WCHM

WOUND CARE AND HYPERBARIC MEDICINE

VOLUME 8, ISSUE 4 — WINTER 2017

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NOTE FROM THE EDITOR

As 2017 ends, we thank all of our sponsors, contributors, and readers for making *WCHM* the only magazine to cover all topics under pressure: wound care, diving, and hyperbaric medicine. *WCHM* started as a paid subscription for a print publication, but as our online audience grew over the years, we offered the magazine exclusively online, compliments of Best Publishing Company and the amazing group of WCHM Elite and VIP Sponsors.

In this issue's hyperbaric medicine section, the Baromedical Nurses Association (BNA) returns with an exciting announcement, the UHMS welcomes Derall Garrett as the new UHMS Hyperbaric Facility Accreditation Director, and registered respirator therapist Jeff Mize describes his responsibilities in the air and on the ground. The UHMS 2018 Winter Symposium on Hyperbaric Medicine and Wound Management is being held at the Snowbird Ski and Summer Resort in Snowbird, Utah. Check out the details for registration and attendance. Finally, learn how to take a new PATH to training with a UHMS program

In the wound care section of *WCHM*, find out about a new study that documents cost and impact of chronic wounds. Also take a sneak peek at the *Textbook of Chronic Wound Care: An Evidence-Based Approach to Diagnosis and Treatment* by Drs. Jayesh Shah, Paul Sheffield and Caroline Fife, due for publication in 2018 by Best Publishing Company.

In this issue, the dive medicine section returns with an excerpt from the revised edition of Dr. Michael Strauss and Dr. Igor Aksenov's *Diving Science* textbook, also due for publication in 2018 by Best Publishing Company.

If you've ever wanted to get an article you authored published to an audience of thousands of wound care and hyperbaric medicine practitioners, 2018 is the year for you to make this happen. Please submit your articles to info@bestpub.com or call 561.776.6066. We also invite you to join our elite group of WCHM advertisers and reach your target audience.

Happy New Year! We look forward to hearing from you.

Lorraine Fico-White
Managing Editor, *WCHM* Magazine

Baromedical Nurses Association (BNA)

By Laura Josefsen, RN, ACHRN
(Source: *hyperbaricnurses.org*)

Exciting things are happening through the BNA! Let's take a look!

First, an important announcement from the November 2017 BNA Newsletter by Annette Gwilliam, BNA President. The BNA will have the 1st Annual BNA Day on April 3, 2018! More information is coming regarding online festivities and education. As a special treat, we will be having a live webinar on CO presented by the nurses at Duke in conjunction with BNA day. If you are not already a member, this is the time to join and be a part of the celebration! There are so many opportunities in this very dynamic organization, including becoming a board member, committee member, or general member. You, your ideas and enthusiasm are welcome!

Annette Gwilliam
BNA President

The BNA is active and networking at the regional UHMS Chapter meetings. The networking opportunities are fun, friendly, helpful and beneficial. The BNA is also networking in Spanish with the new Spanish language email address enfermerashipebaricas@gmail.com.

Continuing education is available through the BNA in two avenues: online education and LIVE webinars. These are free to BNA members and at a nominal charge of $15.00 for each one-hour offering for non-BNA members. The courses are approved by the California Board of Nursing. These courses are offered periodically with certificate of completion emailed within two to three business days. New course offerings are in the works.

The list of the current courses (also listed on the BNA webpage at hyperbaricnurses.org) are:

- Oxygen Toxicity in the Multiplace Chamber
  - Francis Torcotte, BSN, CHRN
  - Kevin Kraft, BSN, ACHRN
  - Jen Siewer, BSN, CHRN
  - Ciara Sentelik, BSN
- Updates to Surveying Hyperbaric Medicine Facilities
  - W. T. Workman, MS, CAsP, CHT-A, FAsMA
- Encouraging Patient Compliance in Hyperbaric Medicine
  - Becky Greenwood, BSN, RN, CWOCN
  - Annette Gwilliam, BSN, RN, CWON, ACHRN
- Promoting Best Practice for Identification and Treatment of Gas Embolism
  - Debbie Critz, BSN, RN, ACHRN
- Developing a Hyperbaric Medicine Program Utilizing National Quality Measures
  - Robin Ortega, MS, BSN, CHRNC, CWCN
- Diabetic Foot Ulcers: HBO Clinical Practice Guidelines
  - Eugene Worth, MD
- Systems Issues and Patient Safety
  - Mary Brann, DNP, MSN, RN
- Necrotizing Fasciitis and Hyperbaric Oxygen Therapy
  - Monica Skarban, MSOLQ, BSN, RN, CHRNC
- HBO Safety
  - John Duffy, MS, CHRNC, CWS

The website has the names and contact information of the board members for you to contact for questions, mentoring, volunteering, education, certification information, etc.

UHMS Welcomes Derall Garrett as New UHMS Hyperbaric Facility Accreditation Director

By Renée Duncan, UHMS Communications Coordinator

Derall Garrett has been selected to join the Undersea and Hyperbaric Medical Society as Hyperbaric Facility Accreditation Director. His appointment is effective Monday, December 4, when he begins work with retiring accreditation director Tom Workman and HFA coordinator Beth Hands.

Mr. Garrett has been working in the field of hyperbaric medicine for more than a decade. He is a graduate of the College of Oceaneering, certified as a commercial diver, and a diver medic. He is a certified hyperbaric technician through the National Board of Diving Hyperbaric Technologist since 2000.

Garrett has experience working with both Class A and B hyperbaric systems in a variety of settings. He is certified by two hyperbaric chamber manufacturers to provide service and maintenance to their Class B hyperbaric systems.

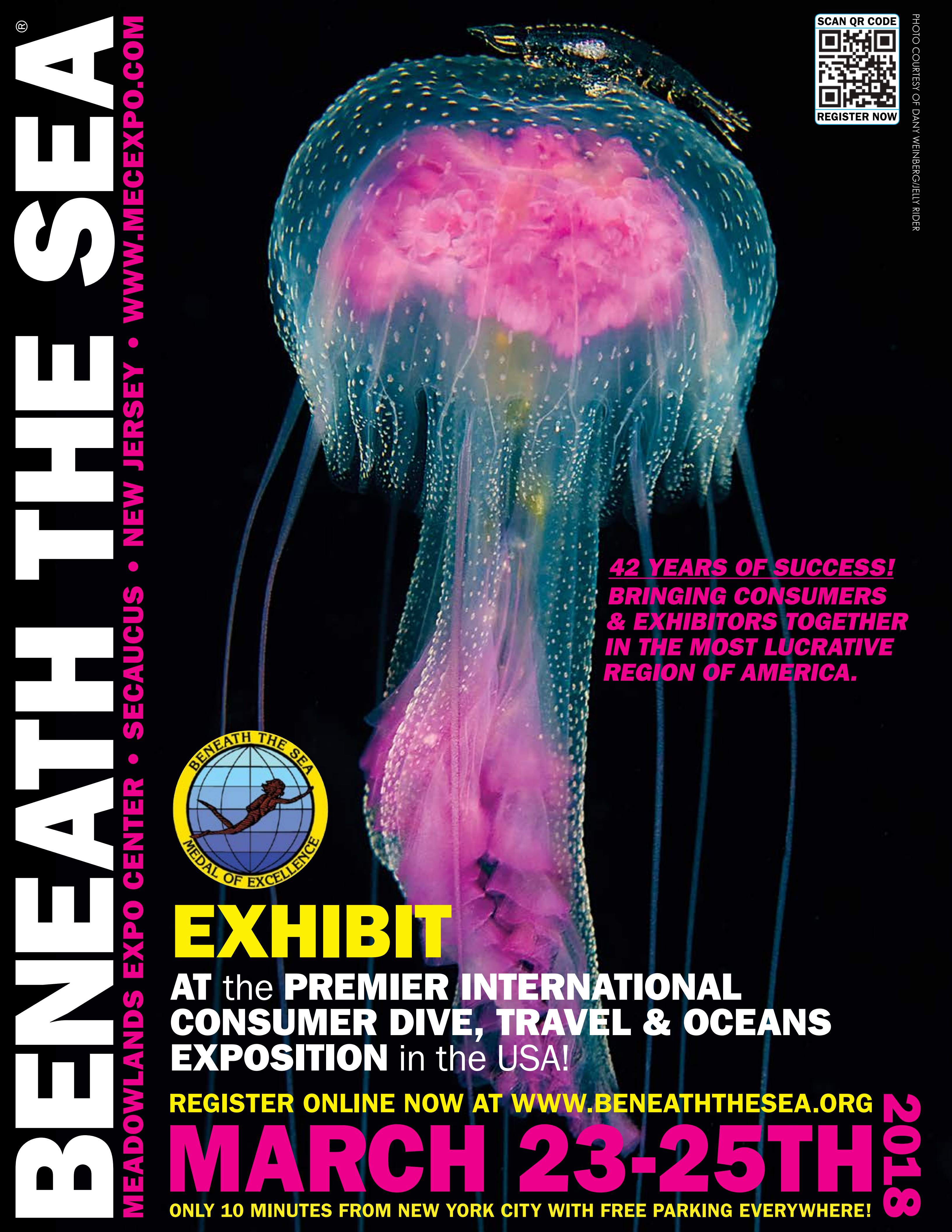
"Derall is uniquely qualified for the position of Director of the HFA department," noted UHMS Executive Director John Peters. "His years of experience as an accreditation surveyor will benefit the department and the UHMS greatly.

"Tom has done a remarkable job preparing the position for Derall," added Peters. "With assistance from Beth Hands, UHMS Accreditation Council Chair Dr. Brett Hart, and myself, Derall will have a dedicated support system as he comes up to speed."

In addition, Tom Workman will provide an expanded department orientation beyond his December 31 retirement date.

Derall Garrett joined Diversified Therapy in 2002 as the safety director for the Wound Care and Hyperbaric Medicine Program at University Community Hospital – Carrollwood, Tampa, Florida. In 2006, Mr. Garrett became the VP of Hyperbaric Services for Innovative Healing Systems until 2012. From 2012 to the present, he has been working under his own branded hyperbaric consulting and service company, providing services globally.

A resident of Melbourne Beach, Florida, Mr. Garrett has been a UHMS member since 2003 and UHMS HFA surveyor since 2013 and has completed numerous surveys over the years. ■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Registered Respiratory Therapist: From Air to Ground

Jeff Mize RRT, CHT, CWCA

In the spring of 1992, I was working as a Life Flight Registered Respiratory Therapist/Paramedic and enjoying every minute. I even liked flights in the cold or smothering heat. The hospital that sponsored the air medical program had taken an unconventional approach in determining the qualifications of the medical crew. The administration was concerned with the potential for "downtime" of the crew, which was the polite way of saying they didn't want to pay people to sit around. With this edict in mind, the administration decided the crew would be comprised of a nurse and a respiratory therapist (RRT). When the crew was not involved in flight(s) or flight activity, the crew members could be utilized throughout the hospital. For the flight therapist/paramedic, that meant being assigned to the emergency department (ER), the intensive care unit (ICU) and the code blue team . . . life was exciting!

My day started like many other days had, with a code in the ER. At the conclusion of the code, I overheard two of the ER physicians discussing the increasing patient volume and need for additional staff in the Hyperbaric Medicine Program. The HBO program was relatively new, less than one year old, and was the only facility within 150 miles capable of providing emergent, critical care 24/7 365. Subscribing to the theory that you can't hear no if you don't ask, I politely interrupted the conversation and asked if they had considered utilizing a registered respiratory therapist. To my surprise, they were open to the idea, and my venture into the field of hyperbaric oxygen therapy began.

In 1992, based on UHMS statistics, fewer than 300 hyperbaric facilities existed. Our program was comprised of registered nurses and one registered respiratory therapist (myself). The entire team had a vast amount of critical care experience, which was necessary. I felt very fortunate to be part of a program dedicated to critical care and also felt fortunate to have been given the opportunity that I assumed few, if any other, RRT had been given. However, this was not the case. Numerous programs were utilizing RRTs.

It is incredible how fast twenty-five years have gone by and how the field has changed. As I mentioned, we were the only 24/7 facility within a 150-mile radius, and we were the only facility. Fast-forward twenty-five years, the city (Kansas City) that once had only one hyperbaric program, now had seventeen (17) hyperbaric centers. Over that period, there have been many changes, some good and others not so good. We have seen the number of programs grow by some projections to over 2,100 centers nationally with the majority also providing wound care services.

When I look back at my days as a flight therapist/paramedic and the concern and ultimately the decision the hospital administration made to develop a versatile, multidiscipline

team, it is eerily similar to what we utilize in wound care and HBO today. I have the opportunity to consult with wound care and hyperbaric centers throughout the country and have noticed a commonality among centers that function efficiently while providing the highest level of care. That commonality is a multidiscipline team utilizing the unique skill set of each professional, while staying within their scope of practice (licensure). They are dedicated to training, obtaining additional qualification(s) or certification and maintaining competency. Is this an unconventional approach? Perhaps, but motivated, qualified and versatile team members is what we all strive to be. ■

About the Author
Jeff Mize RRT, CHT, CWCA

With over thirty years of health-care experience, Jeff has extensive experience in critical care that is the result of seven years as a flight respiratory therapist/paramedic for the Spirit of Kansas City Life Flight.

In 1993, he entered the field of hyperbaric medicine and wound care, advancing to the role of program director and provided oversight for all aspects of administrative, clinical and daily operations within the wound care and hyperbaric facility. Jeff is a principal partner with Midwest Hyperbaric LLC and is the co-founder and Chief Clinical Officer for Wound Reference.

Jeff is a certified hyperbaric technologist (CHT) by the National Board of Diving and Hyperbaric Medical Technology, a certified wound care associate (CWCA) by the American Academy of Wound Management, trained as a UHMS safety director and is a UHMS Facility Accreditation Surveyor.

Jeff is the 2010 recipient of the Gurnee Award and the 2013 recipient of the Paul C. Baker Award for Hyperbaric Oxygen Safety Excellence. He has served on the UHMS Board of Directors (2010-2015,) the UHMS Finance Committee (2010-2015) and the UHMS Scientific Committee (2011-2012).

2018 WINTER SYMPOSIUM: Hyperbaric Medicine & Wound Management

Snowbird Ski and Summer Resort, Snowbird, Utah
January 27-30

UHMS WINTER symposium

Open access: https://www.uhms.org/education/courses-meeting/directly-sponsored/winter-symposium-on-hyperbaric-medicine-wound-care.html

For 50 years the UHMS has been the primary source of information for hyperbaric medicine and physiology worldwide.

The 2018 Winter Symposium on Hyperbaric Medicine and Wound Management will feature updates in the fields of hyperbaric medicine and wound care. This course has as its goal to provide a quality CME opportunity to update knowledge and skills for hyperbaric and wound care for physicians, nurses and technicians, as well as other clinicians and personnel whose practice includes hyperbaric medicine and wound care.

The course features speakers prominent in their respective fields and will provide time to question and interact with these experts in the friendly confines of the Snowbird Ski Resort in Snowbird, Utah.

Get up to 20 hours of continuing education and time on the slopes. Nestled in the legendary Little Cottonwood Canyon, Snowbird averages more than 500 inches of the "greatest snow on Earth" each season. Attendees will enjoy sun-sparkled ski venues and other winter activities between symposium sessions. The feather-light powder, combined with world-famous terrain, offer an unsurpassed mountain meeting experience.

Prices and Deadlines

Room rates:
S/D $249 with a minimum four-night stay, with a resort fee of $25/night

Room reservation deadline:
Monday, 18 December 2017

Course Fees

Member:
PHYSICIAN or EQUIVALENT – $650

Member:
NON-PHYSICIAN – $550

Non-Member:
PHYSICIAN OR EQUIVALENT – $750

Non-Member:
NON-PHYSICIAN – $650

For more detailed information and to register check out the UHMS website listed above or paste this link into your browser: https://www.uhms.org/education/courses-meeting/directly-sponsored/winter-symposium-on-hyperbaric-medicine-wound-care.html

UHMS Program for Advanced Training in Hyperbarics Blocks 1-3 Now Available

Take a new PATH to training.

The UHMS Program for Advanced Training in Hyperbarics/PATH is open to MD, DO, NP and PA candidates who have previously completed a 40-hour introduction to hyperbaric medicine course. Candidates who deferred completion in the Stellenbosch CAQ program in undersea and hyperbaric medicine previously offered by UHMS will be enrolled automatically in this revised program at no charge. Upon completion of the PATH, MD/DO candidates will receive a Certificate of Added Qualification (CAQ) and NP/PA candidates will receive a Certificate of Advanced Education (CAE).

The PATH does not replace fellowship training or board certification in UHM, which is considered the gold standard for training in undersea and hyperbaric medicine. The CAQ/CAE is intended to demonstrate that a candidate has completed a formal education program covering advanced topics in UHM, as well as having submitted clinical cases for formal review.

The PATH is intended to take between 6 to 12 months to complete and represents approximately 100 hours of continuing education credits.

Requirements:

- Must be a current UHMS Member and maintain membership during the duration of certification.
- Must have access to a copy of *Hyperbaric Oxygen Therapy Indications, Thirteenth Edition*.

Components of the UHMS PATH

- Self-directed learning
- Reading assignments – Participants will read selected textbook chapters, seminal articles and other publications.
- Video presentations – Learners will view selected PowerPoint presentations.
- Case presentations/write-ups – Learners will submit 10 HIPAA-compliant case write-ups from the initial consultation to the end-of-treatment summary for peer review by a board-certified UHM faculty member.
- Case conferences – Learners will participate in regularly scheduled web-hosted case conferences led by board-certified UHM faculty members to discuss interesting cases and provide feedback on case workups.
- Skills lab – Learners will have to complete the UHMS Hyperbaric Medicine Skills and Emergency Management course that will be offered periodically throughout the year.
- Examination – Learners will have a pre-test and post-test to assess gained knowledge.

Block Topics:

Block 1: Hyperbaric Physiology and Side Effects (9 credits)

Block 2: Carbon Monoxide Poisoning (7 credits)

Block 3: Chronic Radiation Tissue Injury (11 credits)

The PATH is scheduled for a total of 9 blocks available soon.

Price: $2,000 (does not include registration to skills lab)

For more information and to register click here: https://www.uhms.org/education/credentialing/caq-hyperbaric-physician-certification.html

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 Statement: *The Undersea and Hyperbaric Medical Society designates this enduring material for a maximum of 9 (Block 1); 7 (Block 2); 11 (Block 3) AMA PRA Category 1 Credit(s)™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.*

MOC ABPM: *This activity has been approved by the American Board of Preventive Medicine for up to 6 (Block 2); 11 (Block 3) MOC credits. Claiming ABPM MOC credit is appropriate for those who are ABPM diplomates.*

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 prior to the activity.*

UHMS 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 (UHMS), its affiliates or its employees.*

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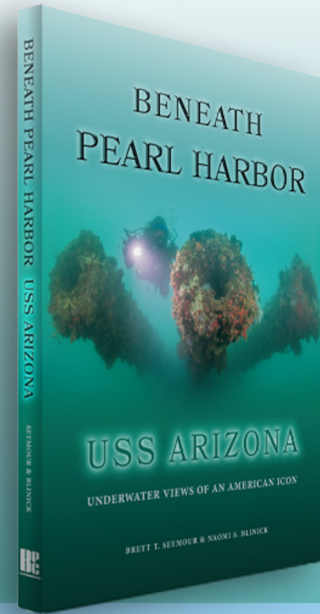
In commemoration of the 75th anniversary of the attack on Pearl Harbor,
Best Publishing Company announces the publication of:

BENEATH PEARL HARBOR: USS *ARIZONA*
UNDERWATER VIEWS OF AN AMERICAN ICON

by Brett Seymour and Naomi Blinick



Experience USS *Arizona* as never before in this collection of images and essays that bring the fallen World War II battleship to life. Explore the submerged ship, its artifacts and history underwater with individuals who have a tangible and passionate connection to the ship—National Park Service divers.

Young Landon's journey to meet his hero, Donald G. Stratton, began with the PBS show "Into the Arizona" and book *Beneath Pearl Harbor* - both created by the SRC and partners to highlight the legacy and National Park Service stewardship of the WWII battleship.

CLICK to watch the short video about Landon's journey.

"It is important for future generations to remember what happened on Dec. 7, 1941, and that becomes more difficult with each passing year. I hope that when someone picks up this book, he or she continues to remember the story of USS *Arizona* and its significance to our nation."
—**Lauren Bruner,** USS *Arizona*

Brett Seymour is the Deputy Chief of the U.S. National Park Service's Submerged Resources Center (SRC).

Naomi Blinick is a freelance photographer and marine biologist.

Available at Amazon.com and BestPub.com

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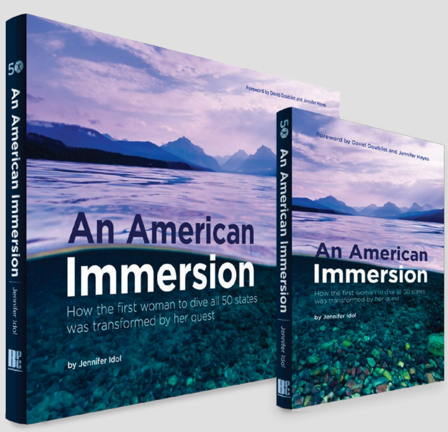
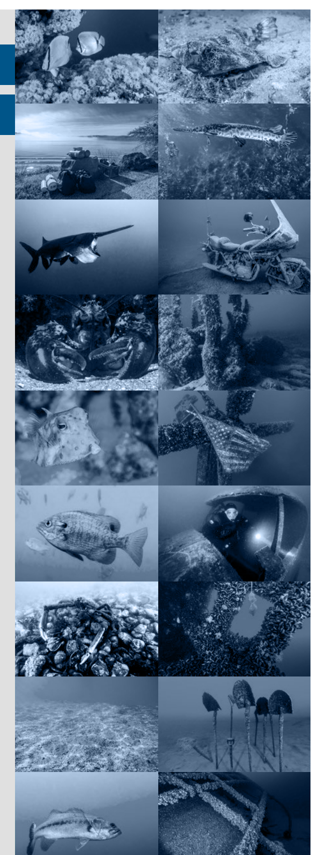
AN AMERICAN IMMERSION
by Jennifer Idol

Hardcover	$60
Paperback	$19.99





Do you long for adventure?
Do you wish you could travel?
Do you have big dreams?

Explore vivid underwater landscapes in this revealing book as you discover how an oil spill inspired a woman's quest to become the first woman to dive all 50 states.

Available on Amazon and BestPub.com

Jennifer Idol is the first woman to dive 50 states and author of *An American Immersion*. She's earned more than 27 certifications and has been diving for 20 years. Her photography and articles are published in *DIVER, Sport Diver, Alert Diver, SCUBA Diving, X-Ray Mag, Outdoor Oklahoma, Underwater Speleology, SCUBA & H2O Adventure,* and *Texas Aquatic Science.*

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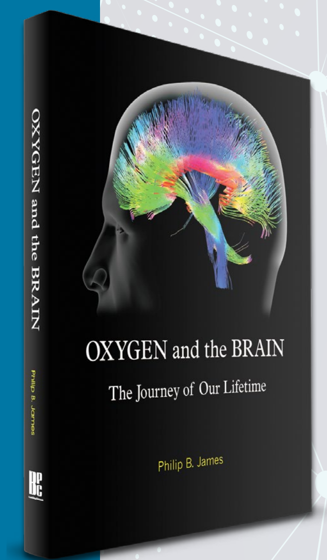
AnAmericanImmersion.com

50 THE UNDERWATER DESIGNER PHOTOGRAPHY & DESIGN

Due to global demand, *Oxygen and the Brain: The Journey of Our Lifetime* by Philip James and *Deep into Deco* by Asser Salama are now available for global distribution through Best Publishing Company's partnership with Ingram.

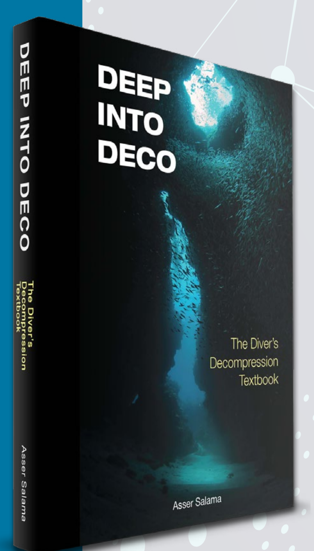
Why is this such big news? Individuals, libraries, dive shops, bookstores, and retailers across the globe can now directly purchase these titles through either Ingram or Best Publishing. Please contact Best Publishing's customer service at **info@bestpub.com** or **+1-561-776-6066** for more information.



OXYGEN AND THE BRAIN: *The Journey of Our Lifetime*

by Philip B. James, MB, ChB, DIH, PhD, FFOM

Following the human journey from conception to old age, Oxygen and the Brain presents evidence amassed over more than a century that can transform the care of patients with birth injury, head trauma, multiple sclerosis, and stroke and can even reverse decline in old age. There is no more necessary and scientific action than to correct a deficiency of oxygen, especially in the brain, and it is simple to give more.



DEEP INTO DECO

by Asser Salama

Deep Into Deco is a comprehensive and well-written reference text that covers various topics of decompression theory. It portrays the latest developments and controversial issues in technical diving in a way that is straightforward, easy to read, understandable and free from technical jargon.

From the early history of experimental trial and error to the latest innovations and changes in decompression concepts, Deep Into Deco brings the science into sharp focus. Without elaborating on mathematical equations or source code, the book demonstrates how commercial software packages calculate deco schedules. It also explores in detail a grab bag of additional points of interest that contribute to our current understanding of decompression theory.

With a writing style that is a mix of strict no-nonsense reporting along with interesting storytelling, Deep Into Deco includes interviews with accomplished divers, industry professionals, researchers and software developers.

This book is a must read for any diver who wants to understand decompression theory, how it evolved, what it accomplished and where the latest research is headed.

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New Study Documents Cost and Impact of Chronic Wounds

Demonstrates Imperative for Wound-Specific Quality Measures, Payment Models, and Federal Research Funding

Compiled by Renée Duncan, UHMS Communications Coordinator

Open-access text: https://www.uhms.org/images/QUARC/oct-2017/Value_In_Health_article.pdf

Medicare expenditures related to wound care are far greater than previously recognized.

This is the conclusion of a recently published study by the Alliance of Wound Care Stakeholders, published online in the International Society for Pharmacoeconomics and Outcomes Research's *Value in Health* journal. The study, the first comprehensive evaluation of Medicare spending on wound care, demonstrates the economic impact of chronic nonhealing wounds in Medicare patients.

The findings and policy implications are compelling. "An Economic Evaluation of the Impact, Cost, and Medicare Policy Implications of Chronic Nonhealing Wounds" analyzed 2014 Medicare data to determine the cost of chronic wound care for Medicare beneficiaries in aggregate, by wound type, and by care setting. This includes diabetic foot ulcers and diabetic infections.

Key Findings

1) Chronic wounds impact nearly 15% of Medicare beneficiaries (8.2 million).

2) A conservative estimate of the annual cost is $28 billion when the wound is the primary diagnosis on the claim. When the analysis included wounds as a secondary diagnosis, the cost for wounds is conservatively estimated at $31.7 billion.

- Surgical wounds and diabetic foot ulcers drove the highest total wound care costs (including cost of infections).
- On an individual wound basis, the most expensive mean Medicare spending per beneficiary was for arterial ulcers followed by pressure ulcers.
- In regard to site of service, hospital outpatient settings drove the greatest proportion of costs, demonstrating a major shift in costs from hospital inpatient to outpatient settings.
- Surgical infections were the largest prevalence category, followed by diabetic wound infections.

The study was funded by the Alliance of Wound Care Stakeholders. The full text of the study is available on the *Value in Health* website and is scheduled to publish in the December issue.

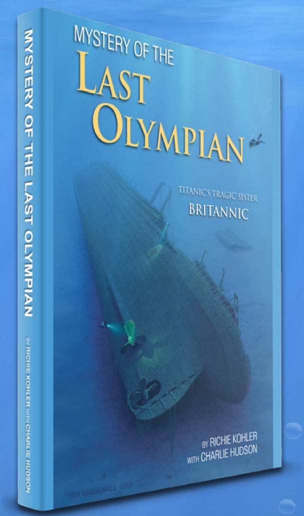
The Alliance of Wound Care Stakeholders

The Alliance is a nonprofit multidisciplinary trade association of physician medical societies and clinical associations whose mission is to promote quality care and access to products and services for people with wounds through effective advocacy and educational outreach in the regulatory, legislative, and public arenas.

Learn more at www.woundcarestakeholders.org. ■

For more information see: https://www.uhms.org/resources/quarc/129-quarc-articles/515-value-in-health-publishes-alliance-s-article-on-impact-and-cost-and-medicare-policy-implications-of-chronic-nonhealing-wounds.html

BEST PUBLISHING COMPANY Presents Two Diving Books!



MYSTERY OF THE LAST OLYMPIAN: *Titanic*'s Tragic Sister *Britannic*

by Richie Kohler with Charlie Hudson

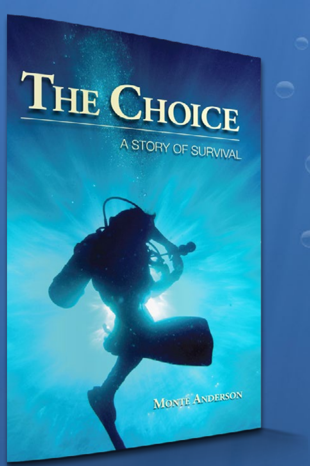
For 100 years the mystery surrounding the sinking of *Titanic*'s tragic sister *Britannic* was a riddle waiting to be solved. This book gives you a firsthand account as Richie Kohler takes readers on the intriguing journey from the rise of the magnificent Olympians to the ship's fateful sinking in 1916. He then moves forward in time through multiple expeditions, beginning with the great Jacques Cousteau, who located the wreck of the ocean liner in 1975. Each successive team of divers who risked their lives uncovered new clues, but it was not until 2009 that Kohler and his dive partner definitively pinpointed the secret that had eluded everyone before then.

Join Kohler, host of the History Channel's *Deep Sea Detectives* and featured in the bestselling book *Shadow Divers,* as he solves the *Mystery of the Last Olympian*.

"In Richie Kohler's new book, the same drive for adventure that captivated my father comes alive as Kohler rediscovers the mysteries surrounding the ship's fateful demise. Their journey spans across past and present, honoring the legacy of an unsinkable ship and the determination of those who risked, or even lost, their lives in the search to uncover its secrets."

~ Jean-Michel Cousteau, explorer, environmentalist, educator, and producer

Available on Amazon and www.bestpub.com.
$19.99 paperback, $12.99 ebook

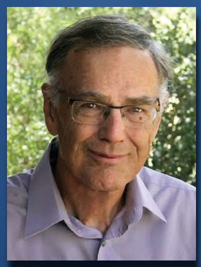


THE CHOICE: *A Story of Survival*

by Monte Anderson

As three friends drove across the Navajo Reservation in northern Arizona after backcountry skiing in Colorado, they talked about their lives. Then one said, "I really shouldn't be alive today."

David Scalia's astounding story occurred in 1982, when a scuba equipment failure caused a devastating accident, but he had a scrapbook documenting everything that happened. He suffered incalculable damage to his body for more than 12 grueling hours. Days later, he was given a profound choice — to live or to die. Almost unbelievable, this is his true story — and it involves some friends and colleagues you may know, including Dr. Gregory Adkisson, Dr. Tom Neuman, and Dr. Paul Phillips.



About the Author: Monte Anderson completed a medical residency at Creighton University and continued his studies with subspecialty training in gastroenterology and hepatology as an army officer at Fort Sam Houston in San Antonio, Texas. After his discharge from the military, most of his career was happily devoted to the Mayo Clinic in Arizona. Feeling that true tales tend to be more compelling than fiction, he has always preferred reading nonfiction, especially since something is always learned in the process. *The Choice: A Story of Survival*, his first effort outside of scientific writing, is nonfiction.

"Dr. Monte Anderson makes his debut in nonmedical writing with The Choice: A Story of Survival and does so with a splash. The nonfiction book relates the fascinating story of his friend's 1982 diving accident near a remote island in Mexico. Dr. Anderson's recounting of the details reflects his tremendous investigative ability, as well as the diver's will to survive."

~ Neil B. Hampson, MD, author of Cherry Red

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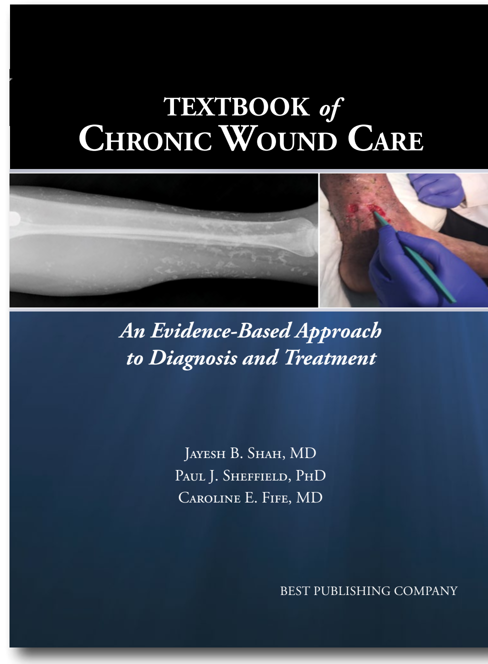
Textbook of Chronic Wound Care Is Coming in 2018

By Jayesh B. SHAH MD, UHM(ABPM), CWSP, FAPWCA, FCCWS, FUHM, FACP, FACHM



Textbook of Chronic Wound Care: An Evidence-Based Approach to Diagnosis and Treatment by Drs. Jayesh Shah, Paul Sheffield, and Caroline Fife, editors, is a companion reference book for the *Wound Care Certification Study Guide, 2nd edition*. Due for presale pricing, discount, and publication by Best Publishing Company in the first quarter of 2018, this textbook provides the best diagnostic and management information for chronic wound care in conjunction with evidence-based clinical pathways illustrated by case studies and more than 350 pictures. The textbook provides up-to-date information for the challenging chronic wound care problems in an easy-to-understand format. The preface for the textbook follows.

The co-editors of this book, Paul J. Sheffield, PhD and Caroline E. Fife, MD, have also edited the *Wound Care Practice*'s first edition in 2004 and its second edition in 2007. Instead of a third edition of *Wound Care Practice*, we decided to write a new textbook focused on evidence-based pathways and that is how the *Textbook of Chronic Wound Care* was created. We realized the traditional experienced-based criteria for selecting wound care interventions is being replaced with evidence-based practice. This textbook has made an attempt to focus on the evidence-based practice approach with case studies, pathways, and key concepts outlined in a majority of the chapters.

The value of evidence-based approach for providing optimal care is established, but the process used to generate this evidence continues to evolve. Many guidelines for wound care are published on *clinicalguidelines.gov* but a textbook that can put all those guidelines in a simple manner to help wound care practitioners in their daily practice was lacking. This book makes a sincere attempt to help the reader apply those guidelines into their clinical practice.

Another reason for this new textbook was to create a companion to our study guide, *Wound Care Certification Study Guide, 2nd edition* (Best Publishing Company, 2016), which will give in-depth knowledge and evidence-based pathway to handle different kinds of chronic wounds. I want to thank all my colleagues and the chapter contributors for their outstanding support for *Wound Care Certification Study Guide, 2nd edition*. Their response to our study guide gave strength to the present editors to venture into this new textbook. All editors and more than 50 contributors are committed in the field of wound care and they believe in making a difference in the lives of our patients through education.

This textbook is organized into eight sections. The first section explores the anatomy, physiology, and biochemistry of wound healing. The second section explores all essentials of wound healing including discussion on etiology of wound, nutritional assessment and management, wound assessment, wound bed preparation, evidence-based selection of wound dressings, advanced wound modalities, and advanced plastic surgical techniques in wound care. The third section discusses pathophysiology, diagnosis, and management of special wound patients including discussion of diabetic foot ulcer, pressure ulcers, venous insufficiency ulcers, lymphedema, and arterial insufficiency ulcers. The fourth section explores atypical wounds, arthropod bites, stings and infestation, radiation wounds, and burns.

The fifth section discusses wound care in special populations like pediatrics, geriatrics and patients with fistulae. The sixth section discusses wound care in different settings like outpatient hospital wound clinic, physician's outpatient office, acute long-term care facility, and nursing home setting. It also discusses ways to incorporate research in wound care practice. The seventh section explores challenges and opportunities in wound care practice in the new era, discusses use of telemedicine in wound care, and presents challenges and opportunities with electronic health records. There is also a discussion on the future of wound care moving from volume to value in the wound care arena and a discussion on patient-centered decision making in wound care and hyperbaric medicine. Finally, section eight looks at disparities in health care in different countries and how wound care is being done in other countries.

A disclaimer by Dr. Fife concerning the NPUAP 2016 Terminology controversy is provided to give you some clarification on certain terminology regarding pressure ulcer through out the textbook.

Thank you for the opportunity to present this textbook that will assist wound care professionals, caregivers, patients, and their families. By working as a team, we can drastically improve the care of our wound care patients globally. ■

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Breath-Hold Diving

Michael B. Strauss, MD, Lientra Q. Lu, BS

This article on breath-hold diving is an excerpt from the extensive revision in progress of Dr. Michael Strauss and Dr. Igor Aksenov's *Diving Science* textbook.

Introduction and Uniqueness

Breath-hold diving is a generic term for diving activities that does not utilize self-contained (SCUBA) or surface-supplied breathing apparatuses. It is a generic term because it includes snorkel diving with or without shallow, brief depth excursions, recreational breath-hold diving in lieu of using SCUBA gear, commercial foodstuff collection diving, competitive game hunting diving, and deep diving, record-setting attempts (Figure 1). Apneic (i.e. without breathing) diving is a term associated with breath-hold diving. Skin diving is another term often associated with breath-hold diving but is not technically correct, since thermal protection may or may not be used with breath-hold diving as well as SCUBA diving. Snorkels are typically used by the recreational breath-hold divers but not usually in the other breath-hold diving types. Thus, snorkel diving is not an exact substitute terminology for breath-hold diving.

Snorkels are an energy-conserving piece of equipment. They negate the extra energy needed to lift one's head out of the water to breathe. In addition they allow the diver to view without interruption the underwater panorama which otherwise would be interrupted by lifting the head out of the water to breathe. Snorkels vary from simple "J-shaped" tubes to tubes with additional curves, bends, and valves.

More elaborate snorkels have no return valves so water does not enter the snorkel tube. The advantage of the valve is the diver need not clear the snorkel tube of water before inhaling. However, the system is not always reliable and exhaling through the snorkel to be sure it is clear of water before inhaling is always recommended. Another snorkel device is a ball-type valve at the top of the snorkel. The purpose of this device is also to prevent inhalation of water should the top end of the snorkel not be above the surface of the water. Such devices add resistance to swimming and increase the chances of entanglements in kelp or lines.

Snorkels are recommended for recreational SCUBA divers. They negate the extra energy expenditures that lifting the head requires with surface swims as may be needed to get to the descent site or return to dive support craft or shoreline.

Each of these five variations of breath-hold diving has typical diving depths, goals and special circumstances (Table 1). Several deserve additional commentaries such as the AMA of Japan, the pearl divers of the South Pacific and the extreme apneic (i.e. nonbreathing, breath-hold) divers) which will be included in the text box below and in succeeding portions of the paper.

The Ama divers of Japan and Korea are female commercial divers that harvest foodstuffs off the bottom. There are two categories of divers the shallow water dives that dive to about 15 feet of seawater (FSW)/5 Meters of seawater (MSW) and the deep divers whose maximum depths are 60 FSW/ 20 MSW.

It appears that women in the process of "natural selection" better tolerated the cold Japanese and Korean waters than

FIGURE 1. Breath-Hold Diver on the Surface

This diver is enjoying the underwater panorama while snorkeling on the surface with only occasional breath-hold depth excursions to explore items on the bottom in 3 to 6 FSW (1 to 2 MSW).

A lycra suit is being worn, more to offer protection from the sun and stings than for thermal comfort in the warm tropical water.

TABLE 1. Types of Breath-Hold (Apneic) Diving

Type	Typical Depths (feet of seawater/meters of seawater)	Goals	Comments
Snorkeling	Surface and depths to 3-6/1-2	Surface swims, viewing a wide expanse of the underwater environment	Ideal for the young diver, for those with fear of going underwater, and for near-surface photography where color rendition is optimized.
Recreational Breath-hold Diving	Surface to 30/10	Exploring shallow depth flora, game collecting (abalone, lobster, scallop)	Requires swimming and breath-holding skills. Ear clearing challenges with each descent.
Commercial Breath-hold Diving	Dive depths: 15/5 to 60/20. Pearl divers to > 100/30	Collect game for livelihood; sale for jewelry	Most publicized and studied are the women "Ama" divers of Japan and Korea and the pearl/coral divers of the South Pacific islands
Competitive Spear Fishing	Depths to 120/40 and more	Spearfishing contests; personal use of fish	Great risks for breath-holding blackouts; hyperventilation breath-holding distractional and diffusional (Chapter 7)
Extreme Apneic Dives	Depths to over 200/60 and static breath-hold times >10 minutes	Set world and personal records	Hazardous; for record attempts, standby personnel required. There are certification associations for record setting dives.

men. This is attributed to the fact that women have additional subcutaneous fat, which is an insulation-type protection for cold water. Now that neoprene wet suits have become available, men divers are taking over these commercial diving activities.

For the deep diver category, in order conserve air, the Ama use stone weights to help them submerge. Men tenders on small surface craft tend the lines. Once the foodstuffs have been collected and placed in a basket along with the weight used for descent, the tenders pull-up the basket and the diver so energy expenditures are almost entirely due to the collecting process on the bottom. The deep diving Amas typical bottom times are about one minute.

Records setting apneic dives generate much attention, often making headlines in newspapers and news broadcasts. Two organizations provide direction for apneic divers. They are AIDA (International Association for Development of Apneic Diving) and CMAS (Confederation Mondiale des Acivities Subaquatiques). Eleven apneic diving disciplines are recognized by AIDA and CMAS and 12 more are practiced locally. Disciplines vary from "static" i.e. breath-holding on the surface to "no limits" i.e. weighted sleds to aid with descent and inflated bags to aid with ascent (Table 2).

TABLE 2. Six of 11 AIDA/CMAS Recognized Types of Apneic Dives and Their Records*

Name	Description	Women's Record	Men's Record
Static	Breath-holding with head submerged	Molchanova (Rus) **9 min 2 sec**	Mifsud (Fra) **11 min 35 sec**
Dynamic w/fins	Underwater swim for distance	Molchanova (Rus) **237 m (777.6 ft)**	Malina (Pol) **300 m (984.3 ft)**
Constant weight	Maximum depth swimming down & backup w/wo fins	Molchanova (Rus) **101 m (331.4 ft) w/ fins**	Molchanov (Rus) **128 m (419.9 ft) w/ fins**
Free immersion	Line for descent & ascent; no fins	Molchanova (Rus) **91 m (298.6 ft)**	Trubridge (Nzl) **124 m (406.8 ft)**
Variable weight constant	Weighted sled descent; line or swimming ascent	Van den Broek (Nld) **130 m (426.5 ft)**	Kastrinakis (Grc) **146 m (479 ft)**
No limits	Weighted sled descent; inflatable lift bag ascent	Streeter (USA) **160 m (524.9 ft)**	Nistch (Aut) **214 m (702.1 ft)**

Note: *As of July 31, 2014. (https://en.wikipedia.org/wiki/AIDA_International)

Abbreviations: Aut = Austria, **Fra** = France, **Ft** = Feet, **Grc** = Greece, **M** = Meters **Nzl** = New Zealand, **Pol** = Poland, **Rus** = Russia, **USA** = United States, **W/WO** = With/without fins

An example of an unrecognized discipline is that of Alex Segura Vendrell. On a static breath-hold he was able to hold his breath face submerged in a pool 24 minutes and 3 seconds after breathing oxygen. This record was set on 7 March 2016.

Advantages and Hazards of Breath-Hold Diving

For those who enjoy freedom of movement and the ability to demonstrate their own water "adaptability," few activities are more exhilarating than breath-hold diving (Figure 2). Without the need for SCUBA tanks, the breath-hold diver has much more mobility and swimming speed capability. This obviates the drag created by the tanks and other related equipment such as regulators and buoyancy compensators when swimming. Preparations and donning of gear is much less for breath-hold diving due to the minimum equipment requirements as compared to that needed for SCUBA diving.

WOUND CARE CERTIFICATION STUDY GUIDE

SECOND EDITION

DR. JAYESH SHAH, in partnership with **DR. PAUL SHEFFIELD** of International ATMO and **DR. CAROLINE FIFE** of Intellicure, has created the perfect tool for anyone studying to take a wound certification exam — AAWM, APWCA, CWCN, NAWC, and more.

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"It was my pleasure to review the second edition of the Wound Care Certification Guide. I found the chapters to be well written and organized, building upon the science of wound healing while including practical clinical applications and sample questions. This text should be useful to all wound care professionals, including the novice and expert alike. It will certainly be an important adjunct for anyone preparing for board examinations."

— Robert J. Snyder, DPM, MSc, CWS; Professor and Director of Clinical Research, Barry University SPM; Past President, Association for the Advancement of Wound Care; Past President, American Board of Wound Management

"The manuscript is the result of a monumental amount of work. I congratulate all involved."

— Terry Treadwell, MD, FACS; Medical Director, Institute for Advanced Wound Care

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FIGURE 2. Breath-Hold Divers "on the Bottom"

"Resting" on the bottom in 33 FSW/10 MSW "uncluttered" with gear. Note: Because of positive buoyancy—a safety precaution—divers needed to hold onto cement anchor in order to remain on the bottom. The anchor line was used to reach the bottom to conserve "air," otherwise it would be expended for a swimming descent.

Other advantages of breath-hold diving include the quietness of not cycling the SCUBA regulator or dealing with exhalation bubbles. These features are less likely to disturb the marine flora for observation and photographic purposes. In addition, diving is essentially "unlimited" with breath-hold diving. Except in extreme situations (to be described later in this chapter), there are no decompression requirements and repetitive dives and immersion times are essentially unlimited.

Finally, breath-hold diving is a good conditioning activity because of the activity associated with it. The mastery of energy conserving movements while swimming underwater and improved performances manifested by increased breath-hold times and depth excursions occur rapidly with breath-hold divers. In the first author's experiences, breath-hold dive times typical increase from about 45 seconds to over one and one-half minutes and depth excursions from 25 feet to 50 feet from the beginning to the end of a week's diving activities. In contrast, the "ideal" SCUBA dive is one that minimizes activity in order to conserve energy and minimizes air usage and is therefore not a beneficial activity for aerobic/cardiac conditioning.

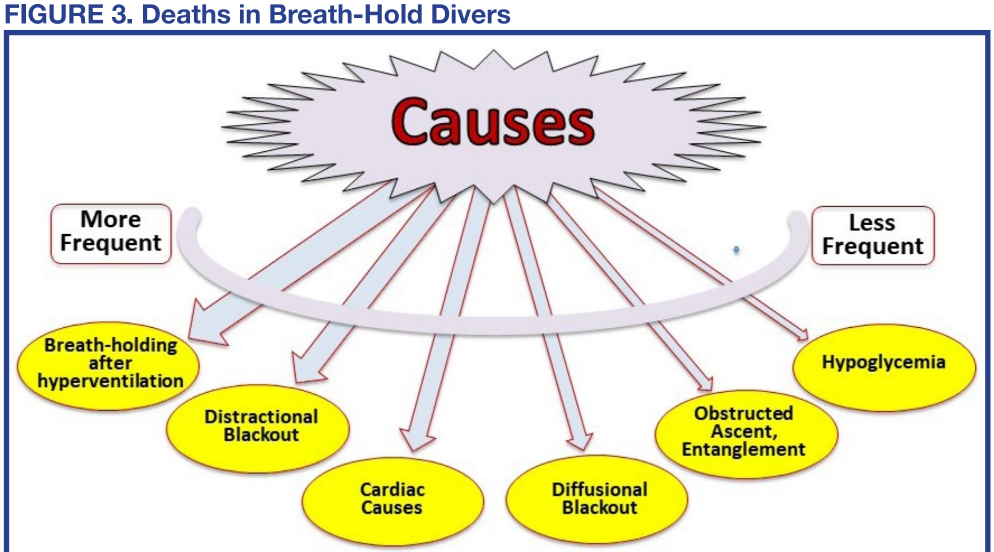
Studies of dive instructors the from the US Navy Submarine Escape Training Tank at Groton, Connecticut demonstrated they rapidly improved their diving abilities after starting their assignments. Changes included increases in total lung capacity and decreased sensitivity (i.e. need to take a breath) from elevated blood carbon dioxide tensions and protection from blackout from lower blood oxygen tensions. These changes were observed after six weeks of training. The increased total lung capacity was thought to offer protection from thoracic squeeze.[1,2]

As in other diving activities, hazards are associated with breath-hold diving. The major one is blackout, which is comprehensively discussed in Chapter 7. The more challenging the diving activities are, such as competitive spear fishing and extreme apneic diving, the greater the risks for blackout are present. This is ironical since inexperience and lack of fitness are major considerations in recreational SCUBA diving accidents while the most experienced, best conditioned divers are the ones at the greatest risk for blackout. A possible exception to this observation is the diver who from lack of knowledge or otherwise excessively hyperventilates in order to extend his/her underwater water breath-hold time (Chapter 7).

PARADOX Inexperienced SCUBA divers primarily experience nonblackout medical problem of diving; experienced breath-hold diver primarily experience blackouts.

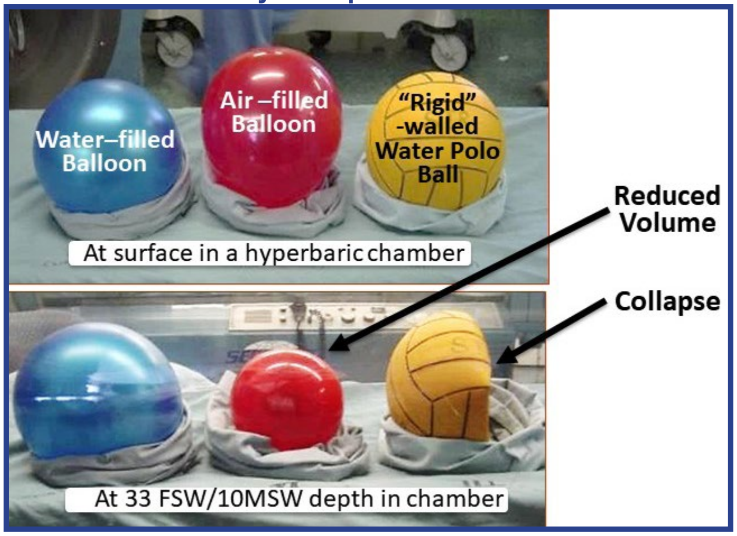
Unfortunately, statistics for breath-hold diving blackout and deaths are meager. In absence of wearing SCUBA gear, causes of death in breath-hold divers are usually listed as drowning without describing antecedent events (Figure 3). When the loss of consciousness is transient, and the diver recovers without sequelae, there is no mechanism to tract such events. This contrasts to a SCUBA diving medical

FIGURE 3. Deaths in Breath-Hold Divers



Deaths in breath-hold divers are usually reported as drownings. Review of dive history and the examination of circumstances can usually discover underlying causes. These causes and their frequencies are "best guesses" from the first author's experiences, reviews of the literature, diving medicine conferences, and discussions with colleagues.

FIGURE 4. The Body's Responses to Increased Ambient Pressure with Breath-holding



The body when descending with breath-hold dives has analogies to the above model. The water-filled balloon transmits pressures equally and undiminished (Pascal's principle) as is the situation with almost 99% of the body. Air-filled, flexible walled structures like the lungs and gut decrease in size (Boyle's law). In both situations no pressure differentials develop.

The rigid-walled, air-filled structures build-up pressure differentials in response to increased pressures. Body structures, rather than collapse, leak fluid and bleed into these structures in response to pressure differentials. It appears the lung's alveoli respond in a similar fashion once they are compressed beyond their residual volume.

problem such as decompression sickness, which is treated with hyperbaric oxygen-recompression and there is better collection of data on such occurrences. The Divers Alert Network (DAN), however, has started collecting data on breath-hold diving accidents in addition to their SCUBA diving data repository.

A second hazard of breath-hold diving is thoracic squeeze. However, it is debatable whether or not this problem is a realistic concern. Ordinarily the majority of the body structures tolerate changes in pressure with breath-hold diving without problems (Figure 4). In theory, thoracic squeeze occurs when the total lung capacity (about 5 liters) during the breath-hold dive descent is compressed to the residual lung volume (about 1 liter).

The single reported case with lung pathology to verify its existence occurred in combination with a blackout.[3] In this case the breath-hold diver loss consciousness during ascent from a 80 FSW/24.3 MSW) bottom drop (i.e. a dilutional blackout—chapter 7), passively lost the tidal volume of air in his lungs and began to sink. It is postulated that once the alveoli were compressed beyond their tidal volume, the pathology as described above occurred.

Application of Boyle's law computes this threshold to be 132 feet. Compression of the lung beyond its residual volume apparently exceeds the alveoli's ability to collapse and because of this, gradients develop that move fluid and blood from the lung capillaries into the alveoli. The result is essentially the diver "drowns" in his/her own body fluids. Obviously, the theoretical thoracic squeeze threshold has been far exceeded with breath-hold dives greater than 132 FSW on repeated occasions without evidence of thoracic squeezes.

Aquatic mammals exhale before they descend on their deep dives. This supposedly minimizes energy expenditures during descent. Thoracic squeeze is avoided by their alveoli being able to collapse completely and then re-expand upon surfacing without injury to the alveoli. This also has other protective benefits for the aquatic mammals. With alveolar collapse, there is no exchange of air across the alveoli, so problems of nitrogen narcosis, oxygen toxicity and decompression sickness do not occur (Chapter 5).

In humans, six different explanations, both empirical and theoretical, explain why apneic divers avoid thoracic squeeze even though the depths of their dives far exceed the theoretical total lung capacity reduction to the residual volume.[4] Proposed explanations include:

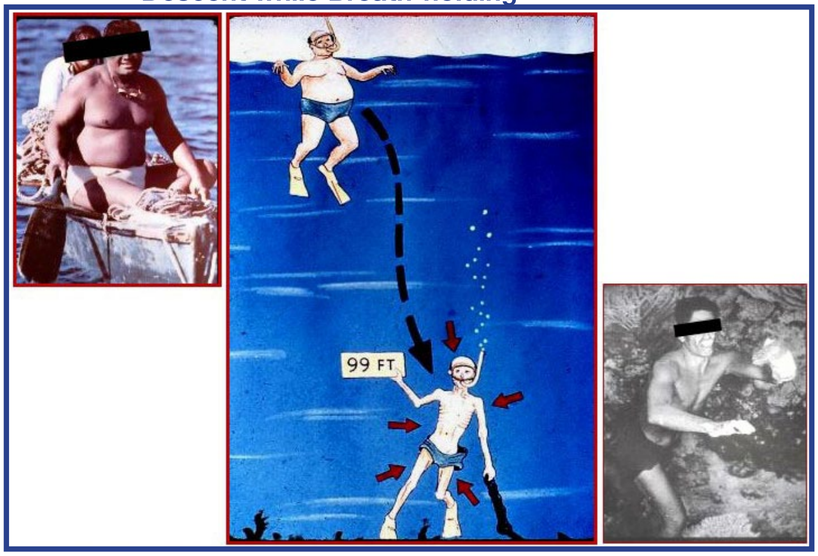
First, the elasticity of the lung tissue (alveolar wall) itself may add an increased margin of tolerance so that damage from collapse of the alveoli does occur until well beyond the theoretical threshold.

Second, as descent continues while breath-holding, the increased ambient pressure symmetrically compresses the chest wall (Figure 5). Thus, there are proportionate decreases in the volume of the chest cavity with the decreases in the lung capacities. The secondary effect of "pressurization" of the air in the alveoli as demonstrated by Boyle's law helps the alveoli resist collapsing.

Third, Expert apneic divers claim to be able to hyperinflate their lungs by "buccal pumping." Thus, they begin their dives not only with a maximal inhalation but with a pressure in their lungs greater than the surface ambient pressure.

Fourth, through neuro mechanisms initiated by the diving reflex, blood shifts from the extremities to the chest cavity. This has been demonstrated in the Ama divers of Japan as well as in a record setting apneic diver. This effect couple with elevation of the diaphragm

FIGURE 5. Caricature to Emphasize Chest Compression with Descent while Breath-holding



Chest and abdomen compression with deep descents while breath-holding have been offered as possible explanations for protection from thoracic squeeze. Symmetrical compression of chest and abdominal contents translates to alveoli. While reducing the volume of the alveoli (Boyle's law) , it increases the pressure with in the alveoli to help prevent their collapse.

and shifting of the abdominal contents into the chest capacity as the air-filled bowel is compressed compensate for the decreased volume of the compressed lung.

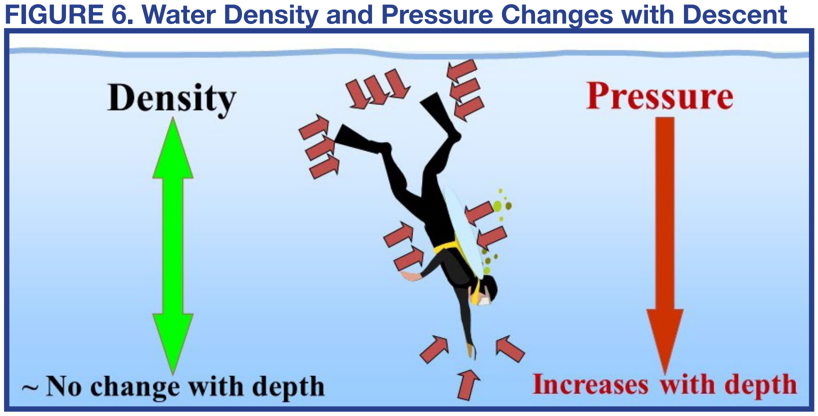
Fifth, congenital or developmental anomalies such as asthma may increase the diver's lung capacities which have been observed to exceed those found in the general population. In addition, acclimatized breath-hold divers significantly increase their TLC's with relative decreases in their RV's with practice. These effects increase the TLC—>RV thresholds thereby lowering the depth where thoracic squeeze will occur. The acclimatizations are short-lived, disappearing within a couple of months after stopping diving activities.

Finally, females may be endowed with hereditary factors that increase their resistance to thoracic squeeze just as they are to cold-water exposure. At one time, a woman exceeded the "no limits" apneic dive depth record.

Middle ear and sinus barotrauma is another risk to breath-hold divers who descend below the surface (Chapter 4). While water is more than 700 times as dense as air, density does not change to any significant degree with descent. In contrast, changes in pressure is a significant consideration in both SCUBA and breath-hold diving (Figure 6). Pressure effects of water with descents are significant for two reasons. First, SCUBA divers have the benefit of descending slowly and halting their descents to facilitate middle ear pressure equilibration. Breath-hold divers do not have this luxury; they must descend as rapidly as possible in order to optimize their bottom times. Second, whereas a SCUBA diver may only perform a few descents and ascents during a day's diving activities, the breath-hold diver will do 20 more in the course of an hour's deep recreational breath-hold dives. Consequently, the experienced breath-hold diver becomes very adept at ear clearing with descents.

Finally, the risk of decompression sickness as a hazard for breath-hold divers must be mentioned for the sake of completeness. In the past, it was believed that human breath-hold divers could not get decompressions sickness. A US Navy diving manual stated that it is virtually impossible for the skin diver, because he cannot take up a troublesome amount of nitrogen–unless he has access to a supply of air at depth.[5] However, decompression

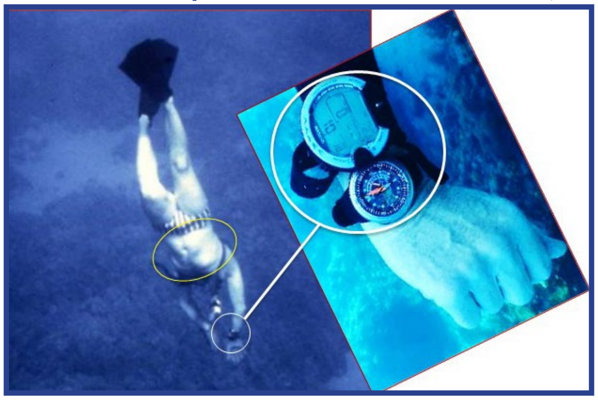
FIGURE 6. Water Density and Pressure Changes with Descent



Water density, which is over 700 times greater than air density, influences movement through water and contributes to the physical stresses of diving such as dealing with waves and currents, but does not change markedly with increased depths.

Pressure has many ramifications for the diver whether SCUBA or breath-holding. For the breath-hold diver, pressure changes are associated with middle ear barotrauma, diffusional blackout and possibly thoracic squeeze.

FIGURE 7. Deep Breath-hold Dive with Fins, Mask, and Snorkel



Note the swimming descent (no descending line available). Blue-gray coloration attests to the depth of the dive with filtering out of red and yellow colors to a homogenous bluish-gray coloration. Dive equipment limited to fins, mask, and snorkel and no lycra protective garment.

Observe that water pressure (yellow oblong) is beginning to compress abdomen.

Dive is being monitored by buddy on surface. Computer depth gauge and dive watch (white circles) are used to time and record depth of dive.

sickness has been observed with repeated deep breath-hold dives and was confirmed by Paulev.[7] In his study, four experienced, well-conditioned, highly-trained dives participated in a series of repetitive breath-hold dives. Their dive profiles involved rapid descents to 65 FSW/20 MSW and bottom times approaching two minutes. Surface intervals varied from a few seconds to a maximum of two minutes so that the accumulated time spent underwater was greater than the accumulate time of the surface intervals. After five hours diving, which included about 60 divers, signs and symptoms of decompression sickness appeared while the divers were on the surface. The diagnosis was confirmed when the findings resolved with recompression in a hyperbaric chamber. When Paulev calculated the amount of nitrogen accumulation with the dive profiles, he found that the tissue nitrogen tensions exceed the maximum allowable (M-values) tissue saturations.[8] This confirmed that decompression sickness can occur in breath-hold divers in extraordinary situations.

Polynesian pearl divers of Tuamotu became paralyzed after repetitive deep breath-hold dives.[6] They called their syndrome “taravana,” which translates into the “falling syndrome.” Symptoms were observed after four to five hours of breath-hold diving to depths as great as 165 FSW/50 MSW with very short surface intervals. Unfortunately, many of the afflicted divers remained permanently paralyzed due to lack of a recompression chamber on their island. Had their symptoms resolved with recompression, the diagnosis of decompression sickness would have been absolutely confirmed in these cases.

It is noteworthy that this problem was not observed in divers on an adjacent island who descended to equivalent depths, but had surface intervals two to three times the durations of the Tuamotu divers.

Special Equipment Needs

Equipment needs and costs are substantially less since fins, masks and snorkels are the main expenditures (Figure 7). In warm water, only a swimsuit is needed, but a Lycra dive skin is recommended for sun and marine animal sting protection. In cooler water, neoprene wetsuit protection is needed, but because of energy expenditures with breath-hold diving, substantial less “rubber” is needed to keep comfortably warm as compared to using SCUBA gear when diving in waters of equal temperature. Also, less weight is needed to neutralize buoyancy if less neoprene is used to maintain thermal comfort in the water.

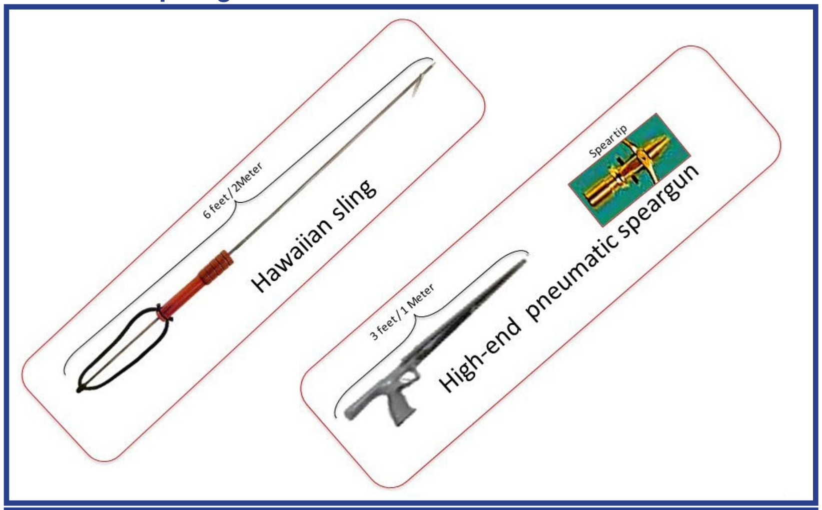
Specialized diving fins are preferred by the competitive spear fisherman. They typically are much longer and much more flexible than the swim fins used by the recreational SCUBA diver. Monofins, where both feet are put into a single fin thereby simulating the tail flukes of dolphins and whales, have been used by apneic divers who do swimming ascents in their personal or world-record-breaking attempts.

For improved mobility for breath-hold divers as well as surface swimmers, neoprene wetsuits are thinner and utilize more flexible, less densely packed bubbles. Dry suits are not a realistic option for the breath-hold diver due to their bulkiness and need to have a separate compressed gas supply to maintain proper inflation of the dry suit.

A dive knife, wristwatch/timer, and depth gauge are essential pieces of equipment for the breath-hold diver (Figure 7). The dive knife should be small, but have a serrated blade to facilitate cutting through nylon rope entanglements and kelp. Depth gauges and watches are necessary to monitor depths and times of the dive. Dive computers may become “frustrated” with the repetitive dives a breath-hold diver does. A simple wrist depth gauge, preferable one that records maximum depth is recommended.

Capillary depth gauges are OK for shallow depths where big changes in the bubble diameter are maximized as demonstrated by Boyle’s law. The friction of the gas bubble in the glass cylinder leads to inaccurate readings. At this time the capillary depth gauge is all but obsolete.

FIGURE 8. Speargun Choices



Speargun options vary from a few dollars for a homemade Hawaiian sling to over a thousand dollars for a high-end pneumatic speargun.

For the spearfisherman, spearguns of varying sophistication are used (Figure 8). The most simple is the Hawaiian sling. Sophistication increases with gunstock-like barrels, multiple surgical tubes, and more precise trigger mechanisms. The most sophisticated are those spearguns that use gas (pneumatic systems) to thrust the spear forward. Prices range from a few dollars for a homemade Hawaiian sling up to $1500.00 for the high-end, gas-charged models.

The Hawaiian sling consists of a cylinder of wood about six inches long with a hole drilled through its center, which holds the spear. A trigger device can be fashioned from a door hinge attached to wood cylinder that has a hole in it to allow the spear to pass through it and the wood cylinder. However, typically the diver uses finger pressure on the spear against the forward portion of the wood cylinder. Surgical tubing is attached to the cylinder. The spear has a barb attached to its pointed end.

The sling is cocked by stretching the surgical tubing over the blunt end of the spear and using the friction of the finger pressure or the obliquity of the door hinge hole to maintain the cocked, surgical tubing tension position of the spear. By releasing finger pressure or closing the hinge (the hole becomes round), the surgical tubing tension causes the spear to shoot out analogous to a hair trigger release. To be effective, the spear point must be close to the target fish.

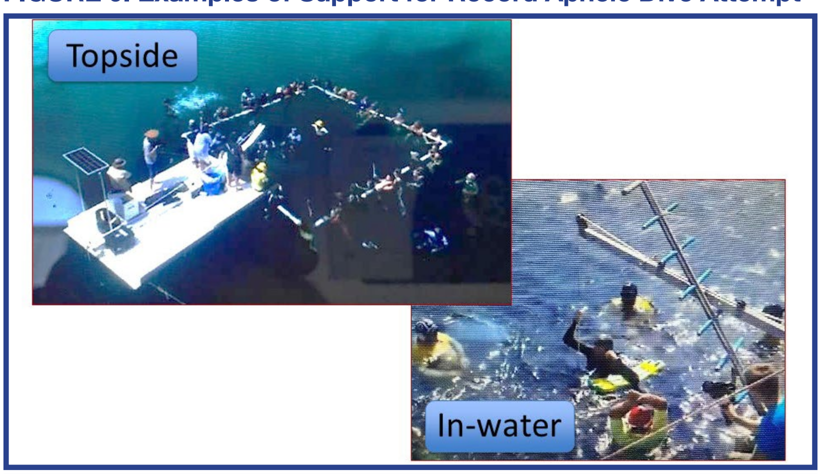
For the record apneic dives, sophisticated equipment and a team approach is necessary (Figure 9). Equipment needs include boat support to platforms at the dive site, descending lines, sleds, depth recording devices, timers, water-filled goggles that accommodate for the refractive index of the water, remote monitors, and communication systems. Personnel include AIDA or CMAS officials to authenticate the dive, standby divers (often with closed circuit SCUBA for great depths), paramedics/ physicians and reporters. Obviously, the world-class apneic diving record attempts are expensive undertakings with possibilities of injuries and deaths. They frequently have equipment sponsors or publication companies help underwrite the costs.

Safety Considerations

As stated previously, breath-hold diving imposes significant risks for the divers engaged in this type of diving activity. Consequently, safety considerations and practices are of paramount importance. As in all diving activities, the buddy system should be used. However, for recreational breath-hold diving, the buddy should be of comparable skill (i.e. depth capabilities and breath-hold times) should a rescue attempt be necessary if the victim is at depth.

Exceptions to the buddy system occur with competitive spearfishing competition and record attempt apneic diving. These activities are done individually. However, these specialized breath-hold diving activities require preplanning, for example, expected duration and maximum depth of the activity so the support staff will know when the diver is expected to reach the surface. In addition, standby

FIGURE 9. Examples of Support for Record Apneic Dive Attempt



A large complement of officials, safety personnel, and standby divers are required in order to maximize the safety of the apneic divers in their attempts to set new records.

SCUBA divers, suited up and ready to or already in the water are immediately available to retrieve the diver in trouble.

While one buddy is on the surface recuperating, the other buddy does the dive and vice versa. The dive site should be chosen so that the water is clear enough that the surface buddy can see the buddy throughout the dive. It is desirable to descend with the aid of a descending line. This conserves energy and can markedly extend the bottom time since hand-over-hand pulling oneself downward uses much less oxygen stores than a swimming descent (Figure 2). The diver should be weighted to be slightly positive so that if unconsciousness occurs, the diver will float to the surface rather than sink. However, the buoyancy effect is mitigated by lung compression so a breath-hold diver on the surface who is neutrally buoyant on the surface will become negatively buoyant after descending 20 FSW/6 MSW to 30 FSW/9 MSW.

Experienced freedivers take advantage of this change in buoyancy with descent. Once they reach a depth where they become negatively buoyant, they can stop their active swimming activities, descend without effort, and thereby conserve their air supply.

The "price paid" is that once ascent is started, active swimming efforts are required until they ascend to a depth where they again become positively buoyant.

Submersion times should be planned so the diver starts the ascent at pre-determined times rather than waiting until "air hunger" dictates urgent surfacing to "catch" one's breath. This is because diffusional blackout (Chapter 7) can give the diver a false sense of comfort/lack of "air hunger" while at depth while during ascent the shifts in oxygen from the blood to the tissues result in hypoxia and loss of consciousness.

While deep breathing is acceptable while resting between breath-hold dives, hyperventilation to the point of numbness and tingling of the hands and feet is condemned. This is because lowering of the blood carbon dioxide levels with hyperventilation alters the breath-hold breakpoint enough that it is not reached before consciousness can be lost (Chapter 7). Another thing to be condemned is to use a SCUBA diver's octopus air supply at depth to extend the bottom time of a breath-hold dive. The reason for this is the possibility of forgetting to exhale while ascending which would not ordinarily be done with a pure breath-hold dive. The result of the expanding gas in the lungs during ascent that was inhaled at depth could result in an arterial gas embolism. Reports exist of probable arterial gas embolisms after breath-hold dives.[9]

Is it hazardous to do recreational breath-hold dives immediately after surfacing from a SCUBA dive? Silent intravascular bubbles are known to exist in the venous side of the blood stream, filtered out through the lungs, and exhaled while ascending from a SCUBA dive. The concern is raised that pressurization during descent with the breath-hold dive, the silent intravascular bubbles, reduced in size aka Boyle's law, will be forced through the lungs into the arterial circulation and result in an arterial gas embolism. While this is a theoretical possibility we are unaware of any reported cases of such.

We postulate that the mechanisms are probable analogous to those that are presumed to occur with spontaneous pneumothoraxes.

Special Challenges

The challenges of breath-hold diving have been presented earlier in this chapter. Special challenges can be associated with the physical challenges of diving (Chapter 4). These include surface currents, rip tides, crashing surf zones, and swells. Without the ability to "duck under" and escape the challenges as is possible with SCUBA diving, the breath-hold diver is vulnerable to panic from exhaustion and/or disorientation. In general, breath-hold diving at night is not recommended. This is because of the reduced orientation associated with darkness, the need to handle dive lights, and the difficulty of checking gauges all during the short process of the breath-hold dive.

Perhaps the greatest challenge for the breath-hold diver is distraction. It is easy to appreciate why a recreational breath-hold diver can become distracted. If near the breath-hold break point and blackout from hypoxia is only moments away, and something special occurs, such as almost ready to grasp a lobster in a crevice or pry loose an abalone or getting the "perfect" underwater photograph, the breath-hold diver may suppress the desire to breath long enough that consciousness is lost in the process. This is setting for distractional blackouts (Chapter 7).

The degree of hypoxia before blackout occurs probably varies greatly from individual to individual. Conditioning and practice improve breath-hold times, increase tolerance to high carbon dioxide tensions, and lower the blackout point from hypoxia. Other factors such as heart arrhythmias or hypoglycemia may be precipitated by the hypoxic stress as the breath-hold break point is approached. These may lead to unconsciousness before the blackout can be attributed to distraction. If the blackout occurs earlier than the expected duration of the breath-hold dive (another strong indication for timing dimes), causes other than blackout must be sought.

Aquatic Mammals Adaptations to Improve Breath-Hold Diving Abilities

In addition to the adaptations of aquatic mammals to diving that were described at the end of each chapter of Part II, additional adaptations make them

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ideal breath-hold divers. These are the adaptations in blood and muscle tissue that improve oxygen transport and storage. Aquatic mammals have twice the oxygen-carrying and storage capacity that terrestrial mammals of corresponding sizes have.[10] This is attributed to larger relative blood volumes, higher percentages of oxygen-carrying red blood cells, better oxygen storage capabilities in muscles, ability to extract oxygen from venous blood, greater oxygen extraction from hemoglobin, and reduction in fluid losses (Table 3). Contraction of the spleen can release large amounts of blood to the core circulation with volume reductions as much as five-fold in the seal versus the two- fold reduction in the elite human apneic diver.[11,12] In addition, like the conditioned human breath-hold diver, aquatic mammals are able to tolerate higher carbon dioxide accumulations before needing to breathe and lower oxygen in the blood before losing consciousness than non-conditioned humans—or even the conditioned human diver.

Splenic contraction has two postulated advantages to the breath-hold diver. First, it moves blood into the core circulation. This may help displace the void created by lung collapse with the descent as a direct effect and reduce the likelihood of thoracic squeeze as an indirect effect.

The second benefit is that the oxygen in the blood (added to the core circulation with the splenic contraction) can be utilized to extend the breath-hold time.

Myths and Misconceptions about Breath-Hold Diving

Myth Counterparts in humans exist for all the adaptations to diving that exist in diving mammals.

Fact Although elements of the diving reflex occur in humans, other adaptations such as ability to collapse lungs with descent, increased myoglobin stores, smaller sizes of red blood cells, enhanced ability to extract oxygen from venous blood, and avoidance of decompression sickness with deep dives do not have counterparts in human divers. Improved tolerance to elevated carbon dioxide tensions and low oxygen tensions observed as well as increased lung capacity in conditioned human breath-hold divers are acclimatizations that occur with practice but disappear when the diving activities cease.

Myth Knowledge is the overriding consideration in record-setting apneic dives.

Fact While knowledge (and safety) is important, natural abilities, experience and conditioning are more important considerations.

Myth The breath-hold breakpoint to breathe cannot be suppressed

Fact Distractions associated with underwater activities such as game collecting can result in the diver suppressing the desire to breathe long enough for the diver to lose consciousness from hypoxia. With deep dives, this may be compounded by the diffusional blackout effect (Chapter 7).

Myth Strong signals (i.e. physiological warning signs) almost always exist as a diver is at risk of becoming unconscious from hypoxia

Fact Physiological warning signs of hypoxia may not be recognized if carbon dioxide elevation, which is the indirect stimulus of impending hypoxia, is altered by hyperventilation, oxygen dilution (i.e. diffusional blackout) or carbon dioxide scrubbers.

Myth Competitive spearfishermen disregard safety practices such as the buddy system.

Fact Contests are carefully

TABLE 3. Enhanced Oxygen Carrying and Storage Capacity Adaptations of Aquatic Mammals

Adaptations	Findings	Advantage	Comment
Relative (liters/mass) **blood volumes**	Increased (versus that of nondiving mammals) based on percentage of body weight	Enhanced perfusion	Incremental increase of blood to core with shunting promotes oxygen delivery to brain & displaces lung collapse occurrence with descent
Increased percentage of oxygen-carrying red blood cells (RBCs)	Decreased size of RBCs; increased percentage of RBCs (20% greater than humans)	Better ability to transit capillaries in low flow states; increased oxygen delivery	Smaller size of RBCs may prevent sludging during low flow states to noncritical structures during diving reflex
Better oxygen storage capacities in muscles (myoglobin)	Greater muscle myoglobin oxygen than nondiving mammals	Reservoir for oxygen to be used by muscles during diving reflex before anaerobic metabolism required	About 50% of total oxygen storage in aquatic mammals at the beginning of the dive is in myoglobin
Oxygen extraction from venous blood	After arterial oxygen is utilized, aquatic mammals extract oxygen from venous blood	Enhanced oxygen utilization; prolongation of dive	This adaptation couples with increased ability to tolerate low blood oxygen & high carbon dioxide tensions
Greater oxygen extraction from hemoglobin	Blood more acidotic with carbon dioxide elevation during breath-hold	More offloading of oxygen from hemoglobin during dive	Acidotic blood is able to offload more oxygen to tissues (Bohr effect)
Fluid conservation	No losses of insensible body fluid from lungs with breath-hold & during filtration from kidneys	Maintenance of blood volume	This contrasts with increased fluid losses in SCUBA divers insensible through respiratory losses & increased urine production

supervised so the topside officials are aware of the diver's planned bottom time and the intended diving area. Another safety feature is to have suited-up standby divers on the scene during each event.

Myth Females are better suited for commercial breath-hold diving than men.

Fact Whereas, women have an improved ability to tolerate cold water, the use of the wetsuit has negated this advantage so men are now involved in these Japanese and Korean commercial diving activities. Although women have done incredible diving feats, records for all categories of apneic diving reside with men divers.

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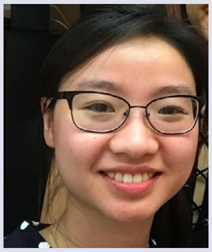

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