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

# E-NEWS

## EDITOR'S NOTE – April 2020

The E-News is the monthly newsletter of CUHMA used to share news and information. We invite relevant content, including news/announcements, upcoming events, new publication abstracts, job postings, professional perspectives, incident reports, and relevant images of related professional scenes. Please share with interested colleagues. Past issues are available at https://cuhma.ca.

Neal W. Pollock, PhD
Université Laval

## NEWS/ANNOUNCEMENTS

### CUHMA Education Committee Update

The Royal College of Physicians and Surgeons of Canada has made changes relevant to our field effective March 16th, 2020. All family medicine practitioners who are not Royal College certified, but who are applying to be Diplomates of the AFC program in Hyperbaric Medicine, will be exempt from participating in the Royal College MOC program and its associated fees following declaration that they are participating in MAINPRO+ and provision of their MAINPRO+ cycle dates. This development means that all AFC applicants will have similar fees regardless of their base specialty.

### CUHMA Position Statement on COVID-19

CUHMA has issued recommendations for hyperbaric chambers during these pandemic times. They represent best practice in what is a rapidly evolving situation. This information was sent to the CUHMA membership electronically last week and will be posted on the website (https://cuhma.ca/news). New information will be shared as it becomes available.

## UPCOMING EVENTS

### UMC Introductory Diving Medicine Course

Undersea Medicine Canada is offering a CSA Z275.2-15 Level 1 'Introductory Course in Diving Medicine - Fitness to Dive' September 28-October 02 in Quebec City, 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 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.

### UHN Introductory Hyperbaric Medicine Course

The University Health Network, Toronto General Hospital, is offering this course November 24-28. The program is suitable for physicians and other health professionals looking to become CHT certified or obtain Level 1 certification. It is accredited by the Undersea and Hyperbaric Medical Society for 40 CME credits, and by the National Board of Diving and Hyperbaric Medical Technology for 40 CME credits. For more information and registration:
https://www.uhn.ca/Surgery/Treatments_Procedures/Hyperbaric_Medicine_Unit#tab4

## RECENT PUBLICATIONS

**Andrew BT, Doolette DJ. Manned validation of a US Navy diving manual, revision 7, VVal-79 schedule for short bottom time, deep air decompression diving. Diving Hyperb Med. 2020; 50(1): 43-8.**

Introduction: The US Navy air decompression table was promulgated in 2008, and a revised version, calculated with the VVal-79 Thalmann algorithm, was promulgated in 2016. The Swedish Armed Forces conducted a laboratory dive trial using the 2008 air decompression table and 32 dives to 40 metres' seawater for 20 minutes bottom time resulted in two cases of decompression sickness (DCS) and high venous gas emboli (VGE) grades. These results motivated an examination of current US Navy air decompression schedules. Methods: An air decompression schedule to 132 feet seawater (fsw; 506 kPa) for 20 minutes bottom time with a 9-minute stop at 20 fsw was computed with the VVal-79 Thalmann algorithm. Dives were conducted in 29°C water in the ocean simulation facility at the Navy Experimental Diving Unit. Divers dressed in shorts and t-shirts performed approximately 90 watts cycle ergometer work on the bottom and rested during decompression. VGE were monitored with 2-D echocardiography at 20-minute

intervals for two hours post-dive. Results: Ninety-six man-dives were completed, resulting in no cases of DCS. The median (IQR) peak VGE grades were 3 (2-3) at rest and 3 (3-3) with limb flexion. VGE grades remained elevated two hours post-dive with median grades 1 (1-3) at rest and 3 (1-3) with movement. Conclusions: Testing of a short, deep air decompression schedule computed with the VVal-79 Thalmann algorithm, tested under diving conditions similar to earlier US Navy dive trials, resulted in a low incidence of DCS.

**AlSalahi SE, Braz ID, Ahmed A, Jenejo RT, Fisher JP. Human cerebrovascular responses to diving are not related to facial cooling. Exp Physiol. 2020; Mar 12[Online ahead of print]**

Diving evokes a pattern of physiological responses purported to preserve oxygenated blood delivery to vital organs such as the brain. We sought to uncouple the effects of trigeminal nerve stimulation on cerebral blood flow (CBF), from other modifiers associated with the diving response, such as apnoea and changes in arterial carbon dioxide tension. Thirty-seven young healthy individuals participated in separate trials of; facial cooling (FC, 3 min) and cold pressor test (CPT, 3 min) under poikilocapnic (Protocol 1) and isocapnic conditions (Protocol 2), facial cooling while either performing a breath-hold (FC +BH) or breathing spontaneously for a matched duration (FC -BH) (Protocol 3), and BH during facial cooling (BH +FC) or without facial cooling (BH -FC) (Protocol 4). Under poikilocapnic conditions neither facial cooling nor CPT evoked a change in middle cerebral artery blood flow velocity (MCA $V_{mean}$; transcranial Doppler) ($P>0.05$ vs. baseline). Under isocapnic conditions, facial cooling did not change MCA $V_{mean}$ ($P>0.05$), whereas CPT increased MCA $V_{mean}$ by 13% ($P<0.05$). Facial cooling with a concurrent BH markedly increased MCA $V_{mean}$ ($\Delta$23%) and internal carotid artery blood flow (ICAQ ; duplex Doppler ultrasound) ($\Delta$26%) ($P<0.001$), but no change in MCA $V_{mean}$ and ICAQ were observed when facial cooling was accompanied by spontaneous breathing ($P>0.05$). Finally, MCA $V_{mean}$ and ICAQ were similarly increased by BH either with or without facial cooling. These findings suggest that physiological factors associated with BH, and not facial cooling (ie, trigeminal nerve stimulation) per se, make the predominant contribution to increases in CBF during diving in humans.

**Blake DF, Crowe M, Lindsay D, Brouff A, Mitchell SJ, Leggat PA, Pollock NW. Comparison of tissue oxygenation achieved breathing oxygen using different delivery devices and flow rates. Diving Hyperb Med. 2020; 50(1): 34-42.**

Introduction: Divers with suspected decompression illness require high concentration oxygen ($O_2$). There are many different $O_2$ delivery devices, with few data comparing their performance. This study evaluated $O_2$ delivery, using tissue $O_2$ partial pressure ($PtcO_2$), in healthy divers breathing $O_2$ via three different delivery devices. Methods: Twelve divers had $PtcO_2$ measured at six limb sites. Participants breathed $O_2$ from: a demand valve using an intraoral mask with a nose clip (NC); a medical $O_2$ rebreathing system (MORS) with an oronasal mask and with an intraoral mask; and a non-rebreather mask (NRB) at 15 or 10 $L \cdot min^{-1}$ $O_2$ flow. In-line inspired $O_2$ $F_IO_2$) and nasopharyngeal $FIO_2$ were measured. Participants provided subjective ratings of device comfort, ease of breathing, and overall ease of use. Results: $PtcO_2$ values and nasopharyngeal $F_IO_2$ were similar with the demand valve with intraoral mask, MORS with both masks and the NRB at 15 $L \cdot min^{-1}$. $PtcO_2$ and nasopharyngeal $F_IO_2$ values were significantly lower with the NRB at 10 $L \cdot min^{-1}$. The NRB was rated as the most comfortable to wear, easiest to breathe with, and overall the easiest to use. Conclusion: Of the commonly available devices promoted for $O_2$ delivery to injured divers, similar $PtcO_2$ and nasopharyngeal $F_IO_2$ values were obtained with the three devices tested: MORS with an oronasal or intraoral mask, demand valve with an intraoral mask and NRB at a flow rate of 15 $L \cdot min^{-1}$. $PtcO_2$ and nasopharyngeal $F_IO_2$ values were significantly lower when the flow rate using the NRB was decreased to 10 $L \cdot min^{-1}$.

**Blatteau JE, Lambrechts K, Ruffez J. Factors influencing the severity of long-term sequelae in fishermen-divers with neurological decompression sickness. Diving Hyperb Med. 2020; 50(1): 9-16.**

Introduction: Numerous studies have been conducted to identify the factors influencing the short-term prognosis for neurological decompression sickness (DCS). However, the long-term sequelae are rarely assessed. The purpose of this study to investigate the factors likely to influence the long-term prognosis. Methods: Twenty-seven Vietnamese fishermen-divers who on average 9 (SD 6) years beforehand had presented with neurological DCS and ongoing sequelae, were questioned and examined. The severity of the initial clinical profile was quantified using a severity score. The long-term sequelae were clinically evaluated by looking for a motor or sensory deficit or muscular spasticity, and by applying a severity score for the sequelae which focussed on gait and sphincter disorders. Results: An initial severity score of $\geq$ 15 is significantly associated with a risk of serious long-term sequelae [OR = 13.7 (95% CI 2.4 to 79.5)]. Furthermore, certain treatment practices such as in-water recompression to depths > 17 metres' seawater breathing air are significantly associated with more serious sequelae. The practice of intensive non-standardised hyperbaric oxygen sessions over prolonged durations (median 30 days [IQR 19.5]) delayed after the initial accident (median 4 days [IQR 6]) also seems unfavourable. Conclusion: This study establishes a link between the initial DCS severity and the

long-term sequelae causing severe gait disorders and sphincter incontinence. Furthermore, this work suggests that certain detrimental treatment practices should be modified. During this field study, we also found that it was possible to reduce sequelae of these divers by offering them an individual programme of self-rehabilitation.

**Bliss C, Huang E, Savaser D. Safety of a continuous glucose monitoring device during hyperbaric exposure. Undersea Hyperb Med. 2020; 47(1): 13-9.**

Background: Hyperbaric oxygen therapy has been demonstrated to lower blood glucose levels in patients with diabetes. Continuous glucose monitoring (CGM) allows glucose monitoring in real time. Battery-operated CGM transmitters have yet to be formally tested and given safety approval for use in a hyperbaric environment. Materials and methods: We evaluated and tested commercially available Dexcom® G6 CGM transmitters under hyperbaric conditions. Each transmitter contains a 3V, 130-mAh (0.39 Wh) lithium manganese dioxide battery (IEC CR1632) and circuit board that are fully encapsulated in epoxy. Each transmitter is pressurized to 90 pounds per square inch (psi) in an autoclave at 40°C for up to 72 hours during manufacturing to ensure that all enclosed air spaces are eliminated from the epoxy. We compared the CGM components against section 14.2.9.3.17.5 of the 2018 National Fire Protection Association 99 (NFPA 99) Health Care Facilities Code requirements. Six CGM transmitters attached to estimated glucose value generators (EGVGs) underwent 11 pressurization cycles to 45 feet of seawater (fsw). All transmitters were returned to the manufacturer to assess post-exposure structural integrity. G6 sensors, which contain no electrical components or compressible air spaces, do not pose a risk in the hyperbaric environment. Results: There was no observed change in preset EGVG readings during hyperbaric exposures. Post-exposure testing revealed no structural compromise after repeated hyperbaric exposures. Conclusions: The CGM transmitter meets section 14.2.9.3.17.5 of the 2018 NFPA 99 requirements for battery-operated devices allowed for use in a hyperbaric environment. This analysis revealed no significant safety concerns with subjecting Dexcom G6 CGM transmitters to hyperbaric environments.

**Çevik MO, Bagli BS, Çevik SG. Hyperbaric oxygen treatment results in a group of Turkish central retinal artery occlusion patients with a combined presence of thrombophilic mutations. Undersea Hyperb Med. 2020; 47(1): 65-73.**

Background: Central retinal artery occlusion (CRAO) is a rare ocular-ischemic syndrome causing irreversible blindness. Its pathophysiology has not been clarified, and no targeted therapies are available yet. Hyperbaric oxygen ($HBO_2$) therapy is already an approved therapy for CRAO and has been shown to improve the visual acuity of CRAO patients safely. However, further clinical data are required to classify $HBO_2$ therapy as a type-I general agreement for CRAO. Materials and methods: Eleven patients with non-arteritic CRAO were enrolled. Patient demographics, medical history, detailed eye examinations, $HBO_2$ therapy results, pre-/post $HBO_2$ therapy visual acuity measurements and genotypes for common thrombophilic mutations (Factor V G1691A Leiden, Factor II G20210A, MTHFR A1298C, MTHFR C677T, and PAI-1-675 4G/5G) were obtained. Result: Six patients (54%) responded to $HBO_2$ therapy compared to five non-responders (46%). Patients admitted before 12 hours responded well to $HBO_2$ therapy. No systemic diseases nor advanced age were statistically correlated to CRAO. A combination of mutations rather than single mutations for each patient could be seen as responsible for CRAO. No Factor V G1691A Leiden mutations and only one FII G20210A mutation were observed. Eight patients (72%) had MTHFR 677T allele, five patients (45%) had MTHFR 1298C allele, and 10 patients (91%) had the PAI-1-675 4G allele. Conclusion: Not a single mutation but a combination of mutations and other unknown factors probably lead to CRAO, and if intervention is timely, $HBO_2$ therapy offers improvement in visual acuity safely.

**Charaghvandi DA, Teguh DN, van Hulst RA. Hyperbaric oxygen therapy in patients suffering from wounds in calciphylaxis: a narrative review. Undersea Hyperb Med. 2020; 47(1): 111-23.**

Background: Calcific uremic arteriolopathy (calciphylaxis) is a rare and highly lethal vascular disease. Vascular calcification with calcium depositions lead to ischemic ulcers associated with gangrene, severe pain and poor healing. Although hyperbaric oxygen ($HBO_2$) therapy has been used in the treatment of calciphylaxis, evidence of its effectiveness is limited. Objective: To determine whether $HBO_2$ therapy has a beneficial effect in the healing of calciphylaxis ulcers. Methods: A search was made in PubMed using a comprehensive strategy to identify the effect of $HBO_2$ on calciphylaxis wounds. Included in the analysis were studies published up to October 2018 involving a minimum of four patients receiving $HBO_2$ therapy. Results: Ten retrospective (case) series were included. This review included a total of 131 patients with calciphylaxis who were treated with $HBO_2$ therapy; of these, 58 patients (45%) had full response on $HBO_2$ with complete wound closure. Regarding partial response, 17 of the patients (13%) experienced substantial wound improvement on different wound scale scores. Conclusion: Patients with calcific uremic arteriolopathy can benefit from $HBO_2$. More research is needed using standardized wound scores. Outcomes related to quality of life and pain relief should also be assessed.

**Clarós P, Końska N, Clarós-Pujol A, Pujol C, Clarós A. Hyperbaric oxygen therapy as a therapeutic option in**

**cochlear implants extrusion treatment in infected wounds. Acta Otolaryngol. 2020; 1-4 Mar 30 [Online ahead of print]**

Background: Cochlear implant extrusion as a result of infection is an uncommon, but serious complication, which can lead to implant removal as the ultimate solution. Objectives: (1) to identify the incidence of cochlear implant extrusion and its causes, (2) to report our management of patients presenting skin complications after cochlear implant surgery (3) to propose new therapeutical options with hyperbaric oxygen therapy (HBOT).Materials and methods: A retrospective analysis of medical documentation of 1250 patients who were operated on with cochlear implants in our department between 1993 and 2015. The medical charts of 25 patients were selected due to reported skin flap complications resulting in CI extrusion. Five of those patients were subsequently removed from the study because of no infection signs. Results: Non-traumatic cochlear implant extrusion occurred in 1.6% of implanted patients, and secondary treatment was effective in 90% of all cases (18 of 20 patients). HBOT as additional treatment was applied in 9 patients. Conclusions: Hyperbaric oxygen therapy can be considered as safe adjuvant treatment option in individual cases of proceeding with cochlear implant extrusion with signs of wound infection. Significance: HBOT may contribute to reducing the need for cochlear implant explantation due to infectious skin flap complication.

**Dunford RG, Denoble PD, Forbes R, Pieper CF, Howle LE, Vann RD. A study of decompression sickness using recorded depth-time profiles. Undersea Hyperb Med. 2020; 47(1): 75-91.**

Introduction: 122,129 dives by 10,358 recreational divers were recorded by dive computers from 11 manufacturers in an exploratory study of how dive profile, breathing gas (air or nitrox [$N_2/O_2$] mixes), repetitive diving, gender, age, and dive site conditions influenced observed decompression sickness (DCSobs). Thirty-eight reports were judged as DCS. Overall DCSobs was 3.1 cases/$10^4$ dives. Methods: Three dive groups were studied: Basic (live-aboard and shore/dayboat), Cozumel Dive Guides, and Scapa Flow wreck divers. A probabilistic decompression model, BVM(3), controlled dive profile variability. Chi-squared test, t-test, logistic regression, and log-rank tests evaluated statistical associations. Results: (a) DCSobs was 0.7/$10^4$ (Basic), 7.6/$10^4$ (Guides), and 17.3/104 (Scapa) and differed after control for dive variability ($p<0.001$). (b) DCSobs was greater for 22%-29% nitrox (12.6/$10^4$) than for 30%-50% nitrox (2.04/$10^4$) ($p\leq0.0064$) which did not differ from air (2.97/$1010^4$). (c) For daily repetitive dives (<12-hour surface intervals (SI)), DCS occurred only following one or two dives (4.3/$1010^4$ DCSobs; $p<0.001$) where SIs were shorter than after three or more dives. (d) For multiday repetitive dives (SIs<48 hours), DCS was associated with high multiday repetitive dive counts only for Guides ($p=0.0018$). (e) DCSobs decreased with age at 3%/year ($p\leq0.0144$). (f) Males dived deeper ($p<0.001$) but for less time than females ($p<0.001$). Conclusion: Collecting dive profiles with dive computers and controlling for profile variability by probabilistic modeling was feasible, but analytical results require independent confirmation due to limited observed DCS. Future studies appear promising if more DCS cases are gathered, stakeholders cooperate, and identified data collection problems are corrected.

**Gabler-Smith MK, Westgate AJ, Kiipman HN. Microvessel density, lipid chemistry and $N_2$ solubility in human and pig adipose tissue. Undersea Hyperb Med. 2020; 47(1):1-12.**

Decompression sickness (DCS) occurs when nitrogen gas ($N_2$) comes out of solution too quickly, forming bubbles in the blood and tissues. These bubbles can be a serious condition; thus it is of extreme interest in the dive community to model DCS risk. Diving models use tissue compartments to calculate tissue partial pressures, often using data obtained from other mammalian species (i.e., pigs). Adipose tissue is an important compartment in these models because $N_2$ is five times more soluble in fat than in blood; at any blood/tissue interface $N_2$ will diffuse into the fat and can lead to bubble formation on ascent. Little is known about many characteristics of adipose tissue relevant to diving physiology. Therefore, we measured microvessel density and morphology, lipid composition, and $N_2$ solubility in adipose tissue from humans and pigs. Human adipose tissue has significantly higher microvascular density (1.79±0.04 vs. 1.21±0.30%), vessel diameter (10.25±0.28 vs. 6.72±0.60 µm), total monounsaturated fatty acids (50.1 vs. 41.2 mol%) and $N_2$ solubility (0.061±0.003 vs. 0.054±0.004 mL N2 $mL^{-1}$ oil) compared to pig tissue. Pig adipose tissue has significantly higher lipid content (76.1±4.9 vs. 64.6±5.1%) and total saturated fatty acids (38.8 vs. 29.5 mol%). Though two important components in gas kinetics within adipose tissue during diving (blood flow rates and degree of perfusion) are not well understood, our results indicate differences between the adipose tissue of humans and pigs. This suggests data from swine may not exactly predict gas dynamics for estimating DCS in humans.

**Harch PG, Andrews SR, Rowe CJ, Lischka JR, Townsend MH, Yu Q, Mercante DE. Hyperbaric oxygen therapy for mild traumatic brain injury persistent postconcussion syndrome: a randomized controlled trial. Med Gas Res. 2020; 10(1): 8-20.**

Persistent postconcussion syndrome (PPCS) after mild traumatic brain injury (mTBI) is a significant public health and military problem for which there is limited treatment evidence. The aim of this study was to determine whether forty 150 kPa hyperbaric oxygen therapies (HBOTs) can

improve symptoms and cognitive function in subjects with the PPCS of mTBI, using a randomized controlled crossover design with 2-month follow-up. Sixty-three civilian and military subjects with mTBI/PPCS were randomized to either 40 HBOTs at 150 kPa/60 minutes, once daily, 5 days per week in 8 weeks or an equivalent no-treatment control period. The Control Group was then crossed over to HBOT. Subjects underwent symptom, neuropsychological, and psychological testing, before and after treatment or control with retesting 2 months after the 40th HBOT. Fifty subjects completed the protocol with primary outcome testing. HBOT subjects experienced significant improvements in Neurobehavioral Symptom Inventory, Memory Index, Automated Neuropsychological Assessment Metrics, Hamilton Depression Scale, Hamilton Anxiety Scale, Post-Traumatic Stress Disorder Checklist, Pittsburgh Sleep Quality Index, and Quality Of Life after Brain Injury compared to the Control Group. After crossing over to HBOT the Control Group experienced near-identical significant improvements. Further improvements were experienced by both groups during the 2-month follow-up period. These data indicate that 40 HBOTs at 150 kPa/60 minutes demonstrated statistically significant improvements in postconcussion and Post-Traumatic Stress Disorder symptoms, memory, cognitive functions, depression, anxiety, sleep, and quality of life in civilian and military subjects with mTBI/PPCS compared to controls. Improvements persisted at least 2 months after the 40th HBOT. The study was registered on ClinicalTrials.gov (NCT02089594) on March 18, 2014 and with the U.S. Food and Drug Administration under Investigational New Drug #113823. The Institutional Review Boards of the United States Army Medical Research and Materiel Command Office of Research Protections Human Research Protection Office and the Louisiana State University School of Medicine (approval No. 7381) approved the study on May 13, 2014 and December 20, 2013, respectively.

**Jiang J, Cooper JS. Carbon monoxide poisoning can act as a stress test to reveal underlying coronary artery disease: case report. Undersea Hyperb Med. 2020; 47(1): 139-43.**

Carbon monoxide (CO) poisoning presents with many different cardiac effects, but one important presentation is its effect as a CO stress test to reveal underlying coronary artery disease (CAD). There are a limited number of publications detailing this phenomenon, but after CO intoxication it is important to suspect CAD in association with mild troponin leak or non-ST segment elevation myocardial infarction (NSTEMI) shown on electrocardiogram (EKG). We recently treated three patients with CO poisoning who had underlying CAD. In the first case a man presented to the emergency department with CO toxicity and an ST segment elevation myocardial infarction (STEMI), resulting in emergent angioplasty and the discovery of severe CAD. The second case involved an individual who presented with CO poisoning with rising troponin levels. An angioplasty discovered a stable 90% occlusion. The third case was a patient with CO poisoning and transient inferior T wave inversion EKG with borderline troponin elevation. Angioplasty showed only 30% occlusion, so the patient's presentation was likely due to direct CO cardiac toxicity. These cases demonstrate the varied presentations that CO poisoning can have on patients with underlying heart disease.

**Kim YS, Nam MS, Park EJ, Lee Y, Kim H, Kim SH, Cha YS. The effect of adjunctive hyperbaric oxygen therapy in patients with central retinal artery occlusion. Undersea Hyperb Med. 2020; 47(1): 57-64.**

Purpose: Central retinal artery occlusion (CRAO) is an ophthalmic emergency with poor prognosis, despite diligent conventional treatment. According to the clinical recommendations of the Undersea and Hyperbaric Medical Society, hyperbaric oxygen ($HBO_2$) is a potentially beneficial treatment; however, the benefit of adjunctive $HBO_2$ in patients with CRAO in Korea remains unclear. The present study aimed to evaluate the effect of adjunctive $HBO_2$ in patients with CRAO. Methods: This registry-based observational study included adult patients who presented to the emergency department or ophthalmology outpatient department within 24 hours of the onset of CRAO symptoms. Data of patients from October 2016 to February 2019 were analyzed. The patients were categorized into two groups according to the use of adjunctive $HBO_2$: no $HBO_2$ and $HBO_2$. Result: During the study period, 34 consecutive patients were enrolled, of which 19 were included in the study. In the total cohort, 10 patients (52.6%) were treated with adjunctive $HBO_2$. There were no statistically significant differences in terms of age, sex, comorbidities, duration from symptoms onset to hospital visit, presence of the cilioretinal artery, and use of anterior chamber paracentesis between the two groups. The $HBO_2$ group showed significantly higher change in best-corrected visual acuity than the no $HBO_2$ group ($p=0.043$). Conclusion: Patients with CRAO in the $HBO_2$ group showed significantly greater visual improvement than those in the no-$HBO_2$ group. Clinicians should consider adjunctive $HBO_2$ in the treatment approach in patients with CRAO who visit the hospital within 24 hours of symptoms onset.

**King AE, Andriano NR, Howle LE. Trinomial decompression sickness model using full, marginal, and non-event outcomes. Comput Biol Med. 2020; 118: 103640.**

Decompression sickness (DCS) is a condition associated with reductions in ambient pressure during underwater

diving and altitude exposure. Determining the risk of DCS from a dive exposure remains an active area of research, with the goal of developing safe decompression schedules to mitigate the occurrence of DCS. This work develops a probabilistic model for the trinomial outcome of full, marginal, and no DCS. The model treats full DCS and marginal DCS as separate, fully weighted hierarchical events. Six variants of exponential-exponential (EE) and linear-exponential (LE) decompression models were optimized to fit dive outcomes from the BIG292 empirical human dive trial data of 3322 exposures. Using the log likelihood difference test, the LE1 trinomial marginal model was determined to provide the best fit for the data. The LE1 trinomial marginal model can be used to better understand decompression schedules, expanding upon binomial models which treat marginal DCS as either a fractionally weighted event or a non-event. Future work could investigate whether the use of marginal DCS cases improves multinomial probabilistic DCS model performance. Model improvement could include the addition of a fourth outcome, where full DCS is split and categorized as serious or mild DCS, creating a tetranomial model with serious, mild, marginal, and no DCS outcomes for comparison with the presently developed model.

**Lippmann J. Rescue and resuscitation factors in scuba diving and snorkeling fatalities in Australia, 2001-2013. Undersea Hyperb Med. 2020; 47(1): 101-9.**

Aim: The aim of this study was to examine first aid measures applied in a large series of Australian dive-related fatalities to better determine where improvements can be made. Methods: The National Coronial Information System was searched to identify scuba diving and snorkeling-related cases reported to various Australian Coroners for the years 2001-2013 inclusive. Coronial documents examined included witness statements, police reports and ambulance and medical reports where available. Information relating to the recovery, rescue and/or resuscitation of the victims was extracted, compiled and analyzed. Results: 126 scuba diving and 175 snorkeling-related fatalities were identified during the study period, with airway management complications reported in one-third. Cardiopulmonary resuscitation was performed in three-quarters of the incidents. An automated external defibrillator was attached to 40 victims as a first aid measure, and shocks were indicated and delivered in five cases. Although three-quarters of the reports included no information about whether supplemental oxygen was provided, it was confirmed in 19% of both the scuba diving and snorkeling incidents. Conclusion: There were often considerable delays in the recognition, rescue and/or recovery of an unconscious snorkeler or diver and, consequently, the time to commencement of basic life support. Such delays can affect chances of survival and need to be minimized. Delivery of supplemental oxygen during resuscitation appears to be relatively infrequent and sometimes suboptimal; improvement appears necessary. Some measures that would have improved availability and/or better use in these cases include the selection of appropriate equipment compatible with likely circumstances and operator skills; improved training and ongoing skills practice; and regular checking and maintenance of equipment. Improved data collection and recording by official on-site investigators, preferably with knowledge of diving, would better inform potential or necessary improvements.

**Magri K, Bigeni S, Azzopardi CP, Camilleri L, Matity L, Muscat S, Meintjes WAJ. Hyperbaric oxygen therapy awareness within a doctor population. Undersea Hyperb Med. 2020; 47(1): 39-50.**

Hyperbaric medicine is a relatively young specialty that remains in the blind spot of most doctors' awareness. This study endeavors to identify the level of awareness of the indications for hyperbaric oxygen (HBO2) therapy among a doctor population in a developed country and factors which may improve referral rates. An anonymized questionnaire was distributed to doctors licensed to practice in Malta. Questions included physician specialty, demographics and previous exposure to diving and/or hyperbaric medicine. Moreover, two scoring systems were used to score subjects on $HBO_2$-related topics. Binomial logistic regression models and generalized linear models were used in the statistical analysis. A total of 152 full replies were obtained and analyzed. Respondents who had visited a hyperbaric unit (HBU) ($p=0.002$) or attended a lecture on $HBO_2$ ($p=0.006$) scored better than their counterparts, indicating better awareness of HBO2 indications and local chamber location. A previous HBU visit ($p=0.001$), being a hospital-based doctor ($p=0.027$) and a history of scuba diving ($p=0.03$) were associated with willingness to refer patients for $HBO_2$ in the future. Encouraging visits to an HBU has been shown to be associated with multiple factors, which are expected to result in improved referral rates. Targeted educational sessions to doctors and medical students are likely to be beneficial in improving correct referral of patients for HBO2. The findings from this study may prove useful in improving appropriate referral rates of patients who may benefit from this useful treatment modality.

**Neheman A, Rappaport YH, Verhovsky G, Bush N, Snodgrass W, Lang E, Zisman A, Efrati S. Hyperbaric oxygen therapy for pediatric "hypospadias cripple"-evaluating the advantages regarding graft take. J Pediatr Urol. 2020 Jan 14[Online ahead of print]**

Introduction: Hypospadias cripple patients pose a major surgical challenge with high complication rates attributed mainly to graft contraction. Hyperbaric oxygen therapy (HBOT) is an established treatment for compromised grafts and used extensively as a salvage therapy for compromised grafts and ischemic non-healing wounds.

Objective: We evaluated the graft-take rates in hypospadias cripple cases undergoing a staged tubularized autograft repair (STAG) and compared between patients treated with or without preemptive HBOT. Materials and methods: All patients underwent a STAG. Patients receiving preemptive HBOT were compared with patients receiving the standard surgical procedure without HBOT. The HBOT protocol included a daily session, 5 days per week for four weeks before the surgery and 10 additional daily sessions immediately after first-stage surgery. Each HBOT session included 90 min exposure to 100% $O_2$ at 2 atmospheres absolute with 5 min air breaks every 20 min. The primary endpoint was graft take. Sequential tubularization without tension at second stage was defined as success. Results: Seven boys received HBOT and 14 boys comprised the control group. All patients in the HBOT group had good graft take with no graft contraction. In the control group, 57% had good graft take and could proceed to the second-stage surgery and 43% had graft contraction (Table). Except for one patient who had claustrophobia while entering the chamber, no significant side-effects developed during the HBOT. Discussion: The basic pathophysiology of compromised flaps includes both ischemia and reperfusion injury, which can be attenuated by HBOT. The beneficial effects of HBOT relates to several mechanisms, including hyperoxygenation, fibroblast proliferation, collagen deposition, angiogenesis, and vasculogenesis. Graft contraction is a well-known complication in hypospadias cripple population with reported failure rate of 39-63%. The HBOT procedure was found to be very effective and the entire HBOT group had a good graft take. Accordingly, all patients in the HBOT group proceeded to a successful second-stage tubularization. In addition, HBOT was found to be safe and generally well tolerated by this pediatric population. Study limitations were a relative small, non-homogenous sample size and lack of prospective randomization. Success was defined as sufficient graft elasticity sufficing for tubularization of the neourethra, and exact graft measurements are lacking in this study. Conclusions: Preemptive HBOT can be used safely in the hypospadias cripple pediatric population and can potentially reduce the expected high surgical failure secondary to graft contraction.

**Pougnet R, Pougnet L, Dewitte JD, Loddé B, Lucas D. Temporary and permanent unfitness of occupational divers. Brest cohort 2002-2019 from the French National Network for Occupational Disease Vigilance and Prevention (RNV3P). Int Marit Health. 2020; 71(1): 71-7.**

Background: In France, the monitoring of professional divers is regulated. Several learned societies (French Occupational Medicine Society, French Hyperbaric Medicine Society and French Maritime Medicine Society) have issued follow-up recommendations for professional divers, including medical follow-up. Medical decisions could be temporary unfitness for diving, temporary fitness with monitoring, a restriction of fitness, or permanent unfitness. The aim of study was to point out the causes of unfitness in our centre. Materials and methods: The divers' files were selected from the French National Network for Occupational Disease Vigilance and Prevention (RNV3P). Only files with a special medical decision were selected, between 2002 and 2019. Results: Three hundred and ninety-six professional divers are followed-up in our centre and 1371 medical decisions were delivered. There were 29 (7.3%) divers with a special medical decision, during 42 (3.1%) medical visit. Twelve (3.0%) had a permanent unfitness. The leading cause of unfitness was pulmonary diseases: emphysema (3), chronic obstructive pulmonary disorder (2), asthma (2). Sixteen (4.0%) divers had temporary unfitness. The leading causes were cardiovascular (4 times) and neurological (6 times). Twelve (3.0%) divers had had at least one decompression sickness. Conclusions: Judgments of permanent unfitness for diving were rare (3.0% of divers), but were because of life-threatening disease. Medical follow-up of occupational divers was justified to decrease the risk of fatal event during occupational dives.

**Rayman G, Vas P, Dhatariya K, Driver V, Hartemann A, Londahl M, Piaggesi A, Apelqvist J, Attinger C, Game F, International Working Group on the Diabetic Foot (IWGDF). Guidelines on use of interventions to enhance healing of chronic foot ulcers in diabetes (IWGDF 2019 update). Diabetes Metab Res Rev. 2020; 36 Suppl 1: e3283.**

The International Working Group on the Diabetic Foot (IWGDF) has published evidence-based guidelines on the prevention and management of diabetic foot disease since 1999. In conjunction with advice from internal and external reviewers and expert consultants in the field, this update is based on a systematic review of the literature centred on the following: the Population (P), Intervention (I), Comparator (C) and Outcomes (O) framework; the use of the SIGN guideline/Cochrane review system; and the 21 point scoring system advocated by IWGDF/EWMA. This has resulted in 13 recommendations. The recommendation on sharp debridement and the selection of dressings remain unchanged from the last recommendations published in 2016. The recommendation to consider negative pressure wound therapy in post-surgical wounds and the judicious use of hyperbaric oxygen therapy in certain non-healing ischaemic ulcers also remains unchanged. Recommendations against the use of growth factors, autologous platelet gels, bioengineered skin products, ozone, topical carbon dioxide, nitric oxide or interventions reporting improvement of ulcer healing through an alteration of the physical environment or through other systemic medical or nutritional means also remain. New recommendations

include consideration of the use of sucrose-octasulfate impregnated dressings in difficult to heal neuro-ischaemic ulcers and consideration of the use of autologous combined leucocyte, platelet and fibrin patch in ulcers that are difficult to heal, in both cases when used in addition to best standard of care. A further new recommendation is the consideration of topical placental derived products when used in addition to best standard of care.

**Sames C, Gorman DF, Mitchell SJ, Zhou L. Professional diver routine health surveillance and certification: an internet-based satisfaction survey of New Zealand divers. Diving Hyperb Med. 2020; 50(1): 28-33.**

Introduction: Professional divers, like many other specialised occupational groups, are subject to regulatory constraints that include mandatory initial medical certification and routine recertification. The New Zealand system of diver certification and health surveillance has undergone modifications in recent years, but its acceptance among end-users has never been formally assessed. Because of the wide variety of tasks, circumstances and personalities encountered in the diving industry, unanimous satisfaction is an unrealistic expectation, but establishing the current mood of divers in this regard and canvassing opinions on possible improvements is an important step towards optimising the certification process. Method: A multi-choice satisfaction questionnaire was added, as a quality assurance measure, to the on-line health questionnaire completed annually by all New Zealand professional divers. A complete 12-month dataset was analysed to determine levels of satisfaction, areas of dissatisfaction and suggestions for improvement. Comparison of the opinions of various diver groups was achieved by stratification into employment-type sub-groups and those working locally, overseas or both. Results: The responses of 914 divers who completed the survey established an 85% satisfaction rate with the existing diver certification system. Dissatisfaction was independent of diving locality. Compliance cost was the most common area of dissatisfaction, particularly among recreational diving instructors. Conclusions: Most New Zealand professional divers consider the current certification system satisfactory. Effective communication between the regulating authority and divers was identified as an important area for further development.

**Tlapák J, Chmátal P, Oniscenko B, Pavlik V, Dosel P, Páral J, Lochman P. The effect of hyperbaric oxygen therapy on gene expression: microarray analysis on wound healing. Undersea Hyperb Med. 2020; 47(1): 31-7.**

Background: Hyperbaric oxygen ($HBO_2$) therapy can have a positive effect on wound healing, angiogenesis and blood flow. No prior study has described the effects of $HBO_2$ therapy and gene expression of this process. The goal of our research was to show the effects of $HBO_2$ and its impact at the molecular level on angiogenesis, proliferation, differentiation, oxidative stress, inflammation, and extracellular matrix formation. Live animal subjects were used for simulating the process of wound healing under standard conditions and under the influence of $HBO_2$. Methods: Two experimental groups were created using injured rabbits (N=24), one group (N=12) treated with hyperbaric therapy twice a day and one (N=12) with standard wound care management. Wounds were surgical, uninfected, and in healthy animal test subjects. We compared the whole genomic analysis of the transcriptome with the use of microarray technology at three intervals during treatment. Results: The induction of the wounds in rabbit skin increased expression of hundreds of genes in both treatment groups. The numbers of elevated and decreased genes gradually reduced as the wound healed. Gene expression analysis showed elevated expression of several genes associated with inflammation in both groups of injured animals. Genes connected to the process of angiogenesis, proliferation, differentiation, oxidative stress and extracellular matrix formation were without statistically significant changes. Conclusion: The evidence did not support that $HBO_2$ had any significant effect on gene expression during wound healing. Additionally, there was no evidence to support that there were changes in gene expression in either treatment group.

**Weaver LK. Carbon monoxide poisoning. Undersea Hyperb Med. 2020; 47(1): 151-69.**

Despite established exposure limits and safety standards as well as the availability of carbon monoxide (CO) alarms, each year 50,000 people in the United States visit emergency departments for CO poisoning. Carbon monoxide poisoning can occur from brief exposures to high levels of CO or from longer exposures to lower levels. Common symptoms can include headaches, nausea and vomiting, dizziness, general malaise, and altered mental status. Some patients may have chest pain, shortness of breath, and myocardial ischemia, and may require mechanical ventilation and treatment of shock. Individuals poisoned by CO often develop brain injury manifested by neurological problems, including cognitive sequelae, anxiety and depression, persistent headaches, dizziness, sleep problems, motor weakness, vestibular and balance problems, gaze abnormalities, peripheral neuropathies, hearing loss, tinnitus, Parkinsonian-like syndrome, and other problems. In addition, some will have cardiac issues or other ailments. While breathing oxygen hastens the removal of carboxyhemoglobin (COHb), hyperbaric oxygen ($HBO_2$) hastens COHb elimination and favorably modulates inflammatory processes instigated by CO poisoning, an effect not observed with breathing normobaric oxygen. Hyperbaric oxygen improves mitochondrial function, inhibits lipid peroxidation transiently, impairs leukocyte adhesion to injured microvasculature, and reduces brain inflammation caused

by the CO-induced adduct formation of myelin basic protein. Based upon three supportive randomized clinical trials in humans and considerable evidence from animal studies, $HBO_2$ should be considered for all cases of acute symptomatic CO poisoning. Hyperbaric oxygen is indicated for CO poisoning complicated by cyanide poisoning, often concomitantly with smoke inhalation.

**Weenink RP, de Jonge SW, van Hulst RA, Wingelaar TT, van Ooij PJAM, Immink RV, Preckel B, Hollmann MW. Perioperative hyperoxyphobia: justified or not? Benefits and harms of hyperoxia during surgery. J Clin Med. 2020; 9(3).**

The use of an inspiratory oxygen fraction of 0.80 during surgery is a topic of ongoing debate. Opponents claim that increased oxidative stress, atelectasis, and impaired oxygen delivery due to hyperoxic vasoconstriction are detrimental. Proponents point to the beneficial effects on the incidence of surgical site infections and postoperative nausea and vomiting. Also, hyperoxygenation is thought to extend the safety margin in case of acute intraoperative emergencies. This review provides a comprehensive risk-benefit analysis for the use of perioperative hyperoxia in noncritically ill adults based on clinical evidence and supported by physiological deduction where needed. Data from the field of hyperbaric medicine, as a model of extreme hyperoxygenation, are extrapolated to the perioperative setting. We ultimately conclude that current evidence is in favour of hyperoxia in noncritically ill intubated adult surgical patients.

**Wingelaar TT, Brinkman P, Hoencamp R, van Ooiji PJA, Maitland-van der Zee AH, Hollmann MW, van Hulst RA. Assessment of pulmonary oxygen toxicity in Special Operations Forces divers under operational circumstances using exhaled breath analysis. Diving Hyperb Med. 2020; 50(1): 2-7.**

Introduction: The Netherlands Maritime Special Operations Forces use closed circuit oxygen rebreathers ($O_2$-CCR), which can cause pulmonary oxygen toxicity (POT). Recent studies demonstrated that volatile organic compounds (VOCs) can be used to detect POT in laboratory conditions. It is unclear if similar VOCs can be identified outside the laboratory. This study hypothesised that similar VOCs can be identified after $O_2$-CCR diving in operational settings. Methods: Scenario one: 4 h $O_2$-CCR dive to 3 metres' seawater (msw) with rested divers. Scenario two: 3 h $O_2$-CCR dive to 3 msw following a 5 day physically straining operational scenario. Exhaled breath samples were collected 30 min before and 30 min and 2 h after diving under field conditions and analysed using gas chromatography-mass spectrometry (GC-MS) to reconstruct VOCs, whose levels were tested longitudinally using a Kruskal-Wallis test. Results: Eleven divers were included: four in scenario one and seven in scenario two. The 2 h post-dive sample could not be obtained in scenario two; therefore, 26 samples were collected. GC-MS analysis identified three relevant VOCs: cyclohexane, 2,4-dimethylhexane and 3-methylnonane. The intensities of 2,4-dimethylhexane and 3-methylnonane were significantly (P=0.048 and P=0.016, respectively) increased post-dive relative to baseline (range: 212-461%) in both scenarios. Cyclohexane was increased not significantly (P=0.178) post-dive (range: 87-433%). Conclusions: VOCs similar to those associated with POT in laboratory conditions were identified after operational $O_2$-CCR dives using GC-MS. Post-dive intensities were higher than in previous studies, and it remains to be determined if this is attributable to different dive profiles, diving equipment or other environmental factors.

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

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