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

E-NEWS

EDITOR'S NOTE – October 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. Direct correspondence to info@cuhma.ca.

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NEWS/ANNOUNCEMENTS

CUHMA Member Profile Updates

All CUHMA members are asked to logon through the online portal (https://cubhma.ca) and ensure that member profile information is current, including address preferences for electronic communications.

UMC Level 1 Dive Medicine Course Completion

A group of physicians came from across Canada to complete an Undersea Medicine Canada Level 1 course held in Quebec City and at the hyperbaric unit of Hôtel-Dieu de Lévis. The graduates will be added to the Diver Certification Board of Canada roster of physicians qualified to conduct the medical examination of commercial divers (two faculty members missing from the photo).

UPCOMING EVENTS

DEMA Show 2023

The Diving Equipment & Marketing Association (DEMA) show will be held November 14-17 at the Ernest N Morial Convention Center in New Orleans, LA. This is a popular industry event. Visit: https://www.demashow.com.

RECENT PUBLICATIONS

Dokmak A, Sweigart B, Orekondy NS, Jangi S, Weinstock JV, Hamdeh S, Kochar GS, Shen B, Levy AN. Efficacy and safety of hyperbaric oxygen therapy in fistulizing Crohn's disease: a systematic review and meta-analysis. J Clin Gastroenterol. 2023 Sep 11. doi: 10.1097/MCG.0000000000001905. Online ahead of print.

Background: Hyperbaric oxygen therapy (HBOT) delivers 100% oxygen in a pressurized chamber, increasing tissue oxygen levels and regulating inflammatory pathways. Mounting evidence suggests that HBOT may be effective for inflammatory bowel disease. Our systematic review and meta-analysis aimed to quantify the efficacy and safety of HBOT in fistulizing Crohn's disease (CD). Methods: A systematic review was conducted using the EMBASE, Web of Science, Pubmed, and Cochrane Library databases according to the "Preferred Reporting Items for Systematic Reviews and Meta-analyses" criteria. Study bias was assessed using the Cochrane Handbook guidelines. Results: Sixteen studies with 164 patients were included in the analysis. For all fistula subtypes, the pooled overall clinical response was 87% (95% CI: 0.70-0.95, I2=0) and the pooled clinical remission was 59% (95% CI: 0.35-0.80, I2=0). The overall clinical response was 89%, 84%, and 29% for perianal, enterocutaneous, and rectovaginal fistulas, respectively. On meta-regression, hours in the chamber and the number of HBOT sessions were not found to correlate with clinical response. The pooled number of adverse events was low at 51.7 per 10,000 HBOT sessions for all fistula types (95% CI: 16.8-159.3, I2=0). The risk of bias was observed across all studies. Conclusion: HBOT is a safe and potentially effective treatment option for fistulizing CD. Randomized control trials are needed to substantiate the benefit of HBOT in fistulizing CD.

Islam Y, Spears M, Brennan M, Pitkin A, Covington D. Effect of drysuit seals on intraocular pressure in non-immersed scuba divers. Undersea Hyperb Med. 2023; 50(3): 307-12.

Objective: This study quantifies the change in intraocular pressure (IOP) secondary to wearing neck seals in scuba diving drysuits. Previous work demonstrates significant pressures exerted by these seals; we hypothesize that they would. Methods: IOP was measured in 33 divers before and while wearing a drysuit using rebound tonometry. The drysuit neck seal pressures were measured using a manometer. A paired two-sample t-test was used to compare IOP before and after drysuit donning. Pearson correlation coefficients were calculated between neck sealing pressures and IOP by side. Results: The mean IOP in the right eye was similar pre- and post-drysuit donning, with baseline mean 15.9 mmHg (3.7 mmHg) versus 15.4 mmHg (4.3 mmHg) post-donning, p=0.41. Similarly, the mean IOP in the left eye was also similar, with mean pre-donning IOP 15.6 (3.8 mmHg) versus 15.4 mmHg (4.7 mmHg) post-donning, p=0.75. The mean right and left neck seal pressures were 23.66 (10.60) mmHg and 23.67 (7.87) mmHg, respectively. Only the correlation between right neck sealing pressure for silicone neck seals and right IOP, pre- and post-donning was significant (pre: 0.97, p-value 0.03, post: 0.98, p-value 0.02). Conclusion: No significant difference overall was detected in IOP with drysuit donning.

Lutter C, Gräber S, Jones G, Groß J, Tadda L, Tischer T. Epidemiology of acute and overuse injuries in underwater rugby. Orthop J Sports Med. 2023; 11(8): 23259671231181582. doi: 10.1177/23259671231181582.

Background: Underwater rugby (UWR) is a team sport. Athletes require a high degree of strength, endurance, speed, and coordination involving intense physical contact. Currently, a paucity of literature exists regarding injury occurrence in UWR. Purpose: To examine the nature and prevalence of acute and overuse injuries in UWR. Study design: Descriptive epidemiology study. Methods: Between November 2020 and March 2021, a total of 720 German UWR athletes were invited to take an online survey developed by orthopaedic specialists with UWR athletes. Data were recorded regarding general and health-related information, training habits, acute injuries that necessitated an interruption in training and/or doctor consultation, as well as overuse injuries. Overuse injuries were evaluated using the Oslo Sports Trauma Research Centre Overuse Injury Questionnaire. Statistical analyses included t tests or rank sum tests depending on normality of distribution. A nonparametric Kruskal-Wallis 1-way analysis of variance on ranks was used for nonnormally distributed data among several groups. Results: This study included 161 active athletes (mean±SD, 36.1±11.9 years old; 75.3% male) for analysis, of whom 90.1% were competing regularly. The performance-level distribution was as follows: first German national league (n=73), second German national league (n = 46), state league (n=17), district league (n=1), and no league (n=24). The mean±SD sport-specific training workload was 5.6±3.0 h/wk, including UWR training, additional swimming (n=71; 44.1%), strength (n=70; 43.5%), and/or endurance training (n=102; 63.4%). Acute injuries were recorded in 78.9% of all athletes. The most typical locations for acute injuries were hand/finger (42.4%), head/face (concussion, ruptured eardrum; 18.1%), wrist (5.5%), or spine (5.0%). Overuse injuries were reported by 42.9% of the participants. The predominant locations for overuse injuries were hand/finger (18.8%), shoulder/clavicle (14.1%), spine and wrist (10.7% each), head/face (8.7%), and ankle joint and knee (6.7% each). Conclusion: In the current study, 3 of 4 athletes reported at least 1 acute injury, and 2 of 5 athletes reported at least 1 overuse injury. Leading injury regions were the hand/finger, head/ear, wrist, and spine.

Marjot J, Mackenzie J, Jepson N, Reeves E, Bennett M. Investigation into the effect of hyperbaric hyperoxia on serum cardiac Troponin T levels as a biomarker of cardiac injury. Diving Hyperb Med. 2023 Sep 30;53(3):281-4. doi: 10.28920/dhm53.3.281-284.

Introduction: There is clinical equipoise as to whether hyperoxia is injurious to the myocardium, both in the setting of acute ischaemic insults and on the stable myocardium. This study examined the effect of extreme hyperoxia - in the form of hyperbaric oxygen treatment - on the myocardium through measurement of high-sensitivity cardiac troponin. Methods: Forty-eight individuals were enrolled to undergo a series of 30 exposures to hyperbaric oxygen for treatment of non-cardiac pathologies. High-sensitivity troponin T was measured before and after each session. Results: There was no clinically significant difference in troponin measurements following acute or recurrent sequential exposures to extreme hyperoxia, despite the studied patient population having a high rate of previous ischaemic heart disease or cardiovascular risk factors. Conclusions: This study demonstrates that profound hyperoxaemia does not induce any measurable cardiac injury at a biochemical level. Neither is there a reduction in cardiac troponin to suggest a cardioprotective effect of hyperbaric hyperoxia. This provides some reassurance as to the cardiac safety of the routine use of hyperbaric oxygen treatment in management of non-cardiac pathology.

Neiberger RJ, Waters ET. Hyperbaric oxygen treatment for paracentral acute middle maculopathy: a case study. Undersea Hyperb Med. 2023; 50(3): 283-7.

A 47-year-old active-duty Navy diver with a complicated past medical history which resulted in his designation as not physically qualified (NPQ) for diving duty in 2016 presented on 07 May 2021 complaining of left-sided

blurred vision. On exam by the attending undersea medical officer, he was found to have a left upper inner and upper outer quadrant visual field defect and a central scotoma. Urgent referral to ophthalmology ruled out retinal detachment but resulted in an initial diagnosis of a left branch retinal artery occlusion without embolus. Considering this a variant of central retinal artery occlusion, hyperbaric oxygen (HBO2) therapy was initiated approximately 12 hours after symptom onset, resulting in complete, though temporary, resolution of the visual field defect. He reported that after completion of his first HBO2 treatment, his visual field deficit began to return, but the deficit again resolved after initiating surface oxygen therapy between HBO2 treatments. After two days of continuous surface oxygen and daily HBO2 treatments, which minimized his visual field defect, his deficits changed to a persistent left lateral peripheral defect and a recurrent central nasal defect. At this time, his periodic ophthalmology evaluation revised his diagnosis to cilioretinal artery occlusion (CrAO). Further evaluation by ophthalmology revealed retinal changes consistent with a secondary diagnosis of paracentral acute middle maculopathy (PAMM), an ophthalmologic condition only recently defined in the literature (2013) [10] secondary to advances in retinal imaging technology. This case is presented to share the findings of this complicated case and to postulate a benefit from using HBO2 for cilioretinal artery occlusion with PAMM.

Paganini M, Moon RE, Giacon TA, Cialoni D, Martani L, Zucchi L, Garetto G, Talamonti E, Camporesi EM, Bosco G. Relative hypoxemia at depth during breath-hold diving investigated through arterial blood gas analysis and lung ultrasound. J Appl Physiol (1985). 2023 Aug 31. doi: 10.1152/japplphysiol.00777.2022.

Pulmonary gas exchange in breath-hold diving (BHD) consists of a progressive increase in arterial PO_2 and PCO_2 (P_aO_2 and P_aCO_2) during descent. However, recent findings have demonstrated that PaO2 does not consistently rise in all subjects. This study aimed at verifying and explaining P_aO_2 derangements during BHD analyzing arterial blood gases and searching for pulmonary alterations with lung ultrasound. After ethical approval, 14 fit breath-hold divers were included. Experiments were performed in warm water (temperature: 31°C). We analyzed arterial blood gases immediately before, at depth, and immediately after a breath-hold dive - to -15 meters of fresh water (mfw) and -42 mfw. Signs of lung interstitial edema and atelectasis were searched simultaneously with a marinized lung ultrasound. In 5 subjects (-15 mfw) and 4 subjects (-42 mfw) the P_aO_2 at depth seems to decrease instead of increasing. P_aCO_2 and lactate showed slight variations. At depth, no lung ultrasound alterations were seen except in one subject (hypoxemia and B-lines at -15 mfw; B-lines at the surface). Lung interstitial edema was detected in 3 and 12 subjects after resurfacing from -15 mfw and -42 mfw, respectively. Two subjects developed hypoxemia at depth and a small lung atelectasis (a focal pleural irregularity of triangular shape, surrounded by thickened B lines) after resurfacing from -42 mfw. Current experiments confirmed that some BH divers can experience hypoxemia at depth. The hypothesized explanation for such a discrepancy is lung atelectasis, which could not be detected in all subjects probably due to limited time available at depth.

Querido AL, Ebbelaar CF, Wingelaar TT. Diving with psychotropic medication: review of the literature and clinical considerations. Diving Hyperb Med. 2023;53(3):259-67. doi: 10.28920/dhm53.3.259-267.

This review discusses the safety concerns associated with diving while using psychotropic medication and the limited literature available on the topic. Despite the risks, some divers continue to dive while taking these medications, and their reasons for doing so are unclear. The exact mechanisms of action of these drugs in hyperbaric environments are poorly understood. While current standards and advice for fitness-to-dive assessments are based on limited evidence and expert opinion, developing evidence-based strategies could improve patient care and optimise diving safety. This review appraises relevant literature in diving medicine and provides clinical perspectives for diving physicians conducting fitness-to-dive assessments on patients using psychotropic medication.

Risberg J, van Ooij PJ, Matity L. From UPTD to ESOT: monitoring hyperoxic exposure in surface-oriented diving. Undersea Hyperb Med. 2023; 50(3): 301-6.

A recent review suggested that the measure $K = t^2 \times PO_2$ [4.57] (t is exposure time in h, PO in atm) should replace unit pulmonary toxic dose (UPTD) as an exposure index for pulmonary oxygen toxicity (POT) in surface-oriented diving. K would better predict reduction in vital capacity (VC) during exposure and allow prediction of recovery. Although K is more accurate estimating VC changes than UPTD, the calculation of K is more extensive, particularly when estimating hyperoxic exposure for dives with multiple PO_2 segments. Furthermore, and in contrast with UPTD, K is difficult to interpret on its own given its non-linear dimension of time. We suggest that a new metric: ESOT (equivalent surface oxygen time) should be used to replace UPTD. $ESOT = t \times PO_2$ [2.285] (t is exposure time in minutes, PO in atm). ESOT=1 is thus the hyperoxic exposure reached after one minute of breathing 100% O_2 at surface pressure. Hyperoxic monitoring by ESOT is more practical than K to apply in an operational environment, with no loss of accuracy in POT prediction. In addition, it intuitively allows interpreting hyperoxic exposures on its own, analogous to UPTD. The daily hyperoxic threshold limits suggested by Risberg and van Ooij for two, five and an unlimited number of successive diving days would translate to ESOTs of 650, 500 and 420, respectively.

Simonnet B, Roffi R, Lehot H, Morin J, Druelle A, Daubresse L, Louge P, de Maistre S, Gempp E, Vallee N, Blatteau JE. Therapeutic management of severe spinal cord decompression sickness in a hyperbaric center. Front Med (Lausanne). 2023 Sep 8;10:1172646. doi: 10.3389/fmed.2023.1172646. eCollection 2023.

Introduction: Spinal cord decompression sickness (scDCS) unfortunately has a high rate of long-term sequelae. The purpose of this study was to determine the best therapeutic management in a hyperbaric center and, in particular, the influence of hyperbaric treatment performed according to tables at 4 atm (Comex 30) or 2.8 atm abs (USNT5 or T6 equivalent). Methods: This was a retrospective study that included scDCS with objective sensory or motor deficit affecting the limbs and/or sphincter impairment seen at a single hyperbaric center from 2010 to 2020. Information on dive, time to recompression, and in-hospital management (hyperbaric and medical treatments such as lidocaine) were analyzed as predictor variables, as well as initial clinical severity and clinical deterioration in the first 24 h after initial recompression. The primary endpoint was the presence or absence of sequelae at discharge as assessed by the modified Japanese Orthopaedic Association score. Results: 102 divers (52±16 years, 20 female) were included. In multivariate analysis, high initial clinical severity, deterioration in the first 24 h, and recompression tables at 4 atm versus 2.8 atm abs for both initial and additional recompression were associated with incomplete neurological recovery. Analysis of covariance comparing the effect of initial tables at 2.8 versus 4 atm abs as a function of initial clinical severity showed a significantly lower level of sequelae with tables at 2.8 atm. In studying correlations between exposure times to maximum or cumulative O_2 dose and the degree of sequelae, the optimal initial treatment appears to be a balance between administration of a high partial pressure of O_2 (2.8 atm) and a limited exposure duration that does not result in pulmonary oxygen toxicity. Further analysis suggests that additional tables in the first 24-48 h at 2.8 atm abs with a Heliox mixture may be beneficial, while the use of lidocaine does not appear to be relevant. Conclusion: Our study shows that the risk of sequelae is related not only to initial severity but also to clinical deterioration in the first 24 h, suggesting the activation of biological cascades that can be mitigated by well-adapted initial and complementary hyperbaric treatment.

St Peter D, Na D, Sethuraman K, Mathews MK, Li AS. Hyperbaric oxygen therapy for central retinal artery occlusion: Visual acuity and time to treatment. Undersea Hyperb Med. 2023; 50(3): 253-64.

Purpose: To evaluate the effectiveness of hyperbaric oxygen (HBO_2) therapy as a treatment for central retinal artery occlusion (CRAO). Methods: A total of 38 patients who underwent HBO_2 for non-arteritic CRAO were identified. Patients with arteritic CRAO, branch retinal artery occlusion, ophthalmic artery occlusion, and other diagnoses were excluded from the analysis. The main outcome measured was the change in visual acuity at the most recent follow-up exam compared to the visual acuity at presentation before the initiation of HBO_2 therapy. Results: The overall visual acuity after HBO_2 compared with the visual acuity at presentation showed a mean improvement of 0.5 logMAR from 2.2 to 1.7 logMAR ($p=0.0003$). Patients who presented with hand motion and light perception vision had a mean improvement of 0.4 logMAR ($p=0.06$) and 0.8 logMAR ($p=0.004$) after HBO_2, respectively. An average visual acuity improvement of 0.5 logMAR ($p=0.01$) was observed when patients underwent HBO_2 earlier than 24 hours of symptom onset. This mean improvement increased to 0.9 logMAR ($p=0.009$) if HBO_2 was initiated within eight hours. Conclusions: HBO_2 may be an effective treatment for non-arteritic CRAO, especially if patients are treated early and present with salvageable vision. The time to treatment and the presenting visual acuity may be predictive factors on the visual prognosis following HBO_2. Further studies with a prospective design and more patients are necessary to determine the long-term outcomes and the optimal protocol for HBO_2 in CRAO patients.

Tanaka HL, Medak AJ, Duchnick J, Lindholm P. Wireless point-of-care ultrasound in a multiplace hyperbaric chamber. Undersea Hyperb Med. 2023; 50(3): 265-72.

Background: Electronic devices remain highly restricted from use during hyperbaric oxygen (HBO2) treatment due to risk of fire in a pressurized, oxygen-rich environment. Over recent decades, point-of- care ultrasound (POCUS) has established utility in most clinical environments except hyperbaric chambers, where only heavily modified POCUS devices have been used. This study evaluated proof of concept, safety, and performance of a wireless off-the-shelf handheld POCUS device in the hyperbaric environment. Materials and methods: The GE Vscan Air was initially tested in a Class C chamber with 100% nitrogen up to 4.0 ATA and monitored. Second, the Vscan Air was paired with an encased Apple iPad, tested previously for hyperbaric use, and both were pressurized to 2.4 ATA in a Class A chamber (21% oxygen) and evaluated. Similarly, it was then tested at 2.8 ATA and also paired wirelessly with an iPad outside the chamber. Device temperature, image quality, functionality, and wireless connection were tested continuously. Results: The GE Vscan Air automatically shut off due to power button depression during initial compression; thus the power button was punctured with an 18-gauge needle to equalize gas pressure. Thereafter, the system performed well throughout all tests without degradation in function or image quality. The device did not overheat nor reach temperatures concerning for fire hazard. Further, wireless connection to out-of-chamber devices was maintained.

Conclusions: Our results suggest that the GE Vscan Air can be used with minor modification in a multi- place hyperbaric chamber. Wireless functionality allows for pairing with a screen and device outside the chamber.

Velej V, Cankar K, Vidmar J. The effects of normobaric and hyperbaric oxygenation on MRI signal intensities in T1-weighted, T2-weighted and FLAIR images in human brain. Radiol Oncol. 2023;57(3):317-24. doi: 10.2478/raon-2023-0043. eCollection 2023 Sep 1.

Background: Dissolved oxygen has known paramagnetic effects in magnetic resonance imaging (MRI). The aim of this study was to compare the effects of normobaric oxygenation (NBO) and hyperbaric oxygenation (HBO) on human brain MRI signal intensities. Patients and methods: Baseline brain MRI was performed in 17 healthy subjects (mean age 27.8±3.2). MRI was repeated after exposure to the NBO and HBO at different time points (0 min, 25 min, 50 min). Signal intensities in T1-weighted, T2-weighted images and fluid attenuated inversion recovery (FLAIR) signal intensities of several intracranial structures were compared between NBO and HBO. Results: Increased T1-weighted signal intensities were observed in white and deep grey brain matter, cerebrospinal fluid (CSF), venous blood and vitreous body after exposure to NBO as well as to HBO compared to baseline (Dunnett's test, $p<0.05$) without significant differences between both protocols. There was also no significant difference in T2-weighted signal intensities between NBO and HBO. FLAIR signal intensities were increased only in the vitreous body after NBO and HBO and FLAIR signal of caudate nucleus was decreased after NBO (Dunnett's test, $p<0.05$). The statistically significant differences in FLAIR signal intensities were found between NBO and HBO (paired t-test, $p<0.05$) in most observed brain structures (paired t-test, $p<0.05$). Conclusions: Our results show that NBO and HBO alters signal intensities T1-weighted and FLAIR images of human brain. The differences between NBO and HBO are most pronounced in FLAIR imaging.

Weaver LK, Deru K, Churchill S, Russo A. A randomized trial of one versus three hyperbaric oxygen sessions for acute carbon monoxide poisoning. Undersea Hyperb Med. 2023; 50(3): 325-42.

Introduction: Hyperbaric oxygen (HBO_2) improves outcome in patients with acute carbon monoxide (CO) poisoning, but optimal dose/timing are unknown. In this double-blind, sham-controlled randomized trial, we compared neuropsychological sequelae at six weeks and six months in patients receiving three HBO_2 sessions or one HBO_2 session and two sham chamber sessions after acute CO poisoning. Methods: After completing one HBO_2 session (3.0 ATA, 60 minutes, 2.0 ATA, 65 minutes), CO-poisoned patients were randomized (1:1): two sham chamber sessions (1 ATA air, 120 minutes) or two additional HBO_2 sessions (2.0 ATA, 90 minutes at pressure, 120 minutes in chamber) completed within 24 hours. Eligible patients were >24 hours from accidental poisoning, English-speaking, and not intubated. We planned 150 participants. Results: The study was stopped early for enrollment futility. From 2006 to 2016, we screened 395 patients: 136 were deemed eligible to participate, and 75 signed informed consent. Two were later withdrawn for past brain injury/PTSD (one sham, one HBO_2), and one for performance validity (sham). Of the 72 analyzed, mean age was 42±15 years, 40 (56%) were male, 20 (28%) had loss of consciousness, and mean initial carboxyhemoglobin was 22±9%. The rate of six-week neuropsychological sequelae was 50% in the one-HBO_2 session group and 55% in the three-HBO_2 sessions group ($p=0.80$), and at six months was 42% versus 46%, respectively ($p=0.76$). Conclusions: There was no difference in the rate of neuropsychological sequelae in those who received three HBO_2 sessions and those who received one HBO_2 sessions and two sham sessions. The higher rate of neuropsychological sequelae compared to an earlier study may be due to neuropsychological test-retest effects or previously identified risk factors for cognitive sequelae (age, duration of poisoning, cerebellar dysfunction). This study's rates of cognitive difficulties, affective complaints, and other symptoms suggest brain injury after CO poisoning is common.

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.

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