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

E-NEWS

EDITOR'S NOTE – July 2020

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

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NEWS/ANNOUNCEMENTS

New Recreational Diver Medical Screening System

The Recreational Scuba Training councils (Europe, US, and World) have endorsed a new recreational diver medical screening system to replace the RSTC medical form used since 1989. The new product remains a three-part system: a participant questionnaire completed by diving candidates; an evaluation form completed by physicians evaluating diving candidates; and diving medical guidance on relevant topics. The diving medical screen committee responsible for the development work comprises Nicholas Bird, Oliver Firth, Tony Frew, Allesandro Marroni, Simon Mitchell, Neal Pollock, and Adel Taher. Additional details found at: https://www.uhms.org/resources/recreational-diving-medical-screening-system.html

https://xray-mag.com/content/medical-statement-form-has-been-updated

UPCOMING EVENTS

UHN Introductory Hyperbaric Medicine Course

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

RECENT PUBLICATIONS

Baines CR, Cooper D, O'Rourke GA, Miller C. Evaluation of the Abbot FreeStyle Optium Neo H blood glucose meter in the hyperbaric oxygen environment. Diving Hyperb Med. 2020;50(2):144-51.

Introduction: This study investigated the effects of hyperbaric oxygen treatment (HBOT) on the accuracy and reliability of point-of-care fingertip capillary blood glucose values in euglycaemic non-diabetic participants compared against venous serum blood glucose samples processed in an accredited pathology laboratory. Method: Ten non-diabetic hyperbaric staff members (age 35-55 years) underwent a standard 243 kPa HBOT exposure for 95 minutes. Blood glucose levels were measured via (i) finger-prick capillary test using the FreeStyle Optium™ Neo H glucometer and (ii) venous serum test using the Cobas 6000 laboratory analyser. Samples were taken at (T1) 0 minutes (pre-HBOT), (T2) 25 minutes, and (T3) 55 minutes into HBOT. Results: All participants were euglycaemic at T1 (BGL 3.8-5.4 $mmol \cdot L^{-1}$). The highest venous serum value was 5.90 $mmol \cdot L^{-1}$ at T3 and the highest capillary value was 6.30 $mmol \cdot L^{-1}$ at T1. Post hoc tests showed a statistically significant difference between the mean capillary result pre-dive (T1) and readings at T2 ($P=0.001$) and T3 ($P<0.001$) while differences between T2 and T3 capillary results were not statistically significant, illustrating the effect of HBOT on capillary beds. Differences in venous values across the time points were not significant. Conclusion: Venous serum glucose samples processed in an accredited laboratory may be more consistently accurate, but capillary point-of-care testing avoids delays in sample processing and provides glucose data that are of clinical relevance. The FreeStyle Optium™ Neo H glucometer is safe to use and provides a reliable measurement of blood glucose in the HBOT environment.

Brügger JW, Rauscher GA, Florian JP. Hyperoxic myopia: a case series of four divers. Undersea Hyperb Med. 2020;47(2):261-5.

Hyperoxic myopia is a phenomenon reported in individuals who have prolonged exposure to an increased partial pressure of oxygen (PO_2) and subsequently have a myopic (nearsighted) change in their vision. To date, there are numerous accounts of hyperoxic myopia in dry hyperbaric oxygen treatment patients; however, there have

been only three confirmed cases reported in wet divers. This case series adds four confirmed cases of hyperoxic myopia in wet divers using 1.35 atmospheres (ATM) PO_2 at the Navy Experimental Diving Unit (NEDU). The four divers involved were the first author's patients at NEDU. Conditions for two divers were confirmed via record review, whereas the other two divers were diagnosed by the first author. All subjects were interviewed to correlate subjective data with objective findings. Each subject completed five consecutive six-hour hyperoxic (PO_2 of 1.35 ATM) dives with 18-hour surface intervals. Each individual was within the US Navy Dive Manual's standards for general health. Visual acuity was measured prior to diving. Within three to four days after diving, the individuals reported blurry vision with an associated myopic refraction shift. Each diver had spontaneous resolution of his myopia over the next two to three weeks, with no significant residual symptoms. The divers in this case series were exposed to an increased PO_2 (1.35 ATM for 30 hours over five days), a lesser exposure than that in other reports of hyperoxic myopia in wet divers diagnosed with hyperoxic myopia (1.3-1.6 ATM for 45-85 hours in 12-18 days). Furthermore, this pulse of exposure was more concentrated than typically seen with traditional hyperbaric oxygen therapy. Hyperoxic myopia continues to be a risk for those conducting intensive diving with a PO_2 between 1.3-1.6 ATM. Additional investigation is warranted to better define risk factors and PO_2 limits regarding ocular oxygen toxicity.

De K, Nanajkar M, Mote S, Ingole B. Coral damage by recreational diving activities in a marine protected area of India: unaccountability leading to 'tragedy of the not so commons.' Mar Pollut Bull. 2020 Jun;155:111190.

Globally, coral reefs have drastically degraded due to local and global environmental stressors. Concurrently, coral reef tourism is rapidly growing in developing economies, which is one of many anthropogenic stressors impacting reefs. At the Malvan Marine Sanctuary, a Marine Protected Area (MPA) on the West coast of India, we investigated the impact of recreational diving on the reef from 2016 to 2019. To evaluate the diver's underwater behavior, a novel approach was used, wherein the video-log broadcasting website www.youtube.com was perused. Evidential proof substantiates heavy physical damage to corals because of recreational diving activity, which may lead to the collapse of coral habitat if it continues unabated. This resource depletion ironically elevates the economy of dependents averting consequences due to lost corals, thus making this a 'tragedy' for corals which are not meant to be 'commons'. The study asserts need for proactive conservation efforts with stringent implementation and restoration initiatives in this MPA.

Edinguele WFOP, Barberon B, Poussard J, Thomas E, Reynier JC, Coulange M. Middle-ear barotrauma after hyperbaric oxygen therapy: a five-year retrospective analysis on 2,610 patients. Undersea Hyperb Med. 2020;47(2):217-28.

Introduction: Hyperbaric oxygen (HBO_2) therapy is the use of oxygen or gas mixtures at a pressure above atmospheric pressure for therapeutic purposes. This treatment is used in numerous pathological processes. Its main side effect is middle ear barotrauma (MEB), which represents a great concern for iatrogenic HBO_2 therapy. The aim of this work is to describe this adverse event in order to highlight clinical elements that can contribute to its prevention and management. Methods: We conducted a five-year retrospective study from January 2013 to December 2017, where 2,610 patients were selected, in the Hyperbaric Medicine Centre, Sainte- Marguerite Hospital of Marseille, France. Results: 262 patients experienced MEB after HBO_2, representing a prevalence of 10.04% and incidence of 0.587%. Their average age was 55±19 years. Women were more affected than men. We have not highlighted a seasonality to this condition. Risk factors were: age older than 55 years, female gender, ear, nose and throat history (cancer, radiotherapy, infections or allergies, malformations or benign tumors), general history (smoking, obstructive breathing disorders, thyroid disorders and obesity), HBO_2-approved indications of sudden deafness and delayed wound healing, and altered tympanic mobility on initial examination. Although the benign stages of Haines-Harris classification were the most encountered in our study, MEB was responsible for premature discontinuation of HBO_2. Conclusion: MEB is a common condition responsible for many premature discontinuations of HBO_2. Its origin is multifactorial, associating non-modifiable and modifiable factors. Better management of this affection will further contribute to making HBO_2 a low-risk treatment

Ercan E, Demir AE, Sabaner E, Toklu AS. Incidence of decompression sickness in hypobaric hypoxia training. Undersea Hyperb Med. 2020;47(2):203-10.

Simulated flight in a hypobaric chamber is a fundamental component in the physiological training of aviators. Although rare, there is always a risk of decompression sickness (DCS) in trainees during hypobaric hypoxia training. In this study we aimed to determine the incidence of altitude-induced DCS and the symptoms manifested in trainees and inside chamber observers (ICOs) during the training sessions. We retrospectively reviewed the records of DCS cases during the period of January 1, 2011, and October 1, 2018. The records of 6,657 trainees and 615 ICOs were evaluated. The gender distribution in 6,657 trainees was 6,578 (98.81%) male and 79 (1.19%) female. The numbers of DCS cases in trainees and ICOs were six (0.09%) and two (0.33%), respectively [(ICOs versus trainees - odds ratio (OR): 3.574; 95% CI 0.720-17.744;

(p>0.05)]. All ICOs were male; no DCS incident was observed among female trainees. Recompression treatments were applied on site, and complete recovery was achieved in all cases. Overall DCS incidence was found to be 0.11% among the 7,193 male subjects, which included trainees and ICOs. The higher incidence of DCS in ICOs was attributed to the physical activities performed at altitudes by ICOs. In such training, established instructions have to be strictly followed by physicians, ICOs and trainees. All trainees and ICOs should be aware of the symptoms and signs of DCS, and medical support including a recompression facility, should be provided on site during hypobaric hypoxia training.

Garcia E, Mitchell SJ. Bubbles in the skin microcirculation underlying cutis marmorata in decompression sickness: preliminary observations. Diving Hyperb Med. 2020;50(2):173-7.

Introduction: The cutaneous form of decompression sickness (DCS) known as cutis marmorata is a frequent clinical presentation. Beyond a general acceptance that bubbles formed from dissolved inert gas are the primary vector of injury, there has been debate about pathophysiology. Hypotheses include: 1) local formation of bubbles in the skin or its blood vessels; 2) arterialisation of venous bubbles across a right to left shunt (RLS) with local amplification in bubble size after reaching supersaturated skin via the arterial circulation; and 3) passage of arterialised venous bubbles to the cerebral circulation with stimulation of a sympathetically mediated vasomotor response. Methods: Four divers exhibiting cutis marmorata had the underlying tissue examined with ultrasound 4-5.5 hours after appearance of the rash. All subsequently underwent transthoracic echocardiography with bubble contrast to check for a RLS. Results: In all cases numerous small bubbles were seen moving within the skin microvasculature. No bubbles were seen in adjacent areas of normal skin. All four divers had a large RLS. Conclusion: This is the first report of bubbles in skin affected by cutis marmorata after diving. The finding is most compatible with pathophysiological hypotheses one and two above. The use of ultrasound will facilitate further study of this form of DCS.

Generaal JD, Lansdorp CA, Boonstra O, van Leeuwen BL, Vanhauten AM, Stevenson MG, Been LB. Hyperbaric oxygen therapy for radiation-induced tissue injury following sarcoma treatment: a retrospective analysis of a Dutch cohort. PLoS One. 2020 Jun 8;15(6):e0234419.

Background and objectives: Sarcomas are commonly managed by surgical resection combined with radiotherapy. Sarcoma treatment is frequently complicated by chronic wounds and late radiation tissue injury (LRTI). This study aims to gain insight in the use and results of hyperbaric oxygen therapy (HBOT) for radiation-induced complications following sarcoma treatment. Methods: All sarcoma patients treated between 2006 and 2017 in one of the five centers of the Institute for Hyperbaric Oxygen in the Netherlands were included for retrospective analysis. Results: Thirty patients were included, 18 (60.0%) patients were treated for chronic wounds and 12 (40.0%) for LRTI. Two patients with chronic wounds were excluded from analysis as HBOT was discontinued within five sessions. In 11 of 16 (68.8%) patients treated for chronic wounds, improved wound healing was seen. Nine of 12 (75.0%) patients treated for LRTI reported a decline in pain. Reduction of fibrosis was seen in five of eight patients (62.5%) treated for LRTI. Conclusions: HBOT is safe and beneficial for treating chronic wounds and LRTI in the sarcoma population. Awaiting further prospective results, we recommend referring to HBOT centers more actively in patients experiencing impaired wound healing or symptoms of delayed radiation-induced tissue injury following multimodality sarcoma treatment.

Guo D, Pan S, Wang MM, Guo Y. Hyperbaric oxygen therapy may be effective to improve hypoxemia in patients with severe COVID-2019 pneumonia: two case reports. Undersea Hyperb Med. 2020;47(2):181-7.

Objectives: To determine whether hyperbaric oxygen (HBO_2) therapy be effective to improve hypoxemia for severe COVID-19 pneumonia patients. Methods: Two male patients ages 57 and 64 years old were treated. Each met at least one of the following criteria: shortness of breath; respiratory rate (RR) ≥30 breaths/minute; finger pulse oxygen saturation (S_pO_2) ≤93% at rest; and oxygen index (P/F ratio: P_aO_2/F_IO_2 ≤300 mmHg). Each case excluded any combination with pneumothorax, pulmonary bullae or other absolute contraindications to HBO_2. Patients were treated with 1.5 atmospheres absolute HBO_2 with an oxygen concentration of more than 95% for 60 minutes per treatment, once a day for one week. Patients' self-reported symptoms, daily mean S_pO_2 (SO_2), arterial blood gas analysis, D-dimer, lymphocyte, cholinesterase (che) and chest CT were conducted and measured. Results: For both patients, dyspnea and shortness of breath were immediately alleviated after the first HBO_2 treatment and remarkably relieved after seven days of HBO_2 therapy. The RR also decreased daily. Neither patient became critically ill. The decreasing trend of SO_2 and P/F ratio was immediately reversed and increased day by day. The lymphocyte count and ratio corresponding to immune function gradually recovered. D-dimer corresponding to peripheral circulation disorders and serum cholinesterase, reflecting liver function had improved. Follow-up chest CT showed that the pulmonary inflammation had clearly subsided. Conclusion: Our preliminary uncontrolled case reports suggest that HBO_2 therapy may promptly improve the progressive hypoxemia of patients with COVID-2019 pneumonia. However, the limited sample size and study design preclude a definitive statement about the potential

effectiveness of HBO_2 therapy to COVID-2019 pneumonia. It requires evaluation in randomized clinical trials in future.

Harlan NP, Ptak JA, Rees JR, Cowan DR, Fellows AM, Kertis JA, Hannigan PM, Peacock JL, Buckey JC. Protocol for an International, Multicenter, Hyperbaric Oxygen Treatment Registry and Research Consortium. JMIR Res Protoc. 2020 Jun 23. doi: 10.2196/18857. Online ahead of print.

Background: Background: Hyperbaric oxygen (HBO_2) (oxygen at pressures higher than atmospheric) is approved for 14 indications by the Undersea and Hyperbaric Medical Society. HBO_2's main effect is to increase oxygen content in plasma and body tissues, which can counteract hypoxia or ischemia. Laboratory studies show that hyperbaric oxygen has effects beyond relieving hypoxia (e.g., promoting angiogenesis in irradiated tissue, anti-inflammatory effects, radiosensitization of tumors, hypoxia preconditioning, fungal growth inhibition) and has potential to treat conditions such as inflammatory bowel disease and pyoderma gangrenosum. Lack of consistently-collected outcomes data on a large cohort of individuals receiving HBO_2 therapy limits its use for both established and new indications. A course of therapy often involves 30-40 visits to a hyperbaric chamber, so the numbers of patients seen at any given center is constrained by chamber capacity. As a result, published HBO_2 outcomes data tend to be from small case series, because few patients with a particular condition are treated at a given center. To solve this problem, a registry that collects and pools data systematically from multiple institutions has been established. Objective: Objective: Collect consistent outcome-data across multiple hyperbaric centers to assess treatment effectiveness and establish a research consortium. Methods: Methods: A consortium of hyperbaric centers who have agreed to collect consistent outcomes data on all patients seen has been assembled. Data are collected at each participating center using Research Electronic Data Capture (REDCap), a web-based, data collection system used frequently for research. Standard outcomes measures have been defined for each condition, which are programmed into the REDCap data collection templates. Governance is through a consortium agreement that defines data security, data sharing, publications, liability, and other issues. Centers obtain IRB/ethics approval to participate either at their own institution or by relying on the IRB at the coordinating center (Dartmouth). Dissemination will occur through a yearly report and by publications based on the data in the registry. Results: Results: Early results from some common indications show significant pre to post treatment changes. Additional indications and outcome measures are being added using the procedures outlined in the consortium agreement. Conclusions: Conclusions: The registry collects consistent outcome information for a therapy that needs further study and a stronger evidence base. It also overcomes the challenge of collecting adequate patient numbers for both established and emerging indications by combining data collection from multiple centers. The data entry requirements should be within the capabilities of existing staff at any given hyperbaric center. By using REDCap, the registry can be expanded to include detailed information on particular indications and long-term follow-up on selected patients without significantly increasing the basic data entry requirements. Through the registry a network of enrolled hyperbaric centers has been established that provides the basis for a clinical trials network.

Jendle JH, Adolfsson P, Pollock NW. Recreational diving in persons with type 1 and type 2 diabetes: advancing capabilities and recommendations. Diving Hyperb Med. 2020;50(2):135-43.

Diving by persons with diabetes has long been conducted, with formal guidelines published in the early 1990s. Subsequent consensus guidelines produced following a 2005 workshop helped to advance the recognition of relevant issues and promote discussion. The guidelines were intended as an interim step in guidance, with the expectation that revisions should follow the gathering of additional data and experience. Recent and ongoing developments in pharmacology and technology can further aid in reducing the risk of hypoglycemia, a critical acute concern of diving with diabetes. Careful and periodic evaluation remains crucial to ensure that participation in diving activity is appropriate. Close self-monitoring, thoughtful adjustments of medications and meals, and careful review of the individual response to diving can assist in optimising control and ensuring safety. Open communication with diving partners, support personnel, and medical monitors is important to ensure that all are prepared to effectively assist in case of need. Ongoing vigilance, best practice, including graduated clearance for diving exposures and adverse event reporting, are all required to ensure the safety of diving with diabetes and to promote community understanding and acceptance.

Kim SK, Thom SR, Kim H, Hwang SO, Lee Y, Park EJ, Lee SJ, Cha YS. Effects of adjunctive therapeutic hypothermia combined with hyperbaric oxygen therapy in acute severe carbon monoxide poisoning. Crit Care Med. 2020 Jun 16. doi: 10.1097/CCM.0000000000004419. Online ahead of print.

Objective: To determine the effects of adjunctive therapeutic hypothermia, by comparing hyperbaric oxygen therapy versus hyperbaric oxygen therapy combined with therapeutic hypothermia in acute severe carbon monoxide poisoning. Design: Retrospective analysis of data from our prospectively collected carbon monoxide poisoning registry. Setting: A single academic medical center in Wonju, Republic of Korea. Patients: Patients with acute

severe carbon monoxide poisoning older than 18 years. Acute severe carbon monoxide poisoning was defined as mental status showing response to painful stimulus or unresponsive at the emergency department, and a continuation of this depressed mental status even after the first hyperbaric oxygen therapy. Patients were classified into the no-therapeutic hypothermia and therapeutic hypothermia groups. Hyperbaric oxygen therapy was performed up to twice within 24 hours after emergency department arrival, whereas therapeutic hypothermia was performed at a body temperature goal of 33°C for 24 hours using an endovascular cooling device after the first hyperbaric oxygen therapy. Interventions: Hyperbaric oxygen therapy versus hyperbaric oxygen therapy combined with therapeutic hypothermia. Measurements and main results: We investigated the difference in the global deterioration scale score at 1 and 6 months after carbon monoxide exposure, between the no-therapeutic hypothermia and therapeutic hypothermia groups. Global Deterioration Scale scores were classified as follows: 1-3 points (favorable neurocognitive outcome) and 4-7 points (poor neurocognitive outcome). During the study period, 37 patients were treated for acute severe carbon monoxide poisoning, with 16 and 21 patients in the no-therapeutic hypothermia and therapeutic hypothermia groups, respectively. The therapeutic hypothermia group demonstrated significantly higher number of patients with favorable outcomes (p=0.008) at 6 months after carbon monoxide exposure and better improvement of the 6-month Global Deterioration Scale score than the 1-month score (p=0.006). Conclusions: Our data suggest that in acute severe carbon monoxide poisoning, patients who were treated using therapeutic hypothermia combined with hyperbaric oxygen therapy had significantly more favorable neurocognitive outcomes at 6 months after carbon monoxide exposure than those treated with hyperbaric oxygen therapy alone.

Kojima Y, Kojima A, Niizeki Y, Yagishita K. Recreational diving-related injury insurance claims among Divers Alert Network Japan members: retrospective analysis of 321 cases From 2010 to 2014. Diving Hyperb Med. 2020;50(2):92-7.

Introduction: Monitoring trends in diving-related injuries enables implementation of effective safety measures. Divers Alert Network Japan (DAN Japan) membership includes insurance covering recreational diving-related injuries and fatalities. Use of claim data provides both a known denominator and demographic data about injured members. Methods: The study analysed 325 insurance claims reported to DAN Japan from 2010 to 2014. Four fatalities were excluded, leaving 321 claims for analysis. Claimants were divided into three age groups: young adults (<40 years); middle-aged (40-59 years) and older adults (≥60 years). The total injury claims rate (ICR), decompression illness (DCI) rate (DCR) and trauma rate (TCR) were calculated. Differences between the sexes within each age group were analysed. Results: The total number of DAN Japan member-years in the period was 80,617, with a mean age of 45 years. Claims were made by 153 males and 168 females with a mean and median age of 46 years. Trauma was the most frequent reason for a claim (113 cases, 35%), followed by DCI (109 cases, 34%). The ICR (per 104 member-years) was 39.8 (95% confidence interval 35.5 to 44.2) and the TCR was 14.0 (11.4 to 16.6). For every age group, the ICR and TCR were significantly higher for females than males. The DCR was 13.5 (11.0 to 16.1) and did not significantly differ between the sexes. Conclusions: The incidence of trauma-related diving injuries exceeds that of claims related to DCI. Females appear to have a higher risk of injury than the general diving population.

Lalieu RC, Raap RDB, Dbois EF, van Hulst RA. Sudden death after oxygen toxicity seizure during hyperbaric oxygen treatment: case report. Diving Hyperb Med. 2020;50(2):185-8.

Acute cerebral oxygen toxicity (ACOT) is a known side effect of hyperbaric oxygen treatment (HBOT), which can cause generalised seizures. Fortunately, it has a low incidence and is rarely harmful. Nevertheless, we present a case of a 37 year-old patient with morbid obesity who died unexpectedly after an oxygen toxicity seizure in the hyperbaric chamber. Considering possible causes, physiologic changes in obesity and obesity hypoventilation syndrome may increase the risk of ACOT. Obesity, especially in extreme cases, may hinder emergency procedures, both in- and outside of a hyperbaric chamber. Physicians in the hyperbaric field should be aware of the possibility of a fatal outcome after ACOT through the described mechanisms and take appropriate preventative measures. Basic airway management skills are strongly advised for involved physicians, especially when specialised personnel and equipment are not immediately available.

Lansdorp CA, Buskens CJ, Gecse KB, D'Haens GR, Van Hulst RA. Wound healing of metastatic perineal Crohn's disease using hyperbaric oxygen therapy: a case series. United European Gastroenterol J. 2020 Jun 12;2050640620934915.

Background: Metastatic Crohn's disease (CD) is a rare manifestation of CD. It involves inflammatory skin lesions with histopathological findings (granulomas) similar to CD, without connection to the gastrointestinal tract. Hyperbaric oxygen therapy (HBO) has been suggested as a possible treatment option. Objective: This study aimed to identify and treat a consecutive series of patients with biopsy-proven metastatic CD and monitor wound healing using prospectively acquired outcomes. Methods: Pathology results of all patients with ongoing perineal wound-healing problems after proctectomy between 2005

and 2018 at the Amsterdam University Medical Centre were assessed for metastatic CD. Patients with a biopsy-proven diagnosis of perineal metastatic CD were offered HBO (40 daily sessions of 100% oxygen at 2.4 atmosphere absolute). Wound healing was monitored using photographs and standardised questionnaires (the Inflammatory Bowel Disease Questionnaire, EuroQol Visual Analogue Scale and the Female Sexual Function Index) at baseline and 1 and 3 months after HBO. Results: Out of 13 patients in the cohort with persisting perineal wounds after proctectomy, six (46%) had biopsy results consistent with metastatic CD. Of these, three accepted treatment with HBO. All three patients were female. One patient had complete healing of her perineal wound; another patient showed initial improvement but had a flare of luminal and perineal disease at the 3-month follow-up. The third patient showed improvement solely in the questionnaires, with higher scores on all three questionnaires. Conclusion: A high rate of metastatic CD was found in patients with ongoing wound-healing problems after proctectomy, implying that the disease might not be as rare in these selected patients as previously thought. HBO might be beneficial in the treatment of metastatic CD.

LeGros TL, Murphy-Lavoie H. HBO_2 for sudden sensorineural hearing loss. Undersea Hyperb Med. 2020;47(2):271-95.

Sudden sensorineural hearing loss (SSNHL) presents as an abrupt onset of hearing loss; 88% of these presentations are idiopathic (ISSHL). Many mechanisms of injury and etiopathologies have been postulated, but they share a common result - hypoxia of the organ of Corti leading to hair cell-cilia fusion, synaptic, dendritic swelling and sustained depolarization. Of all of the various treatments tried, only corticosteroids and hyperbaric oxygen (HBO_2) therapy have shown benefit in randomized controlled trials (RCTs). This paper reviews the pathophysiology of SSNHL, the variety of treatments studied, and the best evidence (both retrospective case controlled and prospective randomized controlled studies) for the use of HBO2 and corticosteroids. The best results are obtained when these two treatments are combined and initiated within 14 days of symptom onset. HBO_2 is given at 2-2.5 ATA for 90 minutes for 10-20 sessions. Steroids should be dosed at 1mg/kg/day and slowly tapered over two to three weeks. If a patient is not a good candidate for or refuses systemic steroids, good results have also been obtained using intratympanic (IT) steroids in combination with HBO2. Patients should be followed by and otolaryngologist before, during and following HBO_2. For severe hearing loss treatment with HBO2 improves by 37.7 dB, 19.3dB for those with moderate loss and 15.6 dB improvement overall. These recoveries, on average, improve a patient's hearing from ranges requiring hearing aids and sign language, to levels at which normal or near-normal hearing is restored.

Liang XX, Hao YG, Duan XM, Han XL, Cai XX. Hyperbaric oxygen therapy for post-stroke depression: a systematic review and meta-analysis. Clin Neurol Neurosurg. 2020 May 16;195:105910.

Objectives: Post-stroke depression (PSD) is common consequence of stroke. However, today the majority of PSD patients remain untreated or inadequately treated, especially in the developing countries. Herein, we performed a meta-analysis to evaluate efficacy and safety of hyperbaric oxygen (HBOT) therapy for PSD. Patients and methods: Seven electronic databases were comprehensively searched for randomized clinical trials (RCTs) from inception to May 2019. Outcome measures included response rate, depression severity, neurological deficit, physical disability and adverse events. Results: A total of 27 RCTs involving 2250 participants were identified. Patients in HBOT group had a higher response rate than patients in control group (response rate: 69.4% vs 51.2%, odds ratio [OR] = 2.51, 95% confidence interval [CI] [1.83-3.43], P = 0.000). HBOT significantly reduced Hamilton Depression (HAMD) -17 item scores (weighted mean difference [WMD] = -4.33, 95% CI [-4.82 to -3.84], P=0.000), HAMD-24 item scores (WMD = -4.31, 95% CI [-5.01 to -3.62], P=0.000), National Institute of Health Stroke Scale (NIHSS) scores (WMD = -2.77, 95% CI [-3.57 to -1.98], P=0.000), Chinese Stroke Scale (CSS) scores (WMD = -3.75, 95% CI [-5.12 to -2.38], P=0.000) and Modified Scandinavian Stroke Scale (MASSS) scores (WMD = -3.66, 95% CI [-6.26 to -1.06], P=0.000). HBOT also improved Barthel Index (WMD = 10.68, 95% CI [7.98-13.37], P=0.000). In subgroup analysis, Group A of studies with hemorrhage patients accounting for less than 20% achieved more reduction of HAMD 17-item score (WMD = -4.47, 95% CI [-5.17 to -3.77], P=0.000) than Group B of studies with hemorrhage patients no less than 20% (WMD = -3.73, 95% CI [-4.20 to -3.26], P=0.000). In addition, patents with HBOT along with antidepressants treatment achieve superior results than patients with antidepressants monotherapy. Patients with HBOT monotherapy achieve a slightly higher response rate than patients with antidepressants monotherapy (OR=1.29, 95% CI [1.04-1.60], P=0.000). Besides, HBOT group reported less adverse events (9.6%vs16.6%, P<0.05). The most frequent side-effect of HBOT is ear pain (26 cases). Conclusion: Based on our pooled analysis, HBOT is effective and safe therapeutic approach for PSD. However, results should be cautiously interpreted due to a relatively poor methodological quality.

Lippmann J, Stevenson C, Taylor DMcD. Scuba diving fatalities in Australia, 2001 to 2013: diver demographics and characteristics. Diving Hyperb Med. 2020;50(2):105-14.

Introduction: This study identified characteristics of victims of fatal scuba diving incidents to determine contributing factors and inform appropriate countermeasures. Methods: The National Coronial Information System (NCIS) was searched to identify scuba diving deaths for 2001-2013, inclusive. Data were extracted from witness and police reports, medical histories and autopsies. Descriptive statistics were used to analyse these data. Results: There were 126 scuba diving-related fatalities identified during the study period. The mean age was 44 years, 99 (79%) victims were male and 83 (77%) were either overweight or obese. Most deaths occurred in New South Wales and Queensland, often in a commercial setting. Twenty-three (79%) Queensland victims were overseas tourists. At least 52 (41%) were novices and 17 (13%) died during training or an introductory scuba experience. Only 35 (28%) were with a buddy when the incident occurred and at least 81 (64%) were still wearing weights when recovered. Conclusions: The age of these victims may reflect an older cohort of participants and the associated higher prevalence of chronic medical conditions. The high prevalence of obesity suggests that this may be a risk factor. The high proportion of deaths in overseas tourists highlights an on-going need for appropriate screening and monitoring in what may be a higher risk cohort. The number of deaths that occurred under instruction highlights the importance of careful assessment of the site, prevailing conditions, an appropriate instructor-student ratio and close supervision.

Lippmann J, Taylor DMcD. Medical conditions in scuba diving fatality victims in Australia, 2001 to 2013. Diving Hyperb Med. 2020;50(2):98-104.

Introduction: This study identified pre-existing medical conditions among scuba diving fatalities in Australia from 2001 to 2013, inclusive, and assessed whether these conditions likely contributed to the deaths. Methods: The National Coronial Information System (NCIS) was searched for scuba diving-related cases during 2001-2013, inclusive. Coronial findings, witness and police reports, medical histories, and autopsy and toxicology reports were scrutinised for pre-existing medical conditions and autopsy findings. Predisposing factors, triggers, disabling agents, disabling injuries and causes of death were analysed using a validated template. Results: There were 126 scuba diving-related fatalities identified during the study period. Forty-six (37%) divers were identified as having a significant medical condition which may have contributed to their incident. The most common condition was ischaemic heart disease (IHD) which had been diagnosed in 15 of the divers. Thirty-two (25%) deaths were attributed to cardiac disabling injuries (DI) such as ischaemic heart disease and arrhythmias, although a cardiac DI was thought likely in another six. Respiratory conditions were implicated in eight (6%) deaths, at least four associated with cerebral arterial gas embolism. At least 14 (11%) divers who had contributory pre-existing medical conditions had been cleared to dive by a medical practitioner within the year prior. Conclusions: Chronic health-related factors played a major role in almost half of these deaths; primarily cardiac conditions such as IHD and cardiac arrhythmias. Although fitness-to-dive (FTD) assessments have limitations, the high incidence of cardiac-related deaths indicates a need for 'older' divers to be medically assessed for FTD.

Moon RD, Weaver LK. Hyperbaric oxygen as a treatment for COVID-19 infection? Undersea Hyperb Med. 2020;47(2):177-9.

Recently the internet has been abuzz with new ideas to treat COVID-19, including hyperbaric oxygen (HBO_2) therapy, undoubtedly driven by the fact that until recently there have been few therapeutic options for this highly contagious and often lethal infection.... Refractory hypoxemia is certainly treatable with hyperbaric oxygen due to the obvious effect of increasing inspired oxygen partial pressure (PO_2), the major reason for using HBO_2 for its established indications. However, the length of time during which patients can safely be administered HBO_2 inside a chamber is limited, due to practical issues of confinement and isolation from other necessary medical interventions, but also because of oxygen toxicity.

Rozloznik M, Lochmanova A, Chmelar D, Hajek M, Korytkova K, Cisarikova M. Experimental use of flow cytometry to detect bacteria viability after hyperbaric oxygen exposure: work in progress report. Diving Hyperb Med. 2020;50(2):152-6.

Introduction: Hyperbaric oxygen treatment (HBOT), based on inhaling pure oxygen under elevated ambient pressure, is used as adjuvant intervention to promote healing in infected wounds. Despite extensive clinical evidence of beneficial effects of HBOT in soft tissue infections the mechanism of action remains to be elucidated. The aim of this study was to evaluate the use of flow cytometry as a novel method to assess the viability of pathogenic bacteria after hyperbaric oxygen (HBO) exposure. Methods: Bacterial strains associated with soft tissues infections: *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* were exposed to oxygen at 2.8 atmospheres absolute (atm abs) (283.6 kPa) pressure for 45, 90, or 120 min, then stained with propidium iodide and thiazole orange and analysed by flow cytometry. Results: *Escherichia coli* and *Staphylococcus aureus* showed no change in viability, nor morphology, the viability of *Pseudomonas aeruginosa* reduced in a dose-dependent manner and *Klebsiella pneumoniae* also showed dye

uptake after HBO. Conclusions: These initial results, indicate diverse sensitivity of bacteria to HBO, and suggest that flow cytometry can be used to monitor viability and morphological changes triggered by HBO exposure in bacteria.

Serena TE, Yaakov R, Serena L, Mayhugh T, Harrell K. Comparing near infrared spectroscopy and transcutaneous oxygen measurement in hard-to-heal wounds: a pilot study. J Wound Care. 2020 Jun 1;29(Sup 6):S4-9.

Objective: Oxygen plays an integral role in all phases of the wound healing process and tissue oxygenation is a key determinant of wound healing. A comprehensive evaluation of patients with hard-to-heal wounds must include measurement of oxygenation in and around the area of skin breakdown. The current gold standard, transcutaneous oxygen measurement (TCOM), has numerous drawbacks and as a result has fallen into disuse. Method: This study compared measurement of tissue oxygenation of near infrared spectroscopy (NIRS) with TCOM in patients with acute and hard-to-heal wounds. The Shapiro-Wilk test was used to evaluate the normality of the data. The level of agreement between NIRS and TCOM was determined using Bland-Altman analysis. The relationship between TCOM and NIRS was examined using Pearson correlation. Results: A total of 24 observations were obtained from 10 patients using TCOM and NIRS. The weighted mean partial pressure of oxygen (pO_2) in the study population was 39.54 mmHg (8.96 standard deviation). Bland-Altman analysis showed that mean difference was positive (18.75), suggesting an overestimation of oxygen measurements using TCOM compared with NIRS. The oxygen levels measured by TCOM and NIRS showed a strong correlation (r=0.74). Conclusion: The wound and hyperbaric community would benefit from a simplified procedure for measuring tissue oxygenation. These findings suggest a strong trend toward correlation between NIRS and TCOM. A further study in a larger population is recommended. NIRS offers several advantages over TCOM. Clinicians have immediate point-of-care visualisation of tissue oxygenation using a handheld device. The procedure takes minutes to perform and is less operator-dependent than TCOM. Finally, NIRS allows measurement of oxygenation in the wound bed, while TCOM does not.

Tchero H, Kangambega P, Fluieraru S, Bekara F, Teot L. Management of infected diabetic wound: a scoping review of guidelines. F1000Res. 2019 May 24;8:737. doi: 10.12688/f1000research.18978.1. eCollection 2019.

Background: Various international guidelines and recommendations are available for management of diabetic foot infections. We present a review of the guidelines and recommendations for management of these infections. Methods: A systematic literature search was conducted through MEDLINE, CENTRAL, EMBASE, LILACS, DARE, and national health bodies. Based on the review of fifteen documents, we present details on the importance of suspecting and diagnosing skin, superficial infections, and bone infections in diabetics. Results: The guidelines recommend classifying the infections based on severity to guide the treatment. While antibiotics have shown the best results, other treatments like hyperbaric oxygen therapy and negative wound pressure have been debated. It is suggested that a team of specialists should be in-charge of managing the infected wounds. Infectious Diseases Society of America (IDSA) 2012 guidelines are widely followed world-over. All guidelines and reviews have consistent suggestions on the assessment of the severity of infection, diagnosis, start, selection, and duration of antibiotic therapy. Conclusions: It is reasonable to conclude that the IDSA 2012 guidelines are commonly followed across the world. There is a consensus among the Australian guidelines, Canadian guidelines, IDSA 2012, National Institute for Health and Care Excellence (NICE) 2015, and International Working Group on the Diabetic Foot (IWGDF) 2016 guidelines on the management of infected wounds for patients with diabetes mellitus.

Tinay I, Celik O, Sekerci CA, Cadirci S, Cevik O, Oroglu B, Sener G, Tarcan T. Hyperbaric oxygen therapy prevents subarachnoid hemorrhage-induced apoptosis and impaired contractility of the rabbit bladder. Neurourol Urodyn. 2020 Jun 1. doi: 10.1002/nau.24418. Online ahead of print.

Aim: To explore the effects of experimental subarachnoid hemorrhage (SAH) on rabbit urinary bladder and to assess the potential protective effects of hyperbaric oxygen therapy (HBOT). Methods: A total of 15 male New Zealand white rabbits were divided randomly to one of three groups: group I was spared as the control group (n=5), group II was exposed to SAH, received no treatment, and acted as the SAH group (n=5) and group III was exposed to SAH and received five sessions of HBOT (started 12 hours after SAH induction and was given twice daily for the first 2 days and once on the third day) and acted as the treatment group (n=5). At 72 hours after the SAH induction, bladders from all animals were removed for in vitro organ bath experiments and biochemical analyses. Results: İsometric tension studies revealed that compared to group I, the contractile responses of the strips to carbachol in group II were significantly decreased whereas HBOT restored the contractile responses ($P<0.05$). Caspase-3 and nitric oxide synthase (NOS) activities of bladder tissues were significantly increased in group II when compared with group I, whereas caspase-3 and NOS activities were significantly decreased in the tissues of group III ($P<0.01$). Conclusions: Subarachnoid hemorrhage stimulates apoptosis of the rabbit bladder and impairs the contractile response of the rabbit bladder to

carbachol. HBOT creates a protective effect in rabbit bladder tissues and restores SAH-induced changes.

Tong B, Niu K, Ku W, Xie W, Dai Q, Hellström S, Duan M. Comparison of therapeutic results with/without additional hyperbaric oxygen therapy in idiopathic sudden sensorineural hearing loss: a randomized prospective study. Audiol Neurootol. 2020 Jun 12;1-6. doi: 10.1159/000507911. Online ahead of print.

Objective: To assess the efficacy of the combination of hyperbaric oxygen (HBO) and pharmacological treatment in patients with idiopathic sudden sensorineural hearing loss (ISSNHL) and define patients amenable for HBO therapy. Methods: Prospective, randomized, trial involving 136 cases with unilateral ISSNHL that were randomly divided into 2 groups: the pharmacological treatment (P) group and HBO + pharmacological treatment (HBO+P) group, which received additional HBO for 14 days besides the pharmacological treatments. Pure tone audiometry gain larger than 15 dBHL was defined as success, and the success rate of each group was calculated. Results: The overall success rate of the HBO+P group and the P group is 60.6% (40/66) and 42.9% (30/70), respectively ($p<0.05$). Furthermore, patients with mild-moderate baseline hearing loss, aged ≤50 years, receiving treatment in ≤14 days, or without accompanied dizziness/vertigo in the HBO+P group had higher success rate than the P group ($p<0.05$). Conclusions: HBO combined with pharmacological treatments leads to better hearing recovery than pharmacological treatments alone.

Ungar OJ, Cavel O, Yahav O, Tsur N, Handzel O. Outcome of balloon eustachian tuboplasty in scuba divers. Ear Nose Throat J. 2020 Jun 18;145561320933957.

Objectives: Good Eustachian tube (ET) function is necessary in order to equalize middle ear (ME) pressure with ambient pressures and avoid barotrauma among divers. Since placement of ventilation tubes is not compatible with diving, balloon eustachian tuboplasty is a potential surgical solution for divers with ET dysfunction (ETD). This is the first report of the outcome of balloon tuboplasty for ETD among divers. Methods: A retrospective analysis of medical records and clinical examinations of adult divers treated in a single tertiary medical center. Results: Four male divers (age range 21-71 years, 5 ETs) underwent balloon tuboplasty for ETD. None had identifiable risk factors for ETD. Symptom duration ranged from 2 to 5 years and was restricted to diving in 3 patients. The most common symptom was difficulties in equalizing air pressure during descent and ascent, followed by aural fullness and hearing loss. The validated Hebrew version of ETD-7 questionnaire (ETDQ-7H) results were normal in 3 ears and pathological (2.9 and 3.3) in 2 ears. The averaged postoperative ETDQ-7H score was 1.2 points, significantly better than the preoperative score ($P<0.05$). While diving, pressure-equalizing sensation improved in all ears. Conclusion: Balloon eustachian tuboplasty is a safe method for treating diving-induced baro-challenge ETD. This procedure can improve symptoms and enable the patient to resume diving.

van Waart H, Harris RJ, Gant N, Vrijdag XC, Challen CJ, Lawthaweesawat C, Mitchell SJ. Deep anaesthesia: the Thailand cave rescue and its implications for management of the unconscious diver underwater. Diving Hyperb Med. 2020;50(2):121-9.

Introduction: In 2018 12 children and one adult were anaesthetised before being extricated through over a kilometre of flooded cave in Thailand. Full face dive masks (FFMs) putatively capable of maintaining constant positive airway pressure (CPAP) were employed. Here we describe the anaesthetic intervention and investigate the CPAP capability of the FFM.Methods: Pressure was measured inside and outside the Interspiro Divator FFM during 10 tidal and 10 vital capacity breaths in divers at the surface and submerged with the mask deployed on open-circuit scuba (10 divers); and a closed-circuit rebreather (five divers). Relative in-mask pressure was calculated as the difference between inside and outside pressures. We also measured the in-mask pressure generated by activation of the second stage regulator purge valve in open-circuit mode. Results: When submerged in open-circuit mode the mean relative in-mask pressure remained positive in normal tidal breathing (inhalation 0.6 kPa [95% CI 0.3-0.9]; exhalation 1.1 [0.8-1.4]) and vital capacity breathing (inhalation 0.8 [0.4-1.1]; exhalation 1.2 [0.9-1.4]). As expected, the relative in-mask pressure was predominantly negative when used on closed-circuit with back mounted counter-lungs due to a negative static lung load. Mean in-mask pressure during purge valve operation was 3.99 kPa (approximately equal to 40 cmH_2O) (range: 2.56 to 5.3 kPa). Conclusions: The CPAP function of the Interspiro Divator FFM works well configured with open-circuit scuba. This may have contributed to the success of the Thailand cave rescue. Caution is required in generalising this success to other diving scenarios.

Vrijdag XC, van Waart H, Sleigh JW, Mitchell SJ. Pupillometry is not sensitive to gas narcosis in divers breathing hyperbaric air or normobaric nitrous oxide. Diving Hyperb Med. 2020;50(2):115-20.

Introduction: Gas narcosis impairs divers when diving deeper. Pupillometry is sensitive to alcohol intoxication and it has been used in anaesthesia to assess nitrous oxide narcosis. It is a potential novel method to quantify narcosis in diving. The aim of this study was to evaluate pupillometry for objective measurement of narcosis during exposure to hyperbaric air or nitrous oxide. Method: Pupil

size in 16 subjects was recorded directly at surface pressure and during air breathing at 608 kPa (equivalent to 50 metres' seawater depth) in a hyperbaric chamber. Another 12 subjects were exposed to nitrous oxide at end-tidal percentages of 20, 30 and 40% in random order at surface pressure. Pupil size and pupil light reflex were recorded at baseline and at each level of nitrous oxide exposure. Results: Pupil size did not significantly change during exposure to hyperbaric air or nitrous oxide. The pupil light reflex, evaluated using percentage constriction and minimum diameter after exposure to a light stimulus, was affected significantly only during the highest nitrous oxide exposure - an end-tidal level of 40%. Conclusion: Pupillometry is insensitive to the narcotic effect of air at 608 kPa in the dry hyperbaric environment and to the effects of low dose nitrous oxide. Pupillometry is not suitable as a monitoring method for gas narcosis in diving.

Wheelock CE, Hess HW, Schlader ZJ, Johnson BJ, Hostler D. Whole-body active heating does not preserve finger temperature or manual dexterity during cold-water immersion. Undersea Hyperb Med. 2020;47(2):253-60.

Background: Cold-water immersion impairs manual dexterity when finger temperature is below 15°C. This exposes divers to increased risk of error. We hypothesized that whole-body active heating would maintain finger temperatures and dexterity during cold-water immersion. Methods: Twelve subjects (six males) (22 ± 2 years old; BMI 23.9 ± 2.5; body fat 16 ± 6%) completed 60-minute head-out water immersion (HOWI) wearing a 7mm wetsuit and 3 mm gloves in thermoneutral water (TN 25°C) and cold water (CW 10°C) while wearing a water-perfused suit (WP) with 37°C water circulated over the torso, arms, and legs. Gross (Minnesota Manual Dexterity Test [MMDT]) and fine (modified Purdue Pegboard [PPT]) dexterity were assessed before, during and after immersion. Core body and skin temperatures were recorded every 10 minutes. Results: MMDT (TN -25 ± 14%; CW -72 ± 23%; WP -67 ± 29%; $p<0.05$) and PPT (TN -16 ± 9%; CW: -45 ± 10%; WP: -38 ± 13%; $p<0.05$) performance decreased during immersion. MMDT and PPT did not differ between CW and WP. Immediately following immersion gross dexterity was recovered in all conditions. Post-immersion fine dexterity was still impaired in CW ($p<0.01$), but not WP or TN. Core and skin temperatures decreased during immersion in CW and WP ($p<0.05$) but did not differ between CW and WP. Conclusion: Manual dexterity decreased during immersion. Dexterity was further impaired during cold-water immersion and was not maintained by water perfusion active heating. Warm water perfusion did not maintain finger temperature above 15°C but hand temperature remained above these limits, suggesting a need to reassess thermal thresholds for working divers in cold-water conditions.

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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