

E-NEWS

EDITOR'S NOTE – April 2023

The E-News is the monthly newsletter of CUHMA, the primary outlet to share news/announcements, upcoming events, abstracts of recent publications, job postings, professional perspectives, and images of relevant professional scenes. Submission of applicable content is welcome. New issues are released on the last business day of each month. Past issues are available at <https://cuhma.ca>. Direct correspondence to info@cuhma.ca.

Neal W. Pollock, PhD
Université Laval

PRESIDENT'S MESSAGE

The objective of CUHMA to promote scientific and clinical excellence in hyperbaric and diving medicine in Canada. This includes promoting awareness and understanding amongst physicians, healthcare professionals, and the public about appropriate indications for hyperbaric treatment. Our guidelines for the practice of clinical hyperbaric medicine and provision of hyperbaric oxygen treatment are frequently cited by various government bodies and departments of health across Canada.

I encourage practitioners with five years of clinical experience to consider applying for the practice eligibility route (PER) of the Royal College of Physicians and Surgeons of Canada Area of Focused Competency Diploma in Hyperbaric Medicine. Information on the PER pathway can be found in the competency training requirements:

<https://www.royalcollege.ca/rcsite/documents/ibd/hyperbaric-medicine-ctr-e>

Request the application through: diplomas@royalcollege.ca

As always in the *E-News* we have included article abstracts that may be of interest to members of the hyperbaric and diving medicine communities. Please remember that an inclusion in the *E-News* of a meeting, course, seminar, conference, or organization is for information purposes only, and does not constitute an endorsement by CUHMA.

Thank you for your continued efforts.

Geoff Zbitnew, MD
Memorial University

NEWS/ANNOUNCEMENTS

OnHMS Formation

The Ontario Hyperbaric Medical Society (OnHMS) has been formed as a not-for-profit organization in Ontario. The board members are Rita Katznelson, Jordan Tarshis, Anton Marinov, Mustafa Wahaj, and Michael Long. For more information visit: <https://onhms.ca>.

UPCOMING EVENTS

Rebreather Forum 4

Rebreather Forum 4 will be held April 20-22 in Valletta, Malta. The purpose of the scientific and leadership meeting is to advance the diving community's state of knowledge regarding rebreather technology and its uses, with the goal of promoting rebreather diving safety. Details and registration: <https://rebreatherforum.tech>.

AAUS Diving for Science Symposium

The 2023 American Academy of Underwater Sciences symposium will be held April 23-29 in Pensacola, FL. Four days of workshops precede business meetings and the two-day science symposium. For details and registration: https://aaus.org/AAUS/annual_symposium.aspx.

SPUMS Annual Scientific Meeting 2023

The South Pacific Underwater Medicine Society annual scientific meeting will be held June 04-09 in Cairns, Australia. The theme is diver health and ocean health amid the storm clouds of climate change. Details and registration: <https://spums.au>.

UHMS Annual Scientific Meeting 2023

The Undersea and Hyperbaric Medical Society (UHMS) annual scientific meeting will be held June 16-18 in San Diego, CA. Visit: <https://www.uhms.org>.

UMC Introductory Diving Medicine Course

Undersea Medicine Canada is offering a Level 1 'Introductory Course in Diving Medicine - Fitness to Dive' September 18-22 in Quebec City, QC. An optional half-day pre-course will be held September 17 for those wanting additional preparation for the program. For more information visit: <https://underseamedicine.ca>.

International Congress of Hyperbaric Medicine

The 20th ICHM will be held November 02-04, 2023 at the Windsor Barra Hotel in Rio de Janeiro, Brazil, hosted by the Brazilian Society of Hyperbaric Medicine. The ICHM is generally held every three years, and is unusual in not being linked to any single institution. There will be simultaneous translation of speeches and question and answer periods. Website details available soon.

RECENT PUBLICATIONS

Arceneaux RL, Cooper KM, Vicinanza MG. Bilateral pneumatic blowout fractures in a patient with silent sinus syndrome while diving. *Orbit.* 2023;1-4. doi: 10.1080/01676830.2023.2181974.

A 37-year-old scuba diver developed sudden severe headache, mid-facial pressure/pain and diplopia while diving. Upon examination, he had signs and symptoms consistent with silent sinus syndrome (SSS), including bilateral enophthalmos, hypoglobus, and diplopia/strabismus in conjunction with CT findings of occluded maxillary sinus ostia, atrophic/collapsed maxillary sinuses, and bilateral orbital floor fractures with fat herniation. As there was no history of trauma or chronic sinusitis, this rare case of bilateral SSS was deemed the cause of the spontaneous fractures (i.e., barotrauma secondary to a lack of equalization to ambient surrounding pressure). Transconjunctival repair of the fractures was successful and maxillary sinus antrostomies re-established aeration of the sinuses. We present this case and its management, as well as review the literature concerning sinus barotrauma as a result of diving and SSS. There have been no reports of orbital fractures primarily caused by scuba diving, nor secondarily from diving with the rare entity, SSS.

Balushi AA, Smart D. Safety and performance of intravenous pumps and syringe drivers in hyperbaric environments. *Diving Hyperb Med.* 2023;53(1):42-50. doi: 10.28920/dhm53.1.42-50.

Introduction: Critically ill patients require continuation of their care when receiving hyperbaric oxygen treatment. This care may be facilitated via portable electrically powered devices such as intravenous (IV) infusion pumps and syringe drivers, which may create risks in the absence of a comprehensive safety evaluation. We reviewed published safety data for IV infusion pumps and powered syringe drivers in hyperbaric environments and compared the evaluation processes to key requirements documented in safety standards and guidelines. **Methods:** A systematic literature review was undertaken to identify English language papers published in the last 15 years, describing the safety evaluations of IV pumps and/or syringe drivers for use in hyperbaric environments. Papers were critically assessed in relation to the requirements of international standards and safety recommendations. **Results:** Eight

studies of IV infusion devices were identified. There were deficiencies in the published safety evaluations of IV pumps for hyperbaric use. Despite a simple, published process for evaluating new devices, and available guidelines for fire safety, only two devices had comprehensive safety assessments. Most studies focused only on whether the device functioned normally under pressure and did not consider implosion/explosion risk, fire safety, toxicity, oxygen compatibility or risk of pressure damage. **Conclusions:** Intravenous infusion (and other electrically powered) devices require comprehensive assessment before use under hyperbaric conditions. This would be enhanced by a publicly accessible database hosting the risk assessments. Facilities should conduct their own assessments specific to their environment and practices.

Huang C, Zhong Y, Yue C, He B, Li Y, Li J. The effect of hyperbaric oxygen therapy on the clinical outcomes of necrotizing soft tissue infections: a systematic review and meta-analysis. *World J Emerg Surg.* 2023 Mar 25;18(1):23. doi: 10.1186/s13017-023-00490-y.

Background: To determine the efficacy of hyperbaric oxygen therapy (HBO) in the treatment of necrotizing soft tissue infections (NSTI), we conducted a meta-analysis of the available evidence. **Methods:** Data sources were PubMed, Embase, Web of Science, Cochrane Library, and reference lists. The study included observational trials that compared HBO with non-HBO, or standard care. The primary outcome was the mortality rate. Secondary outcomes were the number of debridement, amputation rate and complication rate. Relative risks or standardized mean differences with 95% confidence intervals were calculated for dichotomous and continuous outcomes, respectively. **Results:** A total of retrospective cohort and case-control studies were included, including 49,152 patients, 1448 who received HBO and 47,704 in control. The mortality rate in the HBO group was significantly lower than that in the non-HBO group [RR=0.522, 95% CI (0.403, 0.677), p<0.05]. However, the number of debridements performed in the HBO group was higher than in the non-HBO group [SMD = 0.611, 95% CI (0.012, 1.211), p<0.05]. There was no significant difference in amputation rates between the two groups [RR=0.836, 95% CI (0.619, 1.129), p>0.05]. In terms of complications, the incidence of MODS was lower in the HBO group than in the non-HBO group [RR=0.205, 95% CI (0.164, 0.256), p<0.05]. There was no significant difference in the incidence of other complications, such as sepsis, shock, myocardial infarction, pulmonary embolism, and pneumonia, between the two groups (p>0.05). **Conclusion:** The current evidence suggests that the use of HBO in the treatment of NSTI can significantly reduce the mortality rates and the incidence rates of complications. However, due to the retrospective nature of the studies, the evidence is weak, and further research is needed to establish its

efficacy. It is also important to note that HBO is not available in all hospitals, and its use should be carefully considered based on the patient's individual circumstances. Additionally, it is still worthwhile to stress the significance of promptly evaluating surgical risks to prevent missing the optimal treatment time.

Louge P, Pignel R, Serratrice J, Stirnemann J. Validation of sham treatment in hyperbaric medicine: a randomised trial. *Diving Hyperb Med.* 2023;53(1):51-4. doi: 10.28920/dhm53.1.51-54.

Introduction: This study aimed to determine the lowest possible atmospheric pressure in the 111-152 kPa (1.1-1.5 atmospheres absolute [atm abs]) range that would require the patients to equalise their ears, allowing an effective sham for a 203 kPa (2.0 atm abs) hyperbaric exposure. **Methods:** We performed a randomised controlled study on 60 volunteers divided into 3 groups (compression to 111, 132 and 152 kPa (1.1, 1.3, 1.5 atm abs) to determine the minimum pressure to obtain blinding. Secondly, we applied additional blinding strategies (faster compression with ventilation during the fictitious compression time, heating at compression, cooling at decompression) on 25 new volunteers in order to enhance blinding. **Results:** The number of participants who did not believe they had been compressed to 203 kPa was significantly higher in the 111 kPa compressed arm than in the other two arms (11/18 vs 5/19 and 4/18 respectively; P=0.049 and P=0.041, Fisher's exact test). There was no difference between compressions to 132 and 152 kPa. By applying additional blinding strategies, the number of participants who believed they had been compressed to 203 kPa increased to 86.5%. **Conclusions:** A compression to 132 kPa, (1.3 atm abs, 3 metres of seawater equivalent) combined with the additional blinding strategies of forced ventilation, enclosure heating and compression in five minutes, simulates a therapeutic compression table and can be used as a hyperbaric placebo.

Malhotra AK, Chang AP, Lawton JP, Alves AC, Jerath A, Tillmann BW, Foster H, Mashari A, da Costa L, Kumar A. Intraoperative air embolism diagnosis and treatment using hyperbaric oxygen therapy after craniotomy: illustrative case. *J Neurosurg Case Lessons.* 2023 Mar 20;5(12):CASE2342. doi: 10.3171/CASE2342.

Background: This report describes the use of hyperbaric oxygen therapy for the acute management of an intraoperative air embolism encountered during a neurosurgical procedure. Furthermore, the authors highlight the concomitant diagnosis of tension pneumocephalus requiring evacuation prior to hyperbaric therapy. **Observations:** A 68-year-old male developed acute ST-segment elevation and hypotension during elective disconnection of a posterior fossa dural arteriovenous fistula. The semi-sitting position had been used to minimize cerebellar retraction, raising the concern

for acute air embolism. Intraoperative transesophageal echocardiography was utilized to establish the diagnosis of air embolism. The patient was stabilized on vasopressor therapy, and immediate postoperative computed tomography revealed air bubbles in the left atrium along with tension pneumocephalus. He underwent urgent evacuation for the tension pneumocephalus followed by hyperbaric oxygen therapy to manage the hemodynamically significant air embolism. The patient was eventually extubated and went on to fully recover; a delayed angiogram revealed complete cure of the dural arteriovenous fistula. **Lessons:** Hyperbaric oxygen therapy should be considered for an intracardiac air embolism resulting in hemodynamic instability. In the postoperative neurosurgical setting, care should be taken to exclude pneumocephalus requiring operative intervention prior to hyperbaric therapy. A multidisciplinary management approach facilitated expeditious diagnosis and management for the patient.

McGlynn J, Heyboer M. Successful treatment of radiation-induced vaginal soft tissue radionecrosis with HBO₂. *Undersea Hyperb Med.* 2023;50(1):9-15. doi: 10.22462/01.01.2023.16.

Introduction: Radiation therapy to the pelvis can result in radiation-induced vaginal soft tissue necrosis. This significantly impacts quality of life. Studies evaluating the efficacy of HBO₂ are limited. **Methods:** In this retrospective report, we reviewed the medical records of patients treated with once-daily HBO₂ for radiation-induced vaginal soft tissue necrosis. We included females between the ages of 18 to 90 with history of pelvic cancer treated with radiotherapy and resultant soft tissue radionecrosis. Data collected included age, comorbid disease, cancer type, radiation dose, HBO₂ treatment pressure, time, and total treatments. Primary outcome was improvement of radionecrosis; secondary outcomes were improvement of pelvic pain, reduction in need for analgesia, and improvement of vaginal bleeding. **Results:** Seven patients were identified, of which six received HBO₂. One patient had a vaginal fistula. Four patients had documented improvement of radionecrosis. Four out of five patients with pelvic pain had resolution of their pain, with two patients no longer requiring opioid analgesia. Two patients who presented with vaginal bleeding showed improvement with one resolved and one significantly decreased requiring no further hospitalization or transfusion. One patient experienced no documented improvement in any of the measured outcomes. **Conclusion:** In this case series, five out of six (83%) patients treated with HBO₂ for radiation-induced vaginal necrosis improved in at least one outcome measure. While the sample size is small, these results add to the data available that supports the use of HBO₂ in suitable candidates without contraindications who have symptoms related to radiation-induced vaginal soft tissue necrosis.

Nasr HY, Rifkin WJ, Muller JN, Chiu ES. Hyperbaric oxygen therapy for threatened nipple-sparing mastectomy flaps: an adjunct for flap salvage. *Ann Plast Surg.* 2023 Mar 8. doi: 10.1097/SAP.0000000000003441.

Background: Nipple-sparing mastectomy (NSM) is emerging as the standard of care for treatment of breast cancer because of its oncologic safety and superior aesthetic outcomes. However, ischemia or necrosis of the skin flap and/or nipple-areola complex remain frequent complications. Hyperbaric oxygen therapy (HBOT) has emerged as a potential adjunct for flap salvage, although it is not currently a widely accepted practice. Here we review our institution's experience using a protocol of HBOT in patients with signs of flap ischemia or necrosis after NSM. Methods: Retrospective review identified all patients treated with HBOT at our institution's hyperbaric and wound care center because of signs of ischemia after NSM. Treatment parameters consisted of 90-minute dives at 2.0 atmosphere once or twice daily. Patients unable to tolerate dives were considered a treatment failure, whereas those lost to follow-up were excluded from analysis. Patient demographics, surgical characteristics, and treatment indications were recorded. Primary outcomes assessed were flap salvage (no operative revision), need for revision procedures, and treatment complications. Results: A total of 17 patients and 25 breasts met the inclusion criteria. The mean±SD time to initiation of HBOT was 9.47±12.7 days. The mean±SD age was 46.7±10.4 years, and mean ± SD follow-up time was 36.5±25.6 days. Indications for NSM included invasive cancer (41.2%), carcinoma in situ (29.4%), and breast cancer prophylaxis (29.4%). Initial reconstruction included tissue-expander placement (47.1%), autologous reconstruction with deep inferior epigastric flaps (29.4%), and direct-to-implant reconstruction (23.5%). Hyperbaric oxygen therapy indications included ischemia or venous congestion for 15 breasts (60.0%) and partial thickness necrosis for 10 breasts (40.0%). Flap salvage was achieved in 22 of 25 breasts (88.0%). Reoperation was required for 3 breasts (12.0%). Hyperbaric oxygen therapy-related complications were observed in 4 patients (23.5%), which included 3 patients with mild ear pain and 1 patient with severe sinus pressure leading to treatment abortion. Conclusions: Nipple-sparing mastectomy is an invaluable tool for breast and plastic surgeons to achieve oncologic and cosmetic goals. However, ischemia or necrosis of the nipple-areola complex or mastectomy skin flap remains frequent complications. Hyperbaric oxygen therapy has emerged as a possible intervention for threatened flaps. Our results demonstrate the utility of HBOT in this population to achieve excellent NSM flap salvage rates.

Persson G, Lodin-Sundström A, Linér MH, Andersson SHA, Sjögreen B, Andersson JPA. Splenic contraction and cardiovascular responses are augmented during

apnea compared to rebreathing in humans. *Front Physiol.* 2023 Mar 7;14:1109958. doi: 10.3389/fphys.2023.1109958. eCollection 2023.

The spleen contracts during apnea, releasing stored erythrocytes, thereby increasing systemic hemoglobin concentration (Hb). We compared apnea and rebreathing periods, of equal sub-maximal duration (mean 137 s; SD 30), in 18 subjects to evaluate whether respiratory arrest or hypoxic and hypercapnic chemoreceptor stimulation is the primary elicitor of splenic contraction and cardiovascular responses during apnea. Spleen volume, Hb, cardiovascular variables, arterial (S_aO_2), cerebral (S_cO_2), and deltoid muscle oxygen saturations (S_mO_2) were recorded during the trials and end-tidal partial pressure of oxygen ($P_{ET}O_2$) and carbon dioxide ($P_{ET}CO_2$) were measured before and after maneuvers. The spleen volume was smaller after apnea, 213 (89) mL, than after rebreathing, 239 (95) mL, corresponding to relative reductions from control by 20.8 (17.8)% and 11.6 (8.0)%, respectively. The Hb increased 2.4 (2.0)% during apnea, while there was no significant change with rebreathing. The cardiovascular responses, including bradycardia, decrease in cardiac output, and increase in total peripheral resistance, were augmented during apnea compared to during rebreathing. The $P_{ET}O_2$ was higher, and the $P_{ET}CO_2$ was lower, after apnea compared to after rebreathing. The S_cO_2 was maintained during maneuvers. The S_aO_2 decreased 3.8 (3.1)% during apnea, and even more, 5.4 (4.4)%, during rebreathing, while the S_mO_2 decreased less during rebreathing, 2.2 (2.8)%, than during apnea, 8.3 (6.2)%. We conclude that respiratory arrest per se is an important stimulus for splenic contraction and Hb increase during apnea, as well as an important initiating factor for the apnea-associated cardiovascular responses and their oxygen-conserving effects.

Tai CJ, Lu CK, Lee CY, Lee SS, Yang YH. Real-world evidence of hyperbaric oxygen therapy on cardiovascular outcomes in patients with chronic osteomyelitis. *J Infect Public Health.* 2023 Mar 7;16(5):705-12. doi: 10.1016/j.jiph.2023.03.006.

Background: The effectiveness of hyperbaric oxygen (HBO) therapy for chronic osteomyelitis remains inconclusive. In particular, recent studies have shown that chronic osteomyelitis is a crucial risk factor for cardiovascular diseases. However, the preventive effect of HBO on cardiovascular events has not been reported in patients with chronic osteomyelitis. Methods: We conducted a population-based cohort study to evaluate the impact of HBO on patients with chronic osteomyelitis. Overall, 5312 patients with chronic osteomyelitis were selected from the Taiwan National Health Insurance Database to evaluate the impact of HBO in patients with chronic osteomyelitis. Propensity-score (PS) matching and inverse probability weighting (IPTW) were employed to balance covariates between the HBO and non-HBO

groups. The primary outcome was all-cause mortality. The secondary outcomes were myocardial infarction (MI) and stroke hospitalisation. Furthermore, we evaluated the appropriate timing for HBO intervention by the restricted cubic spline (RCS) functions. Results: After 1:4 PS-matching, the HBO group (n=265) was associated with lower 1-year mortality (hazard ratio [HR], 0.49; 95 % confidence interval [CI], 0.25-0.95) than the non-HBO group (n=994); this was consistent with the IPTW weighting results (HR, 0.25; 95 % CI, 0.20-0.33). The risk of stroke was lower in the HBO group (HR, 0.46; 95 % CI, 0.34-0.63) than that in the non-HBO group. However, HBO therapy failed to reduce the risk of MI. Using the RCS model, patients with intervals within 90 days (HR, 1.38; 95 % CI, 1.04-1.84) presented a significant risk of 1-year mortality. After 90 days, as the length of interval increased, the risk gradually decreased and became insignificant. Conclusion: The present study revealed that adjunctive HBO could benefit the 1-year mortality and stroke hospitalisation in patients with chronic osteomyelitis. HBO was recommended to be initiated within 90 days of chronic osteomyelitis hospitalisation.

Untari NDS, Kusumastuti K, Suryokusumo G, Sudiana IK. Hyperbaric oxygen therapy improves recovery at acute motor axonal neuropathy case. J Neurosci Rural Pract. 2023;14(1):145-8. doi: 10.25259/JNRP_9_2022. Epub 2022 Dec 21.

Acute motor axonal neuropathy (AMAN) is a rare immune-mediated disorder characterized by acute flaccid paralysis with elevated levels of GM1 antibodies. It is also known as a subtype of the Guillain-Barre syndrome (GBS) and develops since antigens serve as antibodies in the spinal cord. We report a case diagnosed as AMAN with symptoms of ascending limb symmetrical weakness. A neurological examination revealed a flaccid paralysis with multiple cranial nerve palsies. Electromyography showed an axonal type of GBS. The patient refused bone marrow fluid aspiration. Intravenous immunoglobulin was administered at the high care unit. Unfortunately, despite the standard therapy, an optimal recovery was not obtained. Hyperbaric oxygen (HBO) therapy has been known to be common in illnesses and some clinical diseases. Although it has not been indicated for peripheral neuropathy, a remarkable recovery was soon visible in the HBO-treated AMAN case. The HBO mechanisms involved here are anti-inflammation and immunomodulation.

CUHMA-ACMHS is the Canadian voice for the advancement of hyperbaric and diving medicine throughout our country and beyond. Our activities include continuous medical education for physicians, nurses, respiratory therapists and anyone involved in the fields of hyperbaric and diving medicine. We are also promoting dissemination of clinical research, publishing position statements, liaising with related professional associations and government agencies. Our main goal is advocating on behalf of our patients. Our vision is to be the reference for the development and delivery of hyperbaric and diving medicine in Canada and beyond. Our mission is to promote excellence in hyperbaric and diving medicine through leadership in education, promotion of best practices and advocacy for our patients. Our values are excellence, leadership, collaboration, communication, and integrity.

Canadian Undersea and Hyperbaric Medical Association

10 Plumtree Place, Portugal Cove-St. Philips,
Newfoundland and Labrador, A1M 3T1
info@cuhma.ca <https://cuhma.ca>

Editor: Neal W. Pollock, PhD - neal.pollock@kin.ulaval.ca

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