EUBS 2022 PRAGUE

46th Annual Scientific Meeting

ABSTRACT & CONFERENCE BOOK

31.08. - 03.09.2022
Prague, Czech Republic

Editors:
Michal Hajek
Lukas Hajek
Lukas Robenek
Peter Germonpre

EUBS European Underwater and Baromedical Society

Dear friends and colleagues,

allow me to greet you and, after more than three years of preparation, welcome you to the 46th Annual Scientific Conference EUBS 2022. The center and venue of the conference is the prestigious four-star hotel from the international network NH Prague City Hotel, located not far from the VItava River and the center cities.

The last period was not at all easy for us organizers. Repeated preparation and cancellation of the event due to the covid pandemic and subsequent epidemiological restriction measures, repeated negotiation of the conditions of the event with the hotel management and all interested parties, economic uncertainty resulting from concerns about securing a sufficient number of participants, ever-increasing inflation and enormously rising costs, armed conflict in the Eastern part of Europe as well.

I took the whole situation and organization of this event as a personal challenge and as a certain highlight of my professional career so far. I believe that we coped with all the pitfalls and prepared the event responsibly and at a dignified level.

Our highest wish is that the upcoming conference, after practically a three-year delay, will be attended by as many participants and visitors as possible, because we feel that our professional public is driven by the desire to meet in person both during lectures and during discussions, and above all during social events after the end of the official scientific program, as was the case at dozens of previous conferences.

It was possible to ensure a high-quality scientific program containing almost 60 oral presentations and more than 40 posters, a total of more than 100 scientific papers. Participants from almost 40 countries of the world, from all the world's continents, are registered.

I believe that in the future we will only remember well that we participated in the first post-covid conference in history! Welcome to Prague, the capital of the Czech Republic and the world scene of hyperbaric and diving medicine in 2022!

Michal Hajek, MD, PhD.,
Secretary General, Chair of the Scientific and Local Organizing Committee,
46th EUBS Annual Scientific Meeting 2022.

WELCOME TO PRAGUE

Situated in the northwest of the country on the Vltava River, Prague is the capital and the largest city of the Czech Republic. This magical city of bridges, cathedrals, gold--tipped towers, and church spires is also the fourteenth largest city in the European Union. The city is home to about 1.3 million people, but its larger urban zone has a population of approximately 2 million. Since the Middle Ages Prague has cherished the reputation of one of the most beautiful cities in the world as well as the political, cultural, and economic center of central Europe.

PRAGUE CASTLE

The complex of many monuments, the seat of the President, a beautiful view of Prague, the Golden Lane or the Cathedral of St. Nicholas.
All this is part of Prague Castle and you cannot miss it!

CHARLES BRIDGE

Charles IV. had built many important buildings, the most famous probably being the legendary Charles Bridge, which connects the Lesser Town with the Old Town. Anyone who visits Prague must almost obligatory visit Charles Bridge.

ASTRONOMICAL CLOCK

The most famous Astronomical Clock in the world is in the very heart of Prague - at the Old Town Square. There is a famous exchange of the apostles every hour, which the crowds of tourists will not miss.
It has been refurbished in the last year, so it´s more beautiful than ever.

WENCESLAS SQUARE

Wenceslas Square is one of the main city squares and the centre of the business and cultural communities in the New Town of Prague, Czech Republic. Many historical events occurred there, and it is a traditional setting for demonstrations, celebrations, and other public gatherings. It is also the place with the busiest pedestrian traffic in the whole country. The square is named after Saint Wenceslas, the patron saint of Bohemia. It is part of the historic centre of Prague.

NATIONAL THEATRE

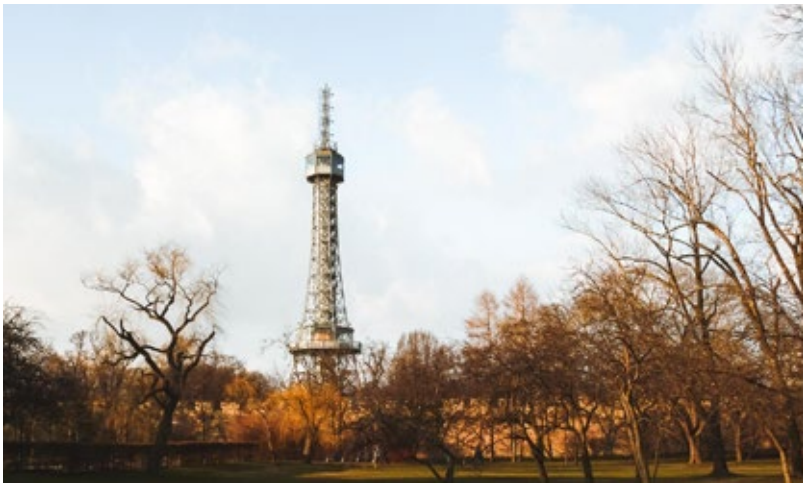
Near the Vltava River, a river that flows through Prague, stands the famous National Theater, which is also reconstructed and one of Prague's monuments. A walk around the river is one of the most beautiful in the city.

VYSEHRAD

According to a legend, Princess Libuše predicted the future glory and size of Prague here. It is a former fortress with a cathedral and a beautiful view of Prague.
Highly recommended.

PETRIN

A romantic walk in the center of Prague? Yes, a small hill Petřín offers you just that. Calmness, beautiful views and above the lookout tower inspired by the famous Eiffel Tower.



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GENERAL INFORMATION

Conference Venue

Hotel NH Prague City
Mozartova 261/1, 150 00 Praha 5

City / Country

Prague, Czech Republic

Currency

Czech crown (CZK) is the official national currency. All the major credit card types are accepted in Czech Republic.

Official Language

The official language of the conference is English

Transport

- For transport around Prague, it is possible to use Prague integrated transport.
- You can also use Uber or Bolt for transportation

Bolt - Android

Bolt - Apple

Uber - Android

Uber - Apple

Registration Package

- Participation in all scientific sessions
- Entrance to the Exhibition
- Daily lunch, coffee breaks and light snacks
- Invitation to the Wednesday Welcome Reception - conference venue
- Invitation to the Thursday Social program - Dinner in a historic brewery in the center of Prague
- Invitation to the Friday Conference Dinner - Boat cruise on the Vltava river
- Printed material of the Conference

SOCIAL EVENTS

Welcome reception

Date: **31.08 - Wednesday**
Time: **19:00 - 21:00**
Venue: **NH Hotel Prague**
Dress code: **Casual**

Dinner at the historic brewery U Medvídků

Date: **01.09 - Thursday**
Time: **20:00 - 23:00**
Venue: **Na Perštýně 5,**
110 00 Staré Město, Prague
Transfer:
800m on foot to Anděl metro station.
Take the metro in the direction of Černý most to Můstek station.
400m on foot to the destination
Dress code: **Casual**

Conference Dinner on the Boat cruise on the Vltava River

Date: **02.09 - Friday**
Time: **20:00 - 23:00**
Venue: **Dvořákovo nábř.,**
110 00 Josefov, Prague
Transfer:
Walk 600m to the stop Bertramka. Tram number 15 in the direction of Olšanské hřbitovy to the stop Čechův most.
Walk 450m to the destination
Dress code: **Smart Casual**

https://www.prague-boats.cz

CONFERENCE SPONSORS

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Czech CEBHC JBI Centre of Excellence

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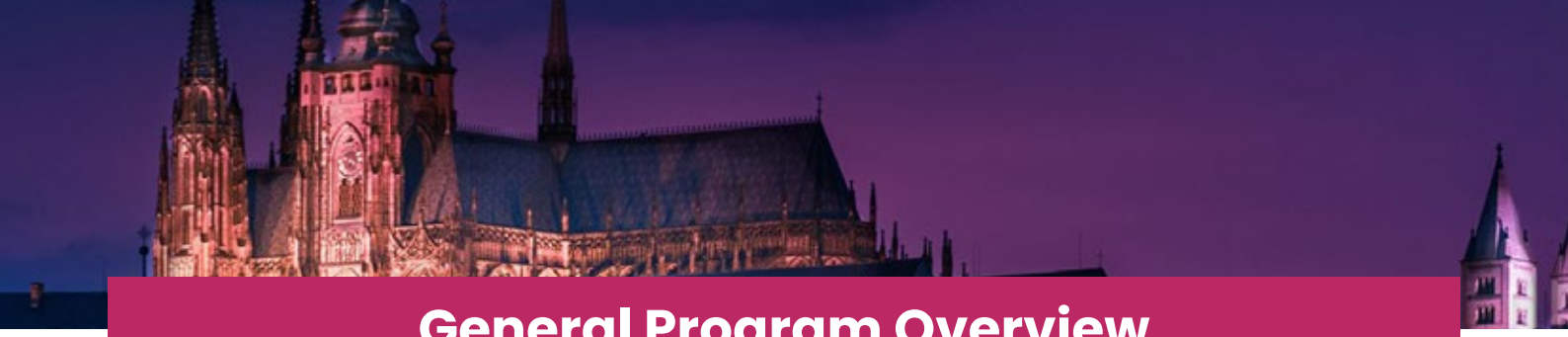


General Program Overview

Wednesday **31.08**	Thursday **01.09**	Friday **02.09**	Saturday **03.09**
	08:30 – 09:00 Gathering & Registration	**08:30 – 09:00** Gathering & Registration	**09:00 – 09:30** Gathering & Registration
	09:00 – 09:15 Opening Ceremony	**09:00 – 17:55** Scientific Session	**09:30 – 10:30** EUBS General Assembly
	09:15 – 17:35 Scientific Session		**10:30 – 13:50** Scientific Session
			13:50 – 14:00 Closing Ceremony
19:00 – 21:00 Welcome reception	**20:00 – 23:00** Dinner in a historic brewery in the center of Prague	**20:00 – 23:00** Conference Dinner on the Boat cruise on the Vltava river	


LÁVKA

Scientific Program

46th Annual EUBS Conference Scientific Program

ORAL PRESENTATIONS

Thursday, September 1st

09:00 - 09:15		**Opening Ceremony**
09:15 - 10:50		**Scientific Session I: Diving/Forensic**
		Session chairs: Peter Germonpre, Miloslav Klugar
09:15 - 09:50	O1	**Invited lecture: The forensic investigation of diving fatalities: the medicolegal procedures.** *František Novomeský, Veronika Rybárová*
09:50 - 10:05	O2	**The forensic analysis of 27 diving fatalities: diver demographics and characteristics.** *Veronika Rybárová, František Novomeský*
10:05 - 10:20	O3	**Does hyperbaric oxygen cause narcosis or hyperexcitability? A quantitative EEG analysis** *Xavier Vrijdag, Hanna van Waart, Chris Sames, Simon Mitchell, Jamie Sleigh*
10:20 - 10:35	O4	**Sixty years of diving medicine in CRIS-UTH. A review of 1000 disbaric diving injuries.** *Jordi Desola, Olga Enciso, Nadia Hamzeh, Evangelos Papoutsidakis*
10:35 - 10:50	O5	**Pulmonary barotrauma during a wreck recovery happened in 1654.** *Jordi Desola*
10:50 - 11:20		**Coffee Break**
11:20 - 13:00		**Scientific Session II: HBOT/DFU/Carbon Monoxide poisoning**
		Session chairs: Bengusu Mirasoglu, Ole Hyldegaard
11:20 - 11:40	O6	**Keynote lecture: The effectiveness and safety of hyperbaric oxygen therapy for chronic diabetic foot ulcers: an overview of systematic reviews with de novo meta-analysis of randomized controlled trials.** *Miloslav Klugar, Lucia Kantorová, Michal Hájek, Andrea Pokorná, Tereza Vrbová, Michal Dubský, Vladimíra Fejfarová, Miroslav Koliba, Petr Krawczyk, Veronika Wosková, Jitka Klugarová*
11:40 - 11:55	O7	**Hyperbaric oxygen therapy for diabetic foot ulcers with leg ischemia (DIONYSIUS trial)** *Joost Meijering, Robin Brouwer, Rutger Lalieu, René Bol Raap, Rigo Hoencamp, Mark Koelemay, Rob van Hulst, Dirk Ubbink*
11:55 - 12:10	O8	**What is the perspective of who pays for the HBOT for wound care?** *Pasquale Longobardi, Nedjoua Belkacem, Chiara Bissoni*
12:10 - 12:25	O9	**Cost effectiveness of hyperbaric oxygen therapy for the treatment of ischaemic diabetic foot ulcers.** *Robin Brouwer, Nick van Reijen, Rigo Hoencamp, Rob van Hulst, Marcel Dijkgraaf, Mark Koelemay, Dirk Ubbink*
12:25 - 12:40	O10	**Twenty-one year overview of HBO treatment of Carbon Monoxide poisoning : refining the indication using a diagnosis and management algorithm.** *William Portier, Nathalie Mouton, Yoerik Neirynck, Dirk Caers, Peter Germonpre*
12:40 - 12:55	O11	**Forty years of hyperbaric medicine in CRIS-UTH. A review of 4500 cases of carbon monoxide poisoning.** *Jordi Desola, Olga Enciso, Nadia Hamzeh, Evangelos Papoutsidakis*

13:00 - 14:00		**Lunch Break / Poster Exhibition**
14:00 - 15:30		**Scientific Session III: Diving/DCS/Preconditioning** Session chairs: František Novomeský, Arne Sieber
14:00 - 14:15	O12	**Influence of prehospital management on the outcome of spinal cord decompression sickness in scuba divers.** *Jean Eric Blatteau, Sophie André*
14:15 - 14:30	O13	**Another Preconditioning Before diving : minitrampoline.** *Costantino Balestra*
14:30 - 14:45	O14	**Eccentric arm work 24 hours prior to hypobaric exposure increases presence of circulating bubbles.** *Frode Gottschalk, Ola Eiken, Antonis Elia, Mikael Gennser*
14:45 - 15:00	O15	**Diving into Decompression Sickness resistant rats gene expression through a miRnome / transcriptome crossed approach.** *François Guerrero, Emmanuel Guerrero, Anthony Guernec, Jérémy Orsat*
15:00 - 15:15	O16	**Transthyretine gene expression and decompression sickness.** *François Guerrero, Jérémy Orsat, Anthony Guernec, Cédric Le Maréchal, Vianney Pichereau*
15:15 - 15:30	O17	**Is Acute Bone Necrosis (ABN) observed on patients with Osteoacticular Decompression Sickness (OADS) a new entity?** *Jorge Calderon, Evangelos Papoutsidakis, Michel Cabrera, Erwin Ojeda*
15:30 - 16:00		**Coffee Break**
16:00 - 17:35		**Scientific Session IV: HBOT/Experimental** Session chairs: Shai Efrati, Miroslav Rozložník
16:00 - 16:20	O18	**Keynote lecture: „From an idea up to an experiment well done"** *Predrag Brkič*
16:20 - 16:35	O19	**Hyperbaric oxygenation reduces death of immature neurons in the adult hippocampal dentate gyrus following brain injury.** *Predrag Brkič, Rada Jeremic, Sanja Dacic, Marina Djelic, Sanja Pekovic*
16:35 - 16:50	O20	**Effects of Hyperbaric Oxygen Therapy on Mitochondrial Respiration and Physical Performance in Middle-Aged Athletes: A Blinded, Randomized Controlled Trial.** *Amir Hadanny, Shai Efrati*
16:50 - 17:05	O21	**The Effect of Hyperbaric Oxygen Therapy (HBOT) on Sports Performance and Recovery.** *Evangelos Papoutsidakis*
17:05 - 17:20	O22	**Hyperbaric oxygen treatment in early phase is effective after muscle contusion injury because VEGF and bFGF induction by nitric oxide promotes angiogenesis and muscle regeneration.** *Naoki Yamamoto*
17:20 - 17:35	O23	**DNA damage, apoptosis and repair in primary and malignant osteoblastic cells after hyperbaric hyperoxia.** *Nele Schönrock, Frauke Tillmans, Susanne Sebens, Wataru Kähler, Sebastian Klapa, Bente Rieger, Harry Scherthan, Andreas Koch*

Friday, September 2nd

09:00 - 10:45		**Scientific Session V: HBOT/TBI/Clinical effects** Session chairs: Jordi Desola, Evangelos Papoutsidakis
09:00 - 09:15	O24	**Hyperbaric oxygen therapy compared to pharmaceutical intervention in fibromyalgia patients following traumatic brain injury: A prospective, randomized two active arms trial.** *Shai Efrati, Jacob N Ablin, Merav Catalogna, Erez Lang, Valeri Alush, Keren Doenyas-Barak, Shachar Finci, Nir Polak, Gregory Fishlev, Calanit Korin, Rachel Yehudit Tzidky, Oshra Meir Genuth*

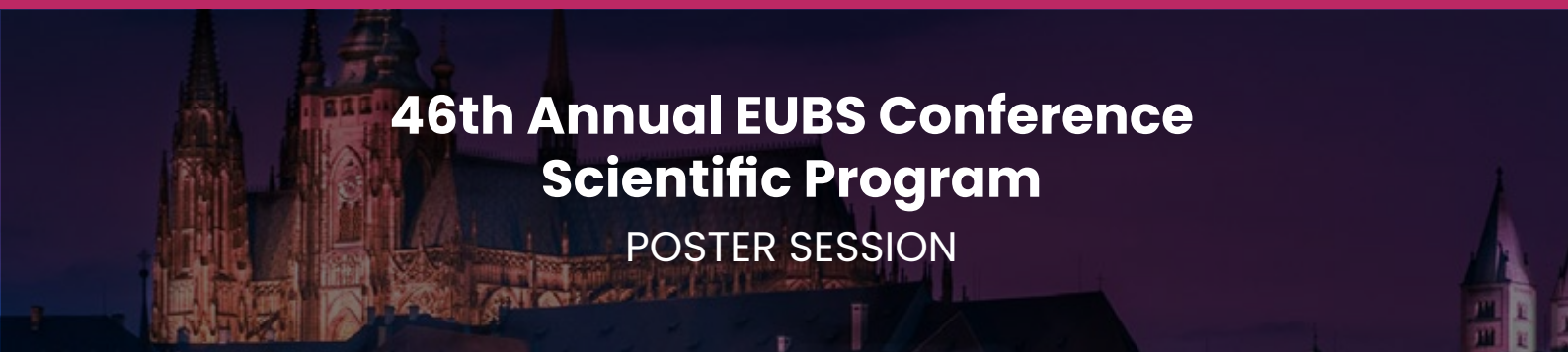
09:15 - 09:30	O25	**The effects of hyperbaric oxygen therapy in children with post-concussion syndrome: randomized controlled trial.** *Amir Hadanny, Shai Efrati*
09:30 - 09:45	O26	**Could delayed HBOT be effective in severe traumatic brain injury (TBI)?** *Pasquale Longobardi, Claudio Costa, Francesco Fontana, Pietro Marano, Chiara Aramini, Paolo Lega, Adriana Pretolani, Chiara Bissoni, Maddalena Vassura*
09:45 - 10:00	O27	**Use of Hyperbaric Oxygen Therapy in infants: experience of two tertiary health care centers** *Bengusu Mirasoglu, Kubra Ozgok Kangal*
10:00 - 10:15	O28	**Hyperbaric Oxygen Therapy with Iloprost Improves Digit Salvage in Severe Frostbite Compared to Iloprost Alone.** *Marie-Anne Magnan, Angele Gayet-Ageron, Pierre Louge, Frederic Champly, Thierry Joffre, Christian Lovis, Rodrigue Pignel*
10:15 - 10:30	O29	**A retrospective analysis of patients treated with hyperbaric oxygen therapy for late radiation tissue injury of the vagina.** *Michelle Möring, Anne Valkenburg, Nicoline Schuur- van 't Hof, Heleen Beekhuizen, Nina Lansdorp*
10:30 - 10:45	O30	**Stem Cell Mobilization by Nominal Hyperbaria.** *KJ MacLaughlin, Rudolf Braun, Jacob Lamers, Matthew Marcou, Marlowe Eldridge*
10:45 - 11:15		**Coffee Break**
11:15 - 13:00		**Scientific Session VI: Diving/Working/Combat/Saturation** Session chairs: Jean-Eric Blatteau, Radek Pudil
11:15 - 11:30	O31	**Diving medical examination before return to diving after COVID-19 - clinical observation study on divers and combat swimmers of the Bundeswehr.** *Andreas Koch, Luisa Graue, Maike Körner, Sebastian Klapa, Wataru Kähler, Bente Rieger*
11:30 - 11:45	O32	**Development of FTD for working divers in Sweden in relation to EDTC-Swedish law by the covid19 pandemic.** *Mats Hagberg*
11:45 - 12:00	O33	**Capsule Project: a physiological survey during 3 days shallow saturation dives in a very limited space.** *François Guerrero, Emmanuel Dugrenot, Erwan L'Her, Emmanuel Gouin, Under The Pole Consortium, Jean-Eric Blatteau*
12:00 - 12:15	O34	**New tunnel trimix saturations: design and validation of the excursions of the Hong Kong TMCLK project.** *P Imbert, A Sidali*
12:15 - 12:30	O35	**Optimisation of Gradient Factor Selection in Military Diving.** *Sven De Ridder, Nathalie Pattyn, Xavier Neyt, Peter Germonpré*
12:30 - 12:45	O36	**Multifrequency bioimpedance to evaluate oxidative/inflammatory stress related to saturation diving: a field study.** *JP Imbert, A Letourneur, L Balesta, J Deter, C Balestra*
12:45 - 13:00	O37	**Full-face snorkel masks safety during rest and exercise.** *Hanna van Waart, Janneke Grundemann, Xavier Vrijdag, Nicole Wong, Nicholas Gant, Simon Mitchell*
13:00 - 14:00		**Lunch Break / Poster Exhibition**
14:00 - 15:40		**Scientific Session VII: Special Session/Hypobaric/Aviation** Session chairs: Mikael Gennser, François Guerrero
14:00 - 14:30	O38	**Hypobaric hypoxia in aeromedical training - fundamentals, methods and practical aspects.** *Boris Oniščenko*
14:30 - 14:55	O39	**Explosive Decompression and rare pulmonary barotrauma.** *Jakub Tlapák*
14:55 - 15:20	O40	**Ophthalmological challenges of the flight and underwater environment.** *Veronika Poláčková*

15:20 - 15:40	O41	**Underwater Analog Space Missions.** *Miroslav Rozložník*
15:40 - 16:10		**Coffee Break**
16:10 - 17:55		**Scientific Session VIII: HBOT/Indications/COVID** Session chairs: Predrag Brkič, Amir Hadanny
16:10 - 16:25	O42	**Hyperbaric Oxygen in Lower Limb Trauma – a multi-centre randomized controlled trial.** *Ian Millar, Folke Lind, Karl-Ake Jansson, Michal Hajek, David Smart, Tiago Fernandes, Rosemary McGinnes, Owen Williamson, Russell Miller, Catherine Martin, Belinda Gabbe, Paul Myles, Peter Cameron*
16:25 - 16:40	O43	**Influence of applied pressure in HBOT SSNHL therapy on the rate of therapeutic gain of patients in particular frequency ranges.** *Zdenka Krajčovičová, Vladimír Meluš, Rastislav Zigo, Barbora Koštialiková*
16:40 - 16:55	O44	**Hyperbaric oxygen therapy induces neuroplasticity and improve neurocognitive functions and symptoms of post-COVID-19 condition: randomized, double blind, sham-controlled clinical trial.** *Shai Efrati, Shani Zilberman-Itskovich, Merav Catalogna, Efrat Sasson, Karin Elman-Shina, Amir Hadanny, Erez Lang, Shachar Finci, Nir Polak, Gregory Fishlev, Calanit Korin, Ran Shorer, Yoav Parag*
16:55 - 17:10	O45	**The Effects of hyperbaric oxygen therapy on recovery from the long COVID-19 condition.** *Dragana Ivkovic, Branislav D. Stefanovic, Branislava Stefanović, Vesna Koletic, Zeljka Jelenkovic, Dejana Savic, Dejana Stanisavljevic, Mihailo Stjepanovic, Spasoje Popevic, Natasa Mujovic, Predrag Brkić, Jelena Cvejic*
17:10 - 17:25	O46	**The effects of hyperbaric oxygenation on lung diffusion capacity among the patients with post COVID-19 condition, a pilot study.** *Dragana Ivkovic, Mihailo Stjepanovic, Spasoje Popevic, Branislav D. Stefanovic, Branislava Stefanović, Vesna Koletic, Zeljka Jelenkovic, Dejana Savic, Dejana Stanisavljevic, Natasa Mujovic, Predrag Brkić, Jelena Cvejic*
17:25 - 17:40	O47	**Safety of Hyperbaric Oxygen Treatment for Post COVID-19 condition. Results from the interim safety analysis of the randomized placebo-controlled double-blind trial (HOT-LoCO).** *Sara El Gharbi, Anders Kjellberg, Adrian Hassler, Emil Boström, Sarah Al-Ezerjawi, Jan Kowalski, Sergiu-Bogdan Catrina, Kenny Rodriguez-Wallberg, Michael Runold, Marcus Stahlberg, Judith Bruchfeld, Malin Nygren-Bonnier, Peter Lindholm*
17:40 - 17:55	O48	**Clinical and immunological effects of Hyperbaric Oxygen Therapy (HBOT) in severe non--intensive COVID-19 patients: interim analysis of a Randomized Control Trial.** *Jacek Kot , Jacek Siewiera, Klaudia Brodaczewska, Natalia Jermakow, Arkadiusz Lubas, Krzysztof AP, Aleksandra Majewska*

Saturday, September 3rd

09:30 - 10:30		**EUBS General Assembly**
10:30 - 11:50		**Scientific Session IX: Diving/Apnoea Diving** Session chairs: Lesley Blogg, Gerardo Bosco
10:30 - 10:50	O49	**Keynote lecture: The effect of scuba diving and freediving on myocardial function: physiological or pathophysiological response?** *Radek Pudil*
10:50 - 11:05	O50	**Effects of freediving depth on diving heart rate and arterial oxygen desaturation.** *Erika Schagatay, Craig Staunton, Arne Sieber, Eric Mulder*
11:05 - 11:20	O51	**Effects of hyperventilation on oxygen kinetics, apnea breaking point, diving response, and spleen contraction during serial static apneas.** *Frank Pernett, Pontus Bergenhed, Pontus Holmström, Eric Mulder, Erika Schagatay*
11:20 - 11:35	O52	**Is cardiac arrhythmia contributing to blackout in breath-hold diving?** *Erika Schagatay, Eric Mulder, Lukas Längle, Frank Pernett, Arne Sieber*
11:35 - 11:50	O53	**Taravana syndrome after a breath hold diving with a underwater thruster, an in situ bubble formation encephalopathy ?** *Romain Roffi, Arnaud Druelle, Jean Morin, Henri Lehot, Jean-Eric Blatteau*

11:50 - 12:20		**Coffee break**
12:20 - 13:50		**Scientific Session X: Miscellaneous** Session chairs: Erika Schagatay, Constantino Balestra
12:20 - 12:35	O54	**Does the most potent Lung Surfactant Dipalmitoylphosphatidylcholine pose a risk for decompression illness in diving mammals?** *Ran Arieli*
12:35 - 12:50	O55	**Repeated HBO2 Exposure Increases Skeletal Muscle Oxidative Stress and Disrupts Calcium Handling.** *Heath G. Gasier, Hagir B. Suliman*
12:50 - 13:05	O56	**Improving the safety of submarine escape and rescue from shallow depth using a 90-kg sheep decompression model.** *Sobakin AS, Lamers JJ, Pegelow DF, Eldridge MW.*
13:05 - 13:20	O57	**Endothelial injury in diving: Atomic Force-, Electronic- and Light-microscopy study of ovine decompressed blood vessels.** *Ran Arieli*
13:20 - 13:35	O58	**Immersion Pulmonary Edema in Tropical Waters – A Systematic Review.** *Tan JKH, Lim SC, Dhillon BK, Kwek JWM, Law DZ*
13:35 - 13:50	O59	**HYMON: a new, innovative, interactive online educational platform for education of hyperbaric medicine** *Miroslav Rozložník, Michal Hájek, Dittmar Chmelař, Miloslav Klugar, Radek Pudil, Zdenka Krajčovičová, Vladimír Meluš*
13:50 - 14:00		**Closing Ceremony**
14:00		**Lunch**



46th Annual EUBS Conference Scientific Program

POSTER SESSION

P01	**Differential diagnosis between stroke and neurological decompression sickness.** *Jean-Eric Blatteau, Alexandra Bourron, Pierre Louge, Emmanuel Gempp, Sébastien de Maistre*
P02	**Datalogger for Assessment of Physiological Parameters of Divers.** *Arne Sieber, Irfan Sehic, Matthias Binder, Eric Mulder, Erika Schagatay*
P03	**Deep rebreather dive results in high-grade venous gas emboli arterialization without clinical decompression sickness symptoms.** *Frauke Tillmans, Rhiannon Brenner, Gabriel Graf, Stefanie Martina, Caitlyn Kulakowski, Grant Dong, Catherine Harris, Virginie Papadopoulou, Robert Furberg, James Chimiak*
P04	**DAN looks at fitness to dive and vaccination results in American and non-American divers.** *Frauke Tillmans, Elizabeth Helfrich, Matias Nochetto, Camilo Saraiva, Peter Lindholm, James Chimiak, Rhiannon Brenner*
P05	**The critical flicker fusion frequency: how reliable?** *Sven Dreyer, Thomas Muth, Jochen Schipke*
P06	**Assessing critical flicker frequency: which confounders?** *Jochen D Schipke, Thomas Muth*
P07	**An echo from the past: building a Doppler repository for big data in diving research.** *S. Lesley Blogg, Rachel Lance, Frauke Tillmans, Kaighley Brett, Fethi Bouak, Laurens Howle, Koshiar Medson, Richard Moon, Virginie Papadopoulou, Peter Lindholm*
P08	**Arterial gas embolism associated with atypical dive profile.** *Elif Ebru ÖZER*
P09	**Show O2-stress-adapted human cells different cell effects after exposure to indirect ionizing radiation (UV-A)?** *Andreas Koch, Wataru Kähler, Ole Westphal, Rieke Scharbrodt, Tobias Schramm, Harry Scherthan, Sebastian Klapa*
P10	**Breath-Hold Diving and Mechanisms of Hypoxemia.** *Gerardo Bosco, Matteo Paganini, Luca Martani, Giacomo Garetto, Ennio Talamonti, Tommaso Giacon, Danilo Cialoni, Enrico Camporesi, Richard Moon, Stephen Thom, Christopher McKnight*
P11	**Normobaric oxygen breathing directly after ascent reduces occurrence of venous gas emboli.** *Mikael Gennser, Lesley Blogg, Anders Rosén*
P12	**Novel sensor for Assessment of Involuntary Breathing Movements (Respiratory Contractions) during Breath-hold Diving** *Arne Sieber, Eric Mulder, Frank Pernett, Irfan Sehic, Erika Schagatay*
P13	**Open exhaust failure affecting damaged or contaminated Avox Pressur-Vak BIBS** *Ian Millar, Andrew Smale, Paul Axton*

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Abstracts

O-1

INVITED LECTURE: THE FORENSIC INVESTIGATION OF DIVING FATALITIES: THE MEDICOLEGAL PROCEDURES

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O-2

THE FORENSIC ANALYSIS OF 27 DIVING FATALITIES: DIVER DEMOGRAPHICS AND CHARACTERISTICS

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Introduction
The study identified demographics and characteristics of victims of fatal scuba diving incidents which were investigated in the Department of Forensic Medicine and Medicolegal Expertises in Martin from 1980 to 2021, inclusive. The aim was to determine contributing factors and risks accompanied the diving fatalities mainly in two inland countries, Slovak and Czech Republic. The pilot retrospective study formed the fundamentals for further monitoring of diving fatalities in these countries as well as allowed these to be included in world diving report in the future and inform appropriate countermeasures.

Methods
The electronic report /The registration report of fatal diving incident/ was established for the purposes of systematic and unified data collection about the diver, the circumstances of the incident, the diving equipment used, autopsy outcomes and their subsequent analysis. Data were extracted from medical, technical, witness and police reports.

Results
27 scuba diving-related fatalities were investigated during the period of 42 years. The mean age of victims was 39 years, 23 (85%) victims were male. In 1997 and 2008, 2 divers died during the same dive. In 7 (26%) cases, diving was performed in overhead environment. One incident was related to the training of a young military diver in the swimming pool. In 21 (78%) cases the diving was performed with a buddy, while in 17 cases the victims separated from their buddies or group prior to the incident or during the incident. Two (7%) divers used rebreathers (e-CCR). In up to 17 (63%) cases the incident leading to death was related to the diver's ascent to the surface (decompression phase), of which in 12 cases it was accompanied by breath-hold resulting in severe overpressure lung injury. The dominant death morphology was pulmonary barotrauma of ascent with massive cerebral arterial gas embolism (12). The following death morphology was drowning (11). The 38 triggers of underwater incidents were identified, while the dominant one was the diver error related to equipment unfamiliarity or misuse, and/or poor decision-making.

Conclusions
After summarizing and thorough evaluation of the complex data, the authors tried to create a virtual profile of a „risky diver", in whom the potential of underwater crisis with a possible fatal outcome is really high. The nowadays technical and educational improvements over time make scuba diving more safe. However, one link of the chain has not changed - the diver himself with all inherent weakness of a human being underwater.

O-3

DOES HYPERBARIC OXYGEN CAUSE NARCOSIS OR HYPEREXCITABILITY? A QUANTITATIVE EEG ANALYSIS

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Objective
Divers breathe higher partial pressures of oxygen at depth than at the surface. The literature and diving community are divided on whether or not oxygen is narcotic. Conversely, hyperbaric oxygen may nduce dose-dependent cerebral hyperexcitability. This study evaluated whether hyperbaric oxygen causes similar narcotic effects to nitrogen, and investigated oxygen's hyperexcitability effect.

Methods
Twelve human participants breathed 'normobaric' air and 100% oxygen, and 'hyperbaric' 100% oxygen at 142 and 284 kPa, while psychometric performance, electroencephalography (EEG) and task load perception were measured. EEG was analyzed with functional connectivity and temporal complexity algorithms. The spatial functional connectivity, estimated using mutual information, was summarized with the global efficiency network measure. Temporal complexity was calculated with a 'default-mode-network (DMN) complexity' algorithm.

Results
Hyperbaric oxygen breathing caused no change in EEG global efficiency or in the psychometric test. However, oxygen caused a significant reduction of DMN complexity and a reduction in task load perception.

Conclusion
Hyperbaric oxygen did not cause the same changes in EEG global efficiency seen with hyperbaric air, which likely related to a narcotic effect of nitrogen. Hyperbaric oxygen seemed to disturb the time evolution of EEG patterns that could be taken as evidence of early oxygen-induced cortical hyperexcitability. These findings suggest that hyperbaric oxygen is not narcotic and will help inform divers' decisions on suitable gas mixtures.

O-4

SIXTY YEARS OF DIVING MEDICINE IN CRIS-UTH. A REVIEW OF 1000 DYSBARIC DIVING INJURIES

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Background
CRIS-UTH has a large experience in the treatment of Dysbaric Diving Injuries (DDI). Since 1959, a monoplace recompression chamber was used; in 1967 a four seats Multiplace Hyperbaric Chamber (MHC) was installed in the Red-Cross Hospital of Barcelona, and since 2010 a large walk-in 18 seats MHC in the Moisès Broggi Hospital of Sant Joan Despí, Barcelona.

Methods
Descriptive analysis of the most relevant data focussed on the kind of divers and dives, location, chronology, onset, latency, symptoms, complementary therapy, Hyperbaric Oxygen Therapy (HBO), and outcome.

Results
Up to 31st December 2021, 1044 injured divers have received medical attention in CRIS-UTH.
Mean age was 35.1 ± 9.823 (10-72). Males 90.96% and Females 9.04%. Decompression sickness (DCS) 66.38%, Intrathoracic Hyperpressure Syndrome (IHS) 17.72%, Sequels of DDI incurred in foreign country 4.98%, Omitted Decompression 4.21%, other DDI 6.70%. Recreational diving 67.9%, Professional 15.56%, Scientific, Rescue, or Military (15.45%). Mean diving depth 34.3 ± 13.932 (3-112) msw; Duration 37.6 ± 35.139 (2 480) min. Latency was 52.9 ± 251.707 (1-3000) min. Neurologic signs/symptoms 287 (32.7%) [Spinal cord 23.5%, Encephalic 20.6%, Peripheral 4.2%]; Inner Ear 136 (15.5%); muscular pain (bends) 169 (19.2%); systemic non-neurologic involvement 142 (16.2%).
Recompression delay from the symptoms onset 19.7 ± 53.674 (1-750) hours. Air-Tables applied in 48 patients (4.93%) until 1984; oxygen tables, from then up to 926 cases (95.07%). Extremely serious 42 cases (4.31%) combining DCS+IHS+Drowning received critical care inside the chamber with mechanical ventilation.
Outcome in the short term of symptomatic cases completely favourable in 39.38%, improved significantly 54.11%, no change in 5.38%, and 4 died during their stay the in the hospital, the last one in 1984.

Discussion
The incidence of DDI has diminished during the last 30 years. Safety procedures and more conservative profiles are the main explanations. On-site sudden-death in divers more than 55 y.o. has dramatically increased. No statistically significant relation between the recompression delay and the outcome. Age is the most significant factor. A combined preliminary therapy in the emergency unit with HBO produced excellent results, even in those extremely critical. Quality of the hospital based Hyperbaric Medical Centre is more important than urgency in the nearest but non-experienced hyperbaric units without medical assistance.

O-5

PULMONARY BAROTRAUMA DURING A WRECK RECOVERY HAPPENED IN 1654.

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Background
Underwater activities have been described since 313 BC from Aristotle reporting a Bell Dive with Alexander the Great. This practice was common after that, and it seems obvious to imagine that a large number of accidents should happen, although very few, or null reliable reports exist.

Method
Analysis of the description of hundreds of Bell Dives performed in March 1654, in the Creus Cape, the most eastern point of the Iberian Peninsula, in a currently very frequented SCUBA diving site in Catalonia, Spain.

Results
This expedition was very well documented, because of some historical and international political events undergone during these recovering operations. Experienced divers, high-level military, and politicians were commanded from the King of the country. Some diving injuries are clearly described in a chapter of the more than 200 hundred pages reporting book. Several divers were drowned, some ones were poisoned by retained carbon dioxide, and two divers suffered a serious pulmonary barotrauma when trying to escape from the contaminated bell with result of immediate death.

Discussion
These reports were not medically oriented, so clinical details are not explicit. However, the descriptions of the accidents, summarized to be used in a trial, included rudimentary but clear descriptions of an episode of explosive pulmonary barotrauma during a free ascent.

Conclusions
To our knowledge, this is the world's oldest description of a dysbaric accident happened during a Bell diving activity.

O-6 KEYNOTE LECTURE

THE EFFECTIVENESS AND SAFETY OF HYPERBARIC OXYGEN THERAPY FOR CHRONIC DIABETIC FOOT ULCERS: AN OVERVIEW OF SYSTEMATIC REVIEWS WITH DE NOVO META-ANALYSIS OF RANDOMIZED CONTROLLED TRIALS

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Background
Chronic non-healing diabetic foot ulcers (DFU) are often associated with hypoxia, insufficient perfusion, and low oxygen consumption. Hyperbaric oxygen therapy (HBOT) has been shown to increase tissue oxygen supply, vasculogenic stem cell levels and proliferation, and accelerate wound healing. The aim was to assess the effectiveness and safety of adjunctive systemic HBOT for chronic DFU compared to the best standard care using an overview of systematic reviews methodology.

Methods
Following an a priori published protocol, we included all types of systematic reviews (SRs) of randomized controlled trials (RCTs) identified in Epistemonikos on 4th January 2022 with no limits. We depicted the results of screening and reasons for exclusion in a PRISMA flowchart. From the identified reviews we extracted the characteristics, critical appraisal, and outcome data for complete ulcer healing, ulcer size reduction, TcPO2, amputation rate, adverse events, mortality, costs, and quality of life for the eligible RCTs. We followed the JBI methodology for umbrella reviews but addressed overlap by performing de novo meta-analyses, with sensitivity and subgroup analyses for risk of bias, number of HBOT sessions, peripheral arterial disease patients, and Wagner grade. We carried out a GRADE assessment of certainty of evidence and presented the results in a Summary of Findings table.

Results
We found 25 eligible systematic reviews and extracted data from 18 RCTs with 1222 patients (630 in HBOT and 592 in control groups). The results from 16 trials with 1100 participants indicate that HBOT likely increases the number of patients with completely healed ulcers at the end of the treatment with odds ratio (OR) 2.40 (95% CI 1.64 to 3.51; I2 33%, moderate certainty of evidence). The results of nine trials with 507 patients indicate that HBOT may decrease the number of any (major and minor combined) amputation (OR 0.46, 95% CI 0.15 to 1.37; I2 78%, low certainty of evidence), and major amputation (OR 0.50, 95% CI 0.23 to 1.10, I2 43%, low certainty of evidence from 6 trials and 447 participants). The evidence from three trials with 184 participants is very uncertain that mean foot TcPO2 at the end of treatment is improved with HBOT (mean difference 14.56 mmHg, 95% CI 1.81 to 27.31, I2 90%, very low certainty of evidence). Evidence is very uncertain that HBOT improves ulcer area reduction (mean difference 10.25%, 95% CI -8.15 to 28.65, I2 91%, very low certainty of evidence). There were no deaths in three of the four trials reporting mortality rates, and the fourth had fewer deaths in the HBOT group.

Conclusions
HBOT likely on the low certainty of evidence increases healing rates, may decrease the number of amputations, and is not associated with severe adverse events or increased mortality in chronic diabetic foot ulcers. More high quality RCTs need to assess ischemic parameters, ulcer area reduction, time to healing, and other outcomes, before conclusions can be drawn.

O-7

HYPERBARIC OXYGEN THERAPY FOR DIABETIC FOOT ULCERS WITH LEG ISCHEMIA (DIONYSIUS TRIAL)

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Background
A common complication of diabetes is the diabetic foot ulcer (DFU),which affects up to 25% of diabetic patients and can make lower extremity amputation necessary. In recent years research has been conducted to determine the effect of hyperbaric oxygen therapy (HBOT) in the treatment of DFUs. Two systematic reviews suggested that HBOT can reduce major amputations by 15% in patients with leg ischemia.

Objective
To provide a definitive answer on the effectiveness of HBOT in patients with DFU and leg ischemia.

Methods
A multinational, multi-arm multi-stage RCT (the DIONYSIUS trial) has been initiated, coordinated from the Netherlands in which 544 patients will be included. Inclusion criteria are: adults with type I or II diabetes, Wagner grade 3 or 4 leg/foot ulcer (existing >4 weeks) and leg ischemia, classified as: ankle pressure <70 mmHg or toe pressure <50 mmHg or TcpO2 <40 mmHg (forefoot). All patients should have had complete vascular assessment and have been discussed in a multidisciplinary team. After inclusion patients will be randomized to one of four trial arms: control group, 20 sessions, 30 sessions or 40 sessions of HBOT. Primary outcome is major amputation rate at 12 months and secondary outcomes are amputation-free survival, minor amputation rate, ulcer healing, mortality, pain scores, quality of life, cost effectiveness and side effects of HBOT. An interim analysis will be performed when 272 patients have reached 3 months of follow-up. Depending on the interim analysis the remaining patients can be randomized to the most favourable intervention group(s), thereby improving the efficiency of the study.

Future prospects
By doing a large scale trial HBOT effectiveness can be determined, which can lead to best evidence ever regarding HBOT treatment for DFU in patients with leg ischemia.

O-8

WHAT IS THE PERSPECTIVE OF WHO PAYS FOR THE HBOT FOR WOUND CARE?

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Background
Evidence-based Medicine refers to clinical trials where, after 4 weeks, the goal is to half the average wound area. In the Real Dataset, instead, the mean healing time is 15 weeks (ranging from 1 week to 5 years). The average cost of Venous Leg Ulcers (VLUs) amounts to $4,000 per month per patient. Diabetic Foot Ulcers (DFUs) ranged from $10,000 to $19,000 per month. The cost of care increases as treatment duration lengthens. The average cost of 2-year or more in treatment is $18,000.
By improving the healing trajectory, HBOT allows an average cost saving of €3,000 per each DFU and of €10,000 for each refractory vasculitis. HBOT reduces the major amputation in DFUs. The Number Needed to Treat (DFUs to be treated to prevent one additional major amputation) ranges from 5 to 7.
The Incremental Cost-effectiveness Ratio (ICER) determines if a new therapy, at the price proposed, provides better value relative to the standard of care (SoC). According to Health Quality Ontario (HQO), the ICER of the HBOT dominates in the SoC.

Methods
To evaluate how many HBOT sessions are required to get the benefit, we propose a formula for calculating the HBOT value that considers the degree of clinical evidence, the Contribution Margin Ratio (CMR), and the number of HBOT sessions. HBOT has a favorable cost value for 12 sessions in Europe and 18 sessions in the US. This contrasts with the observation that at least 30 HBOT sessions are required to significantly improve limb salvage (Abidia, 2003; DAMO2CLES RCT, 2018). Applying the NNT of 7 and considering, as standard, the weighted average cost at 1 year after an amputation proposed by the NICE (the UK, 2012), the Value for Money of HBOT in DFUs appears negative for some countries (the US, France, the UK, the Netherlands), but favorable in most of the other analyzed countries.
Efficiency is useless without effectiveness (Sir Archibald Cochrane). In cost-utility analysis, the ICER is synonymous with the cost per Quality-Adjusted Life Year (QALY) gained. A year in perfect health is considered equal to 1.0 QALY. According to Health Quality Ontario (HQO), HBOT cost is well below the commonly used threshold of $50,000 per Quality-adjusted Life Year (QALY). In the UK, NICE has established a value between £20,000 to £30,000 per QALY.

Discussion
In order to publish a review of the economic studies on HBOT in wound care, EUBS members will be invited to send us information on the economic aspects of wound care therapy in their country.

O-9

COST EFFECTIVENESS OF HYPERBARIC OXYGEN THERAPY FOR THE TREATMENT OF ISCHAEMIC DIABETIC FOOT ULCERS

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Background
Evidence concerning the costs and effectiveness for hyperbaric oxygen therapy (HBOT) as an adjunct in the treatment of ischaemic diabetic foot ulcers (DFUs) is scarce and often also includes patients with non-ischaemic DFUs. The objective of this study is to determine the costs and effectiveness of additional HBOT compared to standard wound care for ischaemic DFUs with regard to limb salvage and health status.

Methods
Using the results from the DAMO2CLES multicentre randomized clinical trial, an economic analysis was conducted from a societal perspective, compromising cost-effectiveness and cost-utility analyses, with a time horizon at 12 months, comparing standard care (SC) with or without HBOT. EQ-5D-3L questionnaires were used to measure health status. Costs were determined per allocated treatment and during follow-up. Cost-effectiveness was defined as cost per limb saved and cost utility as cost per Quality-Adjusted Life Years (QALYs). The difference between treatment groups was determined via an incremental cost-utility ratio (ICER). Sub-analyses were performed based on the Wagner classification.

Results
A total of 120 patients were included, with 60 allocated to HBOT + SC and 60 to SC. Amputation rate was lower in the HBOT+SC group (12%) than in the standard care group (22%). No significant difference in mean costs between treatment groups was found: €3,971 (95%CI -11,138 to 3,556). Also, there was no significant difference in mean QALYs between treatment groups: 0.54 for HBOT+SC vs. 0.56 for SC. This resulted in an ICER of €227,035 per QALY. Cost per limb saved showed an ICER of €37,912 for the HBOT + SC group compared to the SC group. Subgroup analysis for Wagner stages 3&4 patients showed an ICER of €19,005, while HBOT did not show any benefit for those in Wagner stage 2.

Conclusion
Additional treatment with HBOT for patients with ischaemic DFUs does not lead to an increase in costs or patients' health status. Patients with ischaemic DFUs in Wagner stage 3 or 4 might benefit from adjunctive HBOT in terms of limb salvage, at the cost of approximately €19,000 per limb saved.
More evidence is needed regarding Wagner stage 3&4 ischaemic DFUs to assess both effectiveness and cost-effectiveness of HBOT in these patients.

O-10

TWENTY-ONE YEAR OVERVIEW OF HBO TREATMENT OF CARBON MONOXIDE POISONING : REFINING THE INDICATION USING A DIAGNOSIS AND MANAGEMENT ALGORITHM

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Introduction
Carbon Monoxide (CO) intoxication is, in Belgium, still a frequent diagnosis. The precise indication for hyperbaric oxygen treatment (HBOT) is still a matter of debate. Criteria for HBOT, as defined by the ECHM/UHMS guidelines, remain too imprecise for proper patient selection. This results in many patients being treated with HBOT despite only minor intoxication, and other patients not referred even if retrospectively, they had a strong indication for HBOT.
In 2007, the Belgian Advisory Committee for Hyperbaric Oxygen (ACHOBEL) created a management flowchart for CO intoxication, that was distributed to all Belgian hospitals' emergency departments. The Military Hospital Brussels is a referral hospital for HBOT only and does not offer management for non-HBOT CO patients. Therefore, the flowchart's criteria were strictly followed by the physician on call, to select only those patients with a true indication for HBOT. This has resulted in a change in CO patient population referred and treated with HBOT.

Methods
Exposure, symptoms and treatment characteristics of all CO intoxicated patients were prospectively collected over a period of 30 years. Data from the last 21 years (since using a new, large multiplace hyperbaric chamber) were analyzed.

Results
From 2001 to 2021, a total of 2166 CO intoxicated patients were treated at our HBOT center, of which 1917 (87.2%) received HBO. After introduction of the ACHOBEL algorithm, the proportion of patients treated with HBOT rose from 86.8% to 90.2%, while the proportion of patients referred to our hospital for HBOT who were treated with normobaric oxygen decreased from 13.2% to 9.8%. The average number of patients accepted to our hospital for CO intoxication per year decreased from 153.6 in the period 2001-2007 to 77.9 in the period 2008-2021; a much larger decrease than expected based on global epidemiological data in Belgium.
Analysis of validity of referral criteria indicated that after 2007, a lower proportion (6.3% vs 12.4%) was treated with HBOT despite not having a proper indication for HBOT, indicating a more accurate treatment regimen.

Discussion and conclusions
The introduction of a more detailed algorithm for CO intoxication has resulted in a reduction of patient referral as well as a better patient selection, optimizing HBOT treatment indication. We suggest future studies comparing HBOT vs normobaric oxygen should use a patient selection algorithm like the one presented here.

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O-11

FORTY YEARS OF HYPERBARIC MEDICINE IN CRIS-UTH. A REVIEW OF 4500 CASES OF CARBON MONOXIDE POISONING

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Background
CRIS-UTH has a large experience in the treatment of Carbon Monoxide Poisoning (CMP). A prospective protocol was established in 1984 that permits to obtain significant conclusions.

Method
Descriptive analysis of the toxicological, clinical, and therapeutical data of patients poisoned by Carbon Monoxide (CO) in the period 1981-2021.

Results
Up to 31st December 2021, 4530 patients poisoned by CO have been studied. Males were 2186 (48.29%) and females 2341 (51.71%). Mean age: 33.7 ± 18.835 (1-89) n=4497. Origen of CO was domestic devices in 2578 cases (70.4%), exhaust gases from explosion engines in 197 cases (5.4%), smoke inhalation from fire in 300 cases (8.2%), and other sources in 565 cases (15.4%). The clinical status of the patients on arrival to the hospital was Serious or Very serious in 467 cases (13.5%), Moderate in 483 (13.9%), Mild in 545 (15.7%), and Asymptomatic with previous disorders in 1968 cases (56.8%). Most frequent symptoms were Headache (52.1%), Nausea/vomiting (32.9%), Vertigo (7.0%), and Sherry skin rush (5.8%).
74 patients (1.6%) have EKG disorders; 14 cases had a typical EKG of Myocardial infarction with clear enzymatic curves without chest pain; Carboxihaemoglobin (HbCO) could be determined in 2537 cases (56.04%). Values over 10% were detected in 2143 cases (84.47%) with a mean of 23.83 ± 9.363 (10 75). A combined intoxication by CNH due to Smoke inhalation was diagnosed in 64 cases (1.41%).
Hyperbaric Oxygenation (HBO) during 72 minutes at 2.5-3 ATA was applied at 4294 patients (94.85%); 82 of them (2.59%) received critical care assistance inside the chamber with mechanical ventilation; 233 (7.35%) refused the HBO or had side effects. The mean number of HBO sessions was 1.44 ± 1.255 (1-42). HbCO levels on arrival to the Hospital were 23.8 ± 10.407 (0.6-68.0). After HBO the mean was 1.8 ± 1.766 (0.1-6.2) in a matched Student-Test ($p<0.0005$).
Based on clinical recovery and/or diminishing of HbCO, outcome of the symptomatic patients was favourable in the 85.6%, mild sequelae remained in 9.7%, no change in 0.4%, none of the survivors got worse, and 4 patients (0.2%) died. No case of Delayed Neurological Syndrome was reported in the short, medium, or long term follow-up.

Discussion
There was no significant correlation between the levels of HbCO and the clinical status of the patients. The majority of patients significantly improved. Compared to results obtained in other long series, HBO appears to be the best treatment modality for CMP.

O-12

INFLUENCE OF PREHOSPITAL MANAGEMENT ON THE OUTCOME OF SPINAL CORD DECOMPRESSION SICKNESS IN SCUBA DIVERS

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Background
Spinal cord is a target tissue in decompression sickness with unfortunately a high rate of long-term sequelae. The objective was to determine the association of prehospital management on the outcome of spinal cord DCS, especially the influence of the initial clinical presentation and the time to recompression.

Methods
This was a retrospective study using prospectively collected data including divers with spinal cord DCS seen at a single hyperbaric centre study from 2010 to 2018. Information regarding diving, latency of onset of symptoms, time to recompression and pre-hospital management i.e., use of oxygen, treatment and means of evacuation, was analyzed as predictor variable. The initial clinical severity was estimated by the score of the French society of diving and hyperbaric medicine (MEDSUBHYP). The primary endpoint was the presence or absence of sequelae at discharge assessed by the modified score of the Japanese Orthopedic Association.

Results
195 divers (48 ± 12 y, 42 women) were included. 34% had neurological sequelae at discharge. After multivariate analysis, only a MEDSUBHYP score >= 6 and a time to recompression > 194 minutes were significantly associated with incomplete neurological recovery [OR 9.5 (4.6-19.8), p<0.0001 and OR 2.1 (1.03-4.5), p = 0.04, respectively]. Time to recompression only appeared to be significant for patients with high initial clinical severity. As time to recompression increased, the level of sequelae also increased (p=0.014).

Conclusion
Determining the initial clinical severity is critical in identifying patients who need to be evacuated for recompression as quickly as possible.

O-13

ANOTHER PRECONDITIONING BEFORE DIVING: MINITRAMPOLINE

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Background
Despite evolution in decompression algorithms, decompression illness is still an issue nowadays. Reducing vascular gas emboli (VGE) production or preserving endothe-lial function by other means such as diving preconditioning is of great interest. Several methods have been tried, either mechanical, cardiovascular, desaturation aimed or biochemical, with en-couraging results. In this study, we tested mini trampoline (MT) as a preconditioning strategy.

Methods
In total, eight (five females, three males; mean age 36 ± 16 years; body mass index 27.5 ± 7.1 kg/m2) healthy, non-smoking, divers participated. Each diver performed two standardized air dives 1 week apart with and without preconditioning, which consisted of ±2 min of MT jumping. All dives were carried out in a pool (NEMO 33, Brussels, Belgium) at a depth of 25 m for 25 min. VGE counting 30 and 60 min post-dive was recorded by echocardiography together with an assessment of endothelial function by flow-mediated dilation (FMD).

Results
VGE were significantly reduced after MT (control: 3.1 ± 4.9 VGE per heartbeat vs. MT: 0.6 ± 1.1 VGE per heartbeat, p = 0.031). Post-dive FMD exhibited a significant decrease in the absence of precondi-tioning (92.9% ± 7.4 of pre-dive values, p = 0.03), as already described. MT preconditioning pre-vented this FMD decrease (103.3% ± 7.1 of pre-dive values, p = 0.30). FMD difference is significant (p = 0.03).

Conclusions
In our experience, MT seems to be a very good preconditioning method to reduce VGE and endothelial changes. It may become the easiest, cheapest and more efficient pre-conditioning for SCUBA diving.

O-14

ECCENTRIC ARM WORK 24 HOURS PRIOR TO HYPOBARIC EXPOSURE INCREASES PRESENCE OF CIRCULATING BUBBLES

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Background
A rapid reduction in ambient pressure can lead to decompression sickness (DCS). Animal studies have shown that recent musculoskeletal injuries increase the risk of DCS but to date no similar study has been performed in humans. Accordingly, our aim was to investigate if minor (microscopic) muscle injury - as induced by eccentric work and characterized by reduced strength and delayed onset muscle soreness (DOMS) - leads to increased formation of venous gas emboli (VGE) during hypobaric exposure.

Methods
Ten healthy subjects were on two occasions exposed to a simulated altitude of 24000 ft for 90 min, whilst breathing oxygen. Twenty-four hrs prior to one of the altitude exposures, each subject performed 15 min of eccentric arm-crank exercise. The presence of VGE was measured in the right cardiac ventricle using ultrasound, with measurements performed every 5 min at rest and every 15 min after three deep knee bends and three arm flexions. The degree of VGE was evaluated using the 6-graded Eftedal Brubakk scale and the Kissman integrated severity score.

Results
Eccentric exercise induced DOMS (3-9 on a 10-graded scale), reduced isometric m. biceps brachii strength (-25.2 ± 22.7%, p=0.03) and increased the KISS score at 24000 ft, both at rest (from 0.07 to 4.47; p=0.01) and after arm flexions (from 1.12 to 18.62; p=0.03), but not after knee bends (p=0.08).

Conclusions
Delayed onset muscle soreness caused by eccentric work provokes the release of VGE in response to acute decompression.

O-15

DIVING INTO DECOMPRESSION SICKNESS RESISTANT RATS GENE EXPRESSION THROUGH A miRnome / TRANSCRIPTOME CROSSED APPROACH

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Introduction / Background
Susceptibility to decompression sickness (DCS) is characterized by a wide interindividual variability which origin is still poorly understood. This hampers reliable prediction of DCS by decompression algorithms. We previously selectively bred rats with at least a 3-fold greater resistance to DCS than standard ones. In order to better understand DCS mechanisms, we sought study the expression of the genes of these resistant rats.

Materials and ethods
We used a transcriptomic approach coupled and crossed with a miRnome study and a Bioinformatic approach. Transcriptomic : liver samples from Wistar (4 males, 4 females) and DCS-resistant rats (4 males, 4 females) on Agilent Sureprint rat G3 GE 8 x 60 k microarrays followed by a PCR validation. We used same the animals as for the transcriptomic approach, to study circulating miRnome with Qiagen miRNeasy serum and plasma kit. Bioinformatic tools: we used ToppGene for the Gene Ontology and STRING v11.5 for the functional protein association networks.

Results
We have identified 14 genes whose expression is modified between females of the Wistar strain and females of the 10th generation (G10) of our selected strain, as well as 13 genes in males. We then crossed these transcripts with the respective targets of the 44 microRNAs (miRs) whose expression is modified in the G10 females and the 47 miRs whose expression is modified in the G10 males and we obtained 14 results.

Discussion / Conclusion:
These results highlight pathways involved in inflammatory responses, cell signaling and motricity, phagocytosis or apoptosis, confirming the paramount importance of inflammation in DCS physiopathology.

O-16

TRANSTHYRETINE GENE EXPRESSION AND DECOMPRESSION SICKNESS

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Introduction / Background
We previously found that the tetrameric form of the transthyretin (TTR) almost disappeared in rats suffering decompression sickness but not in asymptomatic ones. Loss of stability of the TTR protein due to mutations has been pointed in some pathologies. We therefore sought for differences in the gene expression possibly linked to DCS occurrence in rats.

Materials and Methods
We used RT-qPCR to compare the basal levels of mRNA coding for the TTR in liver and lung samples harvested in 12 standard Wistar rats (6 males and 6 females) and 12 (6 males, 6 females) Wistar rat previously selected fort their resistance to DCS. We also looked for differences in the coding sequence of the TTR gene by using a Sanger sequencing of the mRNA.

Results
We found a higher level of mRNA in lungs from DCS resistant rats (Kruskal-Wallis, $p = 0,004$) but no effect of sex ($p = 0,488$). In the liver, both DCS resistance and female sex are associated with lower mRNA levels (ANOVA, $p = 0,043$ and $p = 0,047$, respectively, for DCS-resistance and sex) but no interaction resistance*sex ($p = 0.259$). Sanger sequencing showed that a thymine has been substituted by cytosine on the third base of codon 46 of DCS resistance rats. However, this variant doesn't change the amino acid in the protein that stays valine. In our DCS resistant strain, Cytosine variant appeared in 3 out of 5 males (60%) and 2 out of 3 females (66%) whereas, in Wistar rats, this variant is absent in 100 % of males (n=5) and females (n=5). The distribution of this mutation occurrence significantly differs ($p= 0,045$, Fisher's exact test).

Discussion / Conclusions
We found differences in the expression and the sequence of the gene coding for the TTR between individuals with different resistance to DCS. Whether they participate to the susceptibility to DCS remains to be confirmed.

O-17

IS ACUTE BONE NECROSIS (ABN) OBSERVED ON PATIENTS WITH OSTEOACTICULAR DECOMPRESSION SICKNESS (OADS) A NEW ENTITY?

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Introduction
OADS is one of the most frequent types of Decompression Sickness (DS), classified by Golding FC as Type 1. It is usually considered a mild decompression illness, with pain relief as therapeutic goal, and does not usually result in damage or sequelae. However, a fraction of OADS patients have osteoarticular "paradoxal" pain (increases with compression) of extremities or have remaining pain after hyperbaric treatment. Dysbaric osteonecrosis (DON) is an avascular necrosis of epiphysis of bones and OADS history is among the risk factors.
We proposed initially that ABN was the linking element between OADS and DON.

Objective
To evaluate by imaging tests, OADS patients with osteoarticular pain refractory to hyperbaric treatment.

Methods
We performed a retrospective study of six divers with OADS diagnosis and poor resolving of the osteoarticular pain, despite the hyperbaric treatment, during 2017-2019, who were studied with computerized tomography (CT) and magnetic resonance imaging (MRI).

Results
In the observed period, we found six cases that met the criteria of the study, finding in all the cases bone lesions, all of them located at the diaphysis of the humerus and compatible with ABN. The results of the study were already presented at the 2019 meeting of Underwater and Hyperbaric Medical Society in Puerto Rico.
We couldn't identify literature supporting the entity of ABN. By the time of evolution and the location of the lesion, cases of traditional DON were excluded, and the possibility of a new entity denominated ABN arose. For that entity, there is no consensus of any treatment protocol or evolution studies. Our hypothesis is that the bone necrosis is related to a compartmental syndrome of the bone and acute ischaemia, initially produced by intra medullary bone bubbles.

Conclusions
We propose a new entity of ABN based on our imaging findings of the divers with OADS and poor healing refractory to hyperbaric treatment. New studies are required for the precise characterization of this new entity, including the proposal of appropriate treatments.

O-18 KEYNOTE LECTURE

"FROM AN IDEA UP TO AN EXPERIMENT WELL DONE"

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O-19

HYPERBARIC OXYGENATION REDUCES DEATH OF IMMATURE NEURONS IN THE ADULT HIPPOCAMPAL DENTATE GYRUS FOLLOWING BRAIN INJURY

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Introduction
Traumatic brain injury (TBI) is a complex injury with a broad spectrum of symptoms and disabilities. Cognitive deficits, particularly of memory, information-processing speed and problems in learning are frequent hallmarks of neuronal damage or neuronal death in the hippocampus (Hippo), a region critical for cognitive function. Growing number of data suggests that hyperbaric oxygenation (HBO) can influence the activity of adult neural stem cells (NSCs). Since the role of NSCs during the recovery after brain injury is still unclear, the aim of this study was to investigate the effects of sensorimotor cortex ablation (SCA) and hyperbaric oxygenation (HBO) upon processes of neurogenesis in the adult Dentate gyrus (DG), a region of hippocampus (Hippo) with a significant role in the process of adult neurogenesis.

Methods
The experiments were conducted on 10 weeks old male Wister rats. Animals were organized into following groups (n = 10 per group): Control (C) intact animals, Control + HBO (CHBO) intact animals subjected to HBO treatment, Sham control (S) animals that underwent surgical procedure without damaging the brain tissue, Sham control + HBO (SHBO), Lesion group (L) – the right sensorimotor cortex was removed by suction ablation and Lesion + HBO (LHBO). HBO protocol: pressure applied 2.5 absolute atmospheres (ATA), for 60 minutes, once daily for 10 consecutive days. Effects of HBO treatment were monitored using immunohistochemistry, double immunofluorescence and were verified with Western blot analysis.

Results
SCA caused a significant loss of neurons in DG compared to the control. Newborn neurons from subgranular zone (SGZ), inner, and partially middle granular cell layer were predominantly affected by SCA. HBO treatment reduces the number of immature neurons undergoing degeneration.

Conclusions
Altogether, the results from L group are confirming the selective vulnerability of immature neurons in the adult DG to SCA injury. More importantly, the results from LHBO group are point to protective effect of HBO in decreasing vulnerability of immature neurons in the adult DG to SCA injury.

Keywords
brain injury, neuroprotection, hippocampus, neurogenesis

O-20

EFFECTS OF HYPERBARIC OXYGEN THERAPY ON MITOCHONDRIAL RESPIRATION AND PHYSICAL PERFORMANCE IN MIDDLE-AGED ATHLETES: A BLINDED, RANDOMIZED CONTROLLED TRIAL

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Introduction
Hyperbaric oxygen therapy (HBOT) has been used to increase endurance performance but has yet to be evaluated in placebo-controlled clinical trials. The current study aimed to evaluate the effect of an intermittent HBOT protocol on maximal physical performance and mitochondrial function in middle-aged master athletes.

Methods
A double-blind, randomized, placebo-controlled study on 37 healthy middle-aged (40–50) master athletes was performed between 2018 and 2020. The subjects were exposed to 40 repeated sessions of either HBOT [two absolute atmospheres (ATA), breathing 100% oxygen for 1 h] or SHAM (1.02ATA, breathing air for 1 h).

Results
Out of 37 athletes, 16 HBOT and 15 SHAM allocated athletes were included in the final analysis. Following HBOT, there was a significant increase in the maximal oxygen consumption (VO2Max) ($p = 0.010$, effect size(es) = 0.989) and in the oxygen consumption measured at the anaerobic threshold (VO2AT) (es = 0.837) compared to the SHAM group. Following HBOT, there were significant increases in both maximal oxygen phosphorylation capacity (es = 1.085, $p = 0.04$), maximal uncoupled capacity (es = 0.956, $p = 0.02$) and mitochondrial mass marker MTG ($p = 0.0002$) compared to the SHAM sessions.

Conclusion
HBOT enhances physical performance in healthy middle-age master athletes, including VO2max, power and VO2AT. The mechanisms may be related to significant improvements in mitochondrial respiration and increased mitochondrial mass.

O-21

THE EFFECT OF HYPERBARIC OXYGEN THERAPY (HBOT) ON SPORTS PERFORMANCE AND RECOVERY. A SYSTEMATIC REVIEW

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Background
Beyond the HBOT indications already recognized by the Undersea and Hyperbaric Medical Society (UHMS) and European Committee for Hyperbaric Medicine (ECHM), new applications have recently been proposed. In the field of sports medicine, HBOT has been used to treat musculoskeletal injuries and intermittent post-concussions or to enhance athlete's performance and accelerate their recovery. The enhancement of the physical performance is thought to be achieved by correcting tissue hypoxia associated with the induction of mitochondrial adaptations. The recovery effect is thought to be due to reducing oxidative stress and inducing stem cell mobilization.

Objective
To evaluate whether Hyperbaric Oxygen improves athletes' sports performance and ameliorates the recovery process.

Methods
A systematic literature review of clinical trials was conducted through May 2022, using standard repositories, such as PubMed, PubMed Central, EMBASE, and ClinicalTrials.gov. The criteria selected were as follows: 1) the study population had to be physically active individuals with regular physical activity, 2) a well-defined HBOT protocol was applied, 3) a control group using only normobaric oxygen was considered, and 4) the study outcomes were evaluated by objective physical or laboratory tests.

Results
A total amount of 18 studies with 284 patients were identified. A substantial heterogeneity was noted between studies in relation to the participants' demographics, the HBOT protocol (pressure and duration of the treatment) applied, and the laboratory equipment used to evaluate the outcome of the HBOT treatment. A single double-blind, randomized, placebo-controlled study of 37 middle-aged athletes treated by HBOT reported a significant improvement in their performance.

Conclusions
Despite the promising findings on HBOT-induced enhancement of physical performance reported by individual, small studies, the lack of consensus in the exercise protocols, the variability of oxygen dosage and HBOT protocols, and the variable selection of measures to evaluate treatments' success, present major limitations, and lead to unreliable conclusions about the role of HBOT in this setting. Therefore, standardized protocols and additional randomized clinical trials are needed to produce evidence-based conclusions about the effect of HBOT on sports performance and recovery.

O-22

HYPERBARIC OXYGEN TREATMENT IN EARLY PHASE IS EFFECTIVE AFTER MUSCLE CONTUSION INJURY BECAUSE VEGF AND bFGF INDUCTION BY NITRIC OXIDE PROMOTES ANGIOGENESIS AND MUSCLE REGENERATION

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Introduction
Vascular disruption and subsequently loss of function result from contusion injury of muscle. Promotion of angiogenesis appears to be crucial for early and complete recovery of motor function. Hyperbaric oxygen (HBO) treatment has been shown to promote early recovery from muscle injury and reactive oxygen species (ROS) upregulation, such as nitric oxide (NO), is likely a key mechanism. Nitric oxide stabilizes hypoxia-inducible factor (HIF) 1 and stimulates secretion of vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF) from endothelial cells and macrophages, leading angiogenesis. The current study investigated whether HBO promotes angiogenesis and muscle regeneration via a NO-mediated pathway.

Materials and Methods
A muscle contusion injury of the gastrocnemius muscle was performed in rats using the drop mass method. Rats were then either treated with HBO or not treated (NT) with HBO. Treatment with HBO consisted of 2.5ATA 100% oxygen for 120 minutes, once a day for 5 consecutive days. The effects inhibition of ROS and NOS (NAC) or NOS (L-NAME) on HBO-induced muscle recovery were also investigated. Three additional treatments were utilized: one immediate HBO treatment (HBO 1T Day0), one treatment one day after injury (HBO 1T Day1) and one treatment three days after injury (HBO 1T Day3) after contusion. Muscles were harvested before and 3, 6 hours, 1, 3, 5, 9 days after contusion. Tissue levels of NO3- (the final oxidized product of NO), HIF1α, VEGF, bFGF, HGF, angiopoietin2 were analyzed by ELISA. The number of proliferating endothelial cell, immature and mature blood vessels, and regenerating muscle fibers were quantified. Muscle tensile strength, twitch and tetanic force, were measured by stimulation of the tibial nerve.

Results
Immediate HBO significantly increased NO3-, VEGF, and bFGF levels and HIF1α. HBO promoted angiogenesis at 3-7 days and muscle healing at 5-7 days after contusion. Administration of either NAC or L-NAME before HBO diminished the effects on angiogenesis and muscle regeneration. The most significant muscle healing and angiogenesis were observed HBO 5T Day 0-4 and HBO 1T Day0.

Discussion / Conclusion
HBO treatment early after muscle contusion promoted angiogenesis and muscle regeneration through a NO-mediated mechanism.

O-23

DNA DAMAGE, APOPTOSIS AND REPAIR IN PRIMARY AND MALIGNANT OSTEOBLASTIC CELLS AFTER HYPERBARIC HYPEROXIA

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Introduction
An exposure to hyperbaric hyperoxia poses a possible threat towards cells and tissues by causing DNA damage through oxidative stress. Most of the studies regarding DNA damage after hyperbaric hyperoxia conducted to date examine either non-human cells or peripheral human lymphocytes. To evaluate whether these findings can be applied to other cell systems, this study investigated the impact of hyperbaric conditions on two human osteoblastic cell lines, the primary 'Human Osteoblasts' HOB and the malignant cell line, 'Sarcoma osteogenic' SAOS-2.

Methods
HOB and SAOS-2 cells were incubated in an experimental hyberbaric chamber (4 ATA, 100% oxygen, 37°C, 4 hours) or as control in a sham chamber (1 ATA, ambient air, 37°C, 4 hours). For analysis, cells were harvested immediately before, directly after and 24 hours after exposure. DNA damage was examined with alkaline comet assay and detection of H2AX+53BP1 colocalizing double strand break foci and apoptosis. The expression of TGFß-1, HO-1 and NQO1 was measured with qRT-PCR.

Results
The alkaline comet assay showed significantly elevated level of nuclei with DNA damage in both cell lines after 4 hours of exposure to hyperbaric hyperoxia. The gammaH2AX analysis showed only a tendency toward an increase in apoptosis in both cell lines, while the DSB focus frequency was similar over time and treatment. Expression of HO-1 increased in HOB and SAOS-2 cells directly after exposure, suggesting the induction of an antioxidative response in these cells. While expression of NQO1 in SAOS-2 cells was not affected, in HOB cells merely a tendency of higher expression was seen after exposure. Expression of TGF-ß1 was negatively affected in the HOB cells 4 hours after exposure.

Conclusion
In summary, this study indicates that DNA-damaging effects caused by hyperbaric hyperoxia occur not only in peripheral lymphocytes but also in osteoblastic cells. Data of damages visualized in Comet Assay and H2AX+53BP1 point towards single rather than double strand breaks after hyperoxic stress. In addition, the effects seem to be only transient and the cells capable of fast repair of the damage.

O-24

HYPERBARIC OXYGEN THERAPY COMPARED TO PHARMACEUTICAL INTERVENTION IN FIBROMYALGIA PATIENTS FOLLOWING TRAUMATIC BRAIN INJURY: A PROSPECTIVE, RANDOMIZED TWO ACTIVE ARMS TRIAL

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Introduction
Fibromyalgia Syndrome (FMS) is a common, chronic condition characterized by widespread pain and associated symptoms. FMS is currently considered to be a prototype of nociplastic pain–conditions, in which pain is attributed to aberrant processing within the brain. Among the potential triggers for FMS, traumatic brain injury (TBI) has been frequently described.
The aim of this study was to compare the effect of HBOT to the current standard pharmacological treatment on FMS patients with a history of TBI.

Methods
A prospective randomized, double active arm trial, including FMS patients with clear history of TBI, aged >18 years who were not treated by either Duloxetine or Pregabalin. Patients were randomized to either HBOT or pharmacological therapy by Duloxetine or Pregabalin. The HBOT protocol included 60 daily session of 90 min of 100% oxygen at 2 ATA with air breaks every 20 min, 5 days per week. Evaluation procedure was done at baseline and 1-3 weeks after the last HBOT session or 3 months of medications protocol and included: pain intensity evaluation (VAS), Widespread pain index (WPI), Fibromyalgia symptoms severity scale (SSS), Physical Function Assessment (FIQ), Global pain scale (GPS), Quality of life questionnaire, Medical Outcome Sleep Scale (MOS) and Psychological questionnaires. Pain threshold was also evaluated in the pain lab by computerized pressure algometer (Medoc LTD, Israel). Brain metabolic activity was evaluated by SPECT.

Results
Sixty-four patients were randomized to one of the two arms. A significant improvement was demonstrated in the HBOT group as compared to the pharmaceutical group with significant group-by-time interaction in all evaluated parameters($p<0.001$) including: pain intensity evaluated using VAS score, FIQ and GPS score, Pain pressure threshold, quality of life, sleep and psychological symptoms.
In correlation with the symptoms improvement there was a significant improvement in the metabolism of the relevant brain regions as demonstrated by brain SPECT. Significant group-by-time interactions between the HBOT compared to the medication groups were demonstrated in the left frontal cortex, and in the right temporal cortex.

Conclusions
HBOT induces significant improvements in all FMS pain measures, quality of life, emotional and social function. The beneficial clinical effect was correlated with increased brain activity in frontal and parietal regions associated with executive function and emotion processing roles.

O-25

THE EFFECTS OF HYPERBARIC OXYGEN THERAPY IN CHILDREN WITH POST-CONCUSSION SYNDROME: RANDOMIZED CONTROLLED TRIAL

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Introduction
Persistent post-concussion syndrome (PPCS) is a common and significant morbidity among the pediatric population following traumatic brain injury (TBI). As the majority of the literatures focuses on acute concussion, the evidence for effective PPCS treatments remains limited. In recent years, evidence has been accumulated about the beneficial effect of hyperbaric oxygen therapy (HBOT) in PPCS adult patients.

Methods
This randomized, sham-control, double blind trial evaluated the effect of hyperbaric oxygen therapy (HBOT on children (age 8-15) suffering from PPCS from mild-moderate TBI event 6 months to 10 years prior. Twenty-five children were randomized to receive daily 60 session of HBOT (n=15) or sham (n=10). Follow-up assessments were performed at baseline and 1-3 weeks after the last HBOT/sham session.

Results
Following HBOT, there was a significant increase in cognitive function including the general cognitive score (d=0.598,, p=0.01), memory (d=0.480, p=0.02), executive function (d=0.739, p=0.003), PCS symptoms including emotional score (p=0.04, d=-0.676), behavioral symptoms including hyperactivity (d=0.244, p=0.03), global executive composite score (d=0.528, p=0.001), planning/organizing score (d=1.09, p=0.007). Clinical outcomes correlated with significant improvement in brain MRI microstructural changes in the supramarginal gyrus, insula, lingual gyrus, inferior frontal gyrus and the fusiform gyrus.

Conclusion
The study suggests HBOT may improve cognitive and behavioral function, PCS, and quality of life in pediatric PPCS patients at the chronic stage, years after injury. Additional data is needed to optimize the protocol and to characterized who are the children who can benefit the most.

O-26

COULD DELAYED HBOT BE EFFECTIVE IN SEVERE TRAUMATIC BRAIN INJURY (TBI)?

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Introduction
In the US there are 611 TBI-related hospitalizations per day. Trauma causes intracranial pressure increases and cerebral perfusion decreases. The brain goes into a metabolic crisis with neurotransmitters released chaotically. Post-concussion syndrome (PCS) and Post-traumatic stress syndrome (PTSD) cause persistent symptoms beyond 3 months after the acute injury, with an impact on daily life. In people with co-morbid conditions, the inter-relationship among TBI, PTSD, and central sensitization symptoms have a profound impact on recovery. Therapy is surgical, pharmaceutical, and rehabilitative. According to the ECHM, HBOT is recommended in acute, moderate, and severe TBI patients and in a highly selected chronic TBI patients who have evidence of metabolically dysfunctional brain regions (GRADE Type 3, Level of evidence B). The main RCTs of HBOT in TBI were analyzed by UHMS; there are important methodological limitations (bias), inconsistency of results, indirectness of evidence, and imprecision.

Case Report
In 2020, a champion who suffered a severe TBI during a handbike competition was treated with 20 HBOT sessions at 3.4 bar with heliox breathing (50% helium, 50% oxygen). The partial pressure (pp) of 1.7 bar for oxygen and helium was intended to protect the mitochondria from apoptosis. This procedure can't be advocated but it worked. The same results could be with pure oxygen at 1.7 bar. Bioregulatory Systems Medicine, a cocktail of low dose natural drugs that regulate Psycho-Neuro-Endocrine-Immunology (P.N.E.I.) networks; rehabilitation, performed in the hyperbaric chamber plus immersive virtual reality and logopedic sensorial stimulation, were associated.
After HBOT, the patient was able to maintain a sitting posture and actively collaborate for physiotherapy. MRI and PET examinations show improvement in the malacia and hydrocephalus (shunt valve is in place). There was a cognitive improvement in memory (perirhinal cortex), executive functions (inferior frontal gyrus), and attention (anterior cingulate gyrus).

Discussion
We suggest pure oxygen at 1.7 bar (or heliox 50/50 at 3.4 bar) to avoid an excess of free radicals, favors the upregulation of hypoxia-inducible factor (HIF), vascular endothelial growth factor (VEGF), indoleamine-pyrrole dioxygenase (IDO, related to the serotonin metabolism) and recruit stem cells needed for repair HBOT. Considering the cost for severe TBI management (USD 269,000-408,000) and HBOT, the value for money spent is favorable to HBOT. Robust RCTs are needed.

O-27

USE OF HYPERBARIC OXYGEN THERAPY IN INFANTS: EXPERIENCE OF TWO TERTIARY HEALTH CARE CENTERS

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Introduction
Use of Hyperbaric Oxygen Therapy (HBOT) for approved indications in pediatric age group has been increasing recently but use in infants remains to be limited. Reports regarding HBOT use in this patient population is scarce except a few encouraging case reports. Possible technical difficulties and complications, together with lack of scientific support may be causing hesitations in referrals. We aimed to share our experiences regarding treating patients younger than one year of age (infants) with HBOT.

Materials and Methods
Infants who received HBOT in Istanbul Faculty of Medicine and Gulhane Research and Training Hospital were analysed retrospectively. Patient files were reviewed and demographic and medical data were documented. The patients were classified into two major groups with regard to conditions they were treated for: carbonmonoxide (CO) intoxication and wound related conditions. HBOT was administered in two multiplace and one monoplace chambers. All patients were checked for possible complications after each session.

Results
Fifty four infants underwent HBOT in two institutions. Median age of the patients was 3.5 months and 15 patients were younger than one month of age. Total number of sessions applied was 275. Of these, 209 sessions were in multiplace chambers. Thirty two infants underwent a total of 36 sessions for CO intoxication. Majority of patients (75.1%) had mild or moderate CO intoxication. All patients except one who was intubated at referral recovered with one HBOT sessions. Twenty two infants underwent HBOT for wound related conditions. Acute peripheral ischemia was the most common (68.7%) condition that was treated. Median number of sessions applied for wound related conditions was 10.5 (2-48). Complete healing or improvement was observed in 77.3% of the patients. No HBOT related complication was encountered.

Discussion
HBOT can be a beneficial treatment option in infants however administration of it in infants may be challenging in some aspects compared to adult treatment. Yet, HBOT seems to be safe and well-tolerated in the infant patients when the operation is carefully planned ahead, necessary measures are taken and teams work in coordination.

O-28

HYPERBARIC OXYGEN THERAPY WITH ILOPROST IMPROVES DIGIT SALVAGE IN SEVERE FROSTBITE COMPARED TO ILOPROST ALONE

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Background and Objectives
Frostbite is a freezing injury that can lead to amputation. Current treatments include tissue rewarming followed by thrombolytic or vasodilators. Hyperbaric oxygen (HBO) therapy might decrease the rate of amputation by increasing cellular oxygen availability to the damaged tissues. The SOS-Frostbite study was implemented in a cross-border program among the hyperbaric centers of Geneva, Lyon, and the Mont-Blanc hospitals. The objective was to assess the efficacy of HBO + iloprost among patients with severe frostbite.

Materials and Methods
We conducted a multicenter prospective single-arm study from 2013 to 2019. All patients received early HBO in addition to standard care with iloprost. Outcomes were compared to a historical cohort in which all patients received iloprost alone between 2000 and 2012. Inclusion criteria were stage 3 or 4 frostbite and initiation of medical care <72 h from frostbite injury. Outcomes were the number of preserved segments and the rate of amputated segments.

Results
Thirty patients from the historical cohort were eligible and satisfied the inclusion criteria, and 28 patients were prospectively included. The number of preserved segments per patient was significantly higher in the prospective cohort (mean 13 ± SD, 10) compared to the historical group (6 ± 5, p = 0.006); the odds ratio was significantly higher by 45-fold (95%CI: 6-335, p < 0.001) in the prospective cohort compared to the historical cohort after adjustment for age and delay between signs of freezing and treatment start.

Conclusions
This study demonstrates that the combination of HBO and iloprost was associated with higher benefit in patients with severe frostbite. The number of preserved segments was two-fold higher in the prospective cohort compared to the historical group (mean of 13 preserved segments vs. 6), and the reduction of amputation was greater in patients treated by HBO + iloprost compared with iloprost only.

O-29

A RETROSPECTIVE ANALYSIS OF PATIENTS TREATED WITH HYPERBARIC OXYGEN THERAPY FOR LATE RADIATION TISSUE INJURY OF THE VAGINA

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Introduction
The use of hyperbaric oxygen therapy (HBOT) on late radiation tissue injury (LRTI) has been well established for some indications, such as radiation cystitis and proctitis. However, the use in patients with LRTI of the vagina, the changes on quality of life and on specific symptoms has not been described.

Methods
The records of all patients referred from the Erasmus medical center (a tertiary hospital) to one of five Da Vinci Clinics for HBOT to treat LRTI of the vagina between 2010 and 2020 were retrospectively analyzed. Patients with a non-vaginal primary complaint, patients with fistulas and patients that received less than 20 sessions were excluded. Information on baseline characteristics, complaints (such as dyspareunia, dryness, bleeding and anatomical changes), quality of life questionnaires and follow up after HBOT was recorded.

Results
19 patients were included, with a median age of 42 years (IQR 34-65 years). The most common primary malignancy was cervical cancer (N=11), followed by anus/rectum cancer (N=5). Most commonly reported symptoms at the start of HBOT were dyspareunia (N=15), pain (N=14), changes in anatomy (N=14) and bleeding (N=13). Patients received an average of 40 sessions of hyperbaric oxygen (daily sessions of 80 min of 100% oxygen at 2.5 ATA) and - patients started HBOT a median of 9 months (ICR 5-19 months) after the start of symptoms. 15 patients (79%) showed improvement at the end of HBOT in 1 or more symptoms present at baseline: 82% of patients with dyspareunia, 71% of patients with pain, 64% with bleeding and 78% with ulceration/necrosis. A total of 7 out of 13 patients (54%) showed improvement in QLQ-C30 Global health scores (scale 0-100), with an overall median improvement of 17 points (IQR 0-25 Points). Out of the 15 patients showing improvement directly after HBOT, 77% showed stable or further improved symptoms at 1 and 3 years follow up. No major adverse events of HBOT were reported.

Conclusions
A majority of patients had a lasting improvement of vaginal complaints after HBOT in this retrospective analysis. Based on this study and the known generic effects of HBOT in LRTI, HBOT is a promising treatment for LRTI of the vagina. Future (controlled) studies are warranted.

O-30

STEM CELL MOBILIZATION BY NOMINAL HYPERBARIA

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Introduction and Objectives
The goal of this study was to determine whether exposure to nominal hyperbaric air would mobilize stem/progenitor cells in peripheral blood in a similar fashion to hyperbaric and normobaric oxygen. Adult stem/progenitor cells are specific cell types that possess the abilities of self-renewal, multipotent differentiation, and repair after injury. Breathing 100% oxygen at hyperbaric levels can activate nitric oxide synthase which plays a prime role in initiating stem/progenitor cell mobilization.
Breathing 100% oxygen at 2.4 Atmospheres Absolute mobilized stem/progenitor cells at a significantly greater rate than 2.0 Atmospheres Absolute. What is unknown is if much smaller increases in oxygen partial pressures will also mobilize stem progenitor cells. We asked the question, does 1.27 ATA of room air mobilize stem progenitor cells?

Methods
We hypothesized that exposure to 1.27 ATA (4psig / 965 Torr) of hyperbaric room air would mobilize stem/progenitor cells in human peripheral blood.
The populations of CD45dim/CD34+/CD133- and CD45dim/CD34-/CD133+ were quantified using flow cytometry in the peripheral blood of human volunteers.

Results
Over the course of 9 daily 90-minute treatments, CD45dim/CD34+/CD133- were mobilized nearly two--fold and increased to 3-fold 72 hours following the tenth and final treatment. CD45dim/CD34-/CD133+ decreased by over 5 fold prior to the tenth treatment and further decreased by over 6 fold 72 hours after the tenth and final treatment. There were no changes in overall lymphocyte count throughout the study.

Discussion
Why are these findings important? First, it was not known prior to this research that breathing a small increase in hyperbaric air would mobilize stem progenitor cells. This knowledge is important as the implications for the use of hyperbaric air as a treatment when hyperbaric oxygen is not available, such as in remote areas, underserved populations, and developing nations could prove to be very beneficial to physicians and patients. Second, because the technology is lightweight and portable, it is hypothetically possible to be used when transporting patients with ischemic injuries or in a warzone to extend the viability of damaged tissue and to reduce exacerbating gas embolism when air-lifting injured soldiers and civilians by high altitude flights are required. Finally, this research has implications for the findings of a placebo effect in the decades-old use of slightly pressurized room air as a placebo in hyperbaric oxygen research.

O-31

DIVING MEDICAL EXAMINATION BEFORE RETURN TO DIVING AFTER COVID-19 - CLINICAL OBSERVATION STUDY ON DIVERS AND COMBAT SWIMMERS OF THE BUNDESWEHR.

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Introduction
The study started in May 2020 after the occurrence of positive antibody test/PCR for SARS-CoV-2 in soldiers. Initial publications postulated significant short-term and long-term effects on organ functions relevant to divers. Moreover, it was observed that pathological lung changes can occur in mild symptomatic patients and even asymptomatic carriers. Many divers and diving physicians became concerned about the possible increasing risk of diving accidents. We established a special assessment, which all divers after COVID-19 infection had to undergo before return to diving. The results of the individual tests of each proband could be compared with data archived at the institute for many years. Even small changes could be detected.

Methods
All scuba divers, combat swimmers and submariners of the Bundeswehr after COVID-19 infection were included (n=68; 6 females, 62 males; age: 33,9±9,4 yrs)). Time of assessment was at least 4 weeks after symptoms disappeared or test negativity. Detailed anamnesis regarding COVID-19 history, subjective wellbeing and performance. Determination of cardiovascular performance with echocardiography and spiroergometry; body plethysmography with CO-diffusion and orientating lung ultrasound; Laboratory testing included cardiac markers (Trop I, per BNP).

Results
At the end of September 2021, 39 persons could be certified fit for diving; 2 persons were fit under special conditions and 2 subjects were certified temporarily unfit. In all examined divers we did not see significant changes in the lung function or in the parameters of the cardiac performance (PWC 170, PWC max, VO2max). The two persons who were certified unfit were detected because of a loss of performance in the anamnesis. Both are suspected to have Long-COVID. Until February 2022 25 more divers had been examined. This clientele deviates significantly from the divers examined up to that point: the vaccination rate in this group was almost complete and the omicron variant likely predominated. All 25 divers had a very mild course, almost none had relevant residual symptoms after the test was negative. In all cases, full fitness to dive could be regained.

Conclusions
The apparatus-based methods of the usual fitness to dive assessment do not provide pointing results. A precise anamnesis with, if necessary, further diagnostics such as echocardiography is indicated to reveal possible residuals after corona infection.

O-32

DEVELOPMENT OF FTD FOR WORKING DIVERS IN SWEDEN IN RELATION TO EDTC-SWEDISH LAW BY THE COVID-19 PANDEMIC

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Introduction
There were many questions regarding the assessment of fitness to dive (FTD) for working divers during spring of 2020 due to COVID-19 pandemic. One of the major reasons was that lung changes did not always show on plain radiographs. It was advocated that CT-thorax was needed. During the spring of 2020 MEDs (medical examiner of divers) was in need for guidance. It was not possible for MEDs to refer working divers for CT-thorax who had had confirmed or suspected COVID-19.

Methods
The Swedish Aeronautical & Naval Medical Association initiated a series of consensus conference to assist guidance. Four consensus conferences were held in June 2020, November 2020, June 2021 and in February 2022. These consensus conferences (zoom) involved MEDs with different specialties e.g. cardiologists, lung specialist, clinical physiologists, occupational health and radiologists.

Results
The consensus conferences early on recognized the importance of measuring saturation during exertion. Thus, an important conclusion was that working divers recovering from COVID-19 should consult their MED and as a minimum do an exercise test (12 METs) with a saturation measurement where a minimum level was 95% and a decrease when exercise was not to be more than 5% (see reference).
Furthermore, it was concluded that exercise test with oxygen saturation measurement should be done at all FTDs for working divers regardless of COVID-19.

Conclusion
National consensus conferences with relevant medical specialists can provide guidance to MEDs adapted to national health care resources.

Reference
Forman 2010, Cardiopulmonary Exercise Testing: Relevant but Underused, Postgraduate Medicine, 122:6, 68-86, DOI: 10.3810/pgm.2010.11.2225

O-33

CAPSULE PROJECT : A PHYSIOLOGICAL SURVEY DURING 3 DAYS SHALLOW SATURATION DIVES IN A VERY LIMITED SPACE

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Introduction / Background
Shallow saturation diving could be a useful tool for marine ethology studies. However, saturation diving as used in the offshore industry is too expensive due to heavy installations and long decompression. To make it accessible to scientific diving, the Under The Pole Consortium designed a light 4.5 m3 inhabitat made for 3 divers maximum (living space 5 times more confined than in professional diving), while monitoring divers conditions to assess their tolerance to this environment.

Materials and Methods
We monitored 12 divers before, during and after 17 saturations dives at 20 msw during 3 days, measuring pulmonary function, hemoglobin saturation, heart rate variability (HRV), critical fusion flicker test (CFF), positive and negative affects schedules (PANAS) and body mass. Spencer bubble grades were assessed with a Doppler on the subclavian artery after surfacing. During saturation, the divers breathed Heliox at pO2 equal to 40 to 50 kPa and at 130 kPa during the 4 hours decompression phase.

Results
Forced Expiratory Flow (FEF) at 25 and 75% is temporarily increased under helium and not affected by breathing 130 kPa O2 before it returns to normal upon surfacing; hemoglobin O2 saturation is increased during the stay at depth; HRV is increased for at least 24h after the dives: the parasympathetic activity decreases during saturation, decompression and 24h beyond while Sympathetic activity increases ; endothelium independent vasorelaxation is decreased at 2h after the dive; CFF is increased at day 3; Body mass is slightly decreased just after the dive and increased 24h after surfacing. The mean bubble grade is 0.71 ± 0.77.

Discussion / Conclusions
The divers have endured well the conditions of saturation diving. The in water accelerated decompression seems to be well tolerated and HRV changes suggest moderate deconditioning which is probably due to the living space.

O-34

NEW TUNNEL TRIMIX SATURATIONS: DESIGN AND VALIDATION OF THE EXCURSIONS OF THE HONG KONG TMCLK PROJECT

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Introduction
The tunnel industry is expanding around the world and tunnel boring machines (TBM) operate at pressures that now requires saturation for workers intervention. The TMCKL project (Hong Kong, 2015-2019) is representative of this a rapid evolution.
The first concern of tunneling is the is instability of soils and the risk of sudden collapse. Emergency procedures are in place for an immediate recompression, but workers might be suddenly exposed to air. Trimix has been adopted to minimize the effect of abrupt PN2 changes.
The second concern are the difficult work conditions inside the TBM that require an additional conservatism relatively to offshore excursions.
Finally, the difficulty for the project was to operate on two parallel TBMs, at two different pressures. Upward and downward excursions were required for flexibility.

Methods
Trimix saturation initially complied with the local regulations specifying a 3.5 bar max PN2. This limit was later restricted to 2 bar PN2 to further reduce narcosis and gas density.
The project defined upward and downward excursions of small distances (0.3-0.4 bar). The storage PO2 was set at 400 mbar. The excursion breathing mix provided 800 mbar PO2. This way, inert gases kept unchanged during downward excursions. The upward excursion involved a slow initial dilution of chamber with helium to reduce the PN2 by 300 mbar. This permitted to prepare the nitrogen change over the 12 hours preceding the excursion.
Workers were monitored after their excursions using doppler bubble detection (5 times inside the lock, shuttle and chamber).

Results
The project ran 30 saturations with working pressures ranging from 3.5 bar to 5.7 bar. Saturations lasted for 14 to 28 days. During these saturations, 330 shuttle runs were performed and 3000 doppler detections recorded. No DCS symptoms were reported after any excursions nor after the final decompression.

Discussion
The TMCKL project has set a method that permitted to design and validate original excursion procedures adapted to the severe conditions of tunnel work.

Conclusion
The tunnel industry obviously differs from the offshore industry and needs to define its own procedures. The TMCKL project has demonstrated that this industry is capable of developing trimix saturations excursions that have no equivalent in commercial or military diving. Further challenges are awaiting this industry as work pressures keep increasing

O-35

OPTIMISATION OF GRADIENT FACTOR SELECTION IN MILITARY DIVING

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Introduction
In 2018, the Belgian Defence introduced a commercial dive computer (Shearwater Perdix) for use by its military divers. Initial experience indicated several operational constraints when using its default Gradient Factors. The main purpose of this research is to provide guidelines for optimal gradient factor selection based on scientific evidence.

Methods
The algorithms of the Cochran dive computer and the Shearwater Perdix dive computer are programmed in Python and validated against publicly available data. Next, these validated algorithms are used to assess the gradient factor settings, and determine which settings approach the decompression profiles used as a reference by the Belgian Defence (Thalmann/NEDU and DCIEM). The optimization uses a nested do-loop for each gradient factor and the cost function is the minimization of the integrated difference between the reference profile and the profile calculated with a particular gradient factor setting.

Results
All reference profiles are approached when GFLO is kept equal to 1.0 and only GFHI is decreased down to a minimum of 0.75 to enlarge the stop times. Using the default settings (GFLO =0.3 and GFHI =0.7) would yield deeper and shorter stops, leading to increased supersaturation for the relatively slower tissues, potentially leading to an increased DCS risk. The current software (embedded rules) inside the Shearwater Perdix dive computer does not allow the selection of the optimal settings. Taking into account the constraints, sub-optimal settings are calculated: a symmetric GF of 0.9/0.9 is the best suboptimal setting to approach the DCIEM tables, except for small bottom times where the lowest setting found amongst all the dives is 0.75/0.75.

Discussion / Conclusions
The default GF settings of the Shearwater Perdix is GFLO=0.3 and GFHI=0.7. Our optimization analysis indicates that it was never required to use a GFLO of 0.3 to approach the targeted reference decompression profiles. On the contrary, all optimal solutions keep the GFLO parameter fixed to 1.0 while, ideally, the GFHI parameter is lowered to increase the shallower stop times. During this research study, no evidence is found that the default GF setting would lead to a safer decompression profile for air dives up to a depth of 60msw. Based on this research, the Belgian Navy divers refrain from using the default gradient factor settings of the Shearwater Perdix dive computer, and instead adopt a symmetrical GF settings approach.

O-36

INTEREST OF MULTIFREQUENCY BIOIMPEDANCE USED IN A CONTEXT OF SATURATION DIVING

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Introduction
The offshore industry is relying on saturation diving and needs monitoring its safety performances. The problem is to define criteria because DCS has become a rare event. We focused on two criteria, one traditionally related to venous gas emboli, another related to non-invasive measurements. In 2017, we measured flow mediated dilatation in North Sea saturation divers. Recently, we have monitored saturation divers using bioimpedance. We derived two indexes from the measurements, the ratio of high/low frequency impedances (IR) and the phase angle at 50 kHz. The IR is associated to water movements between cellular and extracellular compartments and could be related to an inflammatory subclinical tissular oedema (Mitsides et al., 2017)). The phase angle is associated to the cell electrical properties and could measure damages to the cell membrane.

Methods
We have developed a package for the monitoring of the saturation divers. It includes doppler detection (Azoth Systems O'Dive), the PhysioPad tests (Divetech) and an advance bioimpedance device (Aminogram Biody X3). The package was used during 2 saturations conducted by the 4 divers of Gombessa 5 and 6 projects (120 msw, Mediterranean Sea, 2020, 2021).

Results
The results indicate that IR signals vary after each dive and are affected by the diving stress (efforts, time in water, etc.). The phase angle variations have an accumulative aspect that could be associated to the building of fatigue. Both indexes are affected by the final decompression.

Discussion
The current thinking is to first link this inflammation to VGE that are suspected to 1) damage the endothelium by shear stress, 2) trigger platelets and leucocytes activation and 3) create, at least in part, microparticles when they detach from the blood vessel walls. Inflammation is also associated an oxidative stress, linked to diving itself, and responsible for microparticles detected in the blood of divers. The IR and the phase angle signals could provide a description of the two aspects of this inflammatory stress. It remains to establish the parallels between detected microparticles or other oxidative/inflammatory markers and bioimpedance electrical signals.

Conclusion
Bioimpedance could provide an easy, non-invasive and inexpensive way to monitor saturation divers and provide data for the validation of procedures. Further studies are planned in the North Sea for the validation of the monitoring package.

Reference
Mitsides N, Cornelis T, Broers NJH, Diederen NMP, Brenchley P, van der Sande FM, Schalkwijk CG, Kooman JP & Mitra S. (2017). Extracellular overhydration linked with endothelial dysfunction in the context of inflammation in haemodialysis dependent chronic kidney disease. PLoS One 12, e0183281.

O-37

FULL-FACE SNORKEL MASKS SAFETY DURING REST AND EXERCISE

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Introduction
Full-face snorkel masks are widely used in the snorkelling community and have also been adopted as protective personal equipment during the COVID-19 pandemic. By design, in full-face snorkel masks air flow should occur in one direction only. While these masks provide an 'easier' alternative to the traditional mask and snorkel combination, there are concerns about poor ventilation and the potential for rebreathing exhaled air high in carbon dioxide (CO2). This study evaluated levels of oxygen and CO2 in a snorkel equipment and the effect on the wearer while at rest, during light and moderate exercise.

Methods
Twenty healthy participants wore three snorkel equipment: 1) Subea Easybreath; 2) QingSong 180-degree panoramic full-face snorkel mask; and 3) Beuchat Spy snorkel in three conditions: 1) rest in a chair; 2) light intensity exercise on a cycle ergometer to simulate light snorkelling; and 3) moderate intensity exercise to simulate swimming against a current. The condition was discontinued when oxygen saturation (SpO2) dropped below 85%, or end tidal CO2 (ETCO2) exceeded 7.0kPa. SpO2, ETCO2 and end tidal oxygen in the oronasal compartment and CO2 and oxygen fractions in the eye pocket of the mask, breathing frequency and tidal volume were measured continuously.

Results
All snorkel equipment could lead to desaturation of the wearer below 90%. Multiple conditions were discontinued due to hypercapnia (>7.0kPa: 10 Subea; 11 QingSong; and 6 snorkel). Early termination in the full-face masks was usually associated with a poor fit of the internal skirt of the mask. Even with good external fit, the internal skirt was not sealing adequately for all facial types. In all full-face mask conditions CO2 increased while oxygen decreased in the eye pocket with every breath. Tidal volumes and breathing frequencies increased significantly when participants were hypercapnic.

Conclusions
Snorkelling can lead to desaturation and hypercapnia regardless of snorkel equipment. All full-face snorkel masks tested showed rebreathing in the eye pockets of the mask, regardless of internal skirt fit.

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HYPOBARIC HYPOXIA IN AEROMEDICAL TRAINING - FUNDAMENTALS, METHODS AND PRACTICAL ASPECTS

Boris Oniščenko

O-39

EXPLOSIVE DECOMPRESSION AND RARE PULMONARY BAROTRAUMA

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Background
Explosive decompression in aviation is a serious and life-threatening situation. The organism is exposed to extreme changes in pressure, temperature and altitude hypoxia episode, which is increasingly common in military aviation. One of the ways to prepare individuals for this situation is to perform explosive decompression during aeromedical training in a hypobaric chamber under continuous monitoring. Based on the North Atlantic Treaty Organisation (NATO) Standardisation Agreement (STANAG), refreshment of rapid decompression training requirement is nowadays of 5-year intervals or individual in the Czech Air Force. But even this simulation has its risks, such as the occurrence of barotrauma or decompression injury.

Case presentation
A 26-year-old active duty Air Force pilot performed an explosive decompression simulation from 8,000 ft (2,438.4 m) to 25,000 ft (7,620 m) in a 1.5 second interval. The training was interrupted due to the pilot's apparent health complications. After transfer to the emergency department, a CT scan showed bilateral lung barotrauma with emphysema.

Conclusions
Pulmonary barotrauma during explosive decompression military crew training in a hypobaric chamber is an extremely rare complication, as well as in flight. Extensive bilateral tissue damage is even more unexpected. Limits to when this serious complication could occur are still unclear and probably individual. In addition, available data from researches, studies and publications are limited. However, we can state that the incidence of pulmonary barotrauma is higher in individuals with the presence of predisposed lung disease.

Keywords
barotrauma, explosive decompression, hypobaric chamber, emphysema

O-40

OPHTHALMOLOGICAL CHALLENGES OF THE FLIGHT AND UNDERWATER ENVIRONMENT

Veronika Poláčková

O-41
UNDERWATER ANALOG SPACE MISSIONS

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Background
Human space exploration is dangerous at all levels. Analog missions are field tests in locations that have physical similarities to extreme space environments. Based on the habitat location and procedures involved, the analog space mission can be divided into two groups: environmental and mission analogs. Research habitats, where analog space missions are conducted are usually located in Isolated, Confined, and Extreme environments such as deserts, polar regions, lava fields, bunkers, and underwater. The underwater analog space missions are considered high-fidelity environmental spaceflight analog. Currently, there are 3 underwater research analog habitats operational worldwide, two located in the ocean and one located in sweet water, the Deep Lab03.

Materials
The DeepLab 03 is a mobile underwater habitat with an inner volume of 20m3 located in Czechia. One analog space mission was conducted in the Deep Lab03 in 2021 and the other is planned for 08/2022. Three analog astronauts-aquanauts participated in these missions and spent 2 and 7 days underwater at the app. 7m depth. Various psychological and physiological experiments were carried out.

Results
The initial findings from the conducted experiments and missions indicate, that the Deep Lab03 research underwater habitat is a unique high-fidelity environmental spaceflight analog

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HYPERBARIC OXYGEN IN LOWER LIMB TRAUMA – A MULTI-CENTRE RANDOMIZED CONTROLLED TRIAL

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Introduction
Severe musculoskeletal trauma or "crush injury" is an accepted indication for hyperbaric oxygen (HBOT) according to many hyperbaric medical societies but in practice, there is relatively little utilization of HBOT for this indication.

Methods
We conducted a randomized controlled study, enrolling 120 subjects with a severe open lower limb fracture within 48 hours of injury to receive standard care with or without a course of HBOT starting as soon as possible after initial surgery. Follow up occurred over two years, using pre-determined outcome measures.
The study hypothesis was that HBOT would result in lower numbers of acute complications of injury and subsequently, lower rates of longer term complications such as complex wound problems, osteomyelitis, and delayed fracture union. The a-priori primary outcome was the incidence within 14 days of one or more of the acute complications of injury: soft tissue necrosis or acute infection.

Results
The study did not find a statistically significant reduction in the intention to treat primary outcome: 43% vs 58% P=0.12. The study hypothesis was, however, validated by significant reductions in acute wound necrosis: 29% vs 53%, P=0.01; infected necrosis: 9% vs 27%, P=0.01; and fewer major complications over 12 months: 11% vs 35%, P=0.005, including lower rates of wound healing problems and of delayed or non-union. Quality of life measures assessed over two years were superior in HBOT treated patients.

Conclusions
Hyperbaric oxygen can effectively reduce complication rates and improve outcomes when used acutely in severe limb trauma. The optimal number of treatments remains to be clarified but further research and investigations around how best to increase utilization are supported by this trial.

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INFLUENCE OF APPLIED PRESSURE IN HBOT SSNHL THERAPY ON THE RATE OF THERAPEUTIC GAIN OF PATIENTS IN PARTICULAR FREQUENCY RANGES

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Introduction
At present, the treatment of SSNHL is dominated by conservative treatment in the form of systemic corticotherapy, which is associated with the individual possibilities of the HBOT-facility. Other treatment is also given according to the particular practices of the given HBOT-facility. HBO had not been considered in the treatment of these diseases for a long time. Our previous results suggest that the combination of systemic corticotherapy with HBO has a statistically significantly higher benefit for the patient compared to the use of variously combined pharmacotherapy alone. In presented study, we reevaluated the results with an emphasis on verifying the degree of therapeutic benefit in individual therapeutic zones.

Objectives
To objectify the degree of therapeutic benefit of different applied pressures in combination with other parameters for individual frequency ranges in patients with SSNHL.

Methods
We evaluated data from 344 patients suffering from SSNHL within 7 days of hearing loss: 134 patients received the standard treatment protocol (control group), and 170 individuals were treated with additional application of HBOT pressured to 2.0 ATA or 2.5 ATA, respectively. Another group consisted of 40 patients who received HBOT as secondary therapy at an applied pressure of 2.0 ATA. In addition to the therapeutic modality, another criterion was the age of the patients and the time of initiation of HBOT from the onset of the hearing impairment.

Results
Our results support the possibility of optimizing treatment individually, depending on the type and frequency range of hearing impairment in favor of the use of 2.0 ATA in primary and secondary treatment, which is important in terms of minimizing the patient's burden of hyperbaric conditions, but by achieving maximum therapeutic effect. Exceptions are low frequencies, for which we prefer to use the treatment pressure of 2.5 ATA. The resulting effect of the treatment in all frequencies and applied pressure we monitored was optimized for the interval from 2 to 4 days from the onset of the hearing impairment. Based on other results, the acquired knowledge can be extended by the possibility of optimizing the treatment depending on the patient's age in accordance with the interpretation table

Conclusion
Our findings suggest the need to verify the relationship between the degree of benefit of therapy, which in our case proved to be very important. In this way, it would be possible to acquire more knowledge from the unexplored "grey zone" that can help in personalized patient therapy.

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HYPERBARIC OXYGEN THERAPY INDUCES NEUROPLASTICITY AND IMPROVE NEUROCOGNITIVE FUNCTIONS AND SYMPTOMS OF POST-COVID-19 CONDITION: RANDOMIZED, DOUBLE BLIND, SHAM-CONTROLLED CLINICAL TRIAL

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Background
Post-COVID-19 condition refers to a range of persisting physical and psychological symptoms after SARS-CoV-2 infection. This study aims to evaluate the effect of hyperbaric oxygen therapy (HBOT) on post-COVID-19 patients.

Methods
In this randomized, sham-control, double blind trial, 73 post-COVID-19 condition patients were randomized to receive daily 40 session of HBOT (n=37) or sham treatment (n=36). The primary outcome was cognitive functions and secondary outcomes included quality of life, psychological distress, sleep, smell, taste, pain measures and brain microstructure and cerebral blood flow evaluated by MRI.

Results
Following HBOT, there was a significant group-by-time interaction in global cognitive function compared to sham (d=0.495, p=0.038). Specifically, attention and executive function domains had significant group-by-time interaction (d=0.477, p=0.04 and d=0.463, p=0.05 respectively). Significant improvement was also demonstrated in the energy domain (d=0.522 p=0.029), sleep quality (d=-0.48, p=0.042), psychological symptoms (d=0.636, p=0.008), and pain interference (d=0.737, p=0.001).
Clinical outcomes were associated with improved brain perfusion in the supramarginal gyrus (BA40), left supplementary motor area (BA6), and the right insula (BA13). White and gray matter microstructural changes were found in the left frontal precentral gyrus (BA6), right middle frontal gyrus (BA8/10), and superior corona radiate.

Conclusions
HBOT can improve dysexecutive, psychiatric, fatigue and pain interference symptoms of patients suffering from post-COVID-19 condition. HBOT's beneficial effect may be attributed to increased brain perfusion and neuroplasticity in regions associated with cognitive and emotional roles.

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THE EFFECTS OF HYPERBARIC OXYGEN THERAPY ON RECOVERY FROM THE LONG COVID-19 CONDITION

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Introduction
The COVID-19 pandemic poses a major challenge to the hyperbaric medical community in many ways. We were addressed by vascular surgeons to treat several patients who suffered arterial thrombosis and limb gangrene as a complication of COVID-19 infection with hyperbaric oxygen therapy (HBOT). The urgency was to preserve the extremities, and life in couple of cases. Our biggest concern was that the use of HBOT might worsen already impaired respiratory condition among the patients with long COVID-19. Encouraged by the observed positive effects, we continued to include more patients with Post COVID-19 condition, also known as "long" COVID-19. The aim of this study was to determine whether HBOT administration would be beneficial for patients who suffer from prolonged symptoms and various complications of Covid-19 infection.

Methods
A group of 55 patients with post COVID-19 condition was included in HBOT. All patients signed the informed consent to participate in the study, previously approved by Ethical committee of the Centre for Hyperbaric Medicine in Belgrade. We reviewed their detailed medical history. Symptoms and quality of life were investigated using the modified Borg CR10 Scale for rating of perceived exertion (RPE), Post-COVID-19 Functional Status scale (PCFS) and Quality of life (EQ-5D-3L) questionnaire. Baseline pulmonary function tests (PFTs), including spirometry and flow-volume loop, the 6-minute-walk test (6MWT) with pulse oxymetry monitoring of oxygen saturation (SpO2%), were performed before the first HBOT exposure and repeated within 1-3 days after the 10th exposure. HBOT protocol: 2.0 ATA for 70 minutes, 10 sessions, on working days.

Results
HBOT was tolerated well. We found a statistically significant level of improvement of the most patients in observed PFTs parameters after HBOT, as compared to pretreatment values; 6MWT distance ($p<0.001$); PCFS ($p<0.001$); EQ-5D-3L ($p<0.001$); Dyspnea scores (Borg CR19) and SpO2% levels were significantly improved as well. There were no adverse effects, and we did not find any deterioration of pulmonary function.

Conclusions
We found a significant improvement in the observed parameters of pulmonary function, exercise tolerance and quality of life in patients with post COVID-19 condition after HBOT.

Keywords
COVID-19, hyperbaric oxygenation, pulmonary function, quality of life, exercise tolerance

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THE EFFECTS OF HYPERBARIC OXYGENATION ON LUNG DIFFUSION CAPACITY AMONG THE PATIENTS WITH POST COVID-19 CONDITION, A PILOT STUDY

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Introduction
As far as we know up until now, the benefits of hyperbaric oxygen therapy (HBOT) for patients with COVID-19 include alleviation of hypoxia, modulation and reduction of inflammation and the state of hypercoagulation. After the observations of the initial results obtained in our center, we were encouraged to continue the study and treat more patients with various symptoms of post Covid-19 condition with HBOT. The aim was to determine the effects of HBOT on a diffusion lung capacity for carbon monoxide (DLCO) and diffusion coefficient for carbon monoxide (KCO). Considering that they represent highly sensitive markers of impaired lung gas transfer and the extent of lung damage, as well as the most sensitive index of oxygen toxicity.

Methods
The group of 13 patients with post COVID-19 condition was referred to us from The Pulmology Clinic of the Clinical Center of Serbia. They were all suffering from lung impairments, had reduced diffusion lung capacity and decreased exercise tolerance. The study was previously approved by Ethical committee of the Centre for Hyperbaric Medicine in Belgrade. Symptoms and quality of life were investigated using modified Borg CR10 Scale for rating of perceived exertion (RPE), Post-COVID-19 Functional Status scale (PCFS) and Quality of life (EQ-5D-3L) questionnaire. Baseline pulmonary function tests (PFTs), including DLCO, DLCO%, KCO, KCO%, the 6-minute-walk test (6MWT) with pulse oxymetry monitoring of oxygen saturation (SpO2%), were performed before the first HBOT exposure and repeated within 1-3 days after the 10th exposure. HBOT protocol: 2.0 ATA for 70 minutes, 10 sessions on working days.

Results
We found a statistically significant level of improvement of DLCO ($p=0.008$), DLCO% ($p=0.007$), KCO ($p=0.045$), KCO% ($p=0.045$) after HBOT, as compared to pretreatment values. Also, the majority of other observed PFTs parameters, 6MWT distance ($p<0.001$); PCFS, EQ-5D-3L, dyspnea scores (Borg CR10) and SpO2% levels were significantly improved as well. HBOT was well tolerated and there were no adverse effects.

Conclusions
We found a statistically significant level of improvement in the observed parameters of pulmonary function, exercise tolerance and quality of life. These encouraging results are showing that there is a growing need for preparing additional randomized clinical trials directed towards the integration of hyperbaric oxygen therapy in treatment strategies intended to improve the outcome of long-COVID.

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SAFETY OF HYPERBARIC OXYGEN TREATMENT FOR POST COVID-19 CONDITION. RESULTS FROM THE INTERIM SAFETY ANALYSIS OF THE RANDOMIZED PLACEBO-CONTROLLED DOUBLE-BLIND TRIAL (HOT-LOCO)

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Introduction
With ~50 million individuals suffering persistent symptoms after COVID-19, low health related quality of life (HRQoL) is a vast problem. Common symptoms of Long COVID, that persists three months from the onset of COVID-19 are fatigue, shortness of breath and cognitive dysfunction. No effective treatment options exist. Hyperbaric oxygen (HBO2) is a candidate drug. The aim of this interim analysis was to evaluate safety of HBO2 for our cohort.

Methods
Prospective randomised, parallel arms, placebo-controlled, double blind, single-center. 80 previously healthy subjects with Long COVID, randomised to HBO2 or placebo, stratified for sex and disease severity. Subjects received maximum ten HBO2 treatments, 240kPa 90 minutes (20:5) or sham treatments within six weeks from randomisation. Primary endpoints are the physical domains Physical functioning (PF) and Role Physical (RP) in RAND-36 at 13 weeks. Secondary endpoints are the objective physical tests 6-minute walk test (6MWT) and 30 seconds chair stand (CST), EQ-5D and reactive hyperemia index (RHI) at 13 weeks. Safety endpoints are occurrence, frequency and seriousness of Adverse Events (AEs). An independent data safety monitoring board (DSMB) reviewed unblinded data in an interim safety analysis. All investigators are blinded to allocation group. The trial complies with Good Clinical Practice and the Declaration of Helsinki.
Clinicaltrials.gov: NCT04842448, EudraCT: 2021-000764-30.

Results
20 subjects were evaluated in the analysis. Baseline data compared with norm data, Mean(SD). Very low self-reported HRQoL: RAND-36 PF 31.75(19.55) vs 83.5(23.9) p<0.0001, RP 0(0) vs 75.4(37.6) p<0.0001. EQ-5D index 0,36(0,22) vs 0,87(0,02) p<0.0001.Very low physical performance: 6MWT 442(180) vs 662(18) meters p<0.0001. CST 13(5) vs 25(1) stands in 30 seconds. Baseline data of RHI: 35% of the subjects have RHI< 1.67(endothelial dysfunction (ED)) and 30% RHI 1.67-2.10(borderline ED) at baseline.
31 AEs occurred in 60% of subjects. In 20 AEs, there were at least a possible relationship with the study drug, hence interpreted as Adverse Reactions (ARs), most commonly cough and chest pain/discomfort. All AEs were transient.

Discussion / Conclusions
An unexpectedly high frequency of AEs were observed but the DSMB assessed HBO2 to have a favourable safety profile. This safety analysis enables further investigation of the efficacy of HBO2 within the HOT-Lo-CO trial and may help other researchers in designing trials.

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CLINICAL AND IMMUNOLOGICAL EFFECTS OF HYPERBARIC OXYGEN THERAPY (HBOT) IN SEVERE NON-INTENSIVE COVID-19 PATIENTS: INTERIM ANALYSIS OF A RANDOMIZED CONTROL TRIAL

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Introduction
SARS-CoV-2 (severe acute respiratory syndrome coronavirus - 2) is a virus that causes severe acute respiratory syndrome, leading to the disease known as coronavirus disease-19 (COVID-19). It has been hypothesized that the primary pathomechanisms for the severe inflammation in the lungs with massive macrophage activation is the so-called "cytokine storm", which can be modulated by hyperbaric oxygen therapy (HBOT).
Objectives
The aim of the study is to assess the impact of hyperbaric oxygen therapy (HBOT) on the inflammatory process ("cytokine storm") in moderate COVID-19 cases leading to respiratory failure.

Material and methods
In 2021 we started the Randomized Controlled Trial on using Hyperbaric Oxygen Therapy in COVID-19 patients (EudraCT 2020-002722-90). Until this interim analysis, 30 patients were recruited (24 males and six females, average age of 55 years ± 13,4 [SD]). Twenty-eight were successfully randomized to receive either standard treatment (Control group) or standard treatment group with adjunctive Hyperbaric Oxygen Therapy (HBOT group). HBOT was given once daily (60 minutes 100% oxygen at 2.5 ATA) for five consecutive days in a multiplace chamber. The safety and efficacy of HBOT were assessed with blood gas analysis, general biochemistry, blood morphology and markers of inflammatory process measured for ten days of observation.

Results
The groups were similar when comparing all parameters except for IL-6 (see below) during randomization.
There was a statistically significant difference in the level of Interleukin 6 (IL-6) between groups C and HBOT in the initial studies ($p<0.05$), with high values in those patients who died (all were in the C group).
In both groups, the set parameters of oxygenation were maintained (SpO2> 92%), but in the HBOT group, this was achieved by using a lower normobaric oxygen dose ($p<0.05$).
In the C group, 3 of the 14 participants (21.4%) died, while in the HBOT group, there were no deaths (0.0%). The difference in the death rate did not reach statistical significance ($p = 0.067$), but the trend is worth emphasizing.
Both groups showed a statistically significant increase in the percentage of eosinophilia and lymphocytes and a decrease in neurocytes. These changes did not differ between groups.
Statistically significant changes in the HBOT group were observed only in decreasing CRP, ferritin and LDH with an increase in the CD3 population of cells.

Conclusions
In conclusion, in this preliminary interim analysis of the RCT, we confirmed the effectiveness of randomization with the safe conducting of HBOT in moderate COVID-19 pulmonary infection. A tendency to reduce the number of deaths in the HBOT group was observed with lower demand for normobaric oxygenation in the group of patients treated with HBOT. We also observed a significant beneficial effect of HBOT on CRP, ferritin, LDH and the population of the CD3 cells.

Acknowledgement
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O-49 KEYNOTE LECTURE

THE EFFECT OF SCUBA DIVING AND FREEDIVING ON MYOCARDIAL FUNCTION: PHYSIOLOGICAL OR PATHOPHYSIOLOGICAL RESPONSE?

Radek Pudil

O-50

EFFECTS OF FREEDIVING DEPTH ON DIVING HEART RATE AND ARTERIAL OXYGEN DESATURATION

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Introduction
Deep dives might expose freedivers to enhanced risk of hypoxic blackout, due to the rapid drop in alveolar oxygen pressure upon ascent. However, other characteristic features of deep diving can influence the outcome. The oxygen conserving "diving response", directing blood to vital organs and reducing heart rate (HR), has been suggested to be enhanced at depth by lung-compression and by colder water. Further, exercise intensity can vary with different depths, which could affect HR. Recordings of arterial oxygen saturation (SpO2) and HR from dives in ecologically valid conditions are needed to reveal whether desaturation increases with depth, and if the human diving response is enhanced and counteracts this effect. Our aim was to study these integrated effects by underwater pulse-oximetry during real dives in the sea.

Methods
Thirteen competitive freedivers with at least 5 years of experience performed 2-5 dives from a buoy along a vertical line during their regular freediving training in the sea. An underwater reflective pulse oximeter with forehead probes recorded HR and SpO2, continuously. One deep (>35 m) and one shallow (10-25 m) dive per diver was analyzed. Dives shorter than 60s were excluded. With multiple dives from a single participant, only the deepest dive was used for the deep dives and only the longest dive was used for shallow dive analysis. Three divers did not produce dives fitting the depth- or time categories. As such, 10 divers were analyzed for effects of diving depth on SpO2 and HR.

Results
Mean(SD) depth of deep dives was 53(14)m and 17(4)m for shallow dives ($P<0.001$). Durations were similar between deep dives; 120(18)s and shallow dives; 116(43)s (NS). Deep dives resulted in a lower nadir SpO2 at 58(17)% compared to shallow dives; 74(17)% ($P=0.029$). Mean diving HR was higher for deep dives; 66(9)bpm compared to shallow dives; 59(9)bpm ($P=0.002$). The minimum HR (39 bpm) was similar between shallow and deep dives (NS).

Discussion
Arterial desaturation was clearly greater after deep dives, despite similar durations. While a rapid drop in alveolar pressure upon ascent from deep dives could enhance desaturation, other factors clearly contribute. The diving response does not compensate for the specific effects of pressure on gas exchange, and higher over-all HR during deep dives likely reflects higher swimming intensity and oxygen cost. The take-away message is that deep diving is associated with enhanced risk of hypoxic blackout and the cause is multifactorial.

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EFFECTS OF HYPERVENTILATION ON OXYGEN KINETICS, APNEA BREAKING POINT, DIVING RESPONSE, AND SPLEEN CONTRACTION DURING SERIAL STATIC APNEAS

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Background
Hyperventilation is considered a major risk factor for hypoxic blackout during breath-hold diving, as it delays the apnea breaking point while only marginally increasing oxygen supplies. However, little is known about how it affects oxygen kinetics, the diving response, and spleen contraction during serial breath-holding.

Methods
The 18 volunteers were inexperienced or beginners in freediving. During prone rest, they performed two series of 5 apneas with facial immersion (15 ?C) to maximal duration at two-minute intervals, one series after normal breathing and another after 15 seconds of hyperventilation, in weighted order. Spleen size and cardiorespiratory variables were recorded.

Results
Mean apnea duration was longer after hyperventilation (133 vs 111 sec; $p < 0.001$). Hyperventilation reduced pre-apnea ETCO2 (18.6 vs 30.8 mmHg; $p<0.001$), post-apnea ETCO2 (41.1 vs 43.0 mmHg; $p = 0.005$), and delayed onset of involuntary breathing movements (112 vs 89 sec; $p = 0.003$). Pre-apnea ETO2 and SpO2 were similar between all dives. Mean ETO2 after apnea was lower in the hyperventilation trial (88.9 vs 95.3 mmHg; $p = 0.005$) and so was the SpO2 nadir after apnea (90.6 vs 93.6 %; $p<0.001$). The rate of drop in ETO2 and SpO2 was increased after hyperventilation ($p < 0.001$). In the hyperventilation trial we found a serial effect with a progressively lower nadir SpO2; Apnea-1: 94.0 % and Apnea-5: 86.7% ($p<0.001$) and lower end-apnea ETO2; (95.9 vs 84.9 mmHg; $p = 0.002$). In the last hyperventilation apnea, four subjects reached below 75% SpO2, while not in any other dive. There were no differences in diving response bradycardia (19-18%) or spleen volume reduction (33-35%) between conditions or across series.

Conclusions
Even a short period of hyperventilation delays the physiological breaking point during apnea and enhances desaturation versus normal breathing. This effect increases progressively across the hyperventilation series, and a long series of dives could potentially lead to SpO2 levels associated with a hypoxic blackout. There is no change in the hypoxia protective cardiovascular or spleen responses to compensate for this effect. The risk with hyperventilation appears multifactorial and includes a faster drop in SpO2, possibly due to the increased respiratory work with hyperventilation, and a serial effect could be due to incomplete central venous oxygenation between long dives.

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IS CARDIAC ARRHYTHMIA CONTRIBUTING TO BLACKOUT IN BREATH-HOLD DIVING?

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Background
Syncope or "blackout" (BO) in freediving is considered to be caused by the hypoxia that develops during long apneas. However, it has been suggested that cardiac arrhythmias affecting the pumping effectivity could contribute to causing BO. Heart rate (HR) has rarely been recorded during official freediving competitions, where athletes aim for maximal performance. We aimed to record HR during a static apnea (STA) competition.

Methods
Four male freedivers at mean(SD) age 41(12) years, freediving experience 6(5) years, training 4.0(1.5) h/week, and personal best (PB) in STA of 349(43)s, volunteered during national championships. HR was recorded using a Polar T1 heart rate monitor with a chest strap. After individual preparation, divers performed STA floating face down in an indoor pool. Safety routines and AIDA competition rules were followed. Divers wore wetsuit and nose clip, but no swim glasses.

Results
Three divers produced shorter STA than their PB without problems, while one diver ended with a BO at 5:17´, around his PB. He was immediately brought up by safety divers and resumed breathing within 10s of the "blow-tap-talk" procedure. All divers attained similar lowest diving HR of 50(4)bpm, but HR recordings displayed a different pattern for the diver ending with BO. After a short tachycardia the three successful divers developed bradycardia which was more pronounced during the second half of the apnea, while the diver ending with BO developed an early, pronounced bradycardia and, at approximately 2.5 min into the apnea, showed a distinct HR pattern alternating between approximately 50 and 140 bpm (R-R intervals of 1250 and 400ms). This continued until the diver lost consciousness, where the final R-R was alternating between 700 and 400ms. At resumed breathing, the irregular pattern disappeared and HR returned to the pre-dive level. A Poincaré plot showed two main clusters, which we suspect could be due to either bigeminy or a tachyarrhythmia (atrial fibrillation or supraventricular tachycardia) with a variable atrioventricular block.

Discussion
We speculate that the observed arrhythmia could have been a cause of or contributing to the BO, by lowering stroke volume leading to a systolic blood pressure drop, affecting brain perfusion. The hypoxia and acidosis of breath-hold diving are known risk factors for supraventricular and ventricular arrhythmias. Further study of cardiac patterns during maximal dives is needed to determine if arrhythmias contribute to BO in freediving.

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TARAVANA SYNDROME AFTER A BREATH HOLD DIVING WITH AN UNDERWATER THRUSTER, AN IN SITU BUBBLE FORMATION ENCEPHALOPATHY?

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Case Report
We report the case of a 45 year old experienced free diver, without any notable history, who made a series of 4 apneas of about 3 minutes in the 40 meter zone with very rapid descent and ascent speeds in an underwater thruster. During the last apnea, he had consciousness problems.
His MRI scan revealed a diffuse encephalopathy with vasogenic oedema in favour of a taravana syndrome, requiring treatment with hyperbaric oxygen therapy. From the MRI data, we formulate the hypothesis of bubble formation directly in the cerebral structures, particularly at the capillary level, to explain the occurrence of this taravana syndrome.
Prevention messages should be addressed to users of underwater scooters to limit the speed of descent and ascent.

O-54

DOES THE MOST POTENT LUNG SURFACTANT DIPALMITOYL-PHOSPHATIDYLCHOLINE POSE A RISK FOR DECOMPRESSION ILLNESS IN DIVING MAMMALS?

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Introduction / Background

In the search for the hypothesized gas micronuclei from which bubbles evolve during decompression after diving, we succeeded in establishing the chain of events. The lung surfactant dipalmitoylphosphatidylcholine (DPPC) most probably leaks into the blood stream. Leaving the plasma, the DPPC settles on the luminal aspect of blood vessels to create an oligolamellar lining of phospholipids. We named this site an "active hydrophobic spot" (AHS).

During the dive, the nanobubbles formed at the AHS from dissolved gas, an occurrence unrelated to diving activity, become the gas micronuclei from which bubbles evolve upon decompression.

Because the existence of AHS is the main threat of decompression illness (DCI), it is expected that reduction of AHS would be an important adaptation in deep-diving marine mammals. This could be achieved by the reduction of DPPC in lung surfactants, reduced leakage from the lung to the blood or by reduced settling at the luminal aspect at the blood vessels. DPPC is the most potent of surfactants and comprises about 40% of the total surfactants in the human lung and in other terrestrial mammals. Because of the near-perpendicular alignment of its two palmitic acids, it can be packed in a dense layer.

Diving mammals, diving to depths which cause lung collapse, experience many collapsing and expanding of the lung and therefore their surfactants should be adapted to such swings. Lung surfactants were recently studied in diving mammals (Gutierrez et al., 2015; Spragg et al., 2004). Both studies report an increase in phosphatidylcholine (PC) which increases the fluidity and anti-adhesion characteristics of the surfactant. According to both studies, adaptation to diving in marine mammals was attributed to an increase in fluidity and anti-adhesion in the lung PC, enabling the re-expansion of collapsed alveoli upon ascent from a deep dive. Spragg et al., (2004) reported a surprising finding: The deep diving elephant seal, has a high minimal surface tension in comparison with other mammals: Elephant seal (11.2), Sea lion (0), Harbor seal (0) and human (0) mN/m.

The elephant seal also has a lower concentration of DPPC with respect to all surfactant phospholipids than the others. DPPC and other Dipalmitoyl phospholipids: Dipalmitoylphosphatidylglycerine – DPPG and Dipalmitoylphosphatidylinositol - DPPI were plotted as a function of maximal diving depth. All dipalmitoylphospholipids are reduced as a function of diving depth.

O-55

REPEATED HBO2 EXPOSURE INCREASES SKELETAL MUSCLE OXIDATIVE STRESS AND DISRUPTS CALCIUM HANDLING IN MICE

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Introduction
Prolonged and or repeated hyperbaric oxygen (HBO2) exposures causes a decrease in skeletal muscular endurance 1. Oxidants may cause fatigue by interfering with calcium handling and or mitochondrial ATP production. Because oxidants are increased in HBO2, we hypothesized that prolonged and repeated HBO2 exposures disrupts calcium regulation resulting in elevated mitochondrial calcium uptake and impaired mitochondrial activity.

Methods
Eight-week-old male C57BL/6J mice were exposed to air (control) or HBO2 at 2.5 for 4 h on three consecutive days. After the final exposure mice were humanly euthanized with isoflurane before collecting the flexor digitorum brevis (FDB) and tibialis anterior (TA) muscles. The TA muscles were used to measure nuclear and mitochondrial DNA oxidation (8-OHdG) and lipid peroxidation (4-HNE) using immunofluorescence, and S-nitrosylation of ryanodine receptor 1 (RyR1) and STIM1 using a biotin switch assay. The FDB muscles were isolated for measurement of superoxide (dihyroethidium), total glutathione (GSH, 7-amino-4-chloromethylcoumarin), mitochondrial membrane potential (tetramethylrhodamine, methyl ester), and cellular (Fluo-8) and mitochondrial (Rhod-2) calcium levels using fluorescence microscopy.

Results
HBO2 increased superoxide production and nuclear and mitochondrial DNA oxidation and lipid peroxidation ($p<0.01$) without impacting GSH levels. When caffeine was added to the myofibers, maximal sarcoplasmic reticulum (SR)-calcium release was reduced by 59% in HBO2 mice ($p<0.001$), however, this was not accompanied by a change in mitochondrial calcium uptake or S-nitrosylation of RyR1 and STIM1. HBO2 increased mitochondrial membrane potential by 174% over air mice.

Conclusions
Repeated exposure to HBO2 at 2.5 ATA for 4 h causes skeletal muscle oxidative damage and impaired calcium release that is not due to S-nitrosylation of calcium regulatory proteins. Despite not finding an increase in mitochondrial calcium uptake and reduction in mitochondrial activity, these data do provide evidence that SR-calcium release and mitochondrial activity are altered by repeated HBO2 exposures. Whether these responses are responsible for impaired exercise performance remains to be tested.

Keywords
Mitochondria, Oxidants, Sarcoplasmic reticulum, S-nitrosylation

Reference
Myers CM, Kim JS, McCully KK, Florian JP. Effects of repeated, long-duration hyperoxic water immersions on neuromuscular endurance in well-trained males. Front Physiol. 2019;10:858.

O-56

IMPROVING THE SAFETY OF SUBMARINE ESCAPE AND RESCUE FROM SHALLOW DEPTH USING A 90-KG SHEEP DECOMPRESSION MODEL

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Research was funded by NAVSEA the U.S. Navy.

Introduction / Background
This study's aim was to evaluate the risk of the Surface Interval decompression procedures with the aid of a large animal model. Surface Interval Decompression Techniques are an emergency procedure used when rescue operations cannot be carried out using the authorized Transfer Under Pressure (TUP) technique. There have been no known experimental tests on these procedures, and their risks are uncertain. The sheep model of the submariner was applied according to the US Navy Submarine Rescue System (SRS) Decompression Plan to test the Surface Interval Decompression Tables).

Materials and Methods
Twenty-eight Suffolk sheep (92.15±0.88 kg) were compressed to 60 or 70 fsw for 24 hours. The Breathing gases within the chamber were a mixture of oxygen (O2) maintained at 21% and CO2 < 0.05% surface equivalent. After 24 hours, the animals at 70 fsw experienced a decompression of 2 fsw/min to 60 fsw. At that depth all animals received the oxygen pre-breathing (OPB) protocol of 90% oxygen for 90 min. After completion of OPB protocol animals were exposed to a decompression of 30 fsw/min until surfacing. Physical examination and precordial ultrasound bubble detection were performed by an observer who entered the chamber, and clinical signs of DCS for the desired Surface Interval period of 30 or 60 min were recorded. Animals were euthanized at 6 weeks and long bones were examined for dysbaric osteonecrosis.

Results
All 24 treatment animals survived the drop out decompression until euthanasia after being exposed to the air for 24 h at 60 fsw (2.82 ATA) and 70 fsw (3.15 ATA) with 90-min OPB during 30-min and 60-min surface intervals, respectively. None of the 4 controls survived drop out decompression.

Summary / Conclusions
These findings show the protocol described in this study for surface interval decompression appears to be both safe and potentially useful in emergency submarine rescue operations.

Keywords
Disabled submarine, surface interval decompression, sheep model

O-57

ENDOTHELIAL INJURY IN DIVING: ATOMIC FORCE-, ELECTRONIC- AND LIGHT-MICROSCOPY STUDY OF OVINE DECOMPRESSED BLOOD VESSELS

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Introduction
We suggested that nanobubbles which appear at the active hydrophobic spots (AHS) at luminal aspect of blood vessels, are the gas micronuclei from which decompression bubbles evolve, and the endothelial injury during decompression is due to the tearing off cell membranes with the detaching bubbles.

Methods
Ovine blood vessels were stretched over polycarbonate plates or glass microscopic slides and were exposed under saline to hyperbaric pressure (1013 kPa, 19 h). Following decompression the blood vessels were photographed for identification (by bubble formation) of the AHS.

Results
Nanobubbles could not be demonstrated at the AHS, using atomic force microscopy (AFM) because of the roughness of the surface which disabled close contact of the probe. In the electron microscopy, no endothelial cells were observed in samples from the area near the AHS, but the underlying elastin layer of the intima adjacent to the media. Some intact endothelial cells were observed only in locations far from an AHS. In the optical microscopy, no endothelial cells were observed in blood vessels in close proximity to the AHS and in some sections, debris or a detached cluster of endothelial cells were observed. Intact endothelial cells could be found at sites distant from an AHS.

Conclusions
The present study supports our assumption, where detached bubbles tear off endothelial cells and cause the initial endothelial injury following decompression.

O-58

IMMERSION PULMONARY EDEMA IN TROPICAL WATERS – A SYSTEMATIC REVIEW

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Background
Immersion Pulmonary Edema (IPE) is a noncardiogenic form of acute pulmonary edema. When recognised early and treated appropriately, prognosis is good. However, delays in treatment often lead to rapid clinical deterioration. The majority of existing literature on IPE have reported its occurrence mainly in cold waters. Recent studies and reports have suggested multi-factorial contributions to the pathophysiology of IPE, such as cardiopulmonary co-morbidities and a physiological propensity to develop IPE in otherwise healthy individuals. Increasing incidence of cases have also reported the occurrence of IPE in tropical waters, which the authors postulate may be under-diagnosed. They have thus attempted to elucidate and establish any causal relationship between water temperature and the development of IPE, along with other possible risk factors.

Methods
A systematic review of studies on IPE, using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), was conducted to investigate the relationship between water temperature and the occurrence of IPE. A literature search in PUBMED, OVID, Cochrane, Scopus, and Google Scholar was performed using the key words "swimming pulmonary edema", "immersion pulmonary edema" and "IPE". The titles and abstracts were screened for relevance to IPE. Studies where water temperature was not considered, were excluded. Only English Language publications were included.

Results and Discussion
For the purposes of this study, tropical water temperature was defined as >22°C, and "cold water" as <22°C. Characteristics of IPE cases were compared between those exposed to water temperatures above and below 22°C. 10 studies were included in the review. Although reports of IPE in tropical waters were limited, the review suggested that other factors such as physical exertion, immersion and high circulating volume may be more important contributors to the development of IPE due to increased pulmonary vascular pressure. Several individuals appeared to have an increased propensity for developing IPE, some with recurrent episodes. While most of these studies were of Level 4 and 5 evidence, the review highlighted that IPE can occur in tropical waters. Lack of awareness may have contributed to the under-diagnosis of IPE in warmer waters by clinicians who do not manage these conditions regularly.

Conclusions
IPE can occur in tropical waters. Efforts to raise awareness amongst first-responders and Emergency physicians could enable earlier intervention and better outcomes.

O-59

HYMON: A NEW, INNOVATIVE, INTERACTIVE ONLINE EDUCATIONAL PLATFORM FOR EDUCATION OF HYPERBARIC MEDICINE

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Background
The first multi-place hyperbaric chamber was built in 1965 in former Czechoslovakia. Currently, there are 9 multi-place chambers in Czechia and 7 in Slovakia. Despite the similar heritage in hyperbaric medicine in both countries, the situation differs nowadays. While hyperbaric medicine (HM) is recognized as post gradual specialization in the form of a functional course in Czechia, HM is not recognized as a medical specialization in Slovakia. The HM is taught at various levels to the medical student in Czechia, being included in other relevant subjects, such as internal medicine, sports medicine, or medical biophysics up to a self-standing semestral subject at the University of Ostrava. On the contrary, there is no formal education in this field, neither pre-gradual nor post-gradual in Slovakia as in allied health care and in medical professions. In addition, the pandemic lockdowns further restricted access for allied health professions, medical students, and physicians to the HM courses.

Objective
A Czech and Slovak INTERREG-funded project aims to create an online educational platform for medical and allied health students for hyperbaric medicine (HYMON).

Methods and future prospects
To achieve our objective, the leading experts from both countries have been onboarded. The project duration is between September 2021 and April 2023. The main hallmarks of the HYMON platform will be modularity and versatility, automation, full remote capability, innovativeness, interactivity, and excellence. After the development and testing, the HYMON platform will be accessible also to other local and international stakeholders and universities, since the platform and educational materials will be available in Czech, Slovak and English.

P-01

DIFFERENTIAL DIAGNOSIS BETWEEN STROKE AND NEUROLOGICAL DECOMPRESSION SICKNESS

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Introduction
Scuba diving is a provider of specific accidents. However, authentic stroke is described after diving. Therapeutic recompression of a decompression sickness can delay the management of stroke. The objective was to define the orientation criteria between a stroke and a decompression sickness after diving.

Methods
The study was retrospective observational by collecting data from medical records. The hyperbaric chamber of Toulon Military Hospital received 63 cases of cerebral decompression accidents and 6 cases of post-dive stroke between 2011/01/01 and 2016/12/31. For the comparative study, 114 no diver strokes, without contraindication to diving, admitted to the emergency unit over the same period were selected. Data collected included biographical data, cardiovascular risk factors, clinic and dive related parameters.

Results
The criteria for stroke are ($p<0.05$): the presence of a cardiovascular risk factor ; an age over 50 years ; motor signs, facial involvement, phasic disorders, visual disturbances, systematization of signs, objective signs and headaches ; finally, the absence of favorable evolution under oxygen. Sensory signs and bilateral neurological signs favor a decompression sickness ($p <0.05$).

Conclusion
Not every neurological sign after diving is a diving accident. A magnetic resonance imaging (MRI) should be performed if there is a sign pointing to a stroke, although this may delay therapeutic recompression. A study to determine the role of diving in the genesis of thrombotic events would be interesting.

P-02

DATALOGGER FOR ASSESSMENT OF PHYSIOLOGICAL PARAMETERS OF DIVERS

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Introduction
Several devices have been designed to assess physiological parameters of divers. Many times, COTS medical laboratory instrumentation is therefore used in ad-hoc waterproof housings, resulting in cumbersome devices, which may disturb the diver. This is especially a problem for example during breath--hold diving competitions. Alternatively, small holter monitors were designed especially for diving applications, but those ones did not have a screen showing real-time signals from the sensor, which made correct sensor placement and testing difficult.

Methods
A new miniaturized instrument was developed to record a variety of parameters, including plethysmogram (and SO2), breathing movements, RR-interval, temperature, pressure, and optionally also up to 12 lead ECG. Further, a BT 5.0 interface was included as well. An Android app was designed, which allows real-time monitoring of the signals as well as streaming of those to a large screen. A USB interface is used to download measurement data and to charge the Li-Ion Battery.

Results
In total 5 devices were assembled. The overall size of a device is 55x38x18mm? and the depth limit is 300m. The housings were 3D printed with ABS-like resin. The electronics were encapsulated in silicone gel.

Conclusion
The devices are very small and, when mounted directly on a COTS heart rate strap, can be worn under a diving suit. In this position, they are not disturbing the diver. Even though the instrument is then under the suit, thanks to the integrated BT 5.0 interface, all the signals can be checked on an Android phone in real-time making pre-dive preparations simpler and more efficient.

Acknowledgements
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P-03

DEEP REBREATHER DIVE RESULTS IN HIGH-GRADE VENOUS GAS EMBOLI ARTERIALIZATION WITHOUT CLINICAL DECOMPRESSION SICKNESS SYMPTOMS

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Introduction
Following a rebreather dive to a maximum depth of 115 msw with a total dive time of 250 minutes, a middle-aged, male diver presented with high-grade bubble scores (5 and 3 for right and left heart respectively, using the Eftedal-Brubakk scale) but no DCS symptoms within 24 hours. The diver had prior history of being treated for cerebral decompression sickness (DCS) and had subsequently undergone surgery for a patent foramen ovale (PFO) closure.

Methods
As part of a larger observational study across multiple diving days, the following was collected in addition to the dive profile on this dive day: transthoracic echocardiography (TTE) videos, heart rate (HR), and oxygen saturation (SpO2) post-dive at intervals spanning 80 to 180 minutes. Urine specific gravity (USG) and osmolality, neurocognitive performance tests via an iPad-based, validated test battery, and subjective fatigue level via a visual analogue scale were collected between 90-120 minutes post-dive.

Results
TTE revealed venous and arterial gas emboli post-dive at different time points. Urine osmolality post-dive was higher (1060 Osm/kg H2O) on the day of the arterialization than both post-dive measurements recorded on previous days (700 and 870 Osm/kg H2O). HR was found to be slightly increased at the 100, 120, and 140-minute time points compared to previous dive days with comparable dive exposure. The diver's subjective post-dive fatigue was increased compared to previous days. Neurocognitive performance did not appear to be adversely affected, when compared to previous results.

Discussion
We present a case in which grade three arterialization was present without clinical DCS symptoms. The case is of further interest due to the diver's previous DCS and PFO repair since it suggests recurrence of a right-to-left shunting mechanism.

P-04

DAN LOOKS AT FITNESS TO DIVE AND VACCINATION RESULTS IN AMERICAN AND NON-AMERICAN DIVERS

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Introduction / Background
COVID-19 is an infection caused by SARS-CoV-2. To look at impacts on infected divers, Divers Alert Network created the five-year Diver Return After COVID-19 (DRACO) study. Standard and post-COVID return to diving protocols vary per country, playing a role in divers' decisions to see a dive physician for a formal fitness to dive examination and be proactive in preventing further COVID-19 infections by receiving a COVID-19 vaccination. From the first two years of data, we will discuss preliminary return to diving and vaccination results in American and non-American participants.

Materials and Methods
DRACO is an observational, survey-based study housed on Momentive™ (SurveyMonkey). Participants enrolled in DRACO by completing an initial survey covering details of their medical history, infection, current return to diving status, and fitness to dive exam. Participants also receive follow up surveys that ask for updated return to dive and fitness to dive information and vaccination results.

Results
From the 911 American or Canadian ("American") divers (71%) and 378 non-American divers (29%) enrolled in DRACO, 29% in each group indicated they had a fit to dive examination. 28 American divers (11%) indicated they had not been medically cleared to return to dive, whereas 18 non-American divers (17%) indicated they were not medically cleared for diving. 606 American divers and 239 non-American divers indicated they had returned to diving. Of those 845 divers, 13% reported issues.
494 divers completed the 1-year questionnaire. From this cohort, 90% of Americans and 97% non-Americans indicated they had received the COVID-19 vaccine. Infection severity between American and non--American participants was comparable, with 52 American (6%) and 29 European (8%) divers reporting asymptomatic infection, 802 Americans (88%) and 317 non-Americans (84%) reporting a mild infection, 42 Americans (5%) and 26 non-Americans (7%) reporting a moderate infection, and 1% in either group reporting a severe infection.

Discussion / Conclusions
Our findings indicate that vaccination rate is higher in the non-American part of the study cohort, but that more Americans were cleared to dive during their fitness to dive exam after infection, while all other parameters seem comparable between American and non-American participants. The need of a fitness to dive examination to evaluate potential residual symptoms of COVID-19 needs reinforcing in the diving community.

P-05

THE CRITICAL FLICKER FUSION FREQUENCY: HOW RELIABLE?

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Introduction
The critical flicker fusion frequency (cFFF) is defined as the frequency at which an intermittent light stimulus appears to be completely steady to the average observer. CFFF has already been used in diving and hyperbaric medicine.
So far, an increase in cFFF is considered to represent brain activation while a decrease was considered evidence for N2-induced narcosis. Yet, the onset and severity of N2-narcosis depends much on factors as pCO2, cold, fatigue, stress, anxiety and others. Because of this and because of some conflicting results, future research with the use of cFFF is needed for better understanding its utility and application.

Aim / Objectives
We sought to provide additional cFFF data from dry dives.

Methods
Two groups of nine experienced divers of the fire department underwent a training dive to 6 bar in a hyperbaric chamber. The cFFF was determined with a manual flicker device outside the chamber, within the chamber at 1 bar, at 6 bar, at 1,3 bar, and at 1 bar.

Results
Normobaric CFFF inside the chamber was increased vs outside, if measured through the glass of the bull's eye in the chamber door (43.5 vs 48.6 Hz; n=18). CFFF was decreased from 6 bar to the 1.3 bar decompression stop (47.4 vs 45.0 Hz). The normobaric cFFF at the end of the session was decreased vs the onset of the session (45.8 vs 48.6 Hz). At 6 bar, cFFF decreased in parallel with the consecutive measurements ($r = -0.578$).

Discussion
The cFFF change due to the thick glass bull's eye calls attention to a problem with reporting 'true' data, once different media are involved as e.g. with water, glass, and air while recreational / professional diving. The decreased cFFF during decompression is in contrast with a former study and might be explained with the time of measurement (at 6 bar vs during decompression). It is not of surprise that the cFFF decreased during the 5-min exposure to 6 bar depending on the consecutive number of the volunteers, i.e. with their time of exposure. As we needed roughly 30 s for one single measurement, almost 5 min had passed between volunteer '1' and '9'.

Conclusions
(1) Absolute cFFF values of studies will differ in case different optical media are employed.
(2) Changes in cFFF will become apparent or not depending on the time point of the measurement, e.g. during or after the hyperbaric exposure.
(3) Usage of only one flicker device for measurements at several volunteers presents a problem in terms of exposure time

P-06

ASSESSING CRITICAL FLICKER FREQUENCY: WHICH CONFOUNDERS?

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Introduction
Critical flicker fusion frequency (cFFF) is defined as the frequency at which a flickering light cannot be distinguished from a steady, non-flickering light. Thus, cFFF permits the assessment of temporal characteristics of the visual system. Because of this, cFFF has also been used to assess effects of hyperbaric gas mixtures, e.g. as used while diving.

Aim
We wanted to present some confounders that might explain the sometimes conflicting and even paradoxical results of former studies.

Methods
Using a manual flicker device (Scaleo, Esslingen, DE; one LED: 8,000 K), we performed three protocols in eye-healthy volunteers:
1. In one and the same male adult, flicker frequency (FF) was assessed on 70 consecutive days by randomly decreasing or increasing FF; always in the morning and at artificial light or daylight (sunny or clouds).
2. On 28 recreational divers, cFFF was assessed during control (both increasing and decreasing frequencies) and after 5-min breathing of normobaric oxygen.
3. In 112 recreational divers, cFFF and demographic data were assessed.
Results
Ad 1): Up- and down changing the frequency resulted in significant differences (43.5 vs 41.5 Hz), while the three lighting conditions did not.
Ad 2. Again, cFFF during control differed signi¬ficantly between up- and down frequency changes (37.4 vs 35.2 Hz). After O2-breathing, only a similar tendency was seen (37.3 vs 36.2 Hz), while no differences were found between air- and O2 breathing.
Ad 3. There were no significant gender- or BMI-dependent cFFF differences. Yet, cFFF decreased over age ($r = -0.28$; $p < 0.003$), i.e. cFFF in volunteers in the 8th decade was decreased vs in volunteers in the 4th decade of life.

Conclusion
Our protocols shed some more light on special features of cFFF measurements.
Ad 1: Lighting conditions during the measurements -as long as on surround light levels- seem not to play a major role. However, the order of changing the frequency matters in agreement with the perceptual constancy. On the other hand, if the frequency is decreased within a protocol, the term 'fusion' should be avoided but replaced by e.g. 'separation'.
Ad 2: The effect of oxygen on neuronal excitability had been described to be dose-dependent: 0.7 bar O2 had no effect while 1.4 bar impaired cFFF. Our results confirm that normobaric O2 does not affect cFFF, i.e. neuronal excitability.
Ad 3: Expectedly, gender or BMI did not affect the cFFF but age did. Therefore, different cFFF standard values will apply for different age groups.

P-07

AN ECHO FROM THE PAST: BUILDING A DOPPLER REPOSITORY FOR BIG DATA IN DIVING RESEARCH

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Background
Decompression sickness (DCS) remains a major concern for commercial and recreational diving. Venous gas emboli (VGE) detected with ultrasound post-dive are often used as a marker of decompression stress. Being non-invasive, portable, and non-ionizing, ultrasound (Doppler and echocardiography) is suited to regular monitoring and can help elucidate inter- and intra-subject variability in VGE, and DCS susceptibility. However, analyzing these recordings remains a cumbersome task.
Materials and Methods
The development of machine learning algorithms requires well-curated data sets for training, testing and validation. Large amounts of data are key to produce reliable, high-performance algorithms; thus, research collaborations are important to reach the necessary quality and data number thresholds. The field of diving medicine has amassed Doppler recordings from past studies that could be congregated and annotated. In line with other 'big data' projects, we are collecting de-identified Doppler data for publication in an accessible repository with ethical standards upheld by current review boards. The UHMS has offered to host a future repository.

Results
The second data set collected has 697+ individual Doppler recordings from 24 individuals. Dives were made to 100 ft (~30 m) n=70, 120 ft (~36.5 m) n=97, 180 ft (~55 m) n=123, and 59 ft (18 m) n=1.
Summary
This collaboration will include contributions from Duke University, DAN, DRDC Canada, and QinetiQ UK plus others to be confirmed; we would welcome additional collaborations to strengthen the value of this tool.
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P-08

ARTERIAL GAS EMBOLISM ASSOCIATED WITH ATYPICAL DIVE PROFILE

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Introduction
Although diving accidents are very rare at the rate of 1-3/10,000 dives, arterial gas embolism is seen at less than 1/100,000.

Case report
A forty-nine-years-old professional diver made a diving with a hood in order to hunt for sea cucumber, 15 meters. The patient has no features than smoking before diving. There is heavy exercise during the dive and the water temperature is 12°C. While diving at 15 meters, started feeling numbness in arms and legs in about 35 minutes. At the same time, he felt a faulty chest pain on his left side and came to the surface. There is no history of rapid ascent.
Upon arrival, cerebellar tests are normal, neurological examination was normal, Romberg (-), there is a feeling of tingling in the fingers in the distal of the left foot. Brain computed tomography and high resolution thoracic computed tomography (HRCT) was performed to exclude pneumothorax. He was treated with the diagnosis of arterial gas embolism by intravenous fluid and urinary catheter. US Navy Treatment Table 6 was started. Treatment was continued in the patient whose numbness disappeared completely at the 10th minute of the treatment. In the patient whose findings disappeared completely at the exit, thoracic HRCT showed small areas of paraseptal emphysema in both lung apexes, subpleurally located, with the largest diameter measuring 1 cm. He was discharged by suggesting not to dive.

Discussion
Arterial gas embolism, which is the most severe form of pulmonary barotrauma output, can rarely coming to the surface when it reaches the surface or within the first 10 minutes. Questioning the dive profile distinguishes it from type II decompression sickness. In cases who have had lung barotrauma without a history such as rapid exiting and breathing in the dive profile, it should be recommended not to dive because of the high probability of recurrence.

P-09

DO O2-STRESS-ADAPTED HUMAN CELLS SHOW DIFFERENT CELL EFFECTS AFTER EXPOSURE TO INDIRECT IONIZING RADIATION (UV-A)?

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Background
It is scientific consensus that humans can physiologically adapt to low doses of ionizing radiation as well as to repetitive exposures to hyperbaric oxygen by biochemical regulatory mechanisms. In case of hyperoxia cellular adaptation is realized via a number of biochemical reaction patterns, e.g. through upregulation of SOD and catalase, and increase in DNA repair. This is discussed to be similar in adaptation to indirect ionizing radiation like UV-A.
Therefore, the question arises whether human cells, which are already adapted to hyperoxia also show lower levels of DNA-damage, when they are exposed to the fundamentally different stimulus of UV-A radiation.

Methods
Blood from soldiers who had completed approximately 85 dives during three months of training on oxygen circuit diving equipment was used for the experiments. Peripheral blood mononuclear cells (PBMC), isolated from diver´s blood, were subsequently exposed to a UV-A radiator for 10-100 minutes (365nm, 0.074mW/cm2). Samples were taken at 10-minute intervals and the number of DNA-damaged PBMCs was subsequently determined with an alkaline comet assay in 200 cells per subject. PBMCs from subjects who had never been exposed to any hyperbaric and hyperoxic stress served as control group.

Results
The UV-A irradiation experiments showed that the result-curves of the percentage of DNA-damaged cells follow a sigmoidal function in both, the repetitively hyperoxia-exposed subjects as well as the control group. However, the PBMCs from oxygen divers, which were exposed to UV-A radiation between 40 and 70 minutes duration showed significantly (*) less DNA-damages compared to controls.

Conclusion
The presented results show that the adaptive processes, which are induced by repetitive hyperoxic stress also seem to protect to a certain extent against DNA-damaging effects of indirect ionizing radiation. These data demonstrate for the first time that adaptive cellular protection against recurrent hyperoxia appears to be a very basic cellular protective response, which is also effective against similar noxes.

P-10

BREATH-HOLD DIVING AND MECHANISMS OF HYPOXEMIA

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Background
Pulmonary gas exchange in breath hold diving (BDH) consists of a progressive increase in PaO2 and PaCO2 during descent. At depth, PaCO2 rises while PO2 falls due to metabolic consumption. However, recent findings have demonstrated that PaCO2 at maximum depth is highly variable and PaO2 does not consistently rise in all subjects.

Methods
1: To measure arterial blood gas analyses immediately before, at depth, and immediately after a breath--hold dive.
2: To investigate development of lung interstitial edema and atelectasis at depth and after a breath--hold dive with lung ultrasound
3: To study changes in inflammatory patterns, platelets activation, and microbubbles formation after dives at different depths.
4: Assessment of cerebral perfusion and oxygenation through NIRS.

Results
After obtaining university ethics committee approval, 14 well-fit breath-hold divers were included.
1: In 5 subjects (-15 msw) and 4 subjects (-42 msw) the PaO2 at depth decreased instead of increasing; overall, PaCO2 or lactate showed slight variations.
2: At depth, no alterations were seen in lung US except one subject showing focal B-lines. After the dive, four subjects developed signs of basal interstitial edema, and two subjects demonstrated signs of focal lung atelectasis.
3: No statistically significant difference was found in the investigated biomarkers.
4: SpO2 and cerebral blood oxygen saturation remained high during descent and at the bottom, but declined during ascent, similarly between 15 and 42 msw, with greater changes in deeper dives.
Conclusions
Current experiments confirmed that some BH divers can experience hypoxemia at depth. The hypothesized explanation for such a discrepancy is lung atelectasis. No signs of DCS have been reported.

P-11

NORMOBARIC OXYGEN BREATHING DIRECTLY AFTER ASCENT REDUCES OCCURRENCE OF VENOUS GAS EMBOLI

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Background
Normobaric oxygen (NBO) breathing after diving has been used to diminish the risk of decompression sickness and reduce the need for surface interval between dives. However, there are only a few reports on the effects of NBO on venous gas emboli (VGE) prevalence.

Methods
16 Navy divers carried out two air dives each to 42 m with 10 min exposure time in a pressure chamber fitted with a Lanphier-Morin barrier. After one dive the diver was given NBO on mask immediately after ascent, and in the other air (Control). Mask breathing continued for 30 minutes. Ultrasound Doppler recordings of the right heart were carried out every 5 minutes during rest and after three leg kicks (flex) for the first 30 min after ascent and then every 15 minutes until 120 minutes had elapsed. The tests were carried out in a double-blinded fashion. VGE were scored using the Kisman-Masurel (KM) code.

Results
Three of the divers had no VGE in any of the dives and were excluded from statistical testing. For the remaining 13 divers median maximum KM grades for the Control dives were III- at rest, and III after knee flexes. The median maximum KM grades for the NBO were 0 at rest, 0 after knee flexes ($p<0.01$ for both rest and flex). After the NBO period VGE could only be found in two of the divers. In contrast after 30 min mask-breathing air the Control dive 11 of the 13 divers had bubbles present in the central venous circulation ($p<0.01$).

Conclusions
Normobaric oxygen directly after ascent significantly reduced the decompression stress as evidenced by reduced presence of VGE. The effect of time between ascent and start of NBO as well as the length of the dive and the duration of NBO breathing needs to be investigated.

P-12

NOVEL SENSOR FOR ASSESSMENT OF INVOLUNTARY BREATHING MOVEMENTS (RESPIRATORY CONTRACTIONS) DURING BREATH-HOLD DIVING

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Introduction
Breath-hold diving is an underwater sport that eventually leads to hypoxia, and if the diver does not return to the surface in time, he/she will succumb to hypoxic blackout (BO), and without assistance risk drowning. The main physiological warning to the diver that it is time to resume breathing, is the sensation of an urge to breathe that arises some time into the dive. The associated involuntary breathing movements (IBM) occur during the so-called "struggle phase". Those are also often referred to as "contractions", as they are caused by involuntary contractions of the diaphragm and inspiratory muscles. IBMs arise mainly due to the rising PCO2 during apnea and are influenced to a lesser extent by hypoxia and detecting them early could help predict diving breaking points.
Like breathing, IBM cause temporary changes in the circumference of the chest. A common method in laboratories is to measure IBM based on a pneumatic respiratory bellow located at the chest (Andersson & Schagatay, 1998; Palada et al., 2008; Dujic et al., 2009). Unfortunately, this method only works on the surface, as the air in the pneumatic respiratory bellow gets compressed at depth.

Methods
Our approach is based on measuring the tension transferred from an elastic band (of a COTS heart rate strap; Polar) worn around the chest to a U-shaped metallic buckle. A special buckle from stainless steel was designed, with integrated high-resolution micro strain gauges allowing the measurement of tiny forces pulling on the buckle. To achieve waterproofness, the complete buckle, including the strain gauges, was conformally coated with a rubber compound.

Results
The noise-free resolution turned out to be 1mN at a sampling rate of 50Hz, which is about 5 times better than that of the previously used pneumatic breathing belt. This allows very detailed IBM recordings where signals from the heartbeat are very clear, and the onset of IBM is clearly detectable, as seen in this recording from a static apnea. As the measurements are not influenced by ambient pressure, this sensor can also be used for recordings at depth.

Discussion
Detecting the small, initial IBM signals could be important to better understand the breaking points of apnea and be a base for developing a warning system alerting the diver when it is time to surface.

Acknowledgments
This work was supported with funding from the Francis family in memory of their son/brother, who drowned from hypoxic blackout

P-13

OPEN EXHAUST FAILURE AFFECTING DAMAGED OR CONTAMINATED AVOX PRESSUR-VAK BIBS

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Background
The Avox Pressur-Vak II Built in Breathing Systems (BIBS) is a proprietary oxygen demand regulator and oro-nasal mask combined with an overboard dump regulator, designed for use in divers' decompression chambers. It has been widely used over many decades, and in some cases, is used for patients receiving hyperbaric oxygen treatment. It has a reputation for being reliable, easy to clean and maintain, and tolerant of less than ideal maintenance. There have been, however, some limited and anecdotal reports of sudden onset exhaust failure creating "near miss" negative pressure events for users.
Two events occurred in Australia in 2017 and 2018, one leading to death of a patient in a private paramedical clinic. This event led to examinations and testing to determine potential failure modes of this type of equipment. It was noted that other brands of BIBS incorporate negative pressure relief valves.

Methods
The Alfred Hyperbaric Service conducted an examination of a failed regulator on behalf of government authorities. This led to subsequent testing of undamaged sample regulators aiming to identify potential failure mechanisms.

Results
We determined that if there is a small exhaust leak due to corrosion or foreign material in the exhaust valve seat, a sudden deep inhalation can lead to the exhaust diaphragm being stretched into the body of the exhaust regulator in such a way that it impinges upon the lever arm mechanism, opening the exhaust valve fully and keeping it open until the patient mask is removed, an exhaust valve is closed or the chamber is decompressed. This situation can more easily occur if oxygen supply flow or pressure is less than specified by the manufacturer. The differential pressure to which users are exposed in such situations can be close to the full pressure difference between inside and outside the chamber. Regulators that have experienced such an open exhaust failure at 0.7 bar chamber pressure or higher can function normally subsequently, but exhibit a characteristic deformation of the metal disc at the centre of the exhaust diaphragm.

Conclusions
Users of this equipment must follow manufacturer's guidelines for installation, cleaning and testing of BIBS. Divers using this equipment should be kept aware of how to remove a mask under suction. We believe that impaired or untrained persons should not use this equipment inside chamber unless accompanied by a trained attendant.

P-14

HOW TO SURVIVE 33 MIN AFTER THE UMBILICAL OF A SATURATION DIVER SEVERED AT A DEPTH OF 90MSW? – A DETAILED CASE REPORT

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Case Report
In 2012, a severe accident happened during a mission of a professional saturation diver working at 90m on the North Sea bottom. The dynamic positioning system of the diver support vessel crashed, and it drifted away from the working place, while one diver's umbilical became snagged on a steel platform and was severed. After 33min, he was rescued into the diving bell, without exhibiting any obvious neurological injury. In 2019, the media and a later 'documentary' film suggest that a miracle had happened to permit survival of the diver, once his breathing gas supply was limited to only 5min.
Based on the existing data and phone calls with the diver concerned (D), the present case report tries to reconstruct, how D could have survived after he was cut off from breathing gas, hot water, light and communication at a depth of 90m.
D carried bail-out heliox (86/14) within two bottles (2•12•300bar: 7.200L).
Carefully calculating D's varying per-minute breathing gas consumption over time and considering both the decreased viscosity of the helium mix and the pressure-related increase in viscosity did not exhibit a breathing gas gap. Based on the considerable respiratory heat loss, the core temperature was calculated to be down to either 28.8°C or 27.2°C after recovery in the diving bell. In accordance with the literature, these values would be associated with impaired or lost consciousness, respectively.
Relocating D on the drilling template by using a remotely operated vehicle (ROV), the transport of the victim to the bell, and the subsequent care in the hyperbaric chamber must be regarded as exemplary.

Conclusion
(1) D's healthy survival is not a miracle, as it can be convincingly explained by means of reliable data. Remaining with a breathing gas supply sufficient for 5min only, would have ended in death by suffocation.
(2) Highly effective measures in occupational safety, in particular the considerable bail-out heliox reserve, secured the healthy survival. On the other hand, the victim's survival is likely owing to his excellent diving training together with many years of diving routine. Also, the rescue action of the second diver and D's retrieval by the ROV operator is suggestive for carefully selected crew members with a high degree of professional qualification needed to correctly operate in a hostile environment.

P-15

THEO MAVROSTOMOS BEFORE THE RECORD DIVE: I CAN DO THIS! 30 YEARS ANNIVERSARY OF AN ONSHORE DIVE TO 701 M.

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Biography
It is now almost exactly 30 years ago that Theo Mavrostomos settled his 701-m onshore world record that holds to this day. He was at the age of 39 years, when he became the deepest man in the world. Being always familiar with water, Theo found himself brushing hulls of boats in the harbor of Marseille, at the begin of his life as a professional diver.
With an advert, COMEX (France) was looking for candidates to undergo a training to become deep sea divers. After practical and theoretical tests, Theo belonged to 10 of 30 elected. After 3-month training at the French National Institute of Professional Divers (INPP), he left for 6 months in the North Sea. His career as a hyperbaric chamber diver began as a substitute of a team of 3 experienced saturation divers. During that time, Theo spent more than 2,000 days in the hyperbaric chamber. Also, he became member of a world record team that performed manual welding at a water depth of 300 m.
COMEX wanted to break a record of 686 m that was held by divers from Duke University (NC, US). They breathed the conventional heliox with difficulty and suffered trembling and memory lapses. Hydreliox, a mixture of O2, He and H2, had been designed to reduce effects of the high-pressure nervous syndrome. With the project Hydra 10, COMEX planned dives down to 700 m (71 bar) by using hydreliox. In a first attempt, three divers reached 500 m. There, 2 divers gave in, because they were mentally exhausted and afraid for their lives. After intense discussions, Theo convinced the project leader to dive alone: I can do this. In fact, he arrived at 701 m and stayed there for 3 h, to perform exercises for science.

Record dive
The entire dive lasted 42 days starting with a 2-days confinement at 10 m (heliox). During 13 days, the pressure was increased to 675 m using heliox and later hydreliox (max. pH2=20 bar). The entire bottom stage lasted 3 days, containing a 3 h stage at 701 m. So far, the pO2 was maintained at 0.4 bar, i.e. amounted to 0.7% (H2: 49%; He 50%) at 701 m. The decompression lasted 24 days using hydreliox up to 280 m and heliox up to 0 m. PO2 was 0.5 bar up to 120 m, 0.6 bar up to 15 m, and nitrox24 was used until surfacing.
Today, Theo trains the professional divers of tomorrow at the INPP, i.e. the entire project had apparently left no major sequelae. Congratulations!

P-16

SWEDISH SCUBA-DIVERS' OPINIONS ON THE DIVING MEDICAL EXAMINATION

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Introduction
Diving medical examination (med-ex) aims to uncover potential health hazards that may complicate a dive. Many of these abnormalities are age-related. Med-ex is a standardised safety measure for commercial divers in Sweden, but it remains optional in recreational diving. There are different interpretations about med-ex procedures, making many divers question it's validity. This study aims to investigate opinions from swedish scuba-divers on med-ex and to reveal differences between various divers' categories.

Methods
A questionnaire was available online to members of a scandinavian diving website between September--October 2019, including scuba-divers that have resided in Sweden. The initial block of questions explored demographics, diving profile and experience. The 4 main question blocks were about the med-ex (target group, content, physician's competence and frequence). The final block asked about actual habits towards the med-ex. Answers were anonymous and blinded. Results were analysed with the PSPP statistical program using Pearson x2 test for non numeral variables using $p<0.05$ to define statistically significant differences between the various groups

Results
A total of 127 answers were included in findings. Participants were mainly male (109), aged between 31-50, with >100 dives (97). Responders suggested med-ex to be conducted "routinely, not annually" (58) or "if necessary" (50), to include "Health declaration" (108) and "clinical examination" (92), to be applied for "All divers" (73) or "Divers with a known disease" (51) and finally to be conducted by physicians "Certified in diving medicine" (89), "Hyperbaric Specialists" (50) or "Licenced" (46). Significant variations were found in the "total dive years" categories about the content category "clinical examination" ($p=0.042$) and the choice of "General Practitioner" ($p=0.029$). Also between the "total dives" category and the target group "Trainee divers" ($p=0.022$). Participants stated they had attended med-ex "1-5 times" (87), "never" (24), ">5 times" (12) or "annually" (4).

Conclusions
This survey showed that the majority of participants were positive for med-ex, with most of the answers being in preference of a regular or annual clinical examination. Despite the low percentage that undergo med-ex regularly, this result indicates an awareness of med-ex importance for diving safety.

P-17

MEDICAL CONSULTATIONS OF THE SWEDISH SPORTSDIVING FEDERATION DURING 2020-2021

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Introduction / Background
One of the benefits offered to members of the Swedish Sportsdiving Federation (SSDF) is free access to the Federation Physician for non-emergency questions related to diving medicine. This service started in 1995, hitting a peak of 350 consultations in 2005. Consultations are conducted by e-mail or telephone and may lead to multiple communications. This study presents data on this consultation service during the covid-19 pandemic years 2020-2021.

Methods / Materials
The SSDF's medical consultation register for 2020-2021 is analysed. Questions are categorised according to their related medical areas. Unidentified data is presented in tables and diagrams, using Excel statistics. The data is presented regarding monthly distribution, means of communication, and type of contact person.

Results
A total of 142 consultations was registered in 2020 and 101 in 2021. The largest category for 2020 is "Covid-19" (20), followed by "ENT" (19) and "Circulation" (16). For 2021 "Circulation" and "DCS" (15) shared first place, with "ENT" (12) at second place and "Covid-19" (11) at third. "Psychiatrics" appears in 2021 as a new category.
The majority of the consultations for 2020+2021 was conducted by e-mail (113+75), with significantly fewer occuring via telephone (22+25). Most contacts came directly from interested divers (91+74), but a number of questions were received from instructors (22+7), parents/relatives (11+5) and physicians (18+15).

Discussion / Conclusions
The medical, non-emergency consultation appears to be an appreciated service of the SSDF. "Covid-19" was a new category in 2020, beginning in March. The peaks in June 2020 and May 2021 follow the pandemic statistics in Sweden and may reflect its impact on diving. The decrease of covid-related questions appears to follow the publication and updating of guidelines by SSDF. E-mail appears to be the most convenient means of communication for non-emergency issues. The large number of physicians asking for a professional opinion indicates confidence in SSDF's medical advisory service and strengthens the connection between divers and the medicine of the diving field.

P-18

INDIVIDUAL FACTORS OF DECOMPRESSION STRESS IN SPORTS SCUBA DIVERS AND ITS ESTIMATION AND SELF-DETECTION FOR IMPROVED DIVING SAFETY

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Background
Inert gas bubbles frequently occur after SCUBA diving, potentially leading to decompression accidents. Established desaturation regimens like decompression tables or dive computers can not fully prevent diving accidents due to a vast impact of individual factors.

Methods
In 682 pre- and post-dive measurements, we assessed echocardiographically derived bubble grades, dives profiles, fluid loss and a wide range of individual factors. Further, the divers did a self-assessment via Audio-Doppler bubble grading after they received a standardized theoretical and practical training.

Results
Post-dive cardiac bubbles were seen in 47% of all dives and Eftedal-Brubakk bubble grades were significantly correlated with depth (r = 0.46) > air consumption (r = 0.41) > age (r = 0.25) > dive time (r = 0.23) > decompression diving (r = 0.19) > surface time (r = 0.12). No significant correlation was found for blood pressure and heart rate differences, pre-dive daily fluid intake, height, weight, weight loss, sex, body muscle, fat and water contents, stress, freezing and smoking. Eftedal-Brubakk categorical bubble grades for sports diving with compressed air can be approximated by
EB bubble grade = (age / 50 – surface time / 150 + maximum depth / 45 + air consumption / 4500)^2
R2=0.31, p<0.001.
The specificity of Audio bubble detection was 96.1% but the sensitivity was low for lower bubble grades and raised to 25, 35 and 67% for higher bubble grades 3-5. Learning curves as number of trials to achieve a reliable venous signal within 30s were 13 at the subclavian position and 18 at the precordial position. The performance level of the taught skill remained stable over 6 months without further practice.

Discussion
Audio Doppler self assessment can be learned by medical lay people and a clear venous signal can be achieved after a comparably steep learning curve. However, a correct bubble grading is not possible by Audio Doppler since only higher bubble grades can be detected reliably. Still, this is sufficient to provide a reliable qualitative information on appropriate decompression and allows to judge on surface intervals and other measures to avoid decompression incidents.

Conclusion
Simple dive and individual parameters allow reasonable estimation and also qualitative self-detection of especially relevant medium to higher bubble grades for information on relevant decompression stress after ascent. This important individual information can lead to better decision-making on individual safety measures.

P-19

CASE SERIES OF UNUSUAL NEUROLOGIC SYMPTOMS AFTER SCUBA DIVING TRAINING SESSIONS, IN THE CONTEXT OF SARS-COV2 PREVENTIVE MEASURES

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Introduction
In July 2020, 8 divers developed neurological symptoms during the diver training course (PLB) at the French Military Diving School (ECP). The PLB is the first level of training for French military scuba diving. These accidents occurred after the first COVID-related containment. Diver training had undergone many organisational changes and was subject to health restrictions. For all accidents, prior to the onset of symptoms, a dive of less than 10 minutes working time to a maximum depth of 30 metres with an ascent rate of 15m/min was made. During the training dive there is an ascent to the surface and a return to the bottom called a "Yo-yo". This type of diving is considered a risk factor for accidents.
However, the late onset of symptoms, 5 to 50 hours after the dive, is of concern. A scientific study has been conducted to identify the factors that contribute to accidents. The first objective is to describe the circumstances and the cases. The second is the epidemiological investigation and its conclusions.
Description of the cases
Eight divers developed neurological symptoms 5 to 50 hours after the last dive. These eight cases were diagnosed as neurological desaturation accidents and received hyperbaric treatment.

Methods
Scientific survey conducted by the Armed Forces Epidemiology and Public Health Centre by means of a telephone epidemiological questionnaire among all the divers on the course. Comparison of the answers of the accident victims with those of the non-accident victims, taking into account the modifications of the course due to the epidemic context.

Assumptions and results
The contributing factors identified by the survey were "yo-yo" diving, lack of aerobic exercise due to confinement and lack of hydration and a lack of hydration attributed to wearing a mask. However, the long delay between emergence and onset of symptoms remains unexplained.

Conclusion
Since the introduction of these measures, there have been fewer ADDs, but ADDs with late signs persist. Possible impact of CO2 retention linked the wearing of the anti COVID mask not yet determined. Experimental animal and human studies are underway.

P-20

CHANGES IN DIVER WHOLE BLOOD RNA GENE EXPRESSION FOLLOWING HYPERBARIC OXYGEN EXPOSURES

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Introduction
The metabolic processes that respond to a hyperoxic exposure are complex and likely involve multiple biochemical pathways associated with changes in the expression of a number genes important in this stress response. It is known that hyperbaric oxygen (HBO) initiates increases in antioxidant enzymes and anti-inflammatory proteins, decreases neutrophil adhesion and pro-inflammatory cytokine production, and increases apoptosis. What is less well-known is the level or dose of HBO required to initiate changes in gene expression that direct many of the resulting metabolic process involved in the body's response to the hyperoxic exposure. The aim of the current study was to compare human whole blood RNA gene expression following different HBO exposure durations.

Methods
Nine healthy U.S. Navy trained divers (8 males/1 female, mean±SD age =35.1±12.6 yrs) conducted three dry-resting hyperbaric chamber dives of different duration (1, 2, and 4 hours) while breathing 100% humidified O2 at 2 ATA. The order of the dive duration was randomly presented with a minimum of 7 days between the subject's consecutive HBO exposures. Immediately before and two hours after each dive, peripheral blood was taken from the subjects and collected into PaxGene Blood RNA tubes for later differential gene expression analysis using Affymetrix GeneChip Human U133A arrays.

Results
After excluding samples that did not pass quality control, the final analyzed data set included n=7, 4, and 5 for the 1, 2, and 4 h dives, respectively. Among genes that exhibited a fold change > 50%, 13 were found to be differentially expressed following the 1 h dive, 2174 were found to be differentially expressed following the 2 h dive, and 142 were differentially expressed following the 4 h dive. A total of 69 genes exhibited differential expression across all treatment groups (uncorrected p value <0.05). Pathway and functional analyses did not provide evidence for known biological pathways or functions within this latter set of commonly-expressed genes.

Discussion & Conclusions
In our data set, the number of genes showing a >50% fold change in gene expression post-dive did not appear to increase in direct proportion to the duration of the HBO exposure. The small n and individual differences in response to the HBO stress among the subjects included in the 3 treatment conditions, as well as timing of the RNA blood samples post-dive, likely contributed to this observation.

P-21

HEART RATE VARIABILITY FROM UNDERWATER SPIROERGOMETRY: HOW MEANINGFUL?

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Introduction
Cardiovascular fitness of divers is overwhelmingly performed using bicycle ergometry. A more sport-specific alternative presents fit2dive, an underwater spiroergometry system. Purpose of this exploratory study: using fit2dive to investigate the diagnostic value of measures of heart rate variability (HRV) after markedly increasing physical load.

Participants and Methods
Ten scuba divers employed the fit2dive system and stepwise increased fin-swimming speed until exhaustion. Breathing gas consumption (VE) and heart rate (HR) were measured. A three-lead ECG was recorded to analyze for time and frequency domain HRV-measures.

Results
VE increased from 16.5±6.5 to 68.3±26.6l/min. HR increased from 96±13/min (mean±SD) at rest to 170±14/min before exhaustion. Global variability (SDNN: 132±42 vs 54±17ms) decreased along with two measures of parasympathetic activity (RMSSD: 59±31 vs 24±16ms; pNN50: 22±12 vs 3±3%). Measures from the frequency domain decreased (low frequency (LF): 3167±2651 vs 778±705ms²) or remained unaltered (high frequency (HF): 885±652 vs 431±463ms²). Thus, LF/HF decreased from 4.3±2.3 to 2.5±1.4.

Discussion
The sports-specific fit2dive can help assessing diving fitness by employing HRV measures. However, this study supports the view that these measures much depend on HR.

Conclusion
HRV measures regarding altered autonomic control during exercise will lead to serious misinterpretation: as HR increases, variability decreases

P-22

FIRST EVALUATION OF THE GREENFLASH SOLID STATE O2 SENSOR FOR REBREATHER DIVING

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Introduction / Background
In closed circuit mix gas rebreathers, the partial pressure of O2 (pO2) is measured with galvanic O2 sensors. A control loop replaces metabolized O2 with fresh O2 from a small tank. Sensor failures can quickly lead to incorrect pO2 readings and further to non-live-sustaining breathing gas compositions.
Traditional galvanic O2 sensors are failure-prone, have a short lifetime, and incorporate a Pb-anode. Pb is on top of the list of forbidden substances (RoHS directive), but until now, there are no alternative sensors that can be used in already existing instrumentation. Poseidon (Sweden) distributes one solid-state O2 sensor, which can measure a pO2 up to 2 bar, however, due to the digital interface and the required external power supply, this sensor cannot be used as a direct replacement for galvanic O2 sensors.
The GREENFLASH O2 sensor is a solid-state O2 sensor, developed especially to replace galvanic O2 sensors. It is based on fluorescence quenching. Special dyes in the sensing layer emit red light when they are illuminated with green light. There is an inverse relationship between the pO2 and the signal intensity of the red light emission. The new sensor also features an innovative interface, which allows it either to output digital data or it may emulate a galvanic sensor (analog voltage, 10mV@0.21 bar). Due to the very low power electronics, it is possible to use a CR2477 battery as a power supply – no external supply is necessary.

Methods
To evaluate the sensors for rebreather applications, they were first tested in a pressure chamber up to a pO2 of 1.8 bar. Further laboratory tests were carried out to test the temperature compensation as well as cross sensitivities (humidity, CO2, He). After successful lab tests, the sensors were tested in various rebreathers, including JJ, AP Evolution, Mares Horizon and a Dräger LAR VII.

Results
For what concerns linearity and accuracy, we have demonstrated that the GREENFLASH sensors can fulfill EN14143 as well as ISO 80601-2-55:2018. The analog sensor emulation works well – the sensors could be used directly instead of galvanic sensors without any modification of the rebreathers.

Acknowledgement
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P-23

DOPAMINE/BDNF LOSS UNDERSCORES NARCOSIS COGNITIVE IMPAIRMENT IN DIVERS: A PROOF OF CONCEPT IN A DRY CONDITION

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Background
Divers can experience cognitive impairment due to inert gas narcosis (IGN) at depth. Brain-derived neurotrophic factor (BDNF) rules neuronal connectivity/metabolism to maintain cognitive function and protect tissues against oxidative stress (OxS). Dopamine and glutamate enhance BDNF bioavailability. Thus, we hypothesized that lower circulating BDNF levels (via lessened dopamine and/or glutamate release) underpin IGN in divers while testing if BDNF loss is associated with increased OxS.

Methods
To mimic IGN, we administered a deep narcosis test via a dry dive test (DDT) at 48 meters in a multi-place hyperbaric chamber to 6 well-trained divers. We collected: 1) saliva samples before DDT (T0), 25 msw (descending, T1), 48msw (depth, T2), 25msw (ascending, T3), 10 min after decompression (T4) to dopamine and/or reactive oxygen species (ROS) levels; 2) blood and urine samples at T0 and T4 for OxS too. We administered cognitive tests at T0, T2, and re-evaluating the divers at T4.

Results
At 48msw, all subjects experienced IGN, as revealed by the cognitive test failure. Dopamine and total antioxidant capacity (TAC) reached a nadir at T2 when ROS emission was maximal. At decompression (T4), a marked drop of BDNF/glutamate content was evidenced that coincided with a persisting decline in dopamine and cognitive capacity

Conclusions
Divers encounter IGN at -48 msw, exhibiting a marked loss in circulating dopamine levels, likely accounting for BDNF-dependent impairment of mental capacity and heightened OxS. Decline in dopamine and BDNF appears to persist at decompression; thus, boosting dopamine/BDNF signaling via pharmacological or other intervention types might IGN-induced narcosis in deep divers.

P-24

PLASMA PROTEOMIC CHANGES FOLLOWING PROLONGED NITROX30 AND HYPERBARIC OXYGEN CHAMBER DIVES

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Introduction
Identifying early systemic responses to hyperbaric oxidative stress will be critical to predict susceptibility to O2 toxicity. Despite challenges, human plasma proteomics assays have revealed novel peptide variants and protein differences in multiple clinical contexts. Our aim is to identify proteins that reflect an acute systemic response to prolonged hyperbaric stress, and discover potential biomarker pathways for pulmonary O2 toxicity.

Methods
The study was a double-blind, randomized, cross-over design in Navy-trained male diver subjects. Each subject completed two dry resting hyperbaric chamber dives separated by a minimum of one week. One dive exposed subjects to 6.5 hours of 100% oxygen (O2, n=9) at 2ATA and was expected to impart a mild level of pulmonary O2 toxicity in susceptible subjects. The alternate dive was a low-level hyperoxic dive in which subjects breathed 30.6% O2 nitrox mixture (EAN, n=11) at the same depth for the same duration. Venous blood samples were collected before (PRE) and immediately after (POST) each dive in BD™ P100 Tubes. Samples were depleted of the 14 most abundant proteins prior to extraction, digestion, purification, and assay using LC-MS/MS analysis (2-hour runs). MS data files were analyzed using MaxQuant and Scaffold Q+S software using standard statistical approaches.

Results
1234 total proteins were detected and analyzed. Protein expression was similar between O2PRE and EANPRE ($p>0.05$). Eighteen proteins showed significantly altered expression EANPOST ($p<0.05$), including proteins in coagulation and immune signaling and activation, as well as biomarkers identified in other clinical conditions or stress (transthyretin (oxidative stress), gelsolin (arthritis, acute injury and inflammation)). Highly expressed at O2POST (vs. O2PRE) included vacuolar protein sorting proteins, K+ channel subfamily B member 2, catalase, fibulin-like proteins (2), complement proteins (2), hemoglobin subunit beta, apolipoprotein D precursor, and TOM-1-like protein. EANPOST and O2POST differed in biomarkers related to coagulation, immune signaling and activation, and metabolism. Ongoing research includes pathway analysis of identified biomarkers at EANPOST and O2POST.

Discussions/Conclusions
We detected sensitive markers of EANPOST acute stress responses related to immune function and coagulation. This study identifies ~20 proteins in plasma fraction that may indicate an acute systemic response to prolonged hyperbaric stress.

P-25

EVALUATION OF THE PHYSIOLOGICAL VASCULAR RESPONSE TO HBO BY PULSE TRANSIT TIME

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Introduction
According to current knowledge, HBO leads to reactive vasoconstriction. The complex regulation of the microcirculation during the different phases of HBO and differences between healthy subjects and vascular predisposed subjects are not yet fully understood. The measurement of pulse transit time (PTT) and the associated individual and momentary "vascular stiffness" can provide information about the systemic vascular response.

Methods
PTT is determined by ECG and photoplethysmogram. For this study, voluntary patients of HBO with different treatment indications and treatment success were examined. The measurement data were analysed with a specially developed evaluation software for the determination of heart rate, PTT and RR-Interval (ERNST).

Results
The curves of PTT and RR intervals show a correlation. Descriptive statistics show dependencies between the groups. After plotting the RR intervals against the PTT times, a visible difference between the groups was revealed.
For the analysis, these curves were treated as fractals. The fractal dimensions obtained show a different fractal dimension for the different groups with increasing number of HBO therapy sessions. The control group shows no temporal development of their fractal dimension. To the best of our knowledge, this is the first measurement evidence of a vascular system response to hyperbaric oxygen therapy

Conclusions
1. the correlation between PTT and RR intervals does not coincide with the vasoconstriction in response to hyperbaric oxygen described in the literature.
2. in the presence of pre-existing conditions, the vascular response changes in the course of HBO therapy.
Further studies with larger numbers of patients and groups are needed.

P-26

EPITHELIUM-OFF AND EPITHELIUM-ON CORNEAL CROSS-LINKING WITH HYPERBARIC OXYGEN: INCREASED CORNEAL STABILITY?

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Background
Corneal cross-linking (CxL) is an ophthalmologically established treatment for halting the progression of corneal ectasia in patients with keratoconus. According to different treatment protocols the corneal epithelium is either removed in advance (epithelium-off) or remains intact during the treatment (epithelium-on). As CxL is known to be oxygen(O2)-dependent, we examined the effect of hyperbaric (HB) conditions with and without supplemented O2 on the intracorneal O2-concentration (cO2) during epithelium-off and epithelium-on corneal CxL.

Methods
Full thickness porcine corneas were CxLed using 0.1% riboflavin and UV-A irradiance of 3mW/cm? for 30 minutes. Corneas were separated into two protocol groups (grp): with (epithelium-off grp 1-4; n=10 per grp) and without removal of the corneal epithelium (epithelium-on grp 5-8; n=5 per grp). Corneas in each protocol were CxLed under normobaric (conditions (grp 1 and 5), normobaric conditions with supplemented O2 (groups 2 and 6), HB conditions (grp 3 and 7), or HB conditions with supplemented O2 (grp 4 and 8). HB conditions of 2.4 bar were reached in a HBOT chamber. Intracorneal O2 concentrations were measured at a corneal depth of 300?m. Biomechanical properties and resistance to enzymatic digestion with Collagenase A of both treated and control specimens were chosen as efficacy outcomes.

Results
Intracorneal cO2 among corneas treated with HB conditions and supplemented O2 (grp 4 and 8) were found to be 2-28% higher ($P<0.05$) than those of corneas treated with HB conditions (grp 3 and 7), normobaric conditions with supplemented O2(groups 2 and 6) or normobaric conditions (grp 1 and 5). No statistically significant differences in biomechanical stability were found among the different treatment groups. Corneas treated in HB conditions (grp 3) were more resistant ($P<0.05$) towards the enzymatic digestion than corneas treated under normobaric conditions (grp 1).

Conclusions
HBO conditions increase the intracorneal cO2 during epithelium-off and epithelium-on corneal CxL. In thick corneas HBO conditions during CxL do not improve the corneal biomechanical properties. However, as the effects of CxL are limited to the anterior 350 µm of corneal tissue and since the normal porcine cornea is around 800 to 900 µm thick we may have easily missed any stiffening effect in our model. Increased resistance to enzymatic digestion after HBO CxL suggests an effect that should be assessed in further experiments.

P-27

EFFECT OF HYPERBARIC OXYGEN THERAPY ON THE DIFFERENTIATION AND FUNCTION OF OSTEOPOROSIS-RELATED PARAMETERS IN OSTEOBLASTS OF PATIENTS WITH NORMAL BONE DENSITY, OSTEOPENIA OR OSTEOPOROSIS

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Introduction
HBO can induce increased differentiation of osteoblasts, increased alkaline phosphatase (AP) activity and increased serum concentrations of osteoprotegerin (OPG) and exert positive effects on bone regeneration. To date, basic findings on the influence of HBO on osteoblasts of elderly patient:s, especially those with bone metabolic changes, such as osteoporosis, are lacking. Osteoporosis is characterized by decreased osteoblast activity and reduced expression of OPG. OPG binds to the Receptor Activator of NF-□B (RANK) ligand in balanced bone homeostasis and prevents osteoclast activation. The amount of reactive oxygen species (ROS) and thus oxidative stress, which supports the pathogenesis of osteoporosis increases in aging processes. This work analyzes the influence of HBO and ROS-depleting substances (antioxidants) on osteogenic differentiation and osteoporosis-related parameters in osteoblasts.

Methods
Osteoblasts were isolated, cultured, and proliferated from patient femoral heads (n = 21). The following groups were divided by bone density determination using dual-energy X-ray absorptiometry (DXA) measurement: Control (normotensive bone density, □ = 68.42a), osteopenia (□ = 80a), and osteoporosis (□ = 79.75a). This was followed by osteogenic differentiation, HBO for 21 days (5 days/week, 90 min 2 bar over fiO2 1.0), and treatment with an antioxidant of catalase (125 U). Osteogenic differentiation of osteoblasts was quantified by alkaline phosphatase assay and alizarin red S staining followed by re-solution. OPG was analyzed as an osteoporosis-related parameter by ELISA.

Results
HBO significantly increased osteogenic differentiation in the control group, as measured AP activity and the capacity to deposit calcium into the extracellular matrix. Synergistic effects of HBO and catalase resulted in a doubling of osteogenic differentiation in the osteopenia and osteoporosis groups compared with the control group. OPG expression was not significantly affected by HBO.

Conclusion
HBO is an additional therapeutic option in normal bone density as well as osteopenia to increase bone density or improve healing after a fracture event.

P-28

MODELING OF DOPAMINE HOMEOSTASIS UNDER HYPEROXIC AND HYPERBARIC CONDITIONS

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Background
Several neurotransmitter systems, including monoamines, are shown to be affected by inert gasses under pressure, as well as hyperoxia and hypoxia. Striatal dopamine (DA) levels have been reported to decrease, by both exposure to sub-anesthetic nitrogen levels and sub-convulsive oxygen levels, whereas DA is increased in response to helium. DA homeostasis, the balance of synthesis, metabolism, release and reuptake, is regulated by several signaling pathways and metabolite availability that may increase or decrease DA levels. Both DA synthesis and metabolism rely on oxygen, Dopa and DA are prone to oxidation and DA-pathway is modulated by nitric oxide and oxidative stress pathways. A combined experimental and computational approach is taken to investigate how inert gas pressure and oxygen levels affect monoaminergic systems, particularly DA.

Methods
DA homeostasis and the impact of oxygen is modelled using ordinary differential equations based on reported enzyme kinetic values. Cell culture and in vitro studies using purified recombinant proteins are used for experimental studies. Exposure to different oxygen levels and hyperbaric conditions are performed in a dual hyperbaric chamber setup. Quantitative LC-MS/MS is used to measure cellular metabolites of dopamine metabolism. Western blotting and LC-MS/MS based proteomics is used to quantify protein levels and their signaling-mediated regulation.

Results
DA-synthesizing PC12 and serotonin synthesizing SH-SY5Y cells show reduction in cellular monoamine levels under exposure to hyperoxia (pO2 = 60 kPa). Tyrosine hydroxylase, the first and rate-limiting enzyme of DA-synthesis, is decreased and show altered signal regulation. Using purified TH we are investigating structural and functional basis of TH regulation relevant for diving and HBO. Mathematical modeling of TH activity shows a biphasic response to oxygen with an optimum below 1 atm water O2 solubility and high sensitivity towards cofactor and DA concentrations. Modeling of the DA-pathway showed sensitivity towards DA-transport kinetics into storage vesicles and oxidation of Dopa and DA.

Discussion / Conclusions
Monoamine homeostasis in established cell models is sensitive to exposures mimicking saturation diving. Altered regulation of TH is one molecular mechanism involved, but further investigations are needed. Physiological compensatory mechanisms may overshadow some of the observed perturbations of monoamine homeostasis in vivo.

P-29

IMMUNOHISTOCHEMICAL EXPRESSION OF HEME OXYGENASE-1, 4-HYDROXYNONENAL AND HYPOXIA INDUCIBLE FACTORS (1α, 1β, 2α) AFTER HBO PRECONDITIONING IN POSTISCHEMIC ACUTE KIDNEY INJURY INDUCED IN SPONTANEOUSLY HYPERTENSIVE

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Introduction
Renal ischemia/reperfusion injury (IRI) is common cause of acute kidney injury (AKI). Recent studies suggest beneficial effects of hyperbaric oxygen (HBO) preconditioning in IRI, so the aim of this study was to examine those effects in renal IRI performed hypertensive conditions.

Methods
Animals were randomly selected in 3 experimental groups: sham-operated group (SHAM, n=7), AKI control group (AKI, n=9) and AKI group with HBO preconditioning (AKI+HBO, n=12). HBO preconditioning was performed by exposing to pure oxygen (2.026 bar) twice a day for two consecutive days for 60 minutes and 24 hours before AKI induction. AKI was induced by removal of the right kidney and atraumatic clamp occlusion of the left renal artery for 45 minutes.

Results
AKI induction significantly decreased creatinine, urea and phosphate clearances. Significant improvement was observed in group with HBO preconditioning. Also, significantly increased KIM-1 plasma levels in AKI group were decreased in AKI + HBO group. HO-1 activity in kidney tissue, in AKI+HBO group was significantly increased compared to AKI group, without difference between SHAM and AKI group. Considering the immunohistochemical expression, HO-1 expression in SHAM group was diffuse with weak intensity on the apical surface of the proximal tubular cells. In AKI group, the expression was moderate and diffuse in the cytoplasm of the proximal tubular epithelial cells, with strong expression in some tubules. In AKI + HBO group, the intensity of HO-1 expression was diffuse, but with weak intensity in the cytoplasm and on the apical surface of the proximal epithelial tubular cells, as previously noticed in SHAM group. Sham-operated rats did not express 4-HNE in any parenchymal structure. AKI induced abundant and strong glomerular expression of 4-HNE along with expression in interstitial compartment. HBO preconditioning significantly decreased 4-HNE expression both in glomeruli and interstitium. Expression of hypoxia inducible factors: HIF 1α, HIF 1α and HIF 2α, in SHAM group were minimal, with expression in glomeruli and interstitium. AKI caused a pronounced and abundant expression in the glomeruli and interstitium. HBO preconditioning significantly reduced the expression of these parameters, restoring to the expression pattern noticed in SHAM group.

Conclusions
Considering our results, even in hypertensive conditions, we can expect protective effects of HBO preconditioning in experimental model of AKI.

P-30

VOLATILE ORGANIC COMPOUNDS IN BREATH AFTER A HYPERBARIC HELIOX TREATMENT TABLE (COMEX-30)

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Introduction
The COMEX 30 is a hyperbaric treatment table that can be used to manage decompression sickness in severely affected divers. In contrast to the ubiquitously used shallower and shorter hyperbaric oxygen tables, the COMEX 30 table recompresses the patients to a pressure equivalent of 30 meters of depth (405 kPa), whilst breathing a helium-oxygen mix and takes 7,5 hours to complete. This can result in pulmonary oxygen toxicity (POT), a known adverse effect of hyperbaric therapy. POT is an acute reaction to the damaging effects of reactive oxygen species, resulting in pulmonary inflammatory responses and can cause fibrosis if exposure is continued.
Recently, volatile organic compounds (VOCs) in exhaled breath have shown to be early markers for hyperoxic stress. Various VOCs have been found in numerous studies, but since no signs of POT were reported by the subjects, it remains unclear if these molecules are just responses to hyperbaric hyperoxia or genuinely early signs of POT.
The aim of this study is to identify the VOCs after a COMEX 30 in order to detect early markers of hyperoxic stress or even POT. Since more oxygen is breathed during a COMEX 30 compared to the previously tested hyperbaric oxygen tables, it is believed the exhaled VOCs identified in this study will correspond with VOCs associated with POT.

Methods
Ten healthy and non-smoking volunteers participated in the trial at the recompression chamber of the Royal Netherlands Navy's Diving and Submarine Medical Centre. Breath samples were collected just before the hyperbaric exposure and at 30 mins, 2 hours, and 4 hours after finishing the COMEX 30. A Wilcoxon signed-rank test was used to identify the significantly varying ion fragments between the baseline measurement and post-exposure measurements. Identification of the VOCs was conducted using the NIST database. Overall VOC variability was tested using a Skilling-Mack test and a Wilcoxon signed-rank test with Bonferroni correction was used for post-hoc analysis.

Results
Nine human-associated compounds have been identified of which four (nonanal, decanal, ethyl acetate, and tridecane) were significantly varying over time.

Discussion and Conclusions
As in earlier studies on VOCs after hyperbaric hyperoxic exposure, the identified human-associated compounds consisted of alkanes, aldehydes, and esters. All are associated with inflammatory responses or pulmonary diseases such as asthma or lung cancer. Since the majority of subjects reported transient symptoms matching with early-stage POT, the identified VOCs in this study could indicate early-stage pulmonary oxygen toxicity, and not just hyperbaric and hyperoxic exposure.

P-31

PROTOCOL 'HOTPANTS TRIAL'

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Rationale
Pyoderma gangrenosum (PG) is a rare auto-inflammatory neutrophilic dermatosis characterized by a spectrum of clinical presentations with variable courses. Diagnosis and management are challenging in PG. Treatment, including systemic prednisone and anti-TNF therapy, is directed towards reducing pain and associated inflammation that leads to ulceration. Positive effects of hyperbaric oxygen (HBO) therapy have been reported in small case series.

Objective
To investigate the therapeutic efficacy of hyperbaric oxygen adjuvant to standard wound care and regular anti-inflammatory treatment in patients with pyoderma gangrenosum wounds.

Study design
Prospective cohort study with a one year follow-up.

Study population
15 adult patients with pyoderma gangrenosum refractory to systemic anti-inflammatory treatment will be included for adjuvant hyperbaric oxygen therapy. Patients with pyoderma gangrenosum that are eligible but reject hyperbaric oxygen treatment will serve as controls (n=15). In total we will include 30 patients.

Intervention
30 sessions of HBO therapy will be applied adjuvant to regular wound care and systemic anti-inflammatory treatment. Controls continue to be treated with regular wound care and systemic anti-inflammatory treatment.

Main study parameters/endpoints
Wound healing time (time to wound closure). PG wounds will be measured at baseline using a validated, objective 3D photographical wound measurement tool, at 3 and 6 weeks during HBO treatment and after 3 months. Follow up will be until wounds are closed. Patients will take weekly photographs at home using a 2D validated measurement tool of the wounds.

Secondary parameters
Alteration in the expression of markers of inflammation by micro-biopsies of wound edges, non-invasive mitochondrial O2 measurements at wound edges, blood neutrophil count and patient-reported outcomes like WOUND-Q, pain on a numeric rating scale and treatment satisfaction scores. Assessment concerning laboratory findings will be done at baseline before starting the trial, at 3 weeks and at week 6 at the end of HBO treatment. Patient reported outcomes, WOUND-Q will be measured at baseline, 3 weeks, 6 weeks, 3 months, 6 months, and 12 months. Mean NRS scores will be recorded once a week.

P-32

HYPERBARIC OXYGEN TREATMENT AND ADVANCED WOUNDCARE IN A 38 YEAR OLD WOMAN WITH COMPLEX WOUNDS AND MIXED CONNECTIVE TISSUE DISEASE

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Introduction
Mixed connective tissue disease (MCTD) is a chronic inflammatory systemic autoimmune disease, signified by complex interactions including inflammation, dyslipidemia, thrombotic events, and humoral autoimmune processes. One of the possible clinical manifestations is chronic ulceration. The use of hyperbaric oxygen therapy (HBOT) has not yet been described in MCTD.

Material and Methods
A patient with two complex wounds of the right tibia and right medial malleolus because of MCTD was treated using advanced wound care before and after HBOT. Disease progress was monitored prospectively using wound measurements and for quality of life the RAND36 questionnaire score before and after HBOT (with maximum percentages of 100%; higher percentages represent better outcome except a lower percentage for pain suggest a better outcome). Spirometry results 2 months before and 1 month after HBO were also monitored because the patient had a progressive non-specific interstitial pneumonitis and questions about the use of HBOT in a patient with pulmonary complications were raised.

Results
The 38 years old woman had before treatment respectively 6 and 3 months complex wounds of the right medial malleolus and right tibia. Before first treatment with HBO the patient was treated for a period of 7 months with negative pressure therapy, compressive therapy, maggot therapy and later topical application of hydrocortisone and antibiotics. The patient was treated with 40 daily sessions HBOT (80 minutes of 100% oxygen at 2,5 ATA). The wound surfaces before starting HBO were 1,4 cm2 and 6 cm2. The smaller wound was closed after HBOT, and the wound surface of the remaining wound was 4,16 cm2. After HBOT, wound care included epidermal grafting and negative pressure therapy. Six weeks after epidermal grafting the second wound was also closed. The RAND36 (i.e. vitality, mental health, social functioning, pain, mean health change) before HBOT was 35%, 48%, 0%, 80% and 25% and after HBOT the percentages were 50%, 68%, 38%, 68% and 75%.
Spirometry results (vital capacity and total lung capacity) before HBOT were 2,80 liter and 4,06 liter and 3,03 liter and 4,22 liter after HBOT, respectively. No adverse effects were reported during HBOT.

Conclusions
After advanced wound care and HBOT two chronic MCTD ulcers were closed, with improvement in quality of life. HBOT was tolerated well without negative effect on the lung condition. HBOT should be considered in the approach of MCTD ulcers.

P-33

BURNS OF THE LOWER AIRWAY AND TREATMENT WITH HYPERBARIC OXYGEN THERAPY (HBOT): A CASE STUDY

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Introduction
Burns of the lower airway can occur as an extension of burns of the upper airway after inhalation of toxic gases during a fire. They typically have more severe clinical manifestations and prognosis with high mortality driven by respiratory failure and infections. The location of the lesion depends on the duration of the exposure and the size the solubility of the particles of the inhaled gases. Burns provoke a biphasic damage on the airway: Toxins of the liberated gases such as Carbon Monoxide (CO), Cyanide, Oxidants, Acids and Aldehydes provoke direct damage on local tissues during the first hours after inhalation, producing bronchospasm and airway edema. At a later pase, called smokes' particle phase, inflammation and destruction of the peri-bronchial mucosa after particle infiltration occur. Therapeutic approaches include removal of soot and mucus plugs, mechanical ventilation, bronchial wash, and administration of bronchodilatators and antibiotics. HBOT is well known to quickly displace CO from the blood and tissues, it has anti-inflammatory effects that reduce edema, and via neovascularization it can promote the vascular reconstruction of damaged tissues.

Case presentation
A 36 year-old without past medical history was transferred intubated with mechanical ventilation to the Central Military Hospital of Mexico City after suffering facial and body burn from a fire (36% Wallace rule). Exploratory bronchoscopy removed airway soot. A week later, the patient developed significant edema at facial, buccal, cervical and lower airway areas. Fifteen daily 90-min sessions of HBOT were performed at 2.8 ATA. A dramatic decrease in inflammation and edema was noted on repeat bronchoscopy and histopathological examination. One month later, the patient was discharged from the hospital in good and ambulatory condition. He has resumed almost life activities, with only modest dyspnea and productive cough upon significant exertion with associated low FEV1 in spirometry.

Conclusions
HBOT may have an important role in the therapeutic approach of burns of the lower airways by ameliorating inflammation and edema and restoring damaged endobronchial tissues. A multidisciplinary approach, which includes Intensive Care, Pulmonology, and Hyperbaric Medicine, is required to improve patient outcomes.

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EMERGENCY ACTIVITY OF THE HYPERBARIC CENTER OF TUNIS DURING THE PANDEMIC YEARS

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Introduction
The military hyperbaric oxygen therapy (HBOT) center of Tunis was created in 2009.It is the unique facility of the country. Patients are issued from different health structures (private or public). Clinical activity is increasing over the years. Many of the clinical indications involve emergent conditions.

Objective
The COVID-19 pandemic disrupted hospital care routines, as hospitals had to deal with the imergent virus, while continuing to provide health services to the community. This study examines the direct effects of COVID-19 on the emergency work of the hyperbaric center of Tunis.

Methods
The research is a retrospective, comparative analysis of our center's admission rate across, before and during the pandemic.

Results
Along the two years of COVID 19 pandemic 2020-2021, 713 patients were treated for an emergency condition in our facility representing 59% of our overall activity. These patients were divided in two groups: immediate emergencies 447 patients (62.6%), involving Carbon monoxide poisoning (ICO), cerebral air embolism (CAE) and diving accidents (DCI); Delayed emergencies 266 patients (37.3%) such as sudden deafness, crush syndrome, Fournier's gangrene and mediastinitis.
Compared to emergency activity over the years 2018-2019, There was a global drop of 26.1% in 2020 and 13.7% in 2021. Immediate emergencies conditions like diving accidents dropped by -81.8% and Carbon monoxide poisoning -28.5% in 2020 versus -72.7% and -7.9% in 2021. Whereas in delayed emergencies, mild drops were noticed in sudden deafness (-22.9% and -4.2%) or crush syndromes (-27.8%). Treatment protocols were revised according to international recommendations to ensure patients safety using different treatment tables 2.2 ATA instead of 2.5ATA. No viral spread out was seen in our outpatients.

Conclusions
The current COVID-19 pandemic had little impact on emergency care activities and prescriptions in our center. Considering that it is the unique facility in the country, we continued treating our patients during that period. Decrease is probably due to non-referring patients to HBO, it may partially be understood by lockdown measures, or transportation difficulties between the different areas of the country.

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THE HIPPOCRATIC OATH

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Background
The original goals of the statements of Hippocrates can not be strictly applied to the current trends of modern Medicine. For some centuries, thousands of adaptations of the famous Hippocratic Oaths to modern times have arisen. An up-to-date reference for Hyperbaric Medicine should be a need.

Method
Following a direct translation into English from the original edition of the Hippocratic Oath in Greek language, an adaptation to the current roles, needs, and characteristics of Hyperbaric Medicine have been done, respecting the initial ethic and aesthetic rules of the Hippocratic Oath, taking into account modern concepts and figures, and adding some little drops of sense of humour, resulting into a real Hippocratic Oath.

Results
These are the initial statements of the Hippocratic Oath: "I swear by Apollo and Asclepius, by Iphigenia and Panacea, by Boerematon and Kindwallitides, by Elliottanos and Lamberstenides, and I take as witness all the gods of Olympus and of Hyperbaric Heaven, that I shall observe the following oath which I am obliged to perform putting into such endeavour all my strength, my intelligence, my prestige, my reputation, and my meagre economy." And other paragraphs will be: "I will undergo my hyperbaric practice within an honest and professional way. I will not promote false hyperbaric expectative, nor promise unproved success. I will follow scientific principles coming from researchers with knowledge and experience, respecting the agreed indications, quality control, self-criticism, verification of results, and recognition of my own errors. In any hyperbaric centre where I practice, I will accept no other goal than the health of the patients; I will refrain from false statements or fictitious successes even if they are mild, serious, or imaginary... I will establish the best hyperbaric procedures for my patients in search of the most efficient and therapeutic profit for them according to my best knowledge and medical experience, avoiding any kind of malpractice. I will not apply low and ineffective oxygen doses ort too short hyperbaric sessions, but still less too high toxic hyperbaric doses or too excessively long regimes, what I shall not suggest to any patient or colleague.".

Conclusions
The main goals of the Hippocratic Oath can be applied to Hyperbaric Medicine resulting in a kind of Hippocratic Oath that current generations of Hyperbaric Physicians should take into account.

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ADVANCED HYPERBARIC CRITICAL CARE PROVIDED IN A MONOPLACE CHAMBER – A TECHNICAL REPORT

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Background
Monoplace chamber hyperbaric oxygen treatments have long been provided to patients requiring critical care, but by only a small number of hyperbaric units worldwide. Optimal ventilation and delivery and control of infusions are acknowledged to be challenging.

Methods
The Alfred Hyperbaric Service in Melbourne, Australia chose to establish this capability during 2021 in order to maintain service delivery during an eight week shut down of their multiplace chamber for a 20 year overhaul. In undertaking this project, a number of refinements were achieved compared with the methodologies reported in the literature.
A Sechrist 3600 monoplace chamber was utilized. Ventilation was provided for by installing the pneumatic module of a Maquet Servo-I (H) inside with controls outside. The multi-parameter monitoring used in our multiplace chamber was installed in identical fashion inside the monoplace. Endotracheal cuff inflation was provided pneumatically via a sensitive regulator and relief valves. Through hull suction was installed for vacuum wound dressings. Arterial pressure monitoring and blood sampling was undertaken as described by Weaver et al. External syringe drivers had their high pressure alarms recalibrated to enable them to infuse into the chamber. A high pressure radiology infusor was available for larger fluid boluses.

Results
Over the 8 week period, 5 critically ill necrotizing soft tissue infection patients received 13 sessions of hyperbaric treatment without any significant problems, although transfer times were prolonged and high numbers of trained staff were required to deliver safe therapy.

Conclusions
We believe that hyperbaric oxygen can be safely provided to ventilated and inotrope dependent patients in monoplace chambers, but the technical and clinical requirements are high. In our experience, treatment times and staff numbers are greater, not less, than for multiplace chamber intensive care operations. Fluid infusion technology options for monoplace chambers remain sub-optimal and deserve further technical research and development.

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EXTRA-CORPOREAL MEMBRANE OXYGENATION UNDER HYPERBARIC CONDITIONS

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Background
Extra-corporeal membrane oxygenation (ECMO) is increasingly available worldwide for life support of critically ill patients with severely dysfunctional pulmonary gas exchange. Potential complications of this critical care therapy include arterial gas embolism and limb ischaemia secondary to catheter complications, both of which could benefit from hyperbaric treatment if this were possible without disrupting ECMO.

Methods
We undertook an in-vitro evaluation of the potential to continue ECMO under hyperbaric conditions, using a Maquet ROTAFLOW circulator pump connected inside the chamber to its power/control unit from which the standard battery was removed. The controller is supplied with electrical power from dual medical grade power supplies external to the chamber. The manufacturer's standard single use gas exchanger and tubing systems were used, connected into a loop for in-vitro testing.

Results
Rigorous testing of flows and pressures delivered against flow resistance at chamber pressures of 2.8 ATA found no significant deviances from normobaric performance, using both crystalloid fluids and human blood.

Conclusions
After multi-disciplinary risk assessment, we believe that the equipment configuration we have developed and tested may be suitable for use at our institution in ECMO dependent humans with life threatening conditions likely to be significantly improved with hyperbaric oxygen treatment. Further evaluations and criteria for potential clinical use are ongoing.

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HAND HYGIENE KNOWLEDGE FOR HEALTH-CARE WORKERS IN HYPERBARIC FACILITIES

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Introduction / Background
Hand hygiene is one of the most important ways to reduce the prevalence of infections not only in hospitals but in hyperbaric facilities as well. Use of alcohol-based hand sanitizer could pose a risk with O2 and to chamber acrylics, hence frequent hand washing for staff and patients is recommended. Adherence to hand hygiene is the most important practice for preventing the transmission of microorganisms in health care, and directly contributes to patient safety. The purpose of this study was to assess knowledge, attitudes, and practices regarding hand hygiene guidelines among health-care workers in hyperbaric facilities.

Methods / Materials
This is a cross-sectional study that it was conducted using an online questionnaire. The sample of the study was consisted of health-personnel working in hyperbaric facilities globally using purposive sampling technique. The "Hand Hygiene Knowledge Questionnaire for Health-Care Workers" by the World Health Organization was used in this study. It consists of sixteen questions divided into those concerning the demographic characteristics of the sample, their knowledge on hand washing and their knowledge concerning the ways to reduce the prevalence of infections in their hyperbaric facilities.

Results
The sample consisted of 86 individuals which 65% were men and 35% women, with an average of 44±3 years old. Most of the respondents agreed that the main route of cross-transmission of potentially harmful germs between patients in a health-care facility is health-care workers' hands when not clean. 69% of the respondents have answered that performing hand hygiene prevents transmission of germs to the patient. They gave correct answers as far the question about which is the most appropriate timing for performing hand hygiene actions that prevent transmission of germs to the patient and to the health care worker. Almost all participants (89%) agreed that use of jewellery and artificial fingernails should be avoided in order to prevent colonization of hands with harmful germs.

Discussions / Conclusions
The study found that there is a good level of knowledge about hand hygiene among the healthcare personnel working in hyperbaric facilities, but this should be a constant training that will have a longitudinal impact on lowering transmission of infections.

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THE USE OF THE EUROPEAN STRUCTURAL AND INVESTMENT FUND (ESF) IN THE IMPLEMENTATION OF HBOT - PROJECT – IDENTIFICATION OF BENEFITS AND RISKS

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Introduction
After the accession of the Slovak Republic to the EU, the resources of the European Structural and Investment Funds (ESF) have become an important tool for co-financing health technologies in the Slovak Republic, which helps to increase the quality of medical and preventive care and increase its availability. However, the use of the ESF also brings risks and challenging tasks in terms of managing complex project management and their sustainability.

Objective
Chronological analysis of the construction and management of the Center for Hyperbaric Oxygen Therapy of the Faculty of Health TnUAD in terms of financial costs and sustainability of the project.
Methods and Resources
Implementation of the scientific research project "Completion of technical infrastructure for the development of science and research at the University of Trenčín Alexander Dubček through hyperbaric oxygen therapy" (ITMS project code: 26210120019).

Results and Discussion
The provided non-repayable financial contribution amounted to € 3,053,596.36, subject to a 5% financial contribution from the beneficiary organization. The implementation of the project itself lasted 18 months from 10/2012 to 3/2014. The Haux STARMED 2200 Hyperbaric Chamber was installed in the first quarter of 2014 and a series of five annual project sustainability periods was launched immediately, ending in 2019. Total negative cash flows for the project sustainability period were € 113,111.15, positive cash flows accounted for substantially lower amount € 5,976. A total of 10,594 exposures were made during the project monitoring period. The negative aspects of the project implementation included the cost of servicing the equipment after the end of their warranty period, the time required for individual management processes and the non-conformity of some staff with the objectives of the project and its practical implementation.

Conclusion
Our experience has shown that the success of such a large project is possible thanks to the maximum personal and professional commitment of management, but the low identification of some staff with the project implementation, in our experience represents a greater risk than financial risks of the project.

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CONTINUING PROFESSIONAL DEVELOPMENT PROGRAM IN HYPERBARIC OXYGEN THERAPY AND DIVING ACCIDENTS USING A BLENDED LEARNING MODEL OF UNIVERSITY OF THESSALY IN GREECE

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Introduction / Background
Continuing professional development, or CPD, is the ongoing process of developing, maintaining, and documenting professional skills. Blended learning is often also referred to as "hybrid" learning, and can take on a variety of forms in online education environments. The role of the professionals in the field of diving is considered important because it promotes knowledge of those who want to engage in diving and hyperbaric medicine, following the international guidelines. Our purpose is to present the developed program in Hyperbaric Oxygen Therapy and Diving Accidents that uses the blended learning model including practical training in a multiplace hyperbaric chambers to acquire technical skills.

Methods / Materials
This is a presentation of the Continuing Professional Development Program in Hyperbaric Oxygen Therapy and Diving Accidents using a blended learning model that is conducted by Laboratory of Education and Research of Trauma Care and patient safety of University of Thessaly in Greece.

Results
The program aims to educate and train participants by enabling them to provide information services and support of a diving accident and Hyperbaric Oxygen therapy. It provides with 20 ECVET (European credit system for vocational education and training). It is taking place in 3 months time and it has been accredited for Nurses and Operators by the European College of Baromedicine (ECB), European Committee for Hyperbaric Medicine (ECHM) and European Baromedical Association for nurses, operators and technicians (EBAss). Also, it has been accredited for Physicians by the ECB, ECHM and European Diving Technology Committee (EDTC) in level 2H (Hyperbaric Medicine Physician) and 2D (Diving Medicine Physician) according to the 2011 ECHM-EDTC standards as per COST B14 Action.

Discussion
Two cycles of the Blended Learning model program have been completed with great success for the first time internationally and gave participants the opportunity to train on treatment protocols. It also gave the opportunity for the participants to have their own pace and get the knowledge needed. Laboratory of Education and Research of Trauma Care and patient safety of University of Thessaly has made great effort to upgrade to the international and national level the education in the specific field with such a program that anyone from all over the world could participate and be trained under high standards of a University Environment.

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HYPERBARIC MEDICINE'S INSTITUTIONAL FRAMEWORK. A SMALL GUIDE FOR LAWMAKERS AND A CALLING FOR SURVEY

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Introduction
It is a sad reality that Hyperbaric Medicine lacks in many countries a solid institutional framework. What if we were lawmakers for one day and we had one opportunity to produce one legal document with broad coverage of all the different topics of Hyperbaric Medicine?
If there is a need for this multi-chapter regulation, what structure should it have?
Combining ECHM publications and promulgated laws and circulars of 4 countries (UK, Spain, Greece and Cyprus) we present a proposal for the structure of this document and we call for a multinational survey to assess the voids in other countries.

Methods
The initial reference document was the ECHM's European Code of Good Practice on Hyperbaric Oxygen Therapy. Although the majority of decisions and regulations were already known, we conducted thorough research on valid legal documents from national law libraries with multiple keywords relative to Hyperbaric Medicine such as 'Hyperbaric Chamber', 'Diving Medicine', 'Decompression Sickness' etc.

Results
Every country had promulgated laws or regulations that cover partially the Hyperbaric Medicine practice. The suggested structure does not exist in its entirety in none of the 4 countries. UK and Greece present regulations in satisfactory and broad coverage, but not complete. NHS's circular is an excellent and almost complete document. Greece's legal field is characterized with complexity and fragmentation in many regulations.

Conclusions
Hyperbaric oxygen therapy is highly interventional and a solid institutional framework protect health professionals and patients. We call for a survey to assess the degree of legal coverage of our practice.

Reference
A European Code of Good Practice on Hyperbaric Oxygen Therapy. Jacek Kot (Secretary, PL), Jordi Desola (E), Antonio Gata Simao (P), Roly GoughAllen (UK), Robert Houman (B), Jean-Louis Meliet / Francois Galland (F), Christian Mortensen (DK), Peter Mueller (D), Seppo Sipinen (FIN)

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EFFECTS OF ADJUNCTIVE HYPERBARIC OXYGEN IN THE TREATMENT OF NECROTIZING SOFT TISSUE INFECTIONS

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Introduction
Necrotizing soft tissue infections (NSTI) are rapidly progressive disorders characterized by necrosis of deep soft tissues. The number of reported cases in adults is 0,40 cases per 100,000 people/year. The study focus on determining whether there is an impact on the survival of patients with NSTI treated with Hyperbaric Oxygen Therapy (HBO2).

Methods
Retrospective cohort study of all NSTI treated with or without HBO2 between January 2010 and March 2020 at Hospital do Divino Espírito Santo in Ponta Delgada.

Results
73 patients were included. 40 patients were treated with HBO2 therapy, and 33 patients without HBO2 (Non- HBO2). Overall mortality: HBO2 5% and Non- HBO2 36.4%. Most common antibiotic: HBO2 Metronidazole (62.5%) and Non- HBO2 Meropenem (72.7 %). Most frequent isolated microorganism: HBO2 E.Coli (57.9 %), Non- HBO2 E.Coli (42.1)%.

Conclusions
Hyperbaric oxygen therapy was associated with an improved survival and reduced comorbidities and should be considered in all patients with NSTI.

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DIVING ACCIDENTS IN THE AZOREAN ARCHIPELAGO – FAST-TRACK PROTOCOL PROPOSAL

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Introduction/Background
Either done by professionals or by recreational divers, diving is an expanding activity in Azores, an archipelago of 9 islands in the middle of the Atlantic. Consequently, the Azorean Hyperbaric Facilities are contacted by local health institutions or pre-hospital teams to advise about the treatment approach and possible victims' transfer to Hyperbaric Units. Usually this implies the evacuation between islands, by air or sea. As a result, we were challenged by local authorities to create a protocol to unify the response to these scenarios.

Methods/Materials
To elaborate our protocol we reviewed relevant publications on apnoea and scuba diving, pathophysiology of diving, decompression sickness and treatment proposals by selective searching in various scientific databases.

Results
To systemize the approach we created an easy-to-follow chart to be used in the pre-hospital and hospital emergency units, by professionals non-specialized in Diving Medicine. We developed two charts: one for the pre-hospital and another one for the emergency room. In these charts, we give instructions on how to identify victims of possible Diving Accidents, Treatment Procedures, and Articulation and Transfer to medical centres with available Hyperbaric Units.

Discussions/Conclusions
These charts were created with the intention to be used by emergency teams with or without specific knowledge in Diving Accidents. We are in articulation with the local authorities for the final reviews having in mind possible logistic problems.

AUTHOR INDEX

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- IMCA
- MDR 2017/745

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ABSTRACT & CONFERENCE BOOK

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