

E-NEWS

EDITOR'S NOTE – January 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>.

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NEWS/ANNOUNCEMENTS

Call for Presentations – CUHMA ASM 2020

Both thematic lecture and original research abstracts will be considered for oral presentation at the 2020 CUHMA annual scientific meeting to be held October 22-25 in Niagara Falls, ON. Submission deadlines are **February 15** for thematic lectures and **June 15** for original research. Submit abstracts to neal.pollock@kin.ulaval.ca.

Abstract Submission Guidelines (Word file; all text 10 pitch New Times Roman)

Line 1 - informative title, bold and block capitals.

Line 2 - author(s) (surname followed by initials for each; affiliation numbers superscripted after initials).

Line 3 - professional affiliations, starting with superscripted number and separated by a semi-colon.

Lines 4+ (thematic lecture abstracts) - 150-250 words, block format (ie, no indenting), overview of proposed presentation; no references, tables or figures. No line breaks between sections.

Lines 4+ (research abstracts) - maximum 250 words (introduction, methods, results, conclusions, funding acknowledgment [optional]), block format (ie, no indenting), complete data but no references, tables or figures. No line breaks between sections but section headers bold. Funding acknowledgment limited to one line.

UPCOMING EVENTS

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. Hands-on practice included. 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>.

CUHMA Annual Scientific Meeting 2020

The 2020 CUHMA ASM will be held October 22-25 in Niagara Falls, ON. McMaster University CPD will provide accreditation and meeting support. Two days of pre-conference events will be followed by two days of scientific talks. A welcome reception will be held on Friday evening, and the awards banquet on Saturday evening. Visit our website for updates and registration: <https://cuhma.ca>.

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

Aldana PC, Khachemoune A. Diabetic foot ulcers: appraising standard of care and reviewing new trends in management. *Am J Clin Dermatol.* 2019 Dec 17. doi: 10.1007/s40257-019-00495-x. [Epub ahead of print]

Diabetic foot ulcers (DFU) are one of the most common diabetes complications and are associated with significant morbidity and mortality. Current DFU standard of care (SOC) involves four principles: (1) pressure relief, (2) debridement, (3) infection management, and (4) revascularization when indicated. Despite the current SOC, many DFU persist, warranting a new approach for the management of these complex wounds. This review aims to summarize the current SOC as well as the latest trends in adjunctive therapies that may become the new SOC in DFU management. These include negative pressure wound therapy and hyperbaric oxygen therapy, bioengineered skin substitutes, growth factors, shockwave therapy, and several others. These novel therapies have shown significant DFU clinical improvement among subsets of DFU patients. However, much of the literature comes from smaller trials with inconsistent patient selection and outcomes measured, making it difficult to assess the true clinical benefit of these treatments. While novel therapies are promising for the interdisciplinary approach to DFU management, many still lack sufficient evidence, and their efficacy remains to be determined.

Arieli R. In vitro evidence of decompression bubble dynamics and gas exchange on the luminal aspect of blood vessels: Implications for size distribution of venous bubbles. *Physiol Rep.* 2019 Dec;7(24):e14317. doi: 10.14814/phy2.14317.

We found that lung surfactant leaks into the bloodstream, settling on the luminal aspect of blood vessels to create active hydrophobic spots (AHS). Nanobubbles formed by dissolved gas at these AHS are most probably the precursors of gas micronuclei and decompression bubbles. Sheep blood vessels stretched on microscope slides, and exposed under saline to hyperbaric pressure, were photographed following decompression. Photographs of an AHS from a pulmonary vein, containing large numbers of bubbles, were selected in 1-min sequences over a period of 7 min, starting 18 min after decompression from 1,013 kPa. This showed bubble detachment, coalescence and expansion, as well as competition for dissolved gas between bubbles. There was greater expansion of peripheral than of central bubbles. We suggest that the dynamics of decompression bubbles on the surface of the blood vessel may be the closest approximation to true decompression physiology, and as such can be used to assess and calibrate models of decompression bubbles. We further discuss the implications for bubble size in the venous circulation

Banham ND, Lippmann J. Fatal air embolism in a breath-hold diver. *Diving Hyperb Med.* 2019;49(4):304-5.

Cerebral arterial gas embolism (CAGE) from breath-holding or inadequate exhalation during ascent is a well-recognized complication of scuba diving. It does not usually occur with breath-hold (BH) diving in those with normal lungs, as the volume of gas in the lungs on surfacing cannot exceed what it was on leaving the surface. However, a BH diver who breathes from a compressed gas supply at depth essentially becomes a scuba diver and is at risk of pulmonary barotrauma (PBt) and CAGE on ascent. In this case, a 26-year-old male experienced BH diver breathed from a scuba set at approximately 10 metres' seawater depth and ascended, sustaining massive PBt and CAGE with a fatal outcome. BH and scuba divers, especially those with less experience, need to be well-informed about this potential risk.

Begić A, Dilić M. Evaluation of the occlusive arterial disease and diabetic angiopathy treatment effects by hyperbaric oxygenation. *Med Arch.* 2019;73(4):244-8.

INTRODUCTION: One of the most severe complications of atherosclerosis is arterial occlusive disease (AOD) and with diabetic angiopathy (DA), is a common chronic problem in clinical practice worldwide. Hyperbaric oxygen (HBO) therapy is a therapeutic modality for solving all forms of hypoxia. **AIM:** To compare the treatment with HBO therapy in patients with AOD and DA ischemic symptomatology with standard treatment i.e. vasodilators, antibiotics, antiplatelets and statins, and to demonstrate the benefit of the therapeutic modality itself. **METHODS:** We conducted a clinical prospective study and included a total of 80 patients, divided into two groups: 40 patients with the arterial occlusive disease and lower-extremity wounds, with sub-group (n=20) treated with HBO therapy on the top of the standard therapy and 40 patients with diabetic angiopathy and diabetic lower-extremity wounds, with sub-group (n=20) treated with HBO therapy on top of the standard therapy. **RESULTS:** The efficacy of therapy in patients treated with HBO therapy on the top of standard therapy was significantly higher than in the group of HBO non-treated patients. There was a significant improvement in 9 patients treated with HBO therapy, while in HBO non-treated patients the significant improvement effect was observed only in one patient. **CONCLUSION:** HBO therapy is an effective therapeutic component in the healing of diabetic lower-extremity wounds in the patients with AOD and DA. In our patients HBO therapy on the top of standard therapeutic protocol has an effect of reducing the number of lower-limb amputations in patients with AOD and DA. These results support clinical use of HBO therapy for diabetic lower-extremity wound healing.

Benkő R, Miklós Z, Ágoston VA, Ihonvien K, Répás C, Csépanyi-Kömi R, Kerék M, Béres NJ, Horváth EM. Hyperbaric oxygen therapy dampens inflammatory cytokine production and does not worsen the cardiac function and oxidative state of diabetic rats. *Antioxidants (Basel)*. 2019;8(12). pii: E607.

Hyperbaric oxygen therapy (HBOT) is frequently used after soft tissue injuries and in diabetic patients with ulcerated wounds; however, its ability to increase oxidative stress casts doubts. Diabetes (DM) in male Wistar rats (n=20) weighing 300 g were induced by a single dose of streptozotocin. Ten diabetics (DMHBOT) and 10 controls (CHBOT) underwent a one-hour long hyperbaric oxygen treatment protocol (2.5 bar) 12 times after the 3rd week of diabetes. Ten animals remained untreated. Eight weeks after diabetes induction, we measured the 24-hour blood glucose profile and cardiovascular function (sonocardiography and the relaxation ability of aortae). Malonyl-dialdehyde (MDA) and cytokine levels were measured in blood plasma. Poly(ADP-ribose) polymerase (PARP) activity was estimated in cardiac and aortic tissue. HBOT did not alter most of the cardiovascular parameters. PARylation in cardiac and aortic tissues, plasma MDA levels were elevated in diabetic rats. HBOT prevented the increase of MDA in diabetic animals. In addition, levels of the pro-inflammatory cytokine-induced neutrophil chemoattractant-1 (CINC-1) the levels of anti-inflammatory tissue inhibitor of metalloproteases-1 were not altered in diabetes or in hyperoxia. Our results suggest that HBOT does not increase long-term oxidative stress, and, similar to training, the TBARS products, nitrotyrosine formation and poly(ADP-ribosylation) may be eased as a result of hyperoxia.

Bennett MH, Hui CF, See HG, Au-Yeung KL, Tan C, Watson S. The myopic shift associated with hyperbaric oxygen administration is reduced when using a mask delivery system compared to a hood - a randomised controlled trial. *Diving Hyperb Med*. 2019;49(4):245-52.

INTRODUCTION: A temporary myopic shift is a well-recognized complication of hyperbaric oxygen treatment (HBOT). Oxidation of proteins in the crystalline lens is the likely cause. Direct exposure of the eye to hyperbaric oxygen may exacerbate the effect. Our aim was to measure the magnitude of the myopic shift over a course of HBOT when using two different methods of oxygen delivery. **METHODS:** We conducted a randomised trial of oxygen delivery via hood versus oronasal mask during a course of 20 and 30 HBOT sessions. Subjective refraction was performed at baseline and after 20 and 30 sessions. We repeated these measurements at four and 12 weeks after completion of the course in those available for assessment. **RESULTS:** We enrolled 120 patients (mean age 57.6 (SD 11.2) years; 81% male). The myopic shift was significantly greater after both 20 and 30 sessions in

those patients using the hood. At 20 treatments: refractory change was -0.92 D with hood versus -0.52 D with mask, difference 0.40 D (95% CI 0.22 to 0.57, P<0.0001); at 30 treatments: -1.25 D with hood versus -0.63 with mask, difference 0.62 D (95% CI 0.39 to 0.84, P<0.0001). Recovery was slower and less complete in the hood group at both four and 12 weeks. **CONCLUSIONS:** Myopic shift is common following HBOT and more pronounced using a hood system than an oronasal mask. Recovery may be slower and less complete using a hood. Our data support the use of an oronasal mask in an air environment when possible.

Binkley K, Katznelson R. Successful treatment of long standing complex regional pain syndrome with hyperbaric oxygen therapy. *J Neuroimmune Pharmacol*. 2019 Dec 14. doi: 10.1007/s11481-019-09901-x. [Epub ahead of print]

Complex regional pain syndrome (CRPS) is a devastating posttraumatic neuroinflammatory condition with both autoinflammatory and autoimmune features, characterized by unrelenting severe pain and disability, with the majority of affected patients being unable to function socially or vocationally. Remission is more likely in children than adults, and if treatment is started early. Once established, there are no universally effective treatments, and these are desperately needed. A single limb is often involved, but there can be multi-limb spread, and systemic autonomic manifestations. We describe a case of long-standing CRPS with multi-limb spread and systemic autonomic features, controlled only with very high dose oral corticosteroids, which led to several complications. Multiple other treatment modalities failed or were insufficient to control the CRPS and allow tapering of the corticosteroids, but the patient had a dramatic response to hyperbaric oxygen therapy (HBOT), allowing a reduction in prednisone dose to just over the physiologic range. When symptoms started to increase several months later, a second course of HBOT treatments allowed reduction in prednisone dose into the physiologic range while still controlling CRPS symptoms. This case is unique in that it shows that HBOT can be effective in long-standing CRPS, both initially, and for subsequent flares, and adds to the evidence supporting HBOT as a potential treatment for this condition. Graphical Abstract HBOT effect on prednisone dose for symptom control.

Casillas S, Galindo A, Camarillo-Reyes LA, Varon J, Surani SR. Effectiveness of hyperbaric oxygenation versus normobaric oxygenation therapy in carbon monoxide poisoning: a systematic review. *Cureus*. 2019 Oct 15;11(10):e5916.

Carbon monoxide (CO) is a gas product of combustion, considered highly poisonous. Prolonged CO exposure is responsible for more than half of fatal poisonings and is also one of the leading causes of poisoning in Western

countries. We aimed to compare the effectiveness of therapy with hyperbaric oxygen (HBO) versus normobaric oxygen (NBO) in the setting of carbon monoxide poisoning (COP). We independently searched the National Library of Medicine's Medline (PubMed™), ScienceDirect™, and Scielo™ for any relevant studies published from 1989 to 2017, using the following keywords: hyperbaric therapy, hyperbaric oxygenation, normobaric therapy, carbon monoxide poisoning, carboxyhemoglobin, Haldane effect. We analyzed the studies that suggested the effectiveness of HBO or NBO. Also, we searched for studies related to COP; including history, epidemiology (risk factors, incidence, demographics pathophysiology, clinical manifestations, diagnosis, and treatment. Sixty-eight articles were found, sixteen of which dealt with either HBO or NBO or both. Twelve suggested HBO as the treatment of choice in COP; four studies indicated that NBO was an adequate treatment due to its cost-effectiveness and availability in the emergency department (ED). HBO has been shown in several studies to be effective in moderate to high-risk COP situations, being the therapy of choice to avoid sequelae, especially neurologically. NBO can be considered as a reasonable alternative due to its cost-effectiveness. The availability and understanding of different therapeutic interventions are critical in the management of patients with COP in ED and the critical care unit.

Chouchou F, Pichot V, Costes F, Guillot M, Barthélémy JC, Bertoletti L, Roche F. Autonomic cardiovascular adaptations to acute head-out water immersion, head-down tilt and supine position. Eur J Appl Physiol. 2019 Dec 7. doi: 10.1007/s00421-019-04278-4. [Epub ahead of print]

PURPOSE: Thermoneutral head-out water immersion (WI) and 6° head-down tilt (HDT) have been considered as suitable models to increase central blood volume and simulate autonomic cardiovascular adaptations to microgravity, swimming or scuba diving. However, any differences in autonomic cardiovascular adaptations are still unclear. In this study, we hypothesized that WI induces a higher activation of arterial baroreceptors and the parasympathetic system. **METHODS:** Ten healthy men underwent 30 min of WI, HDT, and a supine position (SP). RR intervals (RRI) and blood pressure (BP) were continuously monitored. High frequency power (HF), low frequency power (LF) and LF/HF ratio were calculated to study sympathetic and parasympathetic activities, and a spontaneous baroreflex method was used to study arterial baroreflex sensitivity (aBRS). Lung transfer of nitric oxide and carbon monoxide (TLNO/TLCO), vital capacity and alveolar volume (Vc/VA) were measured to study central blood redistribution. **RESULTS:** We observed (1) a similar increase in RRI and decrease in BP; (2) a similar increase in HF power during all experimental conditions,

whereas LF increased after; (3) a similar rise in aBRS; (4) a similar increase in Vc/VA and decrease in TLNO/TLCO in all experimental conditions. **CONCLUSIONS:** These results showed a cardiac parasympathetic dominance to the same extent, underpinned by a similar arterial baroreflex activation during WI and HDT as well as control SP. Future studies may address their association with cold or hyperoxia to assess their ability to replicate autonomic cardiovascular adaptations to microgravity, swimming or scuba diving.

de Bakker HM, Tijsterman M, de Bakker-Teunissen OJG, Soerdjbalie-Maikoe V, van Hulst RA, de Bakker BS. Prevalence of pulmonary bullae and blebs in post-mortem computed tomography with potential implications for diving medicine: Prevalence of pulmonary bullae and blebs. Chest. 2019 Nov 21. pii: S0012-3692(19)34226-6.

BACKGROUND: Pulmonary bullae and blebs can result in a pneumothorax. Their prevalence in the normal population is currently unknown. We used post-mortem computed tomography (PMCT) from a forensic database to determine the prevalence of pulmonary bullae/blebs in the normal Dutch adult population and its consequence for diving medicine, as they are often considered a contraindication for diving. **METHODS:** Forensic PMCT scans of 130 adults were analysed for the presence of bullae and/or blebs in a cross-section of the Dutch population without pulmonary disorders. The lungs had to be unharmed, expanded and without signs of illnesses. Normal early-stage post-mortem changes in the lungs were accepted. **RESULTS:** Analysis was performed per decade. Group I (21-30 years): n=26. Blebs were observed in four persons, one showed blebs and bullae. Group II (31-40 y): n=28. Blebs in nine individuals, one with bullae. Group III (41-50 y): n=27. Blebs in nine individuals, bullae in 1, bullae and blebs in 4. Group IV (51-60 y): n=28. Blebs in seven individuals and two with bullae and blebs. Group V (61-70 y): n=21. Blebs in three persons, bullae and blebs in two and isolated bullae in one. On average, most bullae/blebs were smaller than 10 mm and none exceeded 20 mm. **CONCLUSION:** By reassessing pulmonary PMCT scans we found a surprisingly high incidence of small bullae and/or blebs in one third (33.8% (95% confidence interval: 25.7-41.9%)) of the general population without underlying lung disease. This finding can have potential implications for diving medicine.

Friedman T, Menashe S, Landau G, Sherf M, Wisner I, Seligman Y, Friedman M, Hadanny A, Efrati S, Heller L. Hyperbaric oxygen preconditioning can reduce postabdominoplasty complications: a retrospective cohort study. Plast Reconstr Surg Glob Open. 2019 Oct 31;7(10):e2417.

BACKGROUND: Hyperbaric oxygen therapy (HBOT) can improve wound healing and has been found to have positive preconditioning effects in animal models. Among esthetic surgical procedures, abdominoplasty poses the highest rate of postoperative complications. The aim of this study was to evaluate the effect of preoperative HBOT as a preconditioning treatment for expected postsurgical complications. **METHODS:** We conducted a retrospective cohort study among patients who underwent abdominoplasty at our institute and private practice between January 2012 and November 2017. Patients who received preoperative HBOT were compared with patients who did not receive HBOT. Surgical complication data and demographic, preoperative and postoperative data from patient records were collected. **RESULTS:** The study included 356 patients. Of them, 83 underwent HBOT preoperatively. Using preoperative HBOT, postoperative complications were significantly reduced from 32.6% (89 patients) to 8.4% (7 patients), $P < 0.001$. Moreover, 17 (6.2%) patients in the comparison group and none in the HBOT group experienced necrosis ($P = 0.016$). In the multivariate analysis, preoperative HBOT was an independent protective factor against postoperative complications (odds ratio, 0.188; 95% CI, 0.082-0.432; $P < 0.001$). After propensity score matching, the study results remained the same. **CONCLUSIONS:** Preoperative HBOT can reduce postoperative complication rate in abdominoplasty patients. Further prospective studies are necessary to validate the findings and characterize patients who benefit the most from this treatment.

Gant N, van Waart H, Ashworth ET, Mesley P, Mitchell SJ. Performance of cartridge and granular carbon dioxide absorbents in a closed-circuit diving rebreather. *Diving Hyperb Med.* 2019;49(4):298-303.

INTRODUCTION: Scrubbers in closed-circuit rebreather systems remove carbon dioxide (CO₂) from the exhaled gas. In an attempt to be more user-friendly and efficient, the ExtendAir® non-granular, pre-formed scrubber cartridge has been developed. The cartridge manufacturer claims twice the absorptive capacity of granular CO₂ absorbent, with less variability, lower work of breathing, and reduced exposure to caustic chemicals after a flood. To our knowledge there are no published data that support these claims. **METHODS:** Cartridge (ExtendAir®) and granular (Sofnolime® 797) scrubbers of equal volume and mass were tested five times in an immersed and mechanically ventilated O₂ptima rebreather. Exercise protocols involving staged (90 minutes 6 MET, followed by 2 MET) and continuous (6 MET) activity were simulated. We compared: duration until breakthrough, and variability in duration, to endpoints of 1.0 kPa and 0.5 kPa inspired partial pressure of CO₂; inspiratory-expiratory pressure difference in the breathing loop; and pH of eluted water after a 5 minute flood. **RESULTS:** Mean difference in scrubber endurance was 0-20% in favour of the

ExtendAir® cartridge, depending on exercise protocol and chosen CO₂ endpoint. There were no meaningful differences in endpoint variability, inspiratory-expiratory pressure in the loop, or pH in the eluted water after a flood. **CONCLUSIONS:** Cartridge and granular scrubbers were very similar in duration, variability, ventilation pressures, and causticity after a flood. Our findings were not consistent with claims of substantial superiority for the ExtendAir® cartridge.

Hara S, Kusunoki T, Honma H, Kidokoro Y, Ikeda K. Efficacy of the additional effect of hyperbaric oxygen therapy in combination of systemic steroid and prostaglandin E1 for idiopathic sudden sensorineural hearing loss. *Am J Otolaryngol.* 2019 Nov 27:102363.

PURPOSE: The efficacies of hyperbaric oxygen therapy (HBO), systemic steroid, prostaglandin E₁, or the combination of any two modalities have been reported in patients with idiopathic sudden sensorineural hearing loss (ISSNHL). However, little is known about the combined efficacy of HBO, systemic steroid, and prostaglandin E₁ for this disorder. We aimed to investigate the efficacy of HBO combined with systemic steroids and prostaglandin E₁ as triple therapy in patients with ISSNHL. **MATERIALS AND METHODS:** We retrospectively evaluated the records of 67 patients with ISSNHL who were treated with systemic steroid and prostaglandin E₁, with (n=38) or without (n=29) HBO. The inclusion criteria included a diagnosis of ISSNHL within 14 days of symptom onset, age ≥ 15 years, treatment according to the protocol, and clinical follow-up of at least 1 month. The patients' hearing levels were evaluated 1 month after hearing loss onset. The primary outcome was hearing improvement on pure tone audiometry. We also evaluated the demographic profiles of patients. **RESULTS:** Patients treated with triple therapy showed significantly greater hearing improvement ($p < 0.01$) than those treated without HBO, despite some differences between the two treatment groups. Multivariate logistic regression analysis revealed a significant positive correlation between pure tone audiometry improvement and hyperbaric oxygen therapy, after adjustment for confounding factors (odds ratio = 7.42; 95% and confidence interval = 2.37-23.3; $p = 0.001$). **CONCLUSION:** HBO with systemic steroid and prostaglandin E₁ administration conferred significant therapeutic benefits for ISSNHL. Therefore, routine use of triple therapy is recommended for patients with ISSNHL.

Johnson DR, Cooper JS. Retinal artery and vein occlusions successfully treated with hyperbaric oxygen. *Clin Pract Cases Emerg Med.* 2019 Sep 25;3(4):338-340. doi: 10.5811/cpcem.2019.7.43017. eCollection 2019 Nov.

We present six cases of central retinal artery occlusion (CRAO) and central retinal vein occlusion (CRVO) that we recently treated with hyperbaric oxygen (HBO₂). Patients in three of the six cases, including the CRVO

case, experienced near to complete restoration of their vision. Another case had marked improvement. Our findings are similar to other case studies with approximately 65-70% improvement in patients treated for CRAO. Physicians should be aware that rapid referral of CRAO and CRVO patients to HBO₂ is efficacious. Such patients should be placed on 100% oxygen by non-rebreather mask as soon as the diagnosis is suspected, pending transportation to HBO₂.

Liao J, Ren J, Qing W, Mu YD, Li P. Impact of hyperbaric oxygen on the healing of teeth extraction sockets and alveolar ridge preservation. Clin Oral Investig. 2019 Dec 3. doi: 10.1007/s00784-019-03117-2. [Epub ahead of print]

OBJECTIVES: The purpose of this study was to investigate the role of hyperbaric oxygen (HBO) in the healing of teeth extraction sockets and in alveolar ridge preservation. This may provide an experimental basis for the widespread application of HBO in oral implantation. **METHODS:** A total of 32 beagle dogs were included in the study and randomly divided equally between an HBO group treated with hyperbaric oxygen (100% O₂, 2.4 atm, 90 min/day, 5 times/week, 6 weeks) and a normobaric oxygen (NBO) group treated with normal air in the same chamber. The lateral incisors of the maxillary and mandible of each dog were extracted, and the right upper and lower incisor extraction sockets (A2C2) were allowed to heal naturally, while left upper and lower incisor sockets (B2D2) received implants of a commercial bone substitute. At 4 and 8 weeks after surgery, clinical observation, cone-beam computerized tomography (CBCT), histomorphology observation, and expression levels of vascular endothelial growth factor (VEGF) and bone morphogenetic protein 2 (BMP-2) were analyzed to evaluate new bone formation, mineralization, and reconstruction. **RESULTS:** After 4 and 8 weeks, bone width and lip contour of the extraction socket in the NBO group were significantly reduced and collapsed in comparison with the HBO group. CBCT showed that the difference in vertical height between the alveolar crest of the labial tongue and palatal side of the extraction sockets was smaller in the HBO than NBO group. There was a significant difference in new bone formation ($P<0.05$) and bone mineral density ($P<0.05$) between the HBO and NBO groups, and the HBO group showed significantly greater new bone and bone reconstruction based on histology. Furthermore, the expression levels of VEGF and BMP-2 were higher in the HBO group. **CONCLUSION:** HBO reduced bone resorption and promoted early bone formation, bone mineralization, and reconstruction in the extraction sockets. HBO greatly reduced the healing time of the extraction sockets and promoted alveolar ridge preservation, thus showing promise for the clinic.

Łuczyński D, Lautridou J, Hjelde A, Monnoyer R, Eftedal I. Hemoglobin during and following a 4-week commercial saturation dive to 200 m. Front Physiol. 2019 Dec 6;10:1494. doi: 10.3389/fphys.2019.01494. eCollection 2019.

Commercial saturation divers must acclimatize to hyperbaric hyperoxia in their work environment, and subsequently readjust to breathing normal air when their period in saturation is over. In this study, we measured hemoglobin (Hb) during and following 4 weeks of heliox saturation diving in order to monitor anemia development and the time for Hb to recover post-saturation. Male commercial saturation divers reported their capillary blood Hb daily, before, and during 28 days of heliox saturation to a working depth of circa 200 m ($n=11$), and for 12 days at surface post-saturation ($n=9-7$), using HemoCue 201+ Hb devices. Hb remained in normal range during the bottom phase, but fell during the decompression; reaching levels of mild anemia (≤ 13.6 g/dl) the day after the divers' return to the surface. Hb was significantly lower than the pre-saturation baseline (14.7 ± 1.1 g/dl) on the fifth day post-saturation (12.8 ± 1.8 g/dl, $p=0.028$), before reverting to normal after 6-7 days. At the end of the 12-day post-saturation period, Hb was not statistically different from the pre-saturation baseline. The observed Hb changes, although significant, were modest. While we cannot rule out effect of other factors, the presence of mild anemia may partially explain the transient fatigue that commercial saturation divers experience post-saturation.

Lundell RV, Arola O, Suvilehto J, Kuokkanen J, Valtonen M, Räisänen-Sokolowski AK. Decompression illness (DCI) in Finland 1999-2018: Special emphasis on technical diving. Diving Hyperb Med. 2019;49(4):259-65.

INTRODUCTION: This is the first published study on decompression illness (DCI) and its treatment in Finland. Diving conditions are demanding, as even in the summer the water temperature below 20 meters' sea/fresh water (msw/mfw) is 4-10°C. Technical diving has become more popular over the years, so the emphasis of this study was to describe DCI in technical divers and compare it with non-technical recreational divers. **METHODS:** This study includes by estimation over 95% of all hyperbaric oxygen-treated DCI patients during the years 1999-2018 ($n=571$). The cases were divided into technical divers ($n=200$) and non-technical divers ($n=371$). We focused on the differences between these two groups. Technical diving was defined as the usage of mixed breathing gases, closed circuit rebreather diving or planned decompression diving. **RESULTS:** The mean annual number of treated DCI cases in Finland was 29 (range 16-38). The number of divers treated possibly indicate a shift towards technical diving. Technical dives were deeper and longer and were mainly performed in cold water or an overhead environment. Technical divers were more likely to utilize first aid 100% oxygen (FAO₂) and sought medical attention earlier than

non-technical divers. Symptom profiles were similar in both groups. Recompression was performed using USN Treatment Table Six in the majority of the cases and resulted in good final outcome. Eighty two percent were asymptomatic on completion of all recompression treatment(s). **CONCLUSION:** This 20-year observational study indicates a shift towards technical diving, and hence a more demanding and challenging style of diving among Finnish divers, with a surprisingly constant number of DCI cases over the years. There is still need for improvement in divers' education in use of FAO₂ for DCI symptoms. Fortunately, the outcome after recompression therapy is generally successful.

Maalej A, Khallouli A, Choura R, Ben Sassi R, Rannen R, Gharsallah H. The effects of hyperbaric oxygen therapy on diabetic retinopathy: a preliminary study. J Fr Ophtalmol. 2019 Dec 9. pii: S0181-5512(19)30485-1.

PURPOSE: The objective of this study was to prospectively assess the effect of hyperbaric oxygen therapy (HBOT) on diabetic retinopathy lesions and macular edema in patients undergoing the treatment for diabetic foot ulcers. **METHODS:** We compared two groups: a first group including 25 patients with non-proliferative diabetic retinopathy treated by HBOT for foot ulcers, and a second group (control group) composed of 25 patients with diabetic retinopathy who did not receive HBOT. The HBOT protocol performed for the patients in the first group was: 30 sessions of 90 minutes each at 2.5 ATA with a mean frequency of five sessions per week. All patients had an ophthalmological exam at baseline (visual acuity, intraocular pressure, fundus exam), fundus photography and an OCT exam. A follow-up exam was performed at the conclusion of the HBOT. **RESULTS:** Compared to the control group, patients treated with HBOT showed a regression or stabilization of diabetic retinopathy lesions and a decrease in central macular thickness. **CONCLUSION:** Hyperbaric oxygen therapy may improve diabetic retinopathy and diabetic macular edema. This therapy may serve as an adjunctive treatment in the management of retinal ischemia and capillary hyperpermeability in diabetic retinopathy.

Nguyen TT, Jones JI, Wolter WR, Pérez RL, Schroeder VA, Champion MM, Heseck D, Lee M, Suckow MA, Mobashery S, Chang M. Hyperbaric oxygen therapy accelerates wound healing in diabetic mice by decreasing active matrix metalloproteinase-9. Wound Repair Regen. 2019 Nov 17. doi: 10.1111/wrr.12782. [Epub ahead of print]

Diabetic foot ulcers are characterized by hypoxia. For many patients, hyperbaric oxygen (HBO) therapy is the last recourse for saving the limb from amputation, for which the molecular basis is not understood. We previously identified the active form of matrix metalloproteinase-9 (MMP-9) as responsible for diabetic

foot ulcer's recalcitrance to healing. Transcription of mmp-9 to the inactive zymogen is upregulated during hypoxia. Activation of the zymogen is promoted by proteases and reactive oxygen species (ROS). We hypothesized that the dynamics of these two events might lead to a lowering of active MMP-9 levels in the wounded tissue. We employed the full-thickness excisional db/db mouse model to study wound healing, and treated the mice to 3.0 atmospheres of molecular oxygen for 90 minutes, 5 days per week for 10 days in an HBO research chamber. Treatment with HBO accelerated diabetic wound healing compared to untreated mice, with more completed and extended re-epithelialization. We imaged the wounds for ROS in vivo with a luminol-based probe and found that HBO treatment actually decreases ROS levels. The levels of superoxide dismutase, catalase, and glutathione peroxidase-enzymes that turn over ROS-increased after HBO treatment, hence the observation of decreased ROS. Since ROS levels are lowered, we explored the effect that this would have on activation of MMP-9. Quantitative analysis with an affinity resin that binds and pulls down the active MMPs exclusively, coupled with proteomics, revealed that HBO treatment indeed reduces the active MMP-9 levels. This work for the first time demonstrates that diminution of active MMP-9 is a contributing factor and a mechanism for enhancement of diabetic wound healing by HBO therapy.

Razdan PS, Buteau D, Pollock NW. A case of Löfgren's syndrome confused with decompression sickness. Diving Hyperb Med. 2019;49(4):306-10.

A broad differential diagnosis is important to provide appropriate care. This may be challenging for conditions like decompression sickness (DCS) which can be easily confused with other conditions. In suspected DCS, treatment may be an important part of the diagnosis. An improvement in symptoms after hyperbaric oxygen treatment (HBOT) is consistent with a DCS event. However, HBOT may also impact symptoms in other conditions, including Löfgren's syndrome (LS). LS, a poorly understood, clinically distinct phenotype of sarcoidosis, is a complex, multi-system granulomatous inflammatory condition. Like DCS, LS symptoms are heterogeneous and idiosyncratic. We report on a patient initially diagnosed with DCS who presented new symptoms suggestive of LS after HBOT.

St Leger Dowse M, Whalley B, Waterman MK, Conway RM, Smerdon GR. Diving and mental health: the potential benefits and risks from a survey of recreational scuba divers. Diving Hyperb Med. 2019;49(4):291-7.

INTRODUCTION: Scuba diving is physically and cognitively demanding. Medical guidance regarding physical and mental health (MH) issues and related prescribed medication is often based on limited evidence. There is a paucity of data concerning diving with MH

issues. This survey aimed to investigate the prevalence of MH issues and use of prescription medications among United Kingdom (UK) sport divers, and the rate of non-compliance with current guidance among divers suffering depression and anxiety. The positive effects of scuba diving on MH were also considered. METHODS: An anonymous online survey was publicised through diving exhibitions and social media. Measures included diver and diving demographics; GAD-7 Anxiety and PHQ-9 depression questionnaires; diagnosed current and/or past MH conditions; medication usage; comorbid medical conditions/treatments; disclosure of past/current MH issues; and perceived MH benefits of diving. RESULTS: Data from 729 respondents revealed MH issues at rates comparable with the general population. Current and/or past MH issues were reported by 111/729, with 60 having active diagnoses, and 45/60 taking prescribed psychotropic medications; 21/45 did not declare their medication on diver self-certification medical forms. The activity of diving was thought to be beneficial to MH by 119/729 respondents. CONCLUSIONS: Divers experienced expected levels of MH issues, but did not comply with current medical guidelines on modifying or abstaining from diving activity or reporting their MH condition. Changes may be needed to diver training to encourage more accurate reporting and aid development of evidence-based protocols. Guidelines could be reconsidered in light of current diver behaviour, risks and potential MH benefits.

Wingelaar TT, Brinkman P, de Vries R4, van Ooij PAM, Hoencamp R, Maitland-van der Zee AH, Hollmann MW, van Hulst RA. Detecting pulmonary oxygen toxicity using eNose technology and associations between electronic nose and gas chromatography-mass spectrometry data. *Metabolites*. 2019 Nov 22;9(12). pii: E286. doi: 10.3390/metabo9120286.

Exposure to oxygen under increased atmospheric pressures can induce pulmonary oxygen toxicity (POT). Exhaled breath analysis using gas chromatography-mass spectrometry (GC-MS) has revealed that volatile organic compounds (VOCs) are associated with inflammation and lipoperoxidation after hyperbaric-hyperoxic exposure. Electronic nose (eNose) technology would be more suited for the detection of POT, since it is less time and resource consuming. However, it is unknown whether eNose technology can detect POT and whether eNose sensor data can be associated with VOCs of interest. In this randomized cross-over trial, the exhaled breath from divers who had made two dives of 1 h to 192.5 kPa (a depth of 9 m) with either 100% oxygen or compressed air was analyzed, at several time points, using GC-MS and eNose. We used a partial least square discriminant analysis, eNose discriminated oxygen and air dives at 30 min post dive with an area under the receiver operating characteristics curve of 79.9% (95% CI: 61.1-98.6;

$p=0.003$). A two-way orthogonal partial least square regression (O2PLS) model analysis revealed an R^2 of 0.50 between targeted VOCs obtained by GC-MS and eNose sensor data. The contribution of each sensor to the detection of targeted VOCs was also assessed using O2PLS. When all GC-MS fragments were included in the O2PLS model, this resulted in an R^2 of 0.08. Thus, eNose could detect POT 30 min post dive, and the correlation between targeted VOCs and eNose data could be assessed using O2PLS.

Wingelaar TT, Endert EL, Hoencamp R, van Ooij PA, van Hulst RA. Longitudinal screening of hearing threshold in navy divers: is diving really a hazard? *Diving Hyperb Med*. 2019 Dec 20;49(4):283-90.

INTRODUCTION: Hearing loss (HL) is common in the adult working population. It is widely assumed that diving is a risk factor for HL. However, studies with sufficient follow-up comparing HL in divers to non-divers are limited. This study aimed to assess the hearing threshold (HT) of Royal Netherlands Navy divers who had been diving for more than 15 years and to compare it to the ISO standard 7029:2017 reference table. METHODS: In this 25-year retrospective cohort study the Royal Netherlands Navy Diving Medical Centre audited the medical records of 1,117 Navy divers. Yearly dive medical assessments were performed according to professional standards, including audiometry. HTs were compared to the ISO 7029:2017 reference table, including Z-distribution, using paired t-tests. RESULTS: Thirty-five divers were included who had been diving for 15 years or longer. The HT increased significantly in nine of the 16 measured frequencies, while the Z-score decreased significantly in nine of the 16 tested frequencies (eight in both ears). In the 25-year follow-up the pattern was more obvious, with one significantly increased HT, and 10 significantly decreased Z-scores. DISCUSSION: The absolute HT increases after 15 years of military diving, but less than would be expected from normal age-related deterioration. Moreover, when comparing Z-scores, this sample of divers actually hear better than non-divers. We conclude that military diving is not an increased risk for HL compared to regular occupational hazards and suggest withdrawing the requirement for routine yearly audiometric evaluation as part of a dive medical examination.

Zenske A, Kähler W, Koch A, Oellrich K, Pepper C, Muth T, Schipke JD. Does oxygen-enriched air better than normal air improve sympathovagal balance in recreational divers? An open-water study. *Res Sports Med*. 2019 Nov 24:1-16.

Effects of the hyperbaric environment on the autonomic nervous system (ANS) in recreational divers are not firmly settled. Aim of this exploratory study was to (1) assess ANS changes during scuba diving via recordings of

electrocardiograms (ECG) and to (2) study whether nitrox40 better improves sympathovagal balance over air. 13 experienced divers (~40 yrs) performed two open-water dives each breathing either air or nitrox40 (25 m/39 min). 3-channel ECGs were recorded using a custom-made underwater Holter-monitor. The underwater Holter system proved to be safe. Air consumption exceeded nitrox40 consumption by 12% (n=13; p<0.05). Both air and nitrox40 dives reduced HR (10 vs 13%; p<0.05). The overall HRV (pNN50: 82 vs 126%; p<0.05) and its vagal proportion (RMSSD: 33 vs 50%; p<0.05) increased during the dive. Moreover, low (LF: 61 vs 47%) and high (HF: 71 vs 140%) frequency power were increased (all p<0.05), decreasing the ratio of LF to HF (22 vs 34%). Conventional open-water dives distinctly affect the ANS in experienced recreational divers, with sympathetic activation less pronounced than vagal activation thereby improving the sympathovagal balance. Nitrox40 delivered two positive results: nitrox40 consumption was lower than air consumption, and nitrox40 better improved the sympathovagal balance over air.

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