CUHMA ACMHS
Canadian Undersea and Hyperbaric Medical Association
Association Canadienne de Médecine Hyperbare et Subaquatique

E-NEWS

EDITOR'S NOTE – February 2023

The E-News is the monthly newsletter of CUHMA, the primary outlet to share news/announcements, upcoming events, abstracts of recent publications, job postings, professional perspectives, and images of relevant professional scenes. Submission of applicable content is welcome. New issues are released on the last business day of each month. Past issues are available at https://cuhma.ca.

Neal W. Pollock, PhD
Université Laval

PRESIDENT'S NOTE

For those of you who attended the annual CUHMA general meeting, concerns were raised by some members regarding costs related to legal expenses incurred in 2022. I am happy to report that a decision in CUHMA's favour will result in partial reimbursement of expenses incurred.

On behalf of the CUHMA board of directors I extend our gratitude to Dr. Paul Cervenko for his many years of service. Paul has been involved as a director-at-large in the past and has worked tirelessly behind the scenes as the head of the elections committee. We wish him all the best as he moves forward to focus on non-medical endeavors.

As we finalize the details of CUHMA's event at the UHMS meeting in San Diego, we are exploring other options for educational opportunities for our members later in the year. If there are specific topics that members would like presented, please reach out to the board. As always, our goal is to improve the practice of diving and hyperbaric medicine in Canada.

Geoff Zbitnew, MD
Memorial University

NEWS/ANNOUNCEMENTS

X-Ray Magazine

X-Ray Mag is a bimonthly publication addressing a broad range of diving topics. It is distributed electronically at no cost to subscribers. Past issues can also be downloaded at no cost: Visit: https://xray-mag.com.

Parks Canada Diving on *HMS Erebus* in Arctic

The Franklin Expedition departed from England in May 1845 with two ships in an effort to find a Northwest Passage. Neither vessel nor any of the crew of 130 returned. The resting place of the *HMS Erebus* was located in 2014 at a depth of 11 m of water near Uqsuqtuuq (Gjoa Haven), King William Island, Nunavut (68°N latitude). The *HMS Terror* was located in 2016 at a depth of 25 m of water approximately 70 km further north. Parks Canada archaeologists conducted a 2022 expedition that included 56 dives on the *Erebus*. For more information, including video: https://www.cbc.ca/news/canada/north/franklin-expedition-excavation-1.6690878.
https://www.smithsonianmag.com/history/archaeologists-get-eerie-first-look-inside-arctic-shipwreck-franklin-hms-terror-180973011.

GUE InDEPTH

Global Underwater Explorers produces InDEPTH as a monthly publication addressing advanced diving topics. It is delivered electronically at no cost to subscribers. A review of the top 10 stories from 2022 is now available: https://gue.com/blog/indepths-top-stories-from-2022.

UPCOMING EVENTS

Rebreather Forum 4

Rebreather Forum 4 will be held April 20-22, 2023 in Valletta, Malta. The purpose of the scientific and leadership meeting is to advance the diving community's state of knowledge regarding rebreather technology and its uses, with the goal of promoting rebreather diving safety. The program includes 22 hours of scheduled sessions plus additional events. The scientific program committee is comprised of Drs. John Clarke, Simon Mitchell, Neal Pollock, Frauke Tillmans, and journalist Michael Menduno. Optional diving activities are planned before and after the meeting. For additional information and registration: https://rebreatherforum.tech.

SPUMS Annual Scientific Meeting 2023

The South Pacific Underwater Medicine Society annual scientific meeting will be held June 04-09 in Cairns, Australia. The theme is diver health and ocean health amid the storm clouds of climate change. Details and registration: https://spums.au.

UHMS Annual Scientific Meeting 2023
The Undersea and Hyperbaric Medical Society (UHMS) will hold a live annual scientific meeting June 16-18 in San Diego, CA. Visit: https://www.uhms.org.

UMC Introductory Diving Medicine Course
Undersea Medicine Canada is offering a Level 1 'Introductory Course in Diving Medicine - Fitness to Dive' September 18-22 in Quebec City, QC. An optional half-day pre-course will be held September 17 for those wanting additional preparation for the program. Upon successful completion of the course, physicians will qualify as CSA Z275.2-15 Level 1 Diving Medical Examiners and can have their names listed with the Diver Certification Board of Canada (DCBC) to conduct commercial diver medicals in Canada. This 40-h course has been accredited for 35 MAINPRO+ CME credits by the College of Family Physicians of Canada. Contact Dr. Debbie Pestell (drdeb1@ns.sympatico.ca; 902-225-8214) or visit: https://underseamedicine.ca for more information.

RECENT PUBLICATIONS

Ajduk J, Peček M, Kelava I, Žaja R, Ries M, Košec A. Comparison of intratympanic steroid and hyperbaric oxygen salvage therapy hearing outcomes in idiopathic sudden sensorineural hearing loss: a retrospective study. Ear Hear. 2023 Jan 25. Online ahead of print.

Objectives: Systemic steroids are the most common first-line therapy in sudden sensorineural hearing loss (SSNHL), with significant improvement in hearing outcomes in over 60% of patients. It is unknown why 40% of patients do not respond to systemic steroid therapy. Salvage treatment includes intratympanic steroids (ITS) and hyperbaric oxygenation (HBO) therapy, with inconsistent results reported. This study aimed to compare the results of ITS and HBO therapy in patients with SSNHL that previously failed systemic steroid therapy. Design: This is a comparative retrospective nonrandomized interventional cohort study, enrolling 126 patients with SSNHL. Out of these, 35 patients received HBO therapy, 43 patients received ITS, and 48 patients did not receive any second-line therapy (control group). Pure-tone audiograms were performed before and after the salvage therapy in the IT and HBO groups and at the same time interval in the control group. Study variables included age, time until therapy initiation, tinnitus status, and hearing outcomes, with a cutoff criteria of cumulative >30 dB improvement on all frequencies indicating recovery. Results: ITS and HBO therapy were associated with statistically significant hearing recovery at all frequencies compared to systemic steroids. The results show an average hearing improvement of 13.6 dB overall frequencies (250 to 8000 Hz) after ITS therapy and 7.4 dB in HBO therapy in comparison to the control group. Presence of significant hearing improvement positively correlated with age, ITS therapy, and HBO therapy. Presence of tinnitus before therapy was negatively correlated with hearing improvement. Patients with tinnitus present at the start of therapy improve 4.67 dB less on average compared to those without tinnitus. ITS therapy significantly reduced tinnitus compared to the other two treatment options. Patients with tinnitus present before therapy significantly improve hearing at low frequencies, compared to the control group. Conclusions: ITS and HBO therapy show superior hearing results compared to observation alone after failed oral steroid therapy for SSNHL. ITS shows an additional positive impact on tinnitus reduction and shows superior hearing outcomes after salvage therapy.

Barković I, Jurilj Z, Marinelli F, Maričić V, Pavlović M, Wensveen TT, Peršić V. Arterial blood gases' analysis in elite breath-hold divers at extreme depths. Eur J Appl Physiol. 2022 Dec 13.

Purpose: To showcase results of arterial blood gases' analysis in elite breath-hold divers sampled at depths where their total lung capacities are below their residual lung volume on surface. Methods: Three male elite breath-hold divers performed body plethysmographies to determine their lung volumes. Two dives were performed, one on normal inhalation to 60 m of depth and the second on complete exhalation to 10 m of depth. Blood samples were taken on five occasions; before the first dive, at 60 and 10 m of depth and immediately after resurfacing after both dives. Results: Arterial blood gases' analysis at 60 m of depth showed an increase in partial pressures of oxygen and carbon dioxide, a consequent decrease in pH and an increase in concentration of HCO_3^-. After resurfacing, in two divers, values mostly returned to normal; hypoxemia was observed in one diver. At 10 m of depth, all values showed similar variation, and hypoxemia was observed in the same diver but at depth. Upon resurfacing, all values returned to normal. Conclusion: This is the first study performed at depths where the total lung capacities of participants are below their residual lung volumes at the surface. Partial pressure of carbon dioxide increases at depth to higher than normal values causing pH to decrease thus exceeding the buffering potential of the blood. In addition, previous assumptions that maximum depth in breath-hold divers is where total lung capacity is reduced to their residual volume proved wrong as our group of divers had no symptoms after resurfacing.

Casadesús JM, Nieto-Moragas J, Serrando MT, Boadas-Vaello P, Carrera A, Aguirre F, Tubbs RS, Reina F. Pulmonary barotrauma in scuba diving-related fatalities: a histological and histomorphometric analysis. Forensic Sci Med Pathol. 2023 Jan 27. Online ahead.

Arterial gas embolism following pulmonary barotrauma occurs in 13-24% of cases of diving deaths. The study

aimed to evaluate the usefulness of a histomorphometric digital analysis in the detection of air space over-distension due to pulmonary barotrauma. The study was performed on lung parenchyma specimens of 12 divers: six had died due to arterial gas embolism following pulmonary barotrauma (mean age at death of 54 years, range of 41-61 years), and six had drowned in saltwater without a diagnosis of pulmonary barotrauma (mean age at death of 54 years, range of 41-66 years) (positive controls). For negative controls, six cases of non-scuba divers (mean age of death of 42 years, range of 23-55 years) who died of intracerebral haemorrhage were evaluated. No significant differences were observed in the characteristics of the air spaces between control groups (positive and negative). However, differences were observed in the area occupied by air spaces and the percentage of air space area when we compared the case group to the controls ($p<0.01$); and there was a slight difference in the maximum and minimum diameters of air space ($p<0.05$). The mean area occupied by air spaces and the mean percentage of air space were the most useful for discriminating pulmonary barotrauma from other causes of death (100% sensitivity and 91.7% specificity). Based on our study, inclusion of an increased pattern of air spaces as a possible diagnostic criterion for pulmonary barotrauma would be useful in discerning the cause of diving death.

Johnson WR, Roney NG, Zhou H, Ciarlone GE, Williams BT, Green WT, Mahon RT, Dainer HM, Hart BB, Hall AA. Comparison of treatment recompression tables for neurologic decompression illness in swine model. Randomized Controlled Trial PLoS One. 2022; 17(10):e0266236.

Background: Significant reductions in ambient pressure subject an individual to risk of decompression illness (DCI); with incidence up to 35 per 10,000 dives. In severe cases, the central nervous system is often compromised (>80%), making DCI among the most morbid of diving related injuries. While hyperbaric specialists suggest initiating recompression therapy with either a Treatment Table 6 (TT6) or 6A (TT6A), the optimal initial recompression treatment for severe DCI is unknown. Methods: Swine were exposed to an insult dive breathing air at 7.06 ATA (715.35 kPa) for 24 min followed by rapid decompression at a rate of 1.82 ATA/min (184.41 kPa/min). Swine that developed neurologic DCI within 1 hour of surfacing were block randomized to one of four United States Navy Treatment Tables (USN TT): TT6, TT6A-air (21% oxygen, 79% nitrogen), TT6A-nitrox (50% oxygen, 50% nitrogen), and TT6A-heliox (50% oxygen, 50% helium). The primary outcome was the mean number of spinal cord lesions, which was analyzed following cord harvest 24 hours after successful recompression treatment. Secondary outcomes included spinal cord lesion incidence and gross neurologic outcomes based on a pre- and post-modified Tarlov assessment. We compared outcomes among these four groups and between the two treatment profiles (i.e., TT6 and TT6A). Results: One-hundred and forty-one swine underwent the insult dive, with 61 swine meeting inclusion criteria (43%). We found no differences in baseline characteristics among the groups. We found no significant differences in functional neurologic outcomes ($p=0.77$ and 0.33), spinal cord lesion incidence ($p = 0.09$ and 0.07), or spinal cord lesion area ($p=0.51$ and 0.17) among the four treatment groups or between the two treatment profiles, respectively. While the trends were not statistically significant, animals treated with TT6 had the lowest rates of functional deficits and the fewest spinal cord lesions. Moreover, across all animals, functional neurologic deficit had strong correlation with lesion area pathology (Logistic Regression, $p<0.01$, Somers' $D=0.74$). Conclusions: TT6 performed as well as the other treatment tables and is the least resource intensive. TT6 is the most appropriate initial treatment for neurologic DCI in swine, among the tables that we compared.

Lee YJ, Jung SK, Lee JH, Kang HD, Oh SH, Ban SD. Efficiency of a 24-hour on-call system for early recompression therapy for acute decompression sickness. Undersea Hyperb Med. 2022;49(4):507-18.

Background: Early recompression therapy is suggested for a better clinical outcome of decompression sickness (DCS) patients. This study analyzed the efficacy of our 24-hour on-call system for early recompression therapy. Methods: We conducted a single-center retrospective cohort study. They were classified into DCS Type I versus Type II, duty time versus non-duty time groups based on the time of emergency department (ED) admission, and hospitalization versus discharge groups according to clinical outcomes. Baseline characteristics, diving variables, and in-hospital course were analyzed. Results: This study investigated 341 acute DCS patients. A total of 81 and 260 patients had Type I and Type II DCS, respectively. While 198 patients accessed the center during duty time, 143 presented during non-duty time. Fifty patients were admitted, and 291 patients were discharged. Total median time from symptom onset to HBO_2 therapy was 259 min: 240 min for the duty group and 292 min for the non-duty group ($p=0.16$); 251 min for the discharged group and 291 min for the hospitalized group ($p<0.001$). The median time from ED admission to HBO_2 therapy was 65 min: 60 min for the duty group and 69 min for the non-duty group ($p=0.23$); 63.4 min for the discharged group and 92 min for the hospitalized group ($p=0.05$). Conclusion: The 24-hour on-call system was able to provide acute DCS patients with early recompression therapy even during non-duty time. However, in terms of the outcome of treatment of patients, quicker arrival at the hospital and swifter recompression therapy are needed.

Lindholm P, Lund H, Blogg L, Gennser M. Profound hypercapnia but only moderate hypoxia found during underwater rugby play. Undersea Hyperb Med. 2022;49(3):367-72.

Background: Underwater rugby is a team sport where players try to score points with a negatively buoyant ball while submerged in a swimming pool. Reports of syncope incidents at the Swedish Championships led to us to investigate end-tidal oxygen and carbon dioxide levels during simulated match play. Methods: Eight male underwater rugby club players of varying experience participated. Repetitive measurements were made while players were defending during simulated match play. Each time a player surfaced they exhaled through a mouthpiece connected to a flow meter and a gas analyzer to measure tidal volume, $P_{ET}O_2$ and $P_{ET}CO_2$. Results: Measurements were made over 12 dives, with an average dive duration of 18.5 seconds. The mean maximal $P_{ET}CO_2$ across the eight participants was 10.0 kPa (~75 mmHg) (range, 9.1-11.7 [~68-88]). The corresponding mean minimum PETO2 was 7.6 kPa (~57 mmHg) (6.3-10.4 [~47-78]). $P_{ET}CO_2$ drifted upward, with the mean upward change from the first to last dive for each participant being +1.8 (~13.5 mmHg) (SD 1.74) kPa. A similar trend for $P_{ET}O2$ was not detected, with a mean change of -0.1 (~0.75 mmHg) (SD 3.79) kPa. Conclusion: Despite high $P_{ET}CO_2$ values that were close to narcotic being recorded, these players seemed to regulate their urge to breathe based on hypoxia rather than hypercapnia.

McPhail S, Steed D, Holdsworth D, Nicol E, Bennett A, Phillips S. Development, design and experience of the UK Military's return to diving pathway following SARS-CoV-2 infection. BMJ Mil Health. 2022 Dec 29;e002327.

After the emergence of the SARS-CoV-2 virus in early 2020, it quickly became clear that symptomatic or asymptomatic infection had the potential to negatively impact on an individual's fitness to dive through effects on the respiratory, cardiovascular or neurological systems. The significance of these effects in the military diving environment was initially unclear due to an absence of data concerning incidence, chronology or severity. In order to safely return divers to the water and maintain operational capability, the UK Military developed a pathway for SARS-CoV-2 positive divers that stratified risk of sequelae and extent of required clinical investigation, while minimising reliance on viral testing and hospital-based investigations. We present this process, provide rationale and support for its design and detail the number of SARS-CoV-2 positive divers who have been returned to full diving fitness following infection of varying degrees of severity.

Millar IL, Lind FG, Jansson KA, Hájek M, Smart DR, Fernandes TD, McGinnes RA, Williamson OD, Miller RK, Martin CA, Gabbe BJ, Myles PS, Cameron PA; HOLLT investigator group. Hyperbaric oxygen for lower limb trauma (HOLLT): an international multi-centre randomised clinical trial. Diving Hyperb Med. 2022 Sep 30;52(3):164-74.

Introduction: Hyperbaric oxygen treatment (HBOT) is sometimes used in the management of open fractures and severe soft tissue crush injury, aiming to reduce complications and improve outcomes. Methods: Patients with open tibial fractures were randomly assigned within 48 hours of injury to receive standard trauma care or standard care plus 12 sessions of HBOT. The primary outcome was the incidence of necrosis or infection or both occurring within 14 days of injury. Results: 120 patients were enrolled. Intention to treat primary outcome occurred in 25/58 HBOT assigned patients and 34/59 controls (43% vs 58%, odds ratio (OR) 0.55, 95% confidence interval (CI) 0.25 to 1.18, P=0.12). Tissue necrosis occurred in 29% of HBOT patients and 53% of controls (OR 0.35, 95% CI 0.16 to 0.78, P=0.01). There were fewer late complications in patients receiving HBOT (6/53 vs 18/52, OR 0.22, 95% CI 0.08 to 0.64, P=0.007) including delayed fracture union (5/53 vs 13/52, OR 0.31, 95% CI 0.10 to 0.95, P=0.04). Quality of life measures at one and two years were superior in HBOT patients. The mean score difference in short form 36 was 2.90, 95% CI 1.03 to 4.77, P=0.002, in the short musculoskeletal function assessment (SMFA) was 2.54, 95% CI 0.62 to 4.46, P=0.01; and in SMFA daily activities was 19.51, 95% CI 0.06 to 21.08, P=0.05. Conclusions: In severe lower limb trauma, early HBOT reduces tissue necrosis and the likelihood of long-term complications, and improves functional outcomes. Future research should focus on optimal dosage and whether HBOT has benefits for other injury types.

Pandey K, Teguh DN, van Hulst RA. Effect of hyperbaric oxygen treatment on skin elasticity in irradiated patients. Diving Hyperb Med. 2022 Sep 30;52(3):208-12.

Background: Hyperbaric oxygen treatment (HBOT) is often used in an attempt to reverse/treat late radiation-induced tissue fibrosis (LRITF). This study aimed to quantify the effects on skin elasticity. Methods: Skin retraction time was used as a marker of skin elasticity in 13 irradiated breast cancer patients. The measurements were carried out on the affected side as well as the unaffected/healthy side at a mirrored location. Readings were taken at the start and end of HBOT (mean 43 sessions, 80 min at 243 kPa). Results: Patient age ranged from 39-70 years. All patients underwent surgical lumpectomy and radiotherapy prior to undergoing HBOT. The mean time between radiotherapy and HBOT was 70 months. Seven of the 13 patients underwent chemotherapy. Mean irradiated skin retraction time improved from 417 (SD 158) pre-HBOT to 171 (24) msec post-HBOT (P<0.001). Mean pre-HBOT retraction time in the non-irradiated skin was 143 (20) msec and did not change.

Conclusions: This promising pilot study that suggests that HBOT may improve skin elasticity in patients with LRITF.

Popa D, Kutz C, Carlile M, Brett K, Moya EA, Powell F, Witucki P, Sadler R, Sadler C. Hypoxia signatures in closed-circuit rebreather divers. Diving Hyperb Med. 2022 Dec 20;52(4):237-44.

Introduction: Faults or errors during use of closed-circuit rebreathers (CCRs) can cause hypoxia. Military aviators face a similar risk of hypoxia and undergo awareness training to determine their 'hypoxia signature', a personalised, reproducible set of symptoms. We aimed to establish a hypoxia signature among divers, and to investigate their ability to detect hypoxia and self-rescue while cognitively overloaded. Methods: Eight CCR divers and 12 scuba divers underwent an initial unblinded hypoxia exposure followed by three trials; a second hypoxic trial and two normoxic trials in randomised order. Hypoxia was induced by breathing on a CCR with no oxygen supply. Subjects pedalled on a cycle ergometer while playing a neurocognitive computer game to simulate real world task loading. Subjects identified hypoxia symptoms by pointing to a board listing common hypoxia symptoms, and were instructed to perform a 'bailout' procedure to mimic self-rescue if they perceived hypoxia. Divers were prompted to bailout if peripheral oxygen saturation fell to 75%, or after six minutes during normoxic trials. Subsequently we interviewed subjects to determine their ability to distinguish hypoxia from normoxia. Results: Ninety-five percent of subjects (19/20) showed agreement between unblinded and blinded hypoxia symptoms. Subjects correctly identified the gas mixture in 85% of the trials. During unblinded hypoxia, only 25% (5/20) of subjects performed unprompted bailout. Fifty-five percent of subjects (11/20) correctly performed the bailout but only when prompted, while 15% (3/20) were unable to bailout despite prompting. During blinded hypoxia 45% of subjects (9/20) performed the bailout unprompted while 15% (3/20) remained unable to bailout despite prompting. Conclusions: Although our data support a normobaric hypoxia signature among both CCR and scuba divers under experimental conditions, most subjects were unable to recognise hypoxia in real time and perform a self-rescue unprompted, although this improved in the second hypoxia trial. These results do not support hypoxia exposure training for CCR divers.

Siewiera J, Brodaczewska K, Jermakow N, Lubas A, Klos K, Majewska A, Kot J. Effectiveness of hyperbaric oxygen therapy in SARS-CoV-2 pneumonia: the primary results of a randomised clinical trial. J Clin Med. 2022 Dec 20;12(1):8.

Mortality in COVID-19 is mainly associated with respiratory failure, cytokine storm, and macrophage activation. Oxygenation and anti-inflammatory effects of hyperbaric oxygen therapy (HBOT) suggest that it is a promising adjunct treatment for COVID-19. Repeated sessions of HBO with standard COVID-19 therapy were used to reduce the inflammation and increase oxygenation. We evaluated the safety and efficacy of HBOT in avoiding the replacement ventilation and/or ECMO and its effect on the inflammatory process. Twenty-eight moderate-to-severe COVID-19 patients were randomized into control or HBOT group. HBOT patients participated in 5 hyperbaric sessions (60 min). Before and after each session blood gas levels and vital parameters were monitored. Blood samples were collected for extended biochemical tests, blood morphology and immunological assays. There were 3 deaths in the control, no deaths in the HBOT group. No adverse events leading to discontinuation of HBOT were observed and patients receiving HBOT required lower oxygen delivery. We observed decrease in CRP, ferritin and LDH and increase in CD_3 in HBOT group compared to control. This study confirmed the feasibility and safety of HBOT in patients with COVID-19 and indicated HBOT can lead to alleviation of inflammation and partial restoration of T cell responses.

CUHMA-ACMHS is the Canadian voice for the advancement of hyperbaric and diving medicine throughout our country and beyond. Our activities include continuous medical education for physicians, nurses, respiratory therapists and anyone involved in the fields of hyperbaric and diving medicine. We are also promoting dissemination of clinical research, publishing position statements, liaising with related professional associations and government agencies. Our main goal is advocating on behalf of our patients. Our vision is to be the reference for the development and delivery of hyperbaric and diving medicine in Canada and beyond. Our mission is to promote excellence in hyperbaric and diving medicine through leadership in education, promotion of best practices and advocacy for our patients. Our values are excellence, leadership, collaboration, communication, and integrity.

Canadian Undersea and Hyperbaric Medical Association

10 Plumtree Place, Portugal Cove-St. Philips,
Newfoundland and Labrador, A1M 3T1
info@cuhma.ca https://cuhma.ca

Editor: Neal W. Pollock, PhD - neal.pollock@kin.ulaval.ca