

E-NEWS

EDITORIAL NOTE – January 2018

Welcome to the inaugural issue of E-News, a new monthly newsletter of CUHMA to share news items and links. We invite your comments and content. We welcome new publication abstracts, news, announcements, job postings, and images of underwater work. Please submit items by the 25th of each month for inclusion in the next release. Past issues of E-News will be available online at <https://cuhma.ca>, serving an ongoing role as an information repository. You should also check out our website for the expanding content coming this year. Finally, remember to reserve November 01-04 for our 2018 annual scientific meeting in Quebec City.

Neal W. Pollock

NEWS/ANNOUNCEMENTS

Call for Abstracts – CUHMA 2018

Both research and review session abstracts will be considered for the 2018 CUHMA annual scientific meeting. The submission deadline is May 15, 2018. Decisions will be returned to corresponding authors by July 15. Proposals and abstracts can be brief, with appropriate titles and 100-150 word descriptions.

STUDENT OPPORTUNITIES

Doctoral Studies in Diving Research

Active recruitment is underway at Université Laval for qualified students wanting to pursue doctoral studies in environmental physiology. The research focus is health and safety in extreme environments, with concentration in decompression stress, monitoring technology, and diver safety. Students will also gain experience with a variety of studies in hyperbaric medicine. Current efforts are funded by the Canadian Institutes of Health Research, Reseau Quebec Maritime, and the Canadian Space Agency. This opportunity is open to highly motivated individuals wanting to dedicate their educational efforts to environmental physiology. Contact Dr. Neal Pollock (neal.pollock@kin.ulaval.ca) for more information. Inquiries would best include concise CVs and a description of key interests and goals.

UPCOMING EVENTS

Hyperbaric Medicine Technologist Course

The Environmental Medicine and Physiology Unit at Simon Fraser University is offering a Hyperbaric Medicine Technologist course February 12-24, 2018. For more information, visit: <http://www.sfu.ca/science/faculty-support/facilities-services/empu/courses/hyperbaric-medical-technologist.html>.

Cold Water Working Diver Workshop

The Cold Water Working Diver workshop will be held March 12-14 in Rimouski, QC. Contact Neal Pollock (neal.pollock@kin.ulaval.ca) for more information.

TEKDiveUSA

TekDiveUSA will be held April 27-28, 2018 in Orlando, FL. This is a biennial advanced and technical diving conference that will draw over 35 USA and overseas specialist companies and offer a wide range of talks and workshops focused on advanced and technical diving, including operational diving, physiology, safety and imaging. For more details, visit: <https://tekdiverusa.com>.

UMC Diving and Hyperbaric Medicine Course

The 3rd Undersea Medicine Canada Introductory Course in Diving Medicine - Fitness to Dive program will be held May 07-11, 2018 in Quebec City and Lévis, QC. 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 from the College of Family Physicians of Canada. For more information, contact Debbie Pestell (drdeb1@ns.sympatico.ca; 902-225-8214) or visit: <https://underseamedicine.ca>.

UHMS Annual Scientific Meeting

The Undersea and Hyperbaric Medical Society (UHMS) annual scientific meeting will be held June 28-30, 2018 in Orlando, FL. Visit: <https://www.uhms.org>. Note: CUHMA members are eligible to receive a 50% discount on UHMS annual membership dues.

CUHMA Annual Scientific Meeting 2018

The 2018 CUHMA ASM will be held in Quebec, QC November 01-04, 2018, hosted by Université Laval and Hôtel-Dieu de Lévis. Two days of workshops will be followed by two days of science talks. Additional events include board and business meetings, and networking sessions. Tentatively planned workshops include:

- Hyperbaric emergency training simulation (HETS)
- 2D ultrasound for decompression research
- Transcutaneous oxygen monitoring (TCOM)
- Problem wound management

An evening reception will be held on November 02 and a banquet on November 03. Visit our website for updates and future registration: <https://cuhma.ca>.

RECENT PUBLICATIONS

Berry NT, Wideman L, Rhea CK, Labban JD, Chon KH, Shykoff BE, Harran J, Florian JP. Effects of prolonged and repeated immersions on heart rate variability and complexity in military divers. *Undersea Hyperb Med.* 2017; 44(6):589-600.

BACKGROUND: The influence of prolonged and repeated water immersions on heart rate variability (HRV) and complexity was examined in 10 US Navy divers who completed six-hour resting dives on five consecutive days. Pre-dive and during-dive measures were recorded daily. **METHODS:** Dependent variables of interest were average heart rate (HR), time-domain measures of HRV [root mean square of successive differences of the normal RR (NN) interval (RMSSD), standard deviation of the NN interval (SDNN)], frequency-domain measures of HRV [low-frequency power spectral density (psd) (LFpsd), low-frequency normalized (LFnu), high-frequency psd (HFpsd), high-frequency normalized (HFnu), low-

frequency/ high-frequency ratio (LF/HF)], and non-linear dynamics of HRV [approximate entropy (ApEn)]. A repeated-measures ANOVA was performed to examine pre-dive measure differences among baseline measures. Hierarchical linear modeling (HLM) was performed to test the effects of prolonged and repeated water immersion on the dependent variables. **RESULTS:** Pre-dive HR ($P=0.005$) and RMSSD ($P<0.001$) varied significantly with dive day while changes in SDNN approached significance ($P=0.055$). HLM indicated that HR decreased during daily dives ($P=0.001$), but increased across dive days ($P=0.011$); RMSSD increased during daily dives ($P=0.018$) but decreased across dive days ($P<0.001$); SDNN increased during daily dives ($P<0.001$); LF measures increased across dive days (LFpsd $P<0.001$; LFnu $P<0.001$), while HF measures decreased across dive days (HFpsd $P<0.001$; HFnu $P<0.001$); LF/HF increased across dive days ($P<0.001$); ApEn decreased during daily dives ($P<0.02$) and across dive days ($P<0.001$). **CONCLUSIONS:** These data suggest that the cumulative effect of repeated dives across five days results in decreased vagal tone and a less responsive cardiovascular system.

Billaut F, Gueit P, Faure S, Costalat G, Lemaitre F. Do elite breath-hold divers suffer from mild short-term memory impairments? *Appl Physiol Nutr Metab.* 2017 Oct 20. doi: 10.1139/apnm-2017-0245. [Epub ahead of print]

Repeated apneas are associated with severe hypoxemia that may ultimately lead to loss of consciousness in some breath-hold divers. Despite increasing number of practitioners, the relationship between apnea-induced hypoxia and neurocognitive functions is still poorly understood in the sport of free diving. To shed light onto this phenomenon, we examined the impact of long-term breath-hold diving training on attentional processing, short-term memory, and long-term mnemonic and executive functions. Thirty-six men matched for age, height and weight were separated into three groups [12 elite breath-hold divers (EBHD, mean static apnea best time 371 sec, 105 months mean apnea experience); 12 novice breath-hold divers (NBHD, mean best time 243 sec, 8.75 months mean apnea experience); and 12 physical education students with no breath-hold diving experience (CTRL)], and performed varied written and computerized neuropsychological tasks. Compared with the two other groups, EBHD were slower to complete the interference card during a Stroop test ($F(1,33)=4.70$, $p<0.05$), and presented more errors on the interference card ($F(1,33)=2.96$, $p<0.05$) and a lower total interference score ($F(1,33)=5.64$, $p<0.05$). The time to complete the interference card test was positively correlated with maximal static apnea duration ($r=0.73$, $p<0.05$) and the number of years of breath-hold diving training ($r=0.79$, $p<0.001$). These findings suggest that breath-hold diving

training over several years may cause mild, but persistent, short-term memory impairments.

Elder MJ, Rawstron JA, Davis M. Hyperbaric oxygen in the treatment of acute retinal artery occlusion. *Diving Hyperb Med.* 2017; 47(4):233-8.

INTRODUCTION: Acute retinal artery occlusion (ARAO) is a major cause of sudden, painless visual loss, often leaving no useful vision in the affected eye. Its incidence is cited at 0.85 per 100,000 persons per year but may be higher because of under-reporting. The natural history is difficult to study, but a spontaneous resolution rate of < 1-8% for acute, non-arteritic ARAO has been cited. Occurrence in an only eye is devastating for the patient. There is currently no consensus regarding management of ARAO and little evidence to support any treatment modality. Despite only limited case series, hyperbaric oxygen treatment (HBOT) is recommended for ARAO by the Undersea and Hyperbaric Medical Society (UHMS) and by the European Committee for Hyperbaric Medicine. **METHODS:** Between early 2003 and December 2012, all ARAO patients presenting to Christchurch Hospital were referred for consideration of HBOT. These 31 consecutive patients' medical records were reviewed retrospectively. The time delay from onset of visual loss to commencing HBOT; the presenting visual acuity; various demographic data; the HBOT administered and the outcome visual acuity were documented. **RESULTS:** All 31 patients underwent at least one HBOT (median 4, range 1-7) at a pressure of 203-284 kPa for 1.5 to 2.0 h. One patient's treatment was terminated after 60 min at their request; another declined further HBOT and one suffered middle ear barotrauma. Thirteen patients also received anticoagulants at the discretion of the referring ophthalmologist. Twenty-three patients had temporarily improved vision with the first HBOT. Seven patients had permanent, good visual recovery (6/18 or better; Snellen chart); and two only modest improvement (6/60). All nine patients who improved permanently were treated within 10 hours of symptom onset. **CONCLUSIONS:** Where available, HBOT is indicated for ARAO. Our protocol may not have been aggressive enough and the UHMS protocol is recommended. A multi-centre, randomised controlled trial is feasible, but would be logistically difficult and expensive and may be ethically unsupportable given the lack of alternative, effective treatments.

Henzel J, Rudziński PN, Kłopotowski M, Konka M, Dzielińska Z, Demkow M. Transcatheter closure of patent foramen ovale for the secondary prevention of decompression illness in professional divers: a single center experience with long-term follow-up. *Kardiol Pol.* 2017 Oct 5. doi: 10.5603/KP.a2017.0182. [Epub ahead of print]

BACKGROUND: Patent foramen ovale (PFO) with occasional right-to-left shunting is associated with an

increased risk of decompression illness (DCI). Divers with a history of repetitive or severe DCI and diagnosed with PFO should be considered for transcatheter closure if they wish to continue with unrestricted diving. **AIM:** To summarize our center's experience in transcatheter PFO closure in professional divers with the history of DCI. **METHODS:** A follow-up of 11 consecutive divers (9 males, 2 females) in whom device PFO closure was performed between 2001-2015 was carried out by phone contact. Available medical records and diving logbooks were reviewed to determine individual DCI symptomatology, indications to the procedure and to evaluate modifications in the diving practice. **RESULTS:** Each patient experienced at least one event of DCI before the procedure, 8 patients experienced more than one event. Total number of reported events was 62. The great majority of events (97%) followed dives consistent with safe decompression policies. The median follow-up was 91 (minimum 9, maximum 172) months. No complications of the intervention were observed. All patients returned to unrestricted, deep diving, performing a total of 3,610 dives with the median number of 225 dives (lower quartile value: 82.5, upper quartile value: 725 dives). The majority of subjects dived as deep as they did before the intervention, or deeper, achieving mean maximum depth of 93.8±35.6 meters (vs. 89.7±25.9 m before the intervention, p=0.71). No episodes of DCI were reported during the follow-up period. **CONCLUSIONS:** Transcatheter closure of PFO appears reasonably effective in secondary prevention of DCI associated with intra-cardiac shunting.

Ilmi MI, Yunus F, Guritno M, Damayanti T, Samoedro E, Nazaruddin AM, Nurwidya F. Comparison of lung function values of trained divers in 1.5 ATA hyperbaric chamber after inhaling 100% oxygen and regular air: a crossover study. *Adv Respir Med.* 2017 Oct 30. doi: 10.5603/ARM.a2017.0038. [Epub ahead of print]

INTRODUCTION: Diving is an activity performed in more than 1 atmosphere absolute pressure (ATA) either underwater or in a hyperbaric chamber. We aimed to compare lung function values of trained divers in 1.5 ATA hyperbaric chambers after inhaling 100% oxygen and regular air. **METHODS:** This experimental study with crossover design involved 18 trained divers in 1.5 ATA hyperbaric room, which is equivalent to a 5-m depth. The 18 subjects as the supplementation group, using oro-nasal mask, inhaled 100% oxygen for 30 min followed by a one-day washout period. The subjects were then crossed-over into control group inhaling only regular air for 30 min. Lung function test was performed before and after supplementation. **RESULTS:** In 18 subjects inhaling regular air, there was a significant difference (p<0.05) in FEV₁/FVC, PEF, FEF₂₅, FEF₅₀, and FEF₇₅. Whereas in 18 subjects inhaling 100% oxygen, significant difference (p<0.05) was observed not only in FEV₁/FVC, PEF, FEF₂₅, FEF₅₀ and FEF₇₅, but also in FEV₁. **CONCLUSIONS:**

There were significant differences in lung function, especially in dynamic volume of trained divers in 1.5 ATA hyperbaric chamber after inhaling 100% oxygen and regular air for 30 min; while there were no significant differences in lung capacity (VC and FVC) in the both groups. Lung function returned to normal following supplementation with a 1-day washout period.

King AE, Murphy FG, Howle LE. Bimodal decompression sickness onset times are not related to dive type or event severity. *Comput Biol Med.* 2017 Oct 10;91:59-68. doi: 10.1016/j.compbio.2017.10.010. [Epub ahead of print]

Human decompression sickness (DCS) is a condition associated with depressurization during underwater diving. Human research dive trial data containing dive outcome (DCS, no-DCS) and symptom information are used to calibrate probabilistic DCS models. DCS symptom onset time information is visualized using occurrence density functions (ODF) which plot the DCS onset rate per unit time. For the BIG292 human dive trial data set, a primary US Navy model calibration set, the ODFs are bimodal, however probabilistic models do not produce bimodal ODFs. We investigate the source of bimodality by partitioning the BIG292 data based on dive type, DCS event severity, DCS symptom type, institution, and chronology of dive trial. All but one variant of data partitioning resulted in a bimodal or ambiguously shaped ODF, indicating that ODF bimodality is not related to the dive type or the DCS event severity. Rather, we find that the dive trial medical surveillance protocol used to determine DCS symptom onset time may have biased the reported event window. Thus, attempts to develop probabilistic DCS models that reproduce BIG292 bimodality are unlikely to result in an improvement in model performance for data outside of the calibration set.

Lance RM, Natoli MJ, Dunworth SAS, Freiburger JJ, Moon RE. The Dewey monitor: pulse oximetry can independently detect hypoxia in a rebreather diver. *Undersea Hyperb Med.* 2017; 44(6):569-80.

Rebreather diving has one of the highest fatality rates per man hour of any diving activity in the world. The leading cause of death is hypoxia, typically from equipment or procedural failures. Hypoxia causes very few symptoms prior to causing loss of consciousness. Additionally, since the electronics responsible for controlling oxygen levels in rebreathers often control their alarm systems, frequently divers do not receive any external warnings. This study investigated the use of a forehead pulse oximeter as an independent warning device in the event of rebreather failure. Ten test subjects (seven male, three female, median age 29, range 26-35) exercised at a targeted rate of 2 L/minute oxygen consumption while on a non-functional rebreather breathing loop (mean consumption achieved 2.09 ± 0.36 L/minute). Each subject was tested both at the

surface and at pressurized depth of 77 fsw (starting $pO_2 = 0.7$ atm). The data show that a pulse oximeter could be used to provide an Mk 16 rebreather diver with a minimum mean of 49 seconds (± 17 seconds SD) of warning time after a noticeable change in blood oxygen saturation ($SpO_2 \leq 95\%$) but before any risk of loss of consciousness (calculated $SpO_2 \leq 80\%$), so that the diver may take mitigating actions. No statistical difference in warning time was found between the tests at surface and at 77 fsw ($P=0.46$).

Pollock NW, Buteau D. Updates in decompression illness. *Emerg Med Clin N Am.* 2017; 35(2): 301-19.

Decompression sickness and arterial gas embolism, collectively known as decompression illness (DCI), are rare but serious afflictions that can result from compressed gas diving exposures. Risk is primarily determined by the pressure-time profile but is influenced by several factors. DCI can present idiosyncratically but with a wide range of neurologic symptoms. Examination is critical for assessment in the absence of diagnostic indicators. Many conditions must be considered in the differential diagnosis. High-fraction oxygen breathing provides first aid but definitive treatment of DCI is hyperbaric oxygen.

Steffensmeier D, Albrecht R, Wendling J, Melliger R, Spahn DR, Stein P, Wyss C. Specialist advice may improve patient selection for decompression therapy following diving accidents: a retrospective observational study. *Scand J Trauma Resusc Emerg Med.* 2017; 25(1):101. doi: 10.1186/s13049-017-0447-0.

BACKGROUND: Even in a landlocked country like Switzerland recreational diving is becoming more and more popular. Smaller lakes in the Alps are located at an altitude of 2500 m above sea level. The incidence of diving accidents among all helicopter emergency service missions and the consecutive medical knowledge about decompression injuries is low. Thus, a collaboration between the Swiss Air-Ambulance (Rega) and the Divers Alert Network (DAN) was initiated to improve patient treatment and identification of decompression injury and necessity of hyperbaric oxygen therapy (HBO). **METHODS:** Retrospective observational study that includes all patients treated by the Rega which have been classified to have had a diving accident from 2005 to 2014. Patient and diving epidemiology was assessed and the impact of DAN collaboration on patient selection and identification of patients needing transport to HBO facilities were analysed. **RESULTS:** In the 10-year observational period 116 patients with diving accidents were treated by Rega. Mean patient age was 40 (SD 11) years and 95 (82%) were male. If the Rega emergency physician suspected a decompression injury (DCI), without DAN contact 27/28 (96%) of these patients were transported directly to a HBO facility, whereas with DAN contact only 53/63 (84%) needed transport to a HBO facility. DAN was involved in 66/96 (69%) of the cases

with suspected DCI on scene, with a significant increase over time ($p=0.001$). Mean flight time to HBO facilities was significantly longer (28.9, SD 17.7 min), compared to non-HBO facilities (7.1, SD 3.2 min, $p<0.001$). Due to specialist advice, patients may have been selected who finally did not need a transport to a HBO facility, although DCI was primarily suspected by the emergency physician on the scene. These patients experienced a significantly reduced flight time to the (non-HBO) hospital of 25.6 (SD 6.5) min ($p<0.001$). DISCUSSION: Collaboration of DAN and Rega may allow a safe patient selection and a consecutive reduction of flight time and costs. Due to international collaborations, evacuation to HBO-facilities for acute recompression therapy can be provided by HEMS within less than 30 min all over Switzerland. CONCLUSIONS: For diving accidents among HEMS missions, specialist advice by diving medicine specialists (DAN) appears mandatory to accurately identify and transport patients with decompression injury, as exposure of emergency physicians towards diving accidents and the diagnosis of DCI is low.

Weaver LK, Deru K. Carboxyhemoglobin half-life during hyperbaric oxygen in a patient with lung dysfunction: a case report. Undersea Hyperb Med. 2017; 44(2):173-7.

INTRODUCTION: The carboxyhemoglobin half-life (COHb $t_{1/2}$) during hyperbaric oxygen (HBO₂) is often quoted as 23 min, derived from the average of two adult male volunteers breathing HBO₂ at 3 atmospheres absolute (ATA). However, the mean COHb $t_{1/2}$ of 12 male volunteer smokers was 26.3 min at 1.58 ATA and in 12 non-intubated carbon monoxide (CO) poisoned patients treated at 3 ATA, was 43 minutes. CASE REPORT: An 81-year old male, poisoned by an improperly ventilated natural gas heater, was intubated for coma, then treated with HBO₂. His PaO₂ /FiO₂ = 283 from aspiration. His initial COHb was 34.4%, and 18 min before HBO₂, 5.9%. After a compression interval of 17 min, the COHb measured after 22 min at 3 ATA was 3.3%. RESULTS: By exponential decay, his COHb $t_{1/2}$ before HBO₂ was 95 min. We estimate the range for COHb $t_{1/2}$ during compression as 62-81 min and for the 3-ATA interval, 58 to 49 min, respectively. The mid-point estimate of COHb $t_{1/2}$ at 3 ATA was 53 min. CONCLUSIONS: The COHb $t_{1/2}$ we calculated is greater than previously reported, but longer in our patient possibly because of concomitant respiratory failure, lung dysfunction, and mechanical ventilation. The often-cited COHb $t_{1/2}$ of 23 min, likely underestimates the actual COHb $t_{1/2}$ in CO-poisoned patients, especially those with cardiopulmonary dysfunction.

Zhang L, Sun Q, Wu D, Yang Y, Yu T, Gao G. Hyperbaric oxygen suppresses growth of *Klebsiella*

***pneumoniae* and enhances effect of tigecycline in vitro. Undersea Hyperb Med. 2017; 44(6):543-9.**

OBJECTIVES: (1) To examine whether hyperbaric oxygen (HBO₂) will inhibit growth of multidrug-resistant *Klebsiella pneumoniae* (MDR-K. pneumoniae) and extensively drug-resistant *Klebsiella pneumoniae* (XDR-K. pneumoniae); (2) To determine whether the effect of tigecycline on XDR-K. pneumoniae will be enhanced by HBO₂. METHODS: The effects of 1.5 hours of treatment with normoxia (21% O₂, 1 atmosphere absolute/ATA) or HBO₂ (100% O₂, 2 ATA) on bacterial counts of eight isolates of MDR-K. pneumoniae and eight isolates of XDR-K. pneumoniae were studied. The effects of five hours of treatment with normoxia (21% O₂, 1 ATA), tigecycline (21% O₂, 1 ATA), HBO₂ (100% O₂, 3 ATA) or HBO₂ + tigecycline (100% O₂, 3 ATA) on proliferation of 10 isolates of XDR-K. pneumoniae were investigated. RESULTS: HBO₂ at 100% O₂, 2 ATA, 1.5 hours suppressed growth of MDR-K. pneumoniae but had no effect on XDR-K. pneumoniae. HBO₂ at 100% O₂, 3 ATA, five hours enhanced the effects of tigecycline on XDR-K. pneumoniae. CONCLUSIONS: HBO₂ in combination with or without tigecycline can be used to eliminate *K. pneumoniae* in vitro, and such treatment may be beneficial for patients with infections caused by *K. pneumoniae*.

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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