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

E-NEWS

EDITORIAL NOTE – October 2019

The E-News is the monthly newsletter of CUHMA used to share news and information. We invite relevant content, including announcements, upcoming conferences, 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.

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NEWS/ANNOUNCEMENTS

Diving Conception Bay, Newfoundland

Some attendees of the CUHMA meeting in St. John's, NL will be getting underwater experience, depicted on the cover of the latest issue of *Wilderness & Environmental Medicine*: https://www.wemjournal.org/current.

Cover Photo: A diver is seen floating above the stern gun on the deck of the *SS Saganaga* in Conception Bay, Newfoundland (47° 35'N, 52° 59'W) in July 2019. The 124 m (407 ft) steel British merchant ship was sunk by two torpedoes fired from a German U-boat (U-513) on September 5, 1942. It is one of four ships sunk by U-boats in Conception Bay after being loaded with iron ore from the Bell Island mines, bound for the Allied war effort. The top of the superstructure is in approximately 18 m of seawater (60 ft), and the bottom at approximately 27 m (90 ft). The water temperature at the bottom ranges from -2 to 7 or 8°C seasonally. Photograph by Sean Romanowski.

UPCOMING EVENTS

CUHMA Annual Scientific Meeting 2019

The 2019 CUHMA ASM will be held this week in St. John's, NL, hosted by Memorial University Faculty of Medicine. Visit https://cuhma.ca or the MU site to register (https://www.med.mun.ca/opd/programs/info.asp?id=4228).

AAUS/CAUS Joint Conference 2019

The American Academy of Underwater Sciences and the Canadian Association for Underwater Science will hold a joint diving for science symposium in Vancouver, BC October 08-11. A variety of workshops augment the main conference. Visit: https://www.aaus.org/annualsymposium.

Hyperbaric Medical Technologist Course 2019

Simon Fraser University is offering a two-week introductory course October 21-November 02 in Burnaby, BC. It will cover the fundamentals of clinical hyperbaric oxygen therapy and practical skills of chamber operation. Week 1 (fundamentals) is accredited by NBDHMT and UHMS for 40 h of AMA PRA Category 1. Week 2 (chamber operation) meets the CSA Z275.4 standards and includes certification by the Diver Certification Board of Canada. For details: https://www.sfu.ca/science/faculty-support/facilities-services/empu/courses/hyperbaric-medical-technologist.html.

UMC Introductory Diving Medicine Course 2019

Undersea Medicine Canada is offering a CSA Z275.2-15 Level 1 'Introductory Course in Diving Medicine - Fitness to Dive' October 28-November 01 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 26-30, 2019. The program will provide participants the basic competencies to practice in hyperbaric medicine. Content will include indications and contraindications for hyperbaric treatments and guidelines on treatment table usage. There will be hands-on practice of clinical skills, chamber management, and clinical emergencies during hyperbaric treatments, as well as theory and historical background. For more information, visit: https://www.uhn.ca/Surgery/PatientsFamilies/Clinics_Tests/Hyperbaric_Medicine_Unit/Pages/Continuing_Education.aspx

Hyperbaric Technician Training Course 2020

Simon Fraser University is offering a hyperbaric technician course February 02-07 in Burnaby, BC. It will cover skills and knowledge to maintain a hyperbaric facility including: operating principles of the main control equipment; air filtration systems; hyperbaric electric systems; and maintenance and inspection of acrylic windows. Hands-on components include: valve & regulator service, Swagelok fittings and tube bending; HP Bauer compressor servicing; oxygen cleaning; and HP cylinder inspection. Visit: https://www.sfu.ca/science/faculty-support/facilities-services/empu/courses/hyperbaric-technician.html.

Hyperbaric Safety Director Course 2020

Simon Fraser University, in Burnaby, BC, is offering this 3-day program in collaboration with International ATMO February 07-09. It will provide necessary tools and resources to fulfill the responsibilities of the Hyperbaric Safety Director (as defined by CSA Z275.1). Both classroom instruction and practical exercises are provided. Visit: https://www.sfu.ca/science/faculty-support/facilities-services/empu/courses/hyperbaric_safety_director.html.

Hyperbaric Medical Emergency Simulation 2020

Simon Fraser University, in Burnaby, BC, is offering this HMES course on February 10. It is an interactive team simulation program aimed at improving team dynamics to optimize patient outcomes in a crisis. It is intended for both physicians and non-physicians. Participants will gain hands-on experience with simulated monoplace and multiplace emergencies. The program is approved for 6.75 h of AMA PRA Category 1 credits. For more information, visit: https://www.sfu.ca/science/faculty-support/facilities-services/empu/courses/hyperbaric-medical-emergency-simulation.html.

International Congress on Hyperbaric Medicine

The 20th ICHM will be held November 11-15, 2020 at the Rio Othon Palace Hotel, in Copacabana, Rio de Janeiro, Brazil. The conference is held every three years, and is unusual in not being linked to any single institution. The scientific program will include oral and poster research presentations and invited lectures by renowned national and international speakers. CUHMA members are being offered 10% off the registration price. Visit www.ichm2020.rio.br.

RECENT PUBLICATIONS

Barak OF, Janjic N, Drvis I, Mijacika T, Mudnic I, Coombs GB, Thom SR, Madic D, Dujic Z. Vascular dysfunction following breath-hold diving. Can J Physiol Pharmacol. 2019 Sep 10. doi: 10.1139/cjpp-2019-0341. [Epub ahead of print]

The pathogenesis of predominantly neurological decompression sickness (DCS) is multifactorial. In scuba diving besides gas bubbles, DCS has been linked to microparticle release, impaired endothelial function, and platelet activation. This study focused on vascular damage and its potential role in the genesis of DCS in breath-hold diving. Eleven breath-hold divers participated in a field study comprising eight deep breath-hold dives with short surface periods, and repetitive breath-hold dives lasting for six hours. Endothelium-dependent vasodilation of the brachial artery, via flow-mediated dilation (FMD), and the number of microparticles (MPs) were assessed before and after each protocol. All measures were analyzed by two-way within-subject analysis of variance (2x2 ANOVA; factors: time and protocol). Absolute FMD was reduced following both diving protocols ($p<0.001$), with no interaction ($p=0.288$) or main effect of protocol ($p=0.151$). There was a significant difference in the total number of circulating MPs between protocols ($p=0.007$), where both increased post-dive ($p=0.012$). The number of CD31+/CD41- and CD66b+ MP subtypes, although different between protocols ($p<0.001$), also increased by 41.0±56.6% ($p=0.050$) and 60.0±53.2% ($p=0.045$) following deep and repetitive breath-hold dives, respectively. Both deep and repetitive breath-hold diving leads to endothelial dysfunction that may play an important role in the genesis of neurological DCS.

Boässon MP, Rienks R, van der Ven A, van Hulst RA. Arrhythmogenicity of scuba diving: Holter monitoring in a hyperbaric environment. Undersea Hyperb Med. 2019; 46(4): 421-7.

INTRODUCTION: About 26% of diving-related fatalities are caused by cardiac disease, part of which might be associated with fatal arrhythmias. This raises the question as to whether fatal arrhythmias are being provoked by hyperbaric conditions themselves or if exercise or stress provokes the fatal arrhythmias in cases of underlying (ischemic) cardiac disease. OBJECTIVE: To measure the influence of hyperbaric conditions (50 msw) on cardiac conduction and arrhythmias in professional divers by means of ECG. METHODS: This is a prospective study on military divers in a hyperbaric chamber with

continuous ECG monitoring using Holter registrations. Supraventricular and ventricular ectopy was registered during hyperbaric conditions. RR, PR, QRS, QT and QTc intervals were calculated at 50 msw and compared with ECGs at rest. RESULTS: Included were 17 male military divers who made 20 dives. A total of 10 PVCs, 45 PACs, four atrial runs and four atrial pairs were seen. Significant prolongation of the PR interval was seen and a decrease of in QRS duration at 50 msw. There was no significant change in the RR, QT and QTc intervals. CONCLUSION: In these divers, no clinically relevant arrhythmias were observed during wet dives in a recompression chamber at 50 msw. We observed a small prolongation of PR interval that is probably not clinically relevant in divers without any known conduction disorders.

Brett KD, Nugent NZ, Fraser NK, Bhopale VM, Yang M, Thom SR. Microparticle and interleukin-1β production with human simulated compressed air diving. Sci Rep. 2019 Sep 16;9(1):13320.

Production of blood-borne microparticles (MPs), 0.1-1 μm diameter vesicles, and interleukin (IL)-1β in response to high pressure is reported in lab animals and associated with pathological changes. It is unknown whether the responses occur in humans, and whether they are due to exposure to high pressure or to the process of decompression. Blood from research subjects exposed in hyperbaric chambers to air pressure equal to 18 meters of sea water (msw) for 60 minutes or 30 msw for 35 minutes were obtained prior to and during compression and 2 hours post-decompression. MPs and intra-particle IL-1β elevations occurred while at pressure in both groups. At 18 msw (n=15) MPs increased by 1.8-fold, and IL-1β by 7.0-fold ($p<0.05$, repeated measures ANOVA on ranks). At 30 msw (n=16) MPs increased by 2.5-fold, and IL-1β by 4.6-fold ($p<0.05$), and elevations persisted after decompression with MPs elevated by 2.0-fold, and IL-1β by 6.0-fold ($p<0.05$). Whereas neutrophils incubated in ambient air pressure for up to 3 hours ex vivo did not generate MPs, those exposed to air pressure at 180 kPa for 1 hour generated 1.4±0.1 MPs/cell ($n = 8$, $p<0.05$ versus ambient air), and 1.7±0.1 MPs/cell ($p<0.05$ versus ambient air) when exposed to 300 kPa for 35 minutes. At both pressures IL-1β concentration tripled ($p<0.05$ versus ambient air) during pressure exposure and increased 6-fold ($p<0.05$ versus ambient air) over 2 hours post-decompression. Platelets also generated MPs but at a rate about 1/100 that seen with neutrophils. We conclude that production of MPs containing elevated concentrations of IL-1β occur in humans during exposure to high gas pressures, more so than as a response to decompression. While these events may pose adverse health threats, their contribution to decompression sickness development requires further study.

Costa DA, Ganilha JS, Barata PC, Guerreiro FG. Seizure frequency in more than 180,000 treatment sessions with hyperbaric oxygen therapy - a single centre 20-year analysis. Diving Hyperb Med. 2019;49(3):167-74.

INTRODUCTION: Hyperbaric oxygen therapy (HBOT) involves the risk of central nervous system oxygen toxicity (CNS-OT), including seizures in patients breathing oxygen at pressures ≥ 2 atmospheres absolute. This study aimed to determine the seizure frequency and assess the clinical benefit of a 5-minute air-break (5´-AIRBK). METHODS: Twenty-year (1999-2018) retrospective analysis of all consecutive treatments with HBOT. Medical records were reviewed to determine patient demographics, comorbidities, HBOT indications, and seizure characteristics and timing. Seizure frequency was compared before and after incorporating a 5´-AIRBK in the treatment protocol. Chi-square testing was performed using SPSS (version 24.0); $P<0.05$ was accepted as statistically significant. RESULTS: We evaluated 188,335 HBOT sessions (74,255 before versus 114,080 after introducing a 5´-AIRBK). A total of 43 seizures were observed: 29 before and 14 after the 5´-AIRBK introduction (3.9 versus 1.2 per 10,000 treatments; $P<0.0001$). Seizures occurred after a median of 57 (range 15-85) minutes following compression and after a median of 21 HBOT sessions (1-126). Patients experiencing seizures were undergoing treatment for: diabetic ulcer (n=11); acute traumatic peripheral ischaemia (ATPI) (n=6); non-diabetic ulcer (n=5); sudden sensorineural hearing loss (n=5); chronic refractory osteomyelitis (n=5); radionecrosis (n=3); necrotising fasciitis (NF) (n=2); and haemorrhagic cystitis after allogeneic bone marrow transplantation (n=1). ATPI and NF had a considerably higher relative frequency of seizures compared to other indications. CONCLUSIONS: A statistically significant lower seizure frequency was achieved with a 5´-AIRBK. Assessing and defining the appropriate patient/treatment profile can be useful to minimise the risk of CNS-OT.

de Asís Fernández F, González-Mohino F, González-Ravé JM. Assessment of sensory sensitivity through critical flicker fusion frequency thresholds after a maximum voluntary apnoea. Diving Hyperb Med. 2019;49(3):186-91.

INTRODUCTION: The influence of acute exercise on sensory sensitivity (SS) differs according to the type and duration of exercise performed. In the present study, we assessed changes on SS soon after a maximal dynamic apnoea. METHODS: Thirty-nine experienced male breath-hold divers were recruited. Critical flicker fusion frequency (CFFF) thresholds were used to measure SS. Thresholds were determined before and after a maximal dynamic apnoea. Immediately after surfacing, heart rate and oxygen saturation (S_pO_2) were recorded for two

minutes. RESULTS: After maximal dynamic apnoea, S_pO_2 was significantly decreased (from mean 97.3% pre-dive to mean 63.1% post-dive; P<0.0001; η2 P=0.86), but this acute hypoxaemia did not trigger changes in SS (post-dive value 102% of baseline; P=0.22; η2 P=0.03). Pearson correlation analysis revealed a moderate association between SS with swimming speed (r=0.423) and apnoea time (r=-0.404). CONCLUSIONS: A maximal dynamic apnoea did not produce changes in central nervous system fatigue or cortical arousal. We found no relationship between the hypoxaemia level reached after a maximal apnoea and changes in the CFFF thresholds. This study suggests that the time of exposure to hypoxia during a maximal voluntary apnoea is not enough to produce changes in SS.

Fernández FA, Rodríguez-Zamora L, Schagatay E. Hook breathing facilitates S_aO_2 recovery after deep dives in freedivers with slow recovery. Front Physiol. 2019 Aug 30;10:1076. doi: 10.3389/fphys.2019.01076. eCollection 2019.

To facilitate recovery from hypoxia, many freedivers use a breathing method called "hook breathing" (HB) after diving, involving an interrupted exhale to build up intrapulmonary pressure. Some divers experience a delay in recovery of arterial oxygen saturation (S_aO_2) after diving, interpreted as symptoms of mild pulmonary edema, and facilitated recovery may be especially important in this group to avoid hypoxic "blackout." We examined the influence of HB on recovery of S_aO_2 in freedivers with slow recovery (SR) and fast recovery (FR) of S_aO_2 after deep "free immersion" (FIM) apnea dives to 30 m depth. Twenty-two male freedivers, with a mean (SD) personal best in the discipline FIM of 57(26) m, performed two 30 m deep dives, one followed by HB and one using normal breathing (NB) during recovery, at different days and weighted order. S_aO_2 and heart rate (HR) were measured via pulse oximetry during recovery. The SR group (n=5) had a faster S_aO_2 recovery using HB, while the FR group (n=17) showed no difference between breathing techniques. At 105 s, the SR group reached a mean (SD) S_aO_2 of 95(5)% using HB, while using NB, their S_aO_2 was 87(5)% (p<0.05), and 105-120 s after surfacing S_aO_2 was higher with HB (p<0.05). In SR subjects, the average time needed to reach 95% S_aO_2 with HB was 60 s, while it was 120 s at NB (p<0.05). HR was similar in the SR group, while it was initially elevated at HB in the FR group (p<0.05). We conclude that HB efficiently increases S_aO_2 recovery in SR individuals, but not in the FR group. The proposed mechanism is that increased pulmonary pressure with HB will reverse any pulmonary edema and facilitate oxygen uptake in divers with delayed recovery

Forner L, Berkowicz A, Dickmeiss E, Hyldegaard O, Jansen EC, Fischer-Nielsen A. Only minor stem cell mobilization in head and neck irradiated patients treated with hyperbaric oxygen. Diving Hyperb Med. 2019;49(3):175-85.

INTRODUCTION: Hyperbaric oxygen (HBO) is used to treat several conditions including late radiation tissue injury. Previous studies have suggested that HBO mobilizes bone marrow derived stem/progenitor cells (SPC) to the peripheral blood, however possible cumulative effects were highly variable. METHODS: We have investigated a possible HBO-induced mobilization of SPCs by determining CD34+CD45dim cell numbers, as well as SPCs in general. The latter were characterized by high aldehyde dehydrogenase (ALDH) activity by use of the Aldefluor® assay. We included ten patients admitted for HBO treatment of radiation tissue injury. Six patients completed the 29-30 HBO treatment exposures. We also investigated possible HBO-induced effects on platelet activation as measured by flow cytometry and functional analyses. RESULTS: We found a weak and insignificant tendency toward mobilization of CD34+CD45dim cells after a single HBO exposure versus before. Additionally, we found an additive effect of 15 HBO exposures on the increase in CD34+CD45dim cells relative to the pre-1st-HBO values. These changes were significantly more than zero but less than a doubling. We could not demonstrate a significant effect of HBO on the content of Aldefluor® positive SPCs in peripheral blood. There was no significant effect on platelet activation overall. However, in patients with increased expression of activation markers at baseline, we found a decrease after one exposure although this was not reflected in functional tests. CONCLUSION: We found a minor statistically significant mobilizing effect of HBO treatment on the bone marrow derived stem/progenitor cell content in peripheral blood after 15 treatments (n=10 patients), but no effect after 30 treatments (n=6 patients). However, because of the low number of patients we cannot confidentially prove or disprove the null hypothesis. The possibility that HBO treatment reduces the number of activated platelets could not be demonstrated nor excluded.

Guillén-Pino F, Morera-Fumero A, Henry-Benítez M, Alonso-Lasheras E, Abreu-González P, Medina-Arana V. Descriptive study of diving injuries in the Canary Islands from 2008 to 2017. Diving Hyperb Med. 2019;49(3):204-8.

INTRODUCTION: This research reports the epidemiology of diving injuries managed in the Hyperbaric Medicine Unit of the Canary Islands University Hospital. METHODS: Data were extracted from the clinical records of all divers injured and admitted to the unit for treatment of dysbaric diving injuries between 2008 and 2017, inclusive. RESULTS: One-hundred and thirty diving injuries were recorded. Most

(71%) occurred in men and 43% were foreigners. Eighteen per cent either had no diving certification or that information was not recorded in the clinical chart. Only a third of the 40% of divers who had some form of on-site first aid treatment received oxygen and oral rehydration. Type 1 decompression sickness (DCS) was diagnosed in 56 divers (43%) and Type 2 in 67 (52%), whilst seven were treated for omitted decompression. At discharge, 122 (94%) were asymptomatic, whilst 5% experienced some residual sensory or other changes. One diver who presented late remained quadriparetic and one, admitted in a state of coma, died. Only 76% of the injured divers had specific diving accident insurance and, of those, 58% were foreign divers. CONCLUSIONS: Over half of the injured divers did not receive any on-site first aid. The majority (94%) of treated injured divers were discharged without sequelae. Based on these data, several public health recommendations for the Canary Islands are made.

Hampson NB, Hauschildt KL, Deru K, Weaver LK. Carbon monoxide poisonings in hotels and motels: The problem silently continues. Prev Med Rep. 2019 Aug 16;16:100975.

Carbon monoxide poisoning remains common in the United States. One component of effective prevention involves identification of scenarios in which poisoning occurs to guide development of appropriate interventions. This study was conducted to determine the significance of the problem of carbon monoxide poisoning occurring in US hotels, motels and resorts. This is a population-based case series of guests staying at US hotels, motels, and resorts from 2005 to 2018. Details of incidents and individuals poisoned with carbon monoxide were collected from online searches and professional experience of the authors. Data extracted included number of incidents and individuals poisoned, age of those poisoned, outcomes, source of carbon monoxide, and lodging type. From January 1, 2005 to December 31, 2018, 905 guests were poisoned in 115 identified incidents, including 22 fatalities. Children represented 16% of those poisoned and 27% of fatalities. Type of lodgings were hotels, motels, and resorts of all classes and located in a majority of states. Most poisonings were caused by natural gas fueled appliances and could likely have been prevented by an in-room carbon monoxide alarm. To reduce morbidity and mortality from unintentional CO poisoning in lodging facilities, government should mandate installation of in-room CO alarms, similar to the current requirement for smoke alarms.

Hesthammer R, Eide T, Thorsen E, Svardal AM, Djurhuus R. Hyperoxia and lack of ascorbic acid deplete tetrahydrobiopterin without affecting NO generation in endothelial cells. Undersea Hyperb Med. 2019;46(4):509-19.

Nitric oxide (NO) may protect against gas bubble formation and risk of decompression sickness. We have previously shown that the crucial co-factor tetrahydrobiopterin (BH4) is oxidized in a dose-dependent manner when exposed to hyperoxia similar to diving conditions but with minor effects on the NO production by nitric oxide synthase. By manipulating the intracellular redox state, we further investigated the relationship between BH4 levels and production of NO in human endothelial cells (HUVECs). HUVECs were cultured with and without ascorbic acid (AA) and the glutathione (GSH) synthesis inhibitor buthionine sulfoximine, prior to hyperoxic exposure. The levels of biopterins and GSH were determined in cell lysates while the production of NO was determined in intact cells. Omitting AA resulted in a 91% decrease in BH4 levels (0.49±0.08 to 0.04±0.01 pmol/10^6 cells, $p\langle 0.001$) at 20 kPa oxygen (O_2), and 88% decrease (0.24±0.03 to 0.03±0.01 pmol/10^6 cells, p=0.01) after exposure to 60 kPa O_2. The NO generation was decreased by 23% (74.5±2.2 to 57.3±5.6 pmol/min/mg protein, $p\langle 0.001$) at 20 kPa O_2, but no significant change was observed at 60 kPa O_2. GSH depletion had no effects on the NO generation. No correlation was found between NO generation and the corresponding intracellular BH4 concentration (p=0.675, r=-0.055) or the BH4 to BH2 ratio (p=0.983, r=0.003), determined across 18 in vitro experiments. Decreased BH4 in HUVECs, due to hyperoxia or lack of ascorbic acid, does not imply corresponding decreases in NO generation.

Heyboer Iii M, Wojcik SM, Swaby J, Boes T. Blood glucose levels in diabetic patients undergoing hyperbaric oxygen therapy. Undersea Hyperb Med. 2019; 46(4): 437-45.

INTRODUCTION: To determine if hyperbaric oxygen (HBO_2) therapy has an effect on diabetic blood glucose levels (BGL) and, if so, the extent of this effect. Also, to examine factors that exacerbate any observed effect. METHODS: This was a retrospective review of prospectively collected quality data on diabetics undergoing HBO_2. Pre- and post-treatment BGL were recorded. Pre-treatment BGL <120 mg/dL received glucose supplementation. Hypoglycemia was defined as BGL <70 mg/dL. BGL <90 mg/dL was included as an elevated hypoglycemia threshold. RESULTS: 77 patients representing 1,825 treatments were included for analysis. No patient had deleterious side effects or required emergency care. BGL decreased in 75.4% of treatments in this group, with a median decrease of 25 mg/dL (IQR=54 mg/dL; range of decreased 374 mg/dL to increased 240 mg/dL). A statistically significant greater percentage of

treatments of patients with type 2 diabetes resulted in a decrease in BGL (1598 or 77.5%) compared to treatments of patients with type 1 diabetes (169 or 51.5%) ($\chi 2(1, n=1767) = 55.37$, $p<0.001$). 1.1% of treatments had post-HBO_2 serum glucose ⟨90 mg/dL, and 0.2% of treatments had post-HBO_2 serum glucose ⟨70 mg/dL. The majority (70%) of patients with post-HBO2 BGL <90 mg/dL were maintained on insulin alone ($\chi 2(2, n=20) = 12.4$, $p=0.002$). Well-controlled diabetics (i.e., those with all BGLs within 50 mg/dL over all pre-HBO_2 treatments) had no post-HBO_2 BGL <70 mg/dL or <90 mg/dL. CONCLUSION: Our results suggest that HBO_2 does not cause a clinically significant decrease in diabetic patient BGL. No patient in our study had deleterious side effects or required emergency care. We found that glucose level of <90 mg/dL occurred more often in those who use insulin. Hyperbaric patients who exhibit consistent BGL values may represent a group who could be managed similarly to the non-diabetic population

Holmström P, Mulder E, Sundström AL, Limbu P, Schagatay E. The magnitude of diving bradycardia during apnea at low-altitude reveals tolerance to high altitude hypoxia. Front Physiol. 2019 Aug 22;10:1075. doi: 10.3389/fphys.2019.01075. eCollection 2019.

Acute mountain sickness (AMS) is a potentially life-threatening illness that may develop during exposure to hypoxia at high altitude (HA). Susceptibility to AMS is highly individual, and the ability to predict it is limited. Apneic diving also induces hypoxia, and we aimed to investigate whether protective physiological responses, i.e., the cardiovascular diving response and spleen contraction, induced during apnea at low-altitude could predict individual susceptibility to AMS. Eighteen participants (eight females) performed three static apneas in air, the first at a fixed limit of 60 s (A1) and two of maximal duration (A2-A3), spaced by 2 min, while S_aO_2, heart rate (HR) and spleen volume were measured continuously. Tests were conducted in Kathmandu (1470 m) before a 14 day trek to mount Everest Base Camp (5360 m). During the trek, participants reported AMS symptoms daily using the Lake Louise Questionnaire (LLQ). The apnea-induced HR-reduction (diving bradycardia) was negatively correlated with the accumulated LLQ score in A1 ($r_s = -0.628$, $p=0.005$) and A3 ($r_s = -0.488$, $p=0.040$) and positively correlated with S_aO_2 at 4410 m (A1: $r=0.655$, $p=0.003$; A2: $r=0.471$, $p=0.049$; A3: $r=0.635$, $p=0.005$). Baseline spleen volume correlated negatively with LLQ score ($r_s=-0.479$, $p=0.044$), but no correlation was found between apnea-induced spleen volume reduction with LLQ score ($r_s=0.350$, $p=0.155$). The association between the diving bradycardia and spleen size with AMS symptoms suggests links between physiological responses to HA and apnea. Measuring individual responses to apnea at sea-level could provide means to predict AMS susceptibility prior to ascent.

Lippmann J. Snorkelling and breath-hold diving fatalities in Australia, 2001 to 2013. Demographics, characteristics and chain of events. Diving Hyperb Med. 2019;49(3):192-203.

INTRODUCTION: The aim of this study was to identify characteristics of victims of fatal snorkelling and breath-hold diving accidents in Australia from 2001-2013, inclusive, to determine underlying factors and risks associated with such activities and inform appropriate countermeasures. METHODS: The National Coronial Information System (NCIS) was searched to identify snorkelling and breath-hold diving-related cases reported to Australian coroners for the years 2001-2013, inclusive. Coronial data in the form of findings, witness and police reports, medical histories and autopsies were collected and collated, and descriptive statistics were used to analyse these data. A chain of events analysis was used to determine the likely sequence of events. RESULTS: There were 175 identified snorkelling-related fatalities during the study period. Most victims were middle-aged males (mean age 49 years). Pre-existing health conditions were possible contributors to 41% of the deaths, the main being ischaemic heart disease. The majority of deaths occurred in Queensland in inexperienced snorkellers, often in commercial settings. The victim's plight often went unnoticed as they were alone, or poorly supervised, when the incident occurred. Apnoeic hypoxia appeared to have been associated with at least 12.5% of the deaths. The main disabling injuries were asphyxia (40%) and cardiac incidents (35%). CONCLUSION: Human factors, such as chronic health conditions, poor skills and inexperience and poor planning can play a substantial role throughout the chain of events leading to a snorkelling fatality. It is important to educate the community, doctors and dive industry professionals about potential problems associated with the interaction between certain health-related conditions, especially cardiovascular conditions, and snorkelling. Close supervision is strongly recommended for inexperienced snorkellers due to their likely poor skills, as well as for experienced breath-hold divers due to the potential for apnoeic hypoxia.

Longobardi P, Hoxha K, Bennett MH. Is there a role for hyperbaric oxygen therapy in the treatment of refractory wounds of rare etiology? Diving Hyperb Med. 2019; 49(3): 216-24.

INTRODUCTION: Delayed wound healing indicates wounds that have failed to respond to more than 4-6 weeks of comprehensive wound care. Wounds with delayed healing are a major source of morbidity and a major cost to hospital and community healthcare providers. Hyperbaric oxygen therapy (HBOT) is a treatment designed to increase the supply of oxygen to

wounds and has been applied to a variety of wound types. This article reviews the place of HBOT in the treatment of non-healing vasculitic, calcific uremic arteriolopathy (CUA), livedoid vasculopathy (LV), pyoderma gangrenosum (PG) ulcers. METHODS: We searched electronic databases for research and review studies focused on HBOT for the treatment of delayed healing ulcers with rare etiologies. We excluded HBOT for ulcers reviewed elsewhere. RESULTS: We included a total of three case series and four case reports including 63 participants. Most were related to severe, non-healing ulcers in patients with vasculitis, CUA, LV, and PG. There was some evidence that HBOT may improve the healing rate of wounds by increasing nitric oxide (NO) levels and the number of endothelial progenitor cells in the wounds. HBOT may also improve pain in these ulcers. CONCLUSION: We recommend the establishment of comprehensive and detailed wound care registries to rapidly collect prospective data on the use of HBOT for these problem wounds. There is a strong case for appropriately powered, multi-centre randomized trials to establish the true efficacy and cost-effectiveness of HBOT especially for vasculitis ulcers that have not improved following immunosuppressive therapy.

Lundell RV, Wuorimaa T, Räisänen-Sokolowski A, Sundholm JK, Rintamäki H, Rissanen S, Parkkola K. Comparison of argon and air as thermal insulating gases in drysuit dives during military Arctic diving equipment development tests. Undersea Hyperb Med. 2019; 46(4): 429-35.

INTRODUCTION: It is vital to protect divers from the cold, particularly in Arctic conditions. The insulating gas layer within the drysuit is crucial for reducing heat loss. The technical diving community has long claimed the superiority of argon over air as an insulating gas. Although argon is widely used, previous studies have shown no significant differences between the two gases. Owing to its lower heat conductivity, argon should be a better thermal insulating gas than air. METHODS: The study aimed to determine whether argon is beneficial for reducing heat loss in divers during development of military drysuit diving equipment in Arctic water temperatures. Four divers completed 14 dives, each lasting 45 minutes: seven dives used air insulation and seven used argon insulation. Rectal and eight skin temperatures were measured from which changes in calculated mean body temperature (MBT) were assessed. RESULTS: There was a significant reduction in area weighted skin temperature over time (0-45 minute) on air dives (ΔTskin = -4.16°C, SE = 0.445, $P<0.001$). On argon dives the reduction was significantly smaller compared to air dives (difference between groups = 2.26°C, SE = 0.358, $P<0.001$). There were no significant changes in rectal temperatures, nor was a significant difference seen between groups. CONCLUSION: Compared to air, argon may be superior as a drysuit insulating gas in Arctic water temperatures for some divers. Argon used as insulating gas can make diving safer and may diminish the risks of fatal diving accidents and occupational hazard risks in professional diving.

Mrakic-Sposta S, Vezzoli A, Rizzato A, Della Noce C, Malacrida S, Montorsi M, Paganini M, Cancellara P, Bosco G. Oxidative stress assessment in breath-hold diving. Eur J Appl Physiol. 2019 Sep 13. doi: 10.1007/s00421-019-04224-4. [Epub ahead of print]

PURPOSE: Breath-hold diving results in significant changes in blood gases' levels. Challenging variations in oxygen partial pressures may induce reactive oxygen species (ROS) production that exacerbate oxidative stress and, consequently, affect endothelial function. The aim of this study was to investigate the effects of breath-hold diving on oxidative stress damage, assessing ROS production. Nitric oxide metabolites, inducible nitric oxide synthase (iNOS), aminothiols, and renal function were evaluated too as markers of redox status and renal damage. METHODS: ROS production was assessed with electron paramagnetic resonance. Oxidative status values were measured at pre- and post-40 m dive in a deep swimming pool (Y-40) from six divers (mean age 46.6±9.3 years; height 176±4 cm; BMI 25±2.9 kg/m^2). RESULTS: Significant ($p<0.05$) increases at post-dive of ROS production rate (0.158±0.003 vs 0.195±0.006 μmol min^{-1}), lipid peroxidation (8-isoprostane: 375.67±195.62 vs 420.49±232.31 pg mg^{-1} creatinine), nitrate (27.91±19.71 vs 30.80±20.44 μM), iNOS (31.30±4.52 vs 35.68±6.72 IU mL^{-1}) and neopterin concentration (96.20±40.41 vs 118.76±27.84 μmol mol^{-1} creatinine) were recorded. Conversely, the antioxidant capacity significantly decreased (3.423 ± 0.089 vs 3.015 ± 0.284 mM) after immersion. CONCLUSION: Overproduction of ROS and consequent oxidative damage to lipids of membrane and antioxidant capacity decreasing reflect also a hypoxic condition, which in the breath-hold diving typically occurs in the last few meters below the surface. iNOS produces NO in large quantities under the examined extreme conditions. Neopterin and creatinine concentration level increased, suggesting an "impairment of renal function" as a likely physiological response to P_aO_2 variations during dive activity.

Oscarsson N, Müller B, Rosén A, Lodding P, Mölne J, Giglio D, Hjelle KM, Vaagbø G, Hyldegaard O, Vangedal M, Salling L, Kjellberg A, Lind F, Ettala O, Arola O, Seeman-Lodding H. Radiation-induced cystitis treated with hyperbaric oxygen therapy (RICH-ART): a randomised, controlled, phase 2-3 trial. Lancet Oncol. 2019 Sep 16. pii: S1470-2045(19)30494-2.

BACKGROUND: Late radiation cystitis is an adverse effect of cancer treatment with radiotherapy in the pelvic region. Symptoms of late radiation cystitis can be assessed

with the Expanded Prostate Index Composite Score (EPIC). Previous reports indicate that hyperbaric oxygen therapy reduces symptoms from late radiation cystitis, but the evidence is predominantly based on non-randomised and retrospective studies. We aimed to assess whether hyperbaric oxygen therapy would mitigate symptoms of late radiation cystitis. METHODS: We did a randomised, controlled, phase 2-3 trial (RICH-ART [radiation induced cystitis treated with hyperbaric oxygen-a randomised controlled trial]) at five Nordic university hospitals. All patients aged 18-80 years, with pelvic radiotherapy completed at least 6 months previously, a score of less than 80 in the urinary domain of the EPIC, and referred to participating hyperbaric clinics due to symptoms of late radiation cystitis, were eligible for inclusion. Exclusion criteria were ongoing bleeding requiring blood transfusion exceeding 500 mL in the past 4 weeks, permanent urinary catheter, bladder capacity less than 100 mL, fistula in the urinary bladder, previous treatment with hyperbaric oxygen therapy for late radiation injuries, and contraindications to hyperbaric oxygen therapy. After computer-generated 1:1 randomisation with block sizes of four for each stratification group (sex, time from radiotherapy to inclusion, and previous invasive surgery in the pelvic area), patients received hyperbaric oxygen therapy (30-40 sessions, 100% oxygen, breathed at a pressure of 240-250 kPa, for 80-90 min daily) or standard care with no restrictions for other medications or interventions. No masking was applied. The primary outcome was change in patient-perceived urinary symptoms assessed with EPIC from inclusion to follow-up at visit 4 (6-8 months later), measured as absolute change in EPIC urinary total score. RICH-ART closed enrolment on Dec 31, 2017; the last follow-up data will be compiled in 2023. RICH-ART is registered with ClinicalTrials.gov, number NCT01659723, and with the European Medicines Agency, number EudraCT 2012-001381-15. FINDINGS: Of 3 patients screened between May 9, 2012, and Dec 20, 2017, 87 patients were enrolled and randomly assigned to either hyperbaric oxygen therapy (n=42) or standard care (n=45). After excluding eight patients who withdrew consent directly after randomisation (one in the hyperbaric oxygen therapy group and seven in the standard care group), 79 were included in the intention-to-treat analyses (n=41 in the hyperbaric oxygen therapy group, n=38 in the standard care group). Median time from randomisation to visit 4 was 234 days (IQR 210-262) in the hyperbaric oxygen therapy group and 217 days (195-237) in the standard care group. The difference between change in group mean of EPIC urinary total score at visit 4 was 10·1 points (95% CI 2·2-18·1; p=0·013; 17·8 points [SD 18·4] in the hyperbaric oxygen therapy group vs 7·7 points [15·5] in the standard care group). 17 (41%) of 41 patients in the hyperbaric oxygen therapy group experienced transient grade 1-2 adverse events, related to sight and hearing, during the period of hyperbaric oxygen therapy. INTERPRETATION: Our results suggest that hyperbaric oxygen therapy relieves symptoms of late radiation cystitis. We conclude that hyperbaric oxygen therapy is a safe and well tolerated treatment.

Rajpal N, Walters ET, Elmarsafi T, Pittman TA, Johnson-Arbor KK. Use of hyperbaric oxygen therapy for tissue ischemia after breast reconstruction. Undersea Hyperb Med. 2019;46(4):461-5.

INTRODUCTION: Mastectomy skin flap necrosis represents a significant complication of breast reconstructive procedures and is reported to occur in 30-52% of patients undergoing breast reconstruction. Early identification of ischemia and early initiation of hyperbaric oxygen (HBO_2) therapy can mitigate the effects of ischemia and rescue otherwise non-viable breast flap tissue. METHODS: We retrospectively examined the outcomes of HBO_2 therapy in eight breasts with compromised mastectomy skin flaps between September 2015 and January 2017. Indocyanine green angiography (ICGA) was used to assess perfusion intraoperatively and post-HBO_2 administration. RESULTS: Seven patients were referred for HBO_2 within 24 hours of mastectomy. One patient failed to improve despite starting hyperbaric treatment within 24 hours. All other patients manifested successful healing of their mastectomy skin flaps with acceptable cosmesis after 10 HBO_2 treatments. The mean relative perfusion of the at-risk area was 13.8% (±3.7%) pre-HBO_2 and 101.6% (±37.3%) post-HBO_2. The average area at-risk pre-HBO_2 was 17.1 cm^2 and reduced to zero post-HBO_2. Relative perfusion values after HBO_2 were found to be 6.8 (±3.4) times greater than those measured prior to HBO_2. CONCLUSIONS: A short course of HBO_2 may be sufficient to successfully rescue at risk post-mastectomy breast flaps. ICGA is a useful adjunct for evaluating post-mastectomy breast flap perfusion before and after HBO_2 therapy.

Riedl P, Škiljić D, Arnell P, Wannholt R, Zetterberg M, Andersson Grönlund M. Myopic shift and lens turbidity following hyperbaric oxygen therapy - a prospective, longitudinal, observational cohort study. Acta Ophthalmol. 2019;97(6):596-602.

PURPOSE: To examine visual acuity, refraction and ocular status before, during and after hyperbaric oxygen therapy (HBOT). METHODS: Twenty-nine patients underwent 40 standard protocol HBOT treatments. In all subjects, refraction and best corrected visual acuity were measured at baseline and after 10, 20, 30, and 40 treatments, and at a 12-week follow-up. A subgroup (n=19) were given additional examinations at baseline, after 40 treatments and at follow-up including measuring central corneal thickness (CCT), corneal curvature, anterior chamber depth, lens thickness, axial length, fundus morphology, blood pressure and intraocular pressure (IOP). Lens colour and opalescence were graded

using the lens opacities classification system III (LOCS III). RESULTS: Myopic shifts [≥0.5 dioptre (D) spherical equivalent (SE)] occurred in 45 (77.6%) eyes. Median refractive changes of -0.75 D SE (right eye; p<0.001) and -0.66 D SE (left eye; p<0.001) were observed between pretreatment and treatment end (Wilcoxon signed rank test). Refraction returned to baseline at follow-up, except for a small persisting change towards myopia, median -0.25 D SE (left eye; p=0.01). Using the LOCS III, median increases in lens nuclear colour, of 0.6 (right eye; p<0.001) and 0.7 (left eye; p<0.001), and opalescence of 0.7 (both eyes; p=0.01) were found at the last examination. Small reductions were noted in CCT of -6.00 µm (right eye; p=0.03) and -4.00 µm (left eye; p=0.03), and IOP of -1.50 mmHg (left eye; p=0.01). CONCLUSIONS: The transient myopic shift may have been due to lenticular refractive index changes. Reduced lens transparency is a potential consequence of HBOT.

Wahl AM, Bidstrup D, Smidt-Nielsen IG, Werner MU, Hyldegaard O, Rotbøll-Nielsen P. A single session of hyperbaric oxygen therapy demonstrates acute and long-lasting neuroplasticity effects in humans: a replicated, randomized controlled clinical trial. J Pain Res. 2019;12:2337-2348.

PURPOSE: Animal studies have demonstrated anti-inflammatory, and anti-nociceptive properties of hyperbaric oxygen therapy (HBOT). However, physiological data are scarce in humans. In a recent experimental study, the authors used the burn injury (BI) model observing a decrease in secondary hyperalgesia areas (SHA) in the HBOT-group compared to a control-group. Surprisingly, a long-lasting neuroplasticity effect mitigating the BI-induced SHA-response was seen in the HBOT-preconditioned group. The objective of the present study, therefore, was to confirm our previous findings using an examiner-blinded, block-randomized, controlled, crossover study design. PATIENTS AND METHODS: Nineteen healthy subjects attended two BI-sessions with an inter-session interval of ≥28 days. The BIs were induced on the lower legs by a contact thermode (12.5 cm^2, 47C°, 420 s). The subjects were block-randomized to receive HBOT (2.4 ATA, 100% O_2, 90 min) or ambient conditions ([AC]; 1 ATA, 21% O_2), dividing cohorts equally into two sequence allocations: HBOT-AC or AC-HBOT. All sensory assessments performed during baseline, BI, and post-intervention phases were at homologous time points irrespective of sequence allocation. The primary outcome was SHA, comparing interventions and sequence allocations. RESULTS: Data are mean (95% CI). During HBOT-sessions a mitigating effect on SHA was demonstrated compared to AC-sessions, ie, 18.8 (10.5-27.0) cm^2 vs 32.0 (20.1-43.9) cm^2 (P=0.021), respectively. In subjects allocated to the sequence AC-HBOT a significantly larger mean difference in SHA in the AC-session vs the HBOT-session was seen 25.0 (5.4-44.7) cm^2 (P=0.019). In subjects allocated to the reverse sequence, HBOT-AC, no difference in SHA between sessions was observed (P=0.55), confirming a preconditioning, long-lasting (≥28 days) effect of HBOT. CONCLUSION: Our data demonstrate that a single HBOT-session compared to control is associated with both acute and long-lasting mitigating effects on BI-induced SHA, confirming central anti-inflammatory, neuroplasticity effects of hyperbaric oxygen therapy.

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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