical Director of the Hyperbaric Medicine and Wound Care Center. In addition, he is the Program Director of the Fellowship in Undersea and Hyperbaric Medicine. He graduated from Case Western Reserve University School of Medicine. He completed residency in Emergency Medicine with Michigan State University at Spectrum Health in Grand Rapids, Michigan and completed a fellowship in Undersea and Hyperbaric Medicine at Hospital of the University of Pennsylvania. Dr.

Heyboer is board certified in Emergency Medicine and Undersea and Hyperbaric Medicine by the American Board of Emergency Medicine.

Enoch T. Huang MD, MPH&TM, FUHM, FACEP, FACCWS

Dr. Huang is the program medical director for hyperbaric medicine and chronic wound care at Legacy Emanuel Medical Center in Portland, OR. He graduated from Princeton University with a degree in chemistry. He attended medical school at Tulane University School of Medicine where he also obtained a master's degree in public health and tropical medicine. He completed a residency in emergency medicine at the University of California, Irvine and went on to complete a fellowship in undersea and hyperbaric medicine at the University of Pennsylvania. He is board-certified in emergency medicine as well as undersea and hyperbaric medicine. He is the founder and past-president of the Columbia Wound Care Community—a multidisciplinary, multihospital group of wound care providers in the greater Portland metropolitan area. He is the past-president of the Undersea and Hyperbaric Medical Society.

Irving "Jake" Jacoby MD, FACP, FACEP, FAAEM, FUHM

Dr. Jacoby is Clinical Professor of Emergency Medicine, Emeritus, at the University of California San Diego School of Medicine, La Jolla, CA. He graduated from the University of Miami with a degree in Chemistry. He attended medical school at the Johns Hopkins University School of Medicine. He completed an Internal Medicine Residency at the Boston City Hospital and Peter Bent Brigham Hospital in Boston, and was Chief Resident in Medicine at the Boston City Hospital. He went on to complete a Fellowship in Infectious Diseases at the Peter Bent Brigham Hospital. He is Board certified in Internal Medicine, Infectious Diseases, Emergency Medicine and Undersea and Hyperbaric Medicine. He has a particular interest in the intersection of infectious diseases and hyperbaric medicine. Additionally he founded and continues to serve as Commander of the San Diego-based Disaster Medical Assistance Team (DMAT CA-4), a response team of the National Disaster Medical System, U.S. Dept of Health & Human Services.

Shawna Kleban MD

Chief Resident, Department of Plastic Surgery, University of Nevada Las Vegas School of Medicine

Tracy Leigh LeGros MD, PhD, FAAEM, FACEP, FUHM

Tracy Leigh LeGros is a Professor of Emergency Medicine and the Director of Faculty Development at the University of Tennessee Health Sciences Center, Regional One Physicians Level 1 Trauma Center in Memphis Tennessee. Prior to this, Tracy was a Clinical Professor in Emergency Medicine and the Program Director of the LSU Undersea and Hyperbaric Medicine Fellowship at University Medical Center in New Orleans, Louisiana. Dr. LeGros obtained her Doctorate in Physiology from LSU School of Graduate Studies and her Medical Doctorate from LSU School of Medicine. She matched her first choice in residency—the Charity Hospital Emergency Medicine Residency. Tracy graduated as a chief resident and the Lauro Award winner at graduation. Dr. LeGros then completed a fellowship in Undersea and Hyperbaric Medicine with Dr. Keith Van Meter. She has been a clinical and academic attending in both emergency medicine and undersea and hyperbaric medicine for the last 20 years.

VIII. Author Biographies (continued)

Simon J. Mitchell MB ChB, PhD, DipAdvDHM (ANZCA), DipOccMed, FUHM, FANZCA

Professor of Anesthesiology, School of Medicine, University of Auckland

Dr. Mitchell is a physician and scientist with specialist training in diving medicine and anesthesiology. His diving career has included more than 6,000 dives spanning sport, scientific, commercial, and military diving. He was elected to Fellowship of the Explorers' Club of New York in 2006 and was the DAN Rolex Diver of the Year in 2015. He is widely published with over 150 papers or book chapters. He has twice been vice president of the Undersea and Hyperbaric Medicine Society (USA) and in 2010 received the society's Behnke Award for contributions to the science of diving and hyperbaric medicine. In the past, Simon was a naval diving medical officer and medical director of the Wesley Centre for Hyperbaric Medicine in Brisbane. He now works as a consultant anesthetist at Auckland City Hospital and Professor of Anesthesiology at the University of Auckland.

Richard E. Moon MD, FRCPC, FACP, FCCP, FUHM

Professor of Anesthesiology and Medicine, Medical Director, Center for Hyperbaric Medicine and Environmental Physiology, Duke University Medical Center, Durham, NC

Dr. Moon has served as president of the UHMS. His publications include diving physiology and medicine, hyperbaric oxygen, and monitoring of patients under anesthesia. His research interests include the study of cardiorespiratory function during diving and high-altitude exposure, decompression procedures, swimming-induced pulmonary edema, hyperbaric oxygen therapy and opioid-induced respiratory depression.

Heather Murphy-Lavoie MD, UHM, FACEP, FAAEM

Clinical Professor of Emergency Medicine, LSU Health Sciences Center
University Medical Center, Emergency Department
Emergency Medicine Residency
Undersea and Hyperbaric Medicine Fellowship, New Orleans, Louisiana

Heather Murphy-Lavoie MD, UHM, FACEP, FAAEM is a clinical professor of medicine at the Louisiana State University School of Medicine. She received her undergraduate degree, with honors, in biomedical engineering from Tulane University. She matriculated in the top third of her class from Tulane School of Medicine. She graduated as a chief resident from Charity Hospital's Emergency Medicine residency and completed her Undersea and Hyperbaric Medicine Fellowship under Dr. Keith Van Meter. She is board certified in emergency medicine and in the subspecialty of Undersea and Hyperbaric Medicine. She is a Fellow in the American College of Emergency Physicians (FACEP) and a Fellow in American Academy of Emergency Medicine (FAAEM). She serves on the Education Committee of the American Academy of Emergency Medicine. She has been on the UHMS Education Committee for 13 years, serving as chair for the last six years, and has been on the HBO_2 Therapy Committee since 2009. In 2006, she brought forth Central Retinal Artery Occlusion (CRAO) as a proposed new indication before the HBO_2 Therapy Committee. It is because of her efforts that CRAO is now an accepted indication. In 2011, she again proposed two new indications before this same august body and coordinated her fellowship team to successfully advocate for the addition of acute idiopathic sensorineural hearing loss as the latest accepted indication. She a nationally recognized lecturer and advocate for the UHM specialty.

Her awards include the following: FUHM status (2014); Paul James Sheffield Education Award for Lifetime Achievement (2012); Caroline Sue Ray Lifetime Achievement Award (2012); Outstanding Lecturer Award for Excellence in Graduate Medical Education; and Hyperbaric Medicine Fellowship (2007 and 2010). She has been instrumental in training 41 UHM fellows to date.

Dr. Murphy-Lavoie has authored numerous scientific publications in emergency medicine and hyperbaric medicine, including over 20 book chapters. She has published extensively on the use of hyperbaric oxygen therapy for ophthalmologic diseases.

Matteo Paganini MD

Emergency Medicine Chief Resident, University of Padova, Italy
Research interests on undersea and hyperbaric medicine, wilderness, prehospital and disaster medicine
Former Italian Navy Cadet, Navy Military School in Venice

Alex Rizzato PhD, MSc

Research fellow, Department of Biomedical Sciences, University of Padova, Italy

William Santiago, MD

Associate Professor, Emergency Medicine

Associate Medical Director, Hyperbaric Medicine & Wound Care

State University of New York, Upstate Medical University, Syracuse, NY

Education: BS (Biology), Wright State University; MD, University of Cincinnati College of Medicine;

Emergency Medicine Residency, SUNY Upstate, Syracuse, NY; Undersea and Hyperbaric Medicine

Fellowship, SUNY Upstate, Syracuse, NY

Board certified in Emergency Medicine and Undersea & Hyperbaric Medicine Certified in Wound Medicine by American Board of Wound Medicine and Surgery.

Ronald Sato MD

Dr. Sato, a native of Hawaii, received his medical degree from Yale University Medical School and trained as a resident at Stanford University. He has participated as a burn fellow at the University of Texas Health Science Center and has taught at Stanford University. In addition to his work on numerous publications related to burn care and plastic reconstructive surgery, he has served on the advisory board of the American Burn Association and as a member of the editorial staff for the *Journal of Burn Care and Rehabilitation*. Dr. Sato has been the director of the Burn Center at Doctors Medical Center for over 19 years, where he has dedicated a large part of his medical career to the treatment of severely burned patients and those with severely infected and chronic wounds.

Davut J. Savaser MD, MPH, FAAEM, FACEP

Hyperbaric Medicine and Chronic Wound Clinic, Legacy Emanuel Medical Center, Portland, Oregon

Dr. Savaser is a board-certified physician in both emergency medicine and undersea & hyperbaric medicine. He practices emergency medicine at multiple locations throughout the Pacific Rim, including practice locations at Legacy Good Samaritan Medical Center and undersea & hyperbaric medicine/wound care at Legacy Emanuel Medical Center, in Portland, Oregon. He has been an active leader in both fields and their societies, having held leadership roles within the American College of Emergency Physicians (ACEP) and the Undersea and Hyperbaric Medical Society (UHMS). He was honored in 2021 with the Excellence in Hyperbaric Medicine Award by the UHMS.

VIII. Author Biographies (continued)

Chai Rick Soh MD

Head, Department of Anaesthesiology, Singapore General Hospital (SGH)
Senior Consultant, Hyperbaric and Diving Medicine Centre, SGH
Senior Consultant, Department of Surgical Intensive Care, SGH
Associate Professor, Duke-NUS Medical School.
Deputy Vice Chair, Education, Anaesthesiology Academic Clinical Program
Co-director, Human Structure and Function Course, Duke-NUS Medical School, Singapore

Michael B. Strauss MD

Dr. Strauss has over a 40-year association with hyperbaric medicine focusing on orthopedic, wound care and diving applications of this discipline. He is a board-certified orthopedic surgeon with over 20 years' service as the orthopedic surgeon coordinator for his medical center's Class 2 (no 24/7 onsite neurosurgeon) trauma center. During this time he served as the medical director for his medical center's nationally recognized hyperbaric medicine program. He has over 200 citations in the medical literature on subjects related to his hyperbaric medicine experiences including those on crush injuries and compartment syndromes. Dr. Strauss generated the crush injury section for the first *Hyperbaric Oxygen Therapy Committee Report* and has updated the information with each succeeding report up to and including the present edition.

William Tettelbach, MD, FACP, FIDSA, FUHM, MAPWCA, CWSP

Dr. William Tettelbach is actively board-certified in Undersea & Hyperbaric Medicine, Infectious Diseases, and Internal Medicine while retaining academic appointments at Duke University School of Medicine and Western University of Health Sciences, College of Podiatric Medicine. His past and current leadership rolls include Program Director of the Duke University Undersea and Hyperbaric Medicine Fellowship satellite site program in Utah, Executive System Medical Director of the Intermountain Health Wound and Hyperbaric Medicine Service line, Executive Medical Director of the Hyperbaric Medicine & Wound Care Service line for the Mountain Division (Alaska, Idaho & Utah) of HCA Healthcare and CMO of Restorix Health. He is a participating member of the CMS advisory panel on Hospital Outpatient Payment as well as a committee member for The Alliance of Wound Care Stakeholders, which acts as one of the voices for Undersea and Hyperbaric Medicine in the Government Affairs health policy arena. His career has been dedicated to teaching providers and improving patients' lives requiring the services of Hyperbaric Medicine, Advanced Wound Care and Infectious Diseases.

Edward O. Tomoye DO, MA

Director, North Central Texas Infectious Disease Group, Richland Hills, Texas
Adjunct Associate Professor of Medicine, University of North Texas, Fort worth, Texas
Fellowship in Infectious disease & Immunology, University of Massachusetts
Fellowship in Undersea & Hyperbaric Medicine, Duke University

Research interests: Effects of hyperbaric oxygen in adults with sickle cell crisis
Efficacy of antimicrobial products in chronic wounds
Carbon monoxide levels in mouth smoke: comparing tobacco brands
Analysis of blood pressure elevation during hyperbaric oxygen treatments

Robert A. van Hulst MD, PhD, FUHM, Capt Navy (ret)
Professor of Hyperbaric and Diving Medicine
Captain Royal Dutch Navy (retired)
Director of Diving and Submarine Medicine, Royal Netherlands Navy

Robert van Hulst is a former navy senior undersea medical officer, with his last position as Director Diving and Submarine Medical Center until 2014. Since 2014 he is a full professor in hyperbaric and diving medicine in the Amsterdam University Medical Center, The Netherlands, and head of the hyperbaric department (Boerema chamber). He is a consultant for the Navy for occupational medicine in submarines and escape and rescue. His PhD thesis (2003) is, "Cerebral air embolism and brain metabolism: effects of ventilation and hyperbaric oxygen in healthy and brain traumatized animals." His research interests include cerebral air embolism, pulmonary oxygen toxicity, preconditioning, ventilation/gas exchange during diving and HBO_2 treatment for wound healing and Crohn's disease.

Keith W. Van Meter MD, FUHM, FAAEM, FACP

Keith Van Meter is currently board certified in Undersea and Hyperbaric Medicine, Pediatric Emergency Medicine, Medical Toxicology and Emergency Medicine. He is an ACS ATLS instructor and Clinical Professor of Medicine at LSU HSC/NOLA and an Adjunctive Professor of Surgery at Tulane School of Medicine. He is the Section Head of Emergency Medicine at LSU HSC/NOLA and the Medical Director of the Baromedical Research Institute in New Orleans, LA. His awards include the Craig Hoffman Memorial Award (1999), the Charles Shilling Award (2007), the Albert Behnke Award (2009), the Jefferson Davis Award (2010), the UHMS Commercial Diving award (2016), and the ADCI Commercial Diving Hall of Fame Election (2014). He is the Treasurer and Board member of NBDHMT.

Lindell K. Weaver MD, FACP, FCCP, FCCM, FUHM

Hyperbaric Medicine Division, Intermountain LDS Hospital, Salt Lake City, Utah Hyperbaric Medicine, Intermountain Medical Center, Murray, Utah
University of Utah School of Medicine, Salt Lake City, Utah
Medical Director and Division Chief, Hyperbaric Medicine, LDS Hospital, Salt Lake City, UT and Intermountain Medical Center, Murray, UT
Professor of Medicine, University of Utah School of Medicine.
Training: BS in engineering science, Arizona State University; internship, Naval Hospital San Diego; military, undersea and diving medical officer training followed by undersea medical officer, U.S. Navy; residency in internal medicine, LDS Hospital, Salt Lake City, UT; fellowship in pulmonary/critical care, University of Utah
Undersea and Hyperbaric Medical Society past president,
Chair, UHMS Hyperbaric Oxygen Therapy Committee

Robert P. Weenink, MD, PhD, Captain (Navy)

Consultant, department of Anesthesiology, Amsterdam University Medical Centers, The Netherlands
Consultant, department of Hyperbaric Medicine, Amsterdam University Medical Centers, The Netherlands
Flight surgeon

Robert Weenink is a military anesthesiologist, working as a clinical anesthesiologist and Helicopter Emergency Medical Service physician in the Amsterdam University Medical Centers. He is a Navy diving medical officer and flight surgeon, and is involved in acute hyperbaric medicine, both clinically and scientifically. His special interests within this field are management of ICU patients in the hyperbaric chamber, and cerebral arterial gas embolism.

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   Comment: A very comprehensive description of the roles of oxygen in healing and the mechanisms of hyperbaric oxygen from physics, physiology and biochemistry perspectives.

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