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Abstracts of Oral Presentations

O-01 BUBBLE SIZE ON DETACHMENT FROM THE LUMINAL ASPECT OF OVINE LARGE BLOOD VESSELS AFTER DECOMPRESSION: THE EFFECT OF MECHANICAL DISTURBANCE

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Introduction
Bubbles nucleate and develop after decompression at active spots on the luminal aspect of ovine large blood vessels. Series of bubbles were shown to detach from the active spot with a mean diameter of 0.7− 1.0 mm in calm conditions.

Methods
The effect of mechanical disturbance, striking the bowl containing the vessel or tangential pulsatile flow, was studied on ovine blood vessels stretched on microscope slides and photographed after hyperbaric exposure.

Results
Diameter on detachment after a heavy blow to the bowl was 0.87 ± 0.43 mm (mean ± SD), no different from bubbles which detached without striking the bowl (0.86 ± 0.28 mm). Bubble diameter on detachment during pulsatile tangential flow at 234 cm/min, 0.99 ± 0.36 mm, was larger than that seen in the same blood vessels in calm conditions (0.81 ± 0.34 mm). The active spots were stained for lipids, proving their hydrophobicity. The most abundant active spots, which produced only a few bubbles, did not stain for lipids thereafter.

Conclusions
Bubbles were not released at small size under pulsatile tangential flow. The possibility that phospholipids were removed along with detached bubbles may correlate with acclimation to diving. The finding of bubble production at the active spots matches observed phenomena in divers: variable sensitivity to decompression, acclimation to diving, the effect of elevated gas load on increased bubble formation, a higher bubble score in the second dive on the same day, and unexplained neurological symptoms after decompression. Large bubbles released from the arterial circulation give serious cause for concern.

Keywords
Adhesion force, decompression bubble, hydrophobic spot, arterial bubbles, blood flow

O-02 SUSCEPTIBILITY TO CNS OXYGEN TOXICITY FOLLOWING A SWITCH FROM DAY TO NIGHT ACTIVITY IS ASSOCIATED WITH CHANGES IN MELATONIN AND ANTIOXIDANT ENZYME ACTIVITY

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Introduction
The greatest risk involved in diving with closed-circuit oxygen apparatus is the development of CNS oxygen toxicity (CSN-OT). Several cases of CNS-OT have occurred recently at a time when the divers were active during the night hours. The purpose of the present study was to investigate in a diurnal rodent model, the fat sand rat (*Psammomys obesus*), whether susceptibility to CNS-OT following a switch from day to night activity is related to changes in the level of melatonin, antioxidant enzyme activity, and reactive nitrogen species.

Materials and Methods
The study was conducted on male fat sand rats divided into two groups and kept in a 12-hour light/dark cycle. The control group was kept awake during the day between the hours of 09:00-15:00, and the experimental animals at night between the hours of 21:00-03:00, over a period of 3 weeks. At the end of this period, 24-h melatonin levels were measured. Each group was then divided into 2 subgroups. One subgroup was administered melatonin 20 min before HBO exposure, whereas the other received the vehicle. The animals were exposed to hyperbaric oxygen (HBO) at 5 ATA. Latency to the first CNS-OT convulsions was recorded, after which the animals were sacrificed and antioxidant enzyme activity, nitrotyrosine and nNOS were measured in the brain.

Results
Latency to CNS-OT was significantly reduced after the transition from day to night activity. This was associated with alterations in the level of melatonin. Acute melatonin administration, however, had no effect on resistance to CNS-OT in any of the experimental groups. Nitrotyrosine level was significantly reduced following melatonin administration in both groups. No change was found in the level of nNOS. Catalase activity increased in the hippocampus following continuous night activity; this effect was reduced by acute melatonin administration.

Conclusions
A significant phase of night activity represents an additional risk factor for the development of CNS-OT in the sand rat. We suggest these changes may be due more to alterations in reactive oxygen than reactive nitrogen species in the hippocampus.

O-03 EFFECT OF SIMULATED AIR DIVE AND DECOMPRESSION SICKNESS ON THE PLASMA PROTEOME OF RATS

J. Lautridou[1], S. Artigaud[2], P. Buzzacott[1], Q. Wang[1], S. Driad[1], A. Mazur[1], K. Lambrechts[1], C. Balestra[3], M. Théron[1], V. Pichereau[2], and F. Guerrero[1]

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Introduction
Decompression sickness (DCS) is a poorly understood systemic disease caused by inadequate desaturation following a reduction in ambient pressure. Although recent studies highlight the importance of circulating factors, the available data are still puzzling. In this study we aimed to identify proteins and biological pathways involved in the development of DCS in rats.

Materials and methods
Male Sprague-Dawley rats (10 weeks old ; 380 - 440 g) were subjected to a same hyperbaric protocol to 1000 kPa absolute pressure with air and classified post-dive according to the presence or absence of clinical symptoms of DCS. A third control group remained at atmospheric pressure. Venous blood was collected 1 hour after surfacing and the plasma proteomes from 6 individuals per group were analyzed by using a two dimensional electrophoresis based proteomic strategy. Proteic spots of interest were characterized by the SAMESPOT software. Identification of these proteins was achieved using tandem mass spectrometry.

Results
The hyperbaric protocol induced 33,3% of DCS (DCS: n=6 ; No DCS : n=12). Quantitative analysis with SameSpot software identified twelve protein spots with abundances significantly changed ($p < 0.05$ with a FDR Rate < 0.1) between the tested conditions. Among these proteins, transthyretin dramatically decreased (up to 6 fold) in animals displaying DCS symptoms although not changed by diving itself.

Conclusion
This study is the first proteomic study of DCS. The main result is that the occurrence of decompression sickness is associated to the disappearance of one circulating protein, namely transthyretin. Whether DCS associated changes of TTR are a cause or a consequence of DCS deserves further investigation.

O-04 THE 'DICHOTOMIC' PRESSURE RESPONSE OF GluN1-4a/b SPLICE VARIANTS OF NMDA RECEPTORS

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Introduction
Professional divers exposed to ambient hyperbaric pressure (HP) above 1.1 MPa develop the High Pressure Neurological Syndrome (HPNS). The glutamate-type N-methyl-D-aspartate receptor (NMDAR) has been implicated in CNS hyperexcitability underlying HPNS. Furthermore, NMDAR subunit GluN1 splice variants have been implicated in selective pressure effects. GluN1-1a/b, GluN1-2a/b, and GluN1-3a/b co-expressed with the GluN2A subunit exhibited differential degrees of increased NMDAR currents at HP. Surprisingly, NMDARs containing GluN1-4a/b variants showed a possible 'dichotomic' response: either an increase or a decrease of the ionic currents. In order to test whether over-expression, variable stoichiometry, or the type of GluN2 subunit could explain such a behavior, we expressed different variations of the receptor.

Materials and Methods
Different concentrations (5ng/0.2ng) of GluN-1-4a/b variant cRNAs were co-expressed with GluN2A or GluN2B subunit cRNA in *Xenopus laevis* oocytes. Ionic currents were measured in Ba^{2+} solution ($[Mg^{2+}]=0$,$[Ca^{2+}]=0$) using two-electrode voltage clamp, in response to bath application of the co-agonists glutamate (100μM) and glycine (10μM) at helium pressures of 0.1 and 5.0MPa.

Results
The statistical analysis of the changes in NMDAR currents at HP are shown in Table 1.

Conclusions
All NMDAR subtypes containing GluN1-4 subunits exhibited 'dichotomic' responses at HP, while other subtypes containing GluN2A/B with different GluN1 subunits (Introduction) always exhibited current increases. Aggregate formation, type of the GluN2 subunit, and modified stoichiometry are not responsible for the HP 'dichotomic' response. These results strongly indicate the importance and specificity of both, GluN1 and GluN2 subunits of NMDAR, in determining its crucial role in HPNS.

Subunit composition	Amplitude (%Δ, 5.0/0.1 MPa) Mean±SEM	n	p
5ng of each subunit			
GluN1-4a+GluN2A	26.58±4.87	7	0.003
	-19.51±10.78	**3**	**0.212**
GluN1-4b+GluN2A	47.38±13.30	9	<0.001
	-38.76±12.13	**2**	**0.224**
GluN1-4a+GluN2B	8.07±2.76	4	0.047
	-22.67±8.72	**5**	**0.023**
0.2ng of each subunit			
GluN1-4a+GluN2A	111.83±35.57	6	0.017
	-59.54±18.84	**3**	**0.162**
GluN1-4b+GluN2A	97.34±33.69	6	0.038
	-54.31±4.75	**4**	**0.052**
Different concentrations			
GluN1-4a(0.2ng) +GluN2B(5ng)	57.58±12.76	7	0.047
	-28.16±10.69	**2**	**0.141**
GluN1-4a(5ng) +GluN2B(0.2ng)	29.49±7.87	4	0.015
	-37.13±6.12	**6**	**0.003**

Table 1. Mean %change±SEM of amplitude is calculated for each pair of measurements and averaged, n, number of experiments, p, degree of statistical significance for paired t-test. Bold numbers indicate decreased response.

O-05 XENON BLOCKS NEURONAL INJURY INDUCED BY TISSULAR GAS BUBBLE FORMATION IN DECOMPRESSION SICKNESS

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* These authors contributed equally to this work and have been ranked by alphabetic order.

Introduction
Despite state-of-the-art hyperbaric oxygen (HBO) treatment in hyperbaric medical units, about 30% of patients suffering neurologic decompression sickness (DCS) still exhibit incomplete recovery[1], thereby indicating that new additional treatment to HBO could help improving neurologic outcome in neurologic DCS patients. Because DCS involves both excitotoxic and ischemic processes[2], we investigated the effect of the noble gas xenon, shown to provide efficient neuroprotection through antagonism at the N-methyl-D-aspartate (NMDA) receptor in animal models of excitotoxic insults and acute ischemic stroke[3], in an ex vivo model of tissular gas bubble-induced neurologic DCS.

Materials and Methods
All experiments were driven in a versatile normobaric-hyperbaric chamber that allows investigating specifically the role of tissular gas bubble formation in DCS[4]. Brain slices, drawn from male adult Sprague-Dawley rats were incubated individually and compressed with medicinal air to 0.4 MPa (4 ATA) for 30 min before decompression to normal pressure (0.1 MPa) at 0.01 $MPa.min^{-1}$ (slow decompression rate) or 0.3 $MPa.min^{-1}$ (fast decompression rate). After decompression, brain slices were incubated with medicinal air or xenon at 50 vol% (with 25% nitrogen and 25% oxygen), shown to provide maximal neuroprotection in models of ischemic insults. Samples were obtained from the removed solution to assess the time course of lactate dehydrogenase (LDH), released from the brain slices after decompression and used as a marker of cell injury. Sham slices, instead of being compressed, were incubated at 0.1 MPa absolute pressure.

Results
We found that xenon blocks the increase in lactate dehydrogenase, (released from the brain slices after decompression and used as a marker of cell injury), induced by fast decompression compared to slow decompression.

Conclusions
These data suggest that xenon could be an efficient additional treatment to HBO for the treatment of neurologic DCS.

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O-06 RIGHT ATRIAL DISTENTION AND INCREASED PLASMA ANP AFTER FINNING WITH NEGATIVE PRESSURE BREATHING ARE ASSOCIATED WITH ULTRASOUND EVIDENCE OF EXTRA VASCULAR LUNG WATER (EVLW)

Castagna O [1-2], Poyet R[3], Gempp E[4], Louge P[5], Blatteau JE[1], Desruelle A-V[1], Schmid B[1] and Regnard J[6] .

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Introduction
Immersion pulmonary edema (IPE) is thought to result from capillary stress failure due to high alveolar-capillary transmural pressure. Physical exertion increases venous return and respiratory load enlarges intra-airway pressure changes. The effects of these immersed-combined strains on the right cardiac chambers have not been yet described.

Subjects and methods
16 healthy scuba divers (33 ±11 yrs ; 77 ± 9 kg ; 185 ±11 cm) were studied upon finning for 30 min at moderate intensity 50 cm below water surface. The inspiratory load amounted to 32.1 ± 4.6 hPa during SCUBA breathing air and the related work of breathing was 2.6 ± 0.4 $J.L^{-1}$. Venous blood sampling and in-water transthoracic cardiac echography followed by lung echography were performed before (baseline) and immediately after the experimental session.

Results
Right atrial volume at the end of finning was twice baseline (mean = SEM; 76.97 ± 2.61 mL vs. 34.28 ± 3.38 mL; p=0.0009, paired t-test). Post-dive plasma Pro-ANP was 5 times higher than baseline (mean ± SEM; 4.77 ± 0.32 $nmol.L^{-1}$ vs. 0.54 ± 0.11 $nmol.L^{-1}$ $p<0.0001$, paired t-test). Conversely, plasma pro-BNP did not change. Echographic signs of extravascular lung water (EVLW as "lung comet tails'") were found in 13 of 16 subjects.
This study revealed that right atrial distension (RAD) and plasma Pro-ANP were markedly increased when ultrasound lung comets (ULC) were present ($p= 0.0008$ and $p<0.0001$: respectively).
The accumulation of EVLW was graded according to respiratory load, right atrial distension, and the increase in plasma Pro-ANP.

Conclusions
RAD could be induced by changes in thoracic pressure during combined exertion and immersed respiratory load that strengthen pulmonary vascular congestion. In addition, the large thoracic pressure swings triggered ANP release, likely to bolster pulmonary interstitial fluid accumulation. We suggest these alterations are instrumental to IPE appearance, ahead of capillary failure.

KEYNOTE LECTURE: THE HISTORY OF HYPERBARIC OXYGEN THERAPY

Richard 'Dick' Clarke is the President of the National Board of Diving & Hyperbaric Technology, the President of National Baromedical Services, Inc. and Director of the Baromedical Research Foundation.

Dick's accumulated experience within the combined discipline of undersea and hyperbaric medicine extends over 50 years. Following service in the British Royal Navy throughout the decade of the 1960's he spent two years a program director at the International Underwater Explorers Society, in the Bahamas. Dick then joined the seabed living program *'Hydrolab',* operating and saturating in underwater habitats in the subtropics and beneath arctic ice, on behalf of the U.S. government's National Oceanographic and Atmospheric Administration. From 1976 to 1985 he was employed by Oceaneering International as an oilfield saturation diving superintendant. During this period he was a member of the team that developed the diver medic training program and its subsequent board certification process.

Over the past 30 years 1985 Dick has centered his hyperbaric and diving medicine operational support, education and research programs at Palmetto Health Richland Hospital/University of South Carolina School of Medicine, in Columbia. Some 8,000 physicians and other health care professionals from throughout the world have trained in this setting. He founded the non-profit Baromedical Research Foundation in 1987. Initially serving as a basic science hyperbaric laboratory it evolved to become the centerpiece of an international clinical trials consortium. One of the Foundations' studies became the first randomized, controlled double-blind long-term follow-up trial to prove therapeutic efficacy of hyperbaric medicine in the setting of deficient wound healing states, namely pelvic late radiation tissue injury. More recent studies have addressed the potential radiation sensitization effect of hyperbaric oxygen in newly diagnosed squamous cell carcinomas of the head and neck.

Dick was instrumental in the development of the Certification in Hyperbaric Technology (CHT) program and continues to serve as president of its certification body, the National Board of Diving & Hyperbaric Medicine. He has written numerous peer reviewed medical and technical articles and authored chapters in several undersea medicine and hyperbaric oxygen therapy textbooks. He serves as a subject matter expert for a number of U.S. purchasers of health care, including Medicare and has held key committee and other leadership positions in the Undersea and Hyperbaric Medical Society.

O-07 ADENOSINE AND CENTRAL NERVOUS SYSTEM OXYGEN TOXICITY

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Introduction
Hyperbaric oxygen (HBO) is widely used in many ways, such as divingoperations and clinical therapy. As oxygen partial pressure increases, oxygen toxicity may take place. Central nervous system oxygen toxicity (CNS-OT) is the most intensive and representative appearance which manifests as grand mal convulsions. It was shown that adenosine, whose level was predominantly controlled by astrocytesin brain, is involved in epilepsy. This study aims to investigate the influences of HBO exposure on the metabolism of adenosine in the brain, furthermore, to confirm the relevanceof adenosine inCNS-OT.

Materials and Methods
HBO exposure was conducted using anesthetized rats exposed to 5 ATA HBO for 80 min, and microdialysis samples of brain tissue were collected continuously. The concentrations of extracellular adenosine, ATP, ADP, AMP were determined. In another experiment, free moving rats were exposed to HBO at the same pressure for 20 min, and the activities of 5'-nucleotidase and adenosine kinase (ADK) in brain tissue were measured. Besides, we investigated the effects of a series of drugs relating to adenosine metabolism on the CNS-OT latency of rats.

Results
During HBO exposure,adenosine content in interstitial fluid in brain increased significantly, while the content of ATP was reduced. HBO exposure significantly inhibited ADK activity and improved 5'-nucleotidase activities. Moreover, intra-cerebro-ventricular injection ofadenosine, ADK inhibitor 5'-dITU, adenosine A_1 receptor (A_1R) agonist CCPA and $A_{2A}R$ antagonist SCH58261 prolonged time to CNS-OT. Adenosine A_1R antagonist DPCPX and $A_{2A}R$ agonist CPCA shortened CNS-OT latency.

Conclusions
HBO exposure increases interstitial brain adenosine content by inhibiting adenosine removal via suppression of ADK activity and by improving adenosine synthesis via promotion of 5'-nucleotidase activity. In addition, improvement of adenosine concentration, activation of adenosine A_1R or suppression of ADK and adenosine $A_{2A}R$ were involved in the prevention of CNS-OT.

O-08 BRAIN ANGIOGENESIS INDUCED BY HYPERBARIC OXYGEN THERAPY CAN BE VISUALIZED BY PERFUSION MRI IN POST TRAUMATIC BRAIN INJURY PATIENTS

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Introduction
Recent clinical studies in patients with chronic neurological impairment due to stroke or traumatic brain injury (TBI) present convincing evidences that hyperbaric oxygen therapy (HBOT) can be the coveted neurotherapeutic method for brain repair. One of the most interesting mechanisms by which HBOT can induce neuroplasticity is angiogenesis. Till now, angiogenesis induced by HBOT was demonstrated only in pre-clinical studies.

Aim
The objective in this study was to assess the neurotherapeutic effect of HBOT in post TBI patients using brain perfusion imaging and clinical cognitive functions.

Methods
The study included 10 post-TBI patients suffering from chronic neuro-cognitive damage due to TBI. Patients were treated with 60 daily HBOT sessions. Imaging evaluation was performed using MRI, which protocol included DSC, DCE, DTI, FLAIR, T2 and SWI. Cognitive evaluation included objective computerized cognitive tests (NeuroTrax).

Results
HBOT was initiated 10.3±3.2 years after the acute brain injury. 60% suffered from moderate to severe TBI, where 40% suffered from mild TBI.
After HBOT, whole-brain perfusion analysis showed significant increased cerebral blood flow (CBF) with mean change of 0.56±0.2 (p=0.005) and cerebral blood volume (CBV) 0.28±0.075 (p=0.001) along with decreased mean transit time (MTT). Changes were found in Grey matter as well as White matter structures. In addition, the average plasma volume (Vp) increased (mean change of 0.53±0.19, NS).
Clinically, HBOT induced significant improvement in the global cognitive scores with a mean change of 6.8±1.9 (p=0.007). The most prominent improvements was seen in information processing speed (IPS), visual spatial processing (VSP) and motor skills indices, with mean changes of 9.6±2.9 (p=0.005), 10.1±4.2 (p=0.0043) and 9.5±4.5 (p=0.013) respectively.

Conclusions
The increase in brain CBV, CBV (mostly Vp) demonstrate for the first time in humans that HBOT can induce brain angiogenesis. In addition the decrease in MTT indicates that brain metabolism was improved. In accordance with brain angiogenesis and improved metabolism, HBOT improved the cognitive functions of the patients.

O-09 GENOTOXICITY OF HYPERBARIC OXYGEN AND REVERSIBLE DNA-PROTECTING ADAPTATION INDUCED BY REPETITVE EXPOSURE

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Introduction
There is evidence for genotoxicity of hyperoxia, but adaptive protection might also be induced. Aim of the study was:
1. To determine the amount of double-strand breaks in PBMCs (peripheral mononuclear blood cells) after a single exposure to high-dose hyperbaric oxygen in vivo.
2. To monitor the decline of the protective adaptation after a phase of repetitive exposures to hyperbaric oxygen in professional closed-circuit divers in a prospective approach.

Methods
1. DNA-damage was determined in freshly isolated PBMCs from subjects (n=12) immediately before and after a 30 minutes mandatory oxygen tolerance test (pO_2=280kPa). All subjects were males, of same age and personal situation, and never been exposed to hyperbaric oxygen before.

2. Likewise by determining DNA-damage in PBMCs. Baseline of DNA-damage was assigned in professional divers (n=7) 24 hours after a three-month period of about 85 repetitive mainly physically strenuous closed-circuit dives (50 to 120min, pO_2≈160kPa). Afterwards PBMCs were exposed to hyperoxia (400kPa, pO_2=100%) ex vivo. DNA-damage was determined hourly for 6 hours. Both experimental steps were repeated weekly with PBMCs of the same subjects over a five weeks period without any further exposure to hyperoxia. All subjects were males of the same age taking part in the same schooling program.

DNA-damage of either investigation was determined by means of the alkaline Comet Assay calculating the percentaged amount of DNA-damage by a visualized binary scoring system as well as by analyzing the computerized estimation of "Tailmoment" and "% Tail DNA" of 200 PBMCs, respectively.

Results
1. PBMCs after oxygen tolerance test showed highly significantly ($p<0,001$) more DNA-damage.

2. The prospective approach revealed that baseline DNA-damage increases significantly ($p_{24h/5w}<0,001$) comparing the first and last determination. Furthermore, percentage of cells with DNA-damage increased hourly under 400kPa and 100% O_2 in an almost linear way. Slopes of graphs from data raised 24 hours after last oxygen dive were significantly ($p_{24h/3w}=0,022$; $p_{24h/5w}<0,001$) smaller than those raised after 3 to 5 weeks afterwards. Slope of graph from data after 1 week was similar to 24 hours graph's slope, likewise 4 and 5 weeks graph's slopes were similar.

Conclusion
Hyperbaric oxygen can produce DNA-damage in PBMCs. Repetitive exposures to hyperoxia in vivo lead to adaptation of PBMCs with less susceptibility towards hyperoxic stress afterwards. This DNA-protecting effect of adaptation decreases with time, whereas up to one week after last exposure protection is still high.

Key words
Hyperoxia, DNA damage, Comet Assay, oxygen-diver, adaptation, hyperbaric oxygen

O-10 PROBING MOLECULAR EVENTS IN CNS O_2 TOXICITY USING ANTI-EPILEPTIC DRUGS

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Introduction
Abnormal excitatory and/or inhibitory neurotransmission are pathogenic factors common to both clinical epilepsy and CNS O_2 toxicity. Certain anti-epileptic drugs (AEDS), with specific mechanisms of action that modulate these neuronal functions in epilepsy also protect against hyperoxic seizures and therefore could be used to infer specific molecular targets on which HBO_2 exerts toxic effects. Using this approach, we exposed mice to HBO_2 after pre-treatment with selected FDA-approved sodium channel blockers or GABA transmission enhancers.

Materials and methods
8 groups of conscious C57Bl mice were exposed to 100 % O_2 at 5 ATA for up to 90 min, after pretreatment with a Na-channel blocker (Carbamazine, CBZ; Lamotrigne, LTG; Primidone, PRM; Zonisamide, ZNS; or Oxcarbazepine, OXC) or with a GABA transmission enhancer (Gabapentin, GBP; Tiagabine, TGB; or Valproic Acid, VPA). Each drug was dissolved in an appropriate vehicle and administered IP at 3 different doses in separate exposures, with a minimum of 8 animals for each dose. For comparison, a 9th group of untreated mice was also exposed to HBO_2 at 5 ATA. Seizure latency, time to onset of observed seizure behavior, was recorded for individual mice.

Results
Of the Na-channel blockers, CBZ (at 25 mg/kg) was the most effective, increasing mean seizure latency more than fourfold compared to untreated animals; whereas PRM was least effective, providing a twofold increase (at 80 mg/kg). Of the GABA transmission enhancers, the reuptake inhibitor TGB was the most effective, increasing seizure latency threefold; and the reuptake inhibitor VPA was least effective (approximately twofold vs. controls). The GABA synthesis enhancer GBP was intermediate in effectiveness.

Conclusions
(i) Some AEDs can significantly delay seizures in HBO_2, in a dose-dependent fashion; (ii) AEDs with specific mechanisms of action can be used as tools to investigate mechanisms of CNS O_2 toxicity; (iii) certain AEDs hold promise as protective agents against hyperoxic seizures.

O-11 SINGLE CENTER STUDY OF DECOMPRESSION SICKNESS (DCS) IN FINLAND 1999-2015: SPECIAL EMPHASIS ON TECHNICAL DIVING

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Introduction
In Finland there are annually 30-50 DCS cases. Majority (60%) were treated in Medioxygen Hyperbaric Center.

Materials and methods
In 1999-2015 we treated and analyzed 323 scuba divers (78% men) with subanalysis of technical divers (n=88, 94% men). Technical diving included use of mixed gases, CCR or air/nitrox dive requiring nitrox/oxygen decompression stops. Average age of diver was 35 years (range 18-62). Divers were experienced (56% had CMAS P3 or higher), number of logged dives averaging 344 with life-time maximum depth 52,7 m (range 10-209 m). Previously 26% suffered DCS.

Results
Amongalldiversaverage diving exposure was 36,1 m/53 min with air 60%, nitrox 19%, trimix 12% or CCR 8%. One third of divers had performed multiday (≥3 consecutive days) diving. Dives occurred in Finnish cold/arctic conditions (68%). The most important risk/predisposing factor was violation of ascent rate (67%). First Aid Oxygen (FAO2) was used in 26% of the cases. Delay to recompression was on average 66 hours, median 26 hours. Presentation included joint pain 58,8%, tingling 34,3%, numbness 32,3%, confusion 30,8%, excessive fatigue 25,9%, itching 20,4%, vertigo 19%, and rarely bladder dysfunction 1,2% or hearing impairment 2,3%. Treatment was USNTT6 (71%) or USNTT5 (21%) as primary recompression, and follow-up treatments USNTT9. Divers received 3,1 treatments (median 2). Complete remission was achieved in 81%, mild residual symptoms in 13%, and 6% stopped divingdue to variousreasonslikechronicresidualsymptomse.g.hearingimpairmentafterinnerear DCS orseveralrecurrencesof DCS. In technical diving the peak incidence occurred in 2005-2009, when 30-52% of all annual DCS cases presented. In technicaldivingaverage diving exposure was 59 m/90 min. In 22% of the technical cases, predisposing factor was identified (47% ascent rate, and 16% dehydration). FAO2 was used in 41%. Delay to recompression was less (34 hours, median 24 hours). However, the protocol and number of treatments and outcome were similar to recreational divers.

Conclusions
Majority of Finnish DCS cases are mild, althoughdivingisoftendemanding (coldwater (4°C), mines/caves, deepdives). Unfortunately, the use of FA02 is still uncommon.

O-12 IMPLEMENTATION OF A PATIENT SAFETY SYSTEM AS PART OF AN ISO 9001 QUALITY SYSTEM, IN A MULTIPLACE HBO FACILITY

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Introduction
The Institute for Hyperbaric Medicine (IvHG) is the largest HBO provider in the Netherlands with 4 multiplace facilities. As part of an ISO certification process we had to describe all our activities during the HBO treatment in a protocolled way. We analysed our processes and divided them into procedures and work instructions. As part of the quality system we implemented a patient safety system as part of the certification process. One of the main components of the patient safety system is the incident reporting system.

Methods
Our quality system consists of a quality manual where responsibilities and procedures are developed. Procedures and work instructions about medical issues and daily routines are included in the operating manual. All (near) incidents are reported in a reporting system. After every (near)incident report severity and frequency are determined. Combining severity and frequency leads to a validation of the risk as high, medium or low. This risk validation is noted in a risk assessment matrix. The (near)incidents reported as high risk are discussed.

Results
In 2014, there are nearly 22 incidents reported by the four locations. From these reports, there are two classified as high risk. The (near) incidents are analyzed with the PRISMA method. (Prevention and Recovery Information System for monitoring and analysis). Analysis helped us to improve patient care, regarding the prevention of risks to patients. It also promotes the culture of the organization to report incidents. The quality of care is enhanced by reporting incidents. By using the Deming circle patient care incidents are analyzed and we produced improvement interventions. The improvement will be discussed with the branches and will be implemented in the organization.

Conclusion
We want to generate a higher response in 2015 to report (near) incidents. Therefore, once a quarter we will apply the PRISMA method and we will implement correct measures on the locations. In this way, we increase safety awareness among hyperbaric physicians and nurses.

O-13 USE OF ECGP IN THE EUROPEAN HYPERBARIC FACILITIES

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Introduction
European Code of Good Practice (ECGP) is a document which is intended to be a reference document for European countries for Guidelines, Regulations, and Standards in Hyperbaric Medicine. It was written by members of Working Group «Safety» of the COST Action B14 «Hyperbaric Oxygen Therapy» and approved by the Management Committee in May 2004. Since then, more and more Hyperbaric Facilities, assimilate the instructions of the ECGP, since they feel more secure when using it.

Aim
The main purpose of this research was to evaluate the impact of the ECGP on the European hyperbaric community.

Materials and Methods
This first evaluation was conducted via an open and large questionnaire, published on EBAss' website, in order to prepare a more detailed study of the real impact and consequences of the ECGP. The study was conducted by healthcare personnel from all Hyperbaric Medicine Units of Europe who completed a questionnaire investigating the knowledge of the existence of ECGP, the extent of use by their Hyperbaric Centres, the degree of assimilation of the guidance of the ECGP by the laws of each country and the view of respondents on the usefulness of the subjects. Statistical Package for Social Sciences (SPSS) 22.0 was used for the analysis.

Results
Forty one healthcare personnel working in the hyperbaric field in Europe, participated in the study (age range: 78% 30-49 years old). The existence of ECGP was known by 73.2% of responders (the 73.3% was 30-49 years old, p=0.02) while in a European country 45.5% (p=0.05) didn't know anything about it. 82.9% of them thought that the ECGP was a useful tool for ensuring quality health provision by their department/facility. 64.9% use all or part of the procedures proposed by the ECGP at their facility; 32.3% feel that "Chapter 6. Risk management" is the most applicable to their department/facility while 32.1% consider that "Chapter 5. Gas supply" is of least use for maintaining proper functions. 58.3% mentioned that the ECGP has not been adopted into current legislation in their country while 85.7% believe that it is necessary/helpful to adopt the ECGP into their country's legislation.

Conclusions
It seems to be necessary to work deeply on this matter to evaluate correctly the impact of the ECGP, in order to maximize its diffusion in Europe.

References
The European Code of Good Practice

O-14 PSYCHOMETRIC FUNCTION OF CHILDREN IN SCUBA DIVING

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Introduction
Less data are available regarding psychological fitness of children and diving.This pilot study will investigate the psychological fitness of children for scuba diving using different psychometric tests.

Materials and Methods
Children, 8-14 years old, with no medical conditions considered incompatible with scuba diving evaluated by physician, member of Centre de Plongée Castors & Marmottes Palmées asbl, Brussels, Belgium and written parental agreement of parents and child were included in this ethical committee approved study. No regular intake of medications influencing psycho-cognitive function was allowed. The subjects were allocated to groups with and without scuba diving experience in open water (≤ 2 dives).
Biometric data and Zung Self-Rating Anxiety Scale(Zung SAS) were collected at start.Psychometric tests (Math processing Task (PEBL) 1, Perceptual Vigilance Task (PEBL) 1, Time Wall (PEBL) 2 and Critical flicker fusion frequency 2) and Urine Specific Gravidity Test 2 were measured before (1,2), during (1) and after (1,2) a standardised scuba diving swimming pool trainig session. The underwater measurements of Math processing Task (PEBL) and Perceptual Vigilance Task (PEBL) were made possible by implementation of these tests in an ICON dive computer by Mares.

Results
Biometric data were comparable between 2 groups (n =7 with and n =6 without scuba diving experience). Zung SAS was within normal range in all children. Urine specific gravidity was significatly decreased in both groups ($p < 0.01$) showing a mild deshydration after training. Results of PEPL tests and Critical flicker fusion frequency were similar before and after training in both children groups except for the Perceptual Vigilance Task (PEBL) with significantly shorter reaction times for the experienced group ($p < 0.05$).Their mild deshydration seems not to have influenced the test results.Scuba diving training in swimming pool did not influence these psychometric tests negatively. Implemetation of tests was easy for investigators and children. No safety events were reported.

Conclusions
These psychometric tests are easy-to-implement, user-friendly and can give usefull additional information regarding the psychological fitness and safety of children for scuba diving in swimming pool.
Further investigation of these different psychometric tests during open water dives with children will be performed in a next study.

O-15 POSSIBLE RISK FACTOR CORRELATED WITH DECOMPRESSION ILLNESS: ANALYSIS OF DAN EUROPE DSL DATA BASE

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Introduction
DCI can occur in SCUBA even if current decompression algorithms are respected.
This study aims at better understanding the causes of DCI cases occurring after "regular recreational dives".

Materials and methods
327 DCI cases from the DAN database were analysed.
Anthropometric, gender and age data, and digital dive profiles were recorded.
The gradient factor (GF - Buhlmann ZHL16 C) was calculated at the end of every dive, considering any previous dive within a 48-hour surface interval.
The following dive-related data were considered and evaluated: current, visibility, water temperature, thermal comfort, diving suit, pre-dive physical condition, physical exercise during the 12-hour pre-dive period, workload during the dive, health-related discomfort or technical problem during the dive. Information about general medical history, alcohol, tobacco or recreational drugs use was also recorded.

Results
The 327 DCI cases affected females (37%) in a higher percentage than their presence in the DAN Data Base (17% - $P<0.05$). The DCI group age was significantly higher than the mean age in the DAN DB ($p<0.05$). Diving Depth and Time were significantly higher in the DCI group with respect to the DAN Data Base even if the median of DCI-GF (0.78) was similar to the median of Data Base-GF (0.75) ($P>0.05$).
Only nine DCI cases showed a GF > 1 (2,7%), the majority of cases 38,4% presented GF values between 0.80 and 0.90, 33,3% were in the 0.70-0.80 range, and 5,8% showed GF values above 0.90. Nineteen cases (19,8%) showed a relatively low GF of less than 0.70. No correlation with the other investigated risk factors could be found.

Conclusion
Considering that only 12 of the 327 analysed DCI cases showed a Gradient Factor > 1, all the others must be considered as "undeserved" according to the current decompression algorithms.
This confirms our previous observations that notwithstanding the estimated inert gas tissue saturation levels were well within "safe limits" according to current algorithms, there exists an evident "grey area" in their "mathematical" ability to predict DCI that needs further research and, most likely, a more physiological approach to decompression.

Keywords
Gradient Factor, compartmental model, Diving, Ascent speed, M-value

O-16 INHALED CO_2 AND SUSTAINABLE HEAVY UNDERWATER WORK; A RISKY COMBINATION

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Introduction
Navy Experimental Diving Unit recently showed significant CO_2 retention during heavy underwater exercise with up to 2 kPa CO_2 in inhaled gas and resistive loading only. Values from end exercise (just before failure) were reported. One may hypothesize better control during mid-exercise steady state.

Methods
Accordingly, minute ventilation (V'_I), end tidal CO_2 partial pressure ($P_{ET}CO_2$), and mask pressures (P_{mask}) were examined after at least five minutes of heavy exercise and at least five minutes before exhaustion from the same study; subject who did not complete ten minutes were excluded from calculations for that condition only.

Results
With minimal external breathing resistance ($R1$), V'_I increased with 1 or 2 kPa CO_2 supplied, but the increased $P_{ET}CO_2$ indicated hypoventilation. P_{mask} less than that with higher resistance ($R2$) indicated that greater V'_I was possible. With $R2$, V'_I did not increase when 2 kPa CO_2 was supplied and $P_{ET}CO_2$ climbed. With $R1$, 2 subjects (13%) were hypercapnic ($P_{ET}CO_2$>7,1 kPa) with 1 kPa supplied CO_2, and 5 (31%) with 2 kPa CO_2. With $R2$, 8 (62%) were hypercapnic with 2 kPa CO_2 supplied. V'_I and $P_{ET}CO_2$ were uncorrelated with resting ventilatory sensitivity to CO_2.

Discussion
Even when divers can continue with a heavy workload for more than five more minutes, their respiratory control may not protect them from hypercapnia in the face of inhaled CO_2.

O-17 OXYGEN PRE-BREATHING 120 MIN BEFORE DIVING DOESN'T ADD BENEFIT COMPARED TO WHOLE BODY VIBRATION ON THE REDUCTION OF POST-DIVE VASCULAR GAS EMBOLI

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Introduction
In this study a « frame-based » counting method was used to compare the effect of three different pre-dive conditioning on post dive vascular gas emboli (VGE). The three different pre-conditioning were 100% normobaric oxygen breathing (Oxygen) by mean of a demand valve regulator, a whole body vibration (Vibration) and the combination of normobaric oxygen breathing and whole body vibration (Oxygen + Vibration).

Materials and Methods
Six experienced divers (6 men, 38 ± 5 years old) who consistently showed bubbles post-dive on echocardiograms (repeated control dives at least 3 times) underwent several controlled, standardized, deep pool SCUBA dive (33m, 20min in 33°C) at least one week apart with the different pre-conditioning. Each preconditioning took place 2 h pre-dive and lasted 30 min. VGE were counted according to the method described by Germonpré et al in 2014.

Results
Each subject acted has its own control and results are expressed as % of individual baseline value. A significant reduction in post dive VGE was observed after Oxygen pre-conditioning (76 ± 18 % of control dive), Oxygen + Vibration pre-conditioning (44 ± 23 %) and Vibration pre-conditioning (15 ± 13 %). Post dive VGE was significantly smaller with Vibration pre-conditionings compared to Oxygen + Vibration pre-conditioning. Post dive VGE was significantly smaller with Oxygen + Vibration pre-conditionings compared to Oxygen alone pre-conditioning.

Conclusions
All three pre-conditioning reduce the VGE. Vibration pre-conditioning is more efficient than Oxygen + Vibration pre-conditioning which is more efficient than Oxygen alone pre-conditioning.

References
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O-18 FLUOXETINE STIMULATES ANTI-INFLAMMATORY IL10 CYTOKINE AND ATTENUATES SENSORY DEFICITS IN A RAT MODEL OF DECOMPRESSION SICKNESS

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Introduction
Fluoxetine, a well-known antidepressant, is recognized as having anti-inflammatory effects in the setting of cerebral ischemia. Recently, we have shown that Fluoxetine dramatically reduced the incidence of lethal neurological decompression sickness (DCS) in a mouse model after rapid decompression[1]. Despite HBO treatment in hyperbaric medical centres, 30% of patients suffering from neurologic DCS still exhibit incomplete recovery[2], including sensory impairments. In this study, we focused on the assessment of sensory neurologic deficits and measurement of circulating cytokines after decompression in rats treated or not with Fluoxetine.

Materials and Methods
78 rats were divided in 2 groups i.e. clinical (n=38) and a cytokine (n=40) groups. In both group, the rats were treated with Fluoxetine (Prozac, 30mg/kg PO, 6h before) or with a saccharine solution (controls). All the rats were exposed to 90 msw for 45 min before staged decompression. In the clinical group, thermal (Hargreaves) and mechanical (von Frey) behavioural tests were performed before, 1h and 48h after surfacing. The dynamic weight-bearing (DWB) distribution with a synchronized video recording was also assessed by a biometric floor instrumented cage (Bioseb®). This device is able to assess postural stability depending on the time spent on 3 or 4 paws. In the cytokine group, blood samples were collected from vena cava 1 h after surfacing for detection of 23 cytokines/chemokines (Merck Millipore).

Results
Paw withdrawal force after mechanical stimulation was increased at 1h after surfacing in controls but not in the Fluoxetine group. Paw withdrawal latency after thermal stimulation was increased at 48h after surfacing in controls but not in the Fluoxetine group. DWB assessment highlighted a lack of stability onto 3 paws for controls at 48h after surfacing resulting in a greater time spent on 4 paws, and a better stability onto 3 paws for the Fluoxetine group. Circulating levels of IL10 cytokine were significantly decreased after decompression in controls but maintained at baseline level in the Fluoxetine group.

Conclusions
This study suggests that Fluoxetine has a beneficial effect on the sensory neurological recovery. We hypothesize that the observed effect is mediated through maintained anti-inflammatory cytokine IL10 production.

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O-19 A WAY TO ENHANCE DCS RISK PREDICTABILITY FOR AIR AND MIXED GAS DIVING EXPOSURES

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Introduction
There exist two common ways to assess the physiological stress induced by decompression. The first approach, developed by the US Navy, relies on a statistical predictive tool calibrated on a large *diving profile/DCS* database[1]. The second approach, justified early by DRDC[2], relies simply on bubble measurements through Doppler detections. We determined here a new composite decompression stress index that improves DCS risk predictability.

Materials and Methods
Dive data from the DRDC database (8700 exposures / 106 DCS up to 2013) were explored. Several decompression stress indices involving as main parameters i/ a calculation of the inert gas load Q in the body and ii/ the total ascent time, TAT, were investigated for single air dives and mixed gas exposures. The ROC method was used to assess the relevance of a given index for diagnosis compared with the well-used P $\bar{t}$ index. Additionally, the bubble data subset was utilized to modulate the stress index according to an observed DCS risk ratio between grades. The objective was to determine a modulated stress index to get the best ROC curves for estimating DCS risk

Results
The best decompression stress index, I=(Q-Q*)/TAT$^{\square}$ where Q* is a threshold value of inert gas load and $\square$ a constant, showed a ROC curve with an area under curve (AUC) of 0.74 ± 0.07 (95% CI) against 0.65 ±0.06 for the P $\bar{t}$ index. When modulated in accordance with the bubble peak grade monitored at the precordial level (0 to 4), the AUC can reach 0.82 ±0.06. For mixed gas, the use of this index proved also successful with an AUC of 0.91 ± 0.04.

Conclusions
The combination of diving profile, gas breathed and bubble monitoring information may significantly improve the predictability of DCS risk.

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O-20 TENTATIVE MEASUREMENT OF DECOMPRESSION STRESS DURING COMMERCIAL AIR DIVING OPERATIONS

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Introduction
A project was launched by Technip, a leading diving company, to assess the nature of DCS among commercial divers and define a decompression stress based on the combination of few simple physiological measures.

Methods
Monitoring sessions were conducted at a diving school in France (Ecole Nationale de Scaphandriers) during air training dives in full commercial configuration, at 48 msw, with 15 min bottom time. Decompression was conducted according to French MT92 Tables, either with air stops (13 divers), or air and oxygen stops at 6 msw (24 divers).
29 divers were involved in the tests (ages 29.6 +/- 7.2 years old; height of 179.6 +/- 7.33 cm; BMI value of 24.6 +/- 2.74 kg/m2).
The diver's monitoring included information on 1) the dive exposure (decompression profile, breathing mix), 2) the dive conditions (work, cold), 3) the divers (sex, age, etc.), 4) the divers' condition (fatigue, hydration), 5) the bubbles dose (echocardiography and Doppler bubble grade) and 6) the endothelial function (flow mediated dilation or FMD).

Results
For the same bottom phase, the results indicate a significant difference between air decompression and air and oxygen decompression. On the one hand, the proportion of divers with detected bubbles is lower after decompressions with oxygen stops (0.17%) than with air only stops (0.53%, p=0.026 Mann-Withney test). On the other hand, the FMD variation is significantly higher after decompressions with oxygen stops (mean 0.96+/-0.036)) than with air only stops (0.98+/- 0.040, p=0.028 M-W test).

Discussion
The data indicate that the bubble count and the FMD variations are not correlated. They suggest that 1) the bubble grade is mainly affected by the physics of inert gas exchange and bubble growth and 2) that the FMD is mainly associated to the oxidative stress. We believe that these two measures define two dimensions of the decompression stress considered. Their influence could not be quantified because the monitored dives were safe dives with no incident. However, their interaction suggests that a safe decompression is a trade off between oxygen level and bubble grades.

O-21 EFFECT OF GAS SWITCH ON DECOMPRESSION FROM TRIMIX DIVES

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Introduction
It has become relatively common among technical divers to use decompression gases with different inert gas content to accelerate decompressions. However, in contrast to saturation dives, data indicating that inert gas shifts after a bounce dive will result in less decompression obligation is scant (Doolette & Mitchell 2013). In the present study decompressions using either trimix gas, or air after trimix dives were compared.

Methods
Wet trimix dives were carried out in a hyperbaric chamber using the semiclosed rebreather IS-Mix. The gas composition in the breathing circuit was 21% O_2, 35% He, 44% N_2. Decompressions, calculated with the DCAP Towanda II algorithm, were either carried out with trimix on the rebreather or with air using an open system. The following dive profiles were used (depth (msw)/time (min)/decompression time (min)) for trimix 60/15/59, 40/20/29, and 40/25/46, and for the air decompressions 60/15/49, 40/20/22, and 40/25/38. The decompressions using air were 17% – 25% shorter. Divers were monitored for bubbles up to 2 h after the dives. Bubbles were graded according to the Kisman-Masurel (KM) scale.

Results
Forty-eight dives with trimix and 24 dives with air decompressions were carried out without any complications. The median maximum KM grades were midway between KM II+ and III- for trimix decompressions and were KM II for air (Mann-Whitney test N.S). The ratio of dives with KM scores ≥ III+ was 10/48 (21%) for the trimix decompressions and 5/24 (21%) for the air decompressions.

Conclusion
The shift to air did not produce more bubbles despite the fact that the decompression tables were shorter. This indicates that exchange of helium for nitrogen during decompression may also have a beneficial effect after a bounce dive. However, further experiments using the same decompression profiles both with air and trimix need to be carried out to confirm this finding.

Reference
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O-22 SURVEY ON THE USE OF HYPERBARIC OXYGEN THERAPY FOR CARBON MONOXIDE POISONING IN EUROPE

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Introduction
Carbon monoxide poisoning (COP) is an acute and important indication of hyperbaric oxygen therapy (HBOT).Variations in patient selection andtreatment protocol, however, still remain. The aim of this survey wasto identify practice differences in the treatment of COP with HBO among centers in Europe.

Materials and Methods
The medical directors of hyperbaric centers in Europe were identified through oxynet.org and were invited by email to fill the survey. The survey was conducted through the surveymonkey.com website andthe questionnaire comprised8 questions.

Results
A total of 179 centers were invited. Overall, 68 centers from 23 countries responded.Of these, 6 (8%) which replied that they did not use HBO for COP and 10 (14%) that did not complete the survey were excluded and the study was conducted with the remaining 52 centers. While transient or prolonged unconsciousness was unanimously recognized as an indication of HBOT, positive neurological findings, ECG suggesting acute ischemia and pregnancy were considered important indications of HBOT in over 95% of the centers. Treatment duration varied between 60 to 120 minutes and treatment pressure between 1, 5 to 3, 0 ATA.Among responders 39% (18/46) reported to deliver a single session within the first 24 hs of COP and 34.8% (16/46) two sessions. Only 9 (19.6%) of the centers delivered 3 sessions within the first 24 hs of COP. Half (23/46; 50%) of the centers reported that the total number of HBOT delivered was 1, repeated if symptoms persisted after first dive. While 17 (32.7%) centers allowed a maximum of 6 hs prior to HBOT commencement, 16 (30.8%) received patients with COP until 24 hs. Number of patients treated with COPin the past year ranged from1 to 430, with a median of 32.Overall, 14 (14/45; 31.1%) centers reported to treat 50 or more patients in the past year.

Conclusion
Our results showed that the indications of COP for HBOT are not still universally recognized. Additionally, HBOT protocols used at European hyperbaric centers variedsignificantly showing a need for further studies

O-23 HYPERBARIC OXYGEN CAN INDUCE NEUROPLASTICITY AND IMPROVE COGNITIVE FUNCTION OF PATIENTS SUFFERING FROM ANOXIC BRAIN DAMAGE

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Introduction
Cognitive impairment may occur in 42-50% of cardiac arrest survivors. Hyperbaric oxygen therapy (HBO2) has recently been shown to have neurotherapeutic effects in patients suffering from cognitive impairment consequent to stroke and mild traumatic brain injury. However, there is only sparse data regarding the neuroplasticity potential of HBO2 in patients suffering from chronic cognitive impairments consequent to anoxic brain injury (ABI).

Objective
The objective in this study was to assess the neurotherapeutic effect of HBO2 in patients suffering from chronic cognitive impairments (CCI) due to cardiac arrest.

Methods
Retrospective analysis of patients with CCI caused by cardiac arrest treated with 60 daily HBO2 sessions. Evaluation included objective computerized cognitive tests (NeuroTrax), Activity of Daily Living (ADL) and Quality of life questionnaires. The results of these tests were compared with changes in brain activity as assessed by single photon emission computed tomography (SPECT) brain imaging.

Results
The study included 11 cases of CCI patients. Patients were treated with HBO2 0.5-7.5 years (mean 2.6±0.6 years) after cardiac arrest. HBO2 was found to induce statistically significant improvement in memory, attention and executive function, of 12%, 20% and 24% mean relative changes, respectively. The clinical improvements were found to be well correlated with increased brain activity in relevant brains area as assessed by computerized analysis of the SPECT imaging.

Conclusions
Although further research is needed, the results demonstrate the beneficial effect HBO2 can have on cognitive impairments in patients after ABI, even months to years after the acute event.

O-24 ASSESSMENT OF ENDOTHELIAL FUNCTION IN DIABETIC FOOT ULCER PATIENTS – A PRELIMINARY STUDY

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Introduction
Foot ulcer is a common complication to diabetes. Treatment of diabetic foot ulcer is often protracted and in 19-34% non-healing. Hyperbaric oxygen therapy (HBOT) has proven to increase the opportunity of ulcer healing in diabetic patients. HBOT improves leukocyte function, stimulates vascularization and enhances fibroblast activity and collagen synthesis. The endothelial layer takes part in maintaining vascular homeostasis that is crucial for ulcer healing. Endothelial dysfunction is found in diabetic patients and might contribute to protracted healing progress.
A new FDA-approved non-invasive technique based on pulse amplitude tonometry called peripheral arterial tonometry is a standardized method for monitoring the peripheral endothelial function. Peripheral arterial tonometry measures the digital blood flow and uses a post-to-pre occlusion signal to provide an index of endothelial function called Reactive Hyperemia Index (RHI). A RHI below 1.68 is considered as endothelial dysfunction whereas above is defined as normal.
The aim of the present study was continuous evaluations of the peripheral endothelial function in diabetic foot ulcer patients during sessions of HBOT.

Materials and Methods
Three diabetic foot ulcer patients were prospectively studied. The subjects underwent thirty sessions of hyperbaric oxygen therapy in a multiplace hyperbaric chamber and were treated equal to a RH14 table (ascent/descent rate: 9.4 feet/minute; depth: 47 feet sea water; time at depth: 90 minutes). The peripheral endothelial function was assessed at 0th, 10th, 20th and 30th HBOT session using peripheral arterial tonometry (Itamar Medical, Israel).

Results
At first HBOT session, RHI was found in the three diabetic foot ulcer patients to be 1.19; 1.20 and 1.35 respectively. At tenth HBOT session, RHI was increased to 1.42; 1.60 and 1.38. At the twentieth HBOT session, RHI further increased to 1.93; 2.34 and 1.65. At thirty and last HBOT session, the RHI was found to be 2.19; 2.24 and 1.90.

Conclusions
Peripheral arterial tonometry seems to be a quick, operator-independent and reliable technique for monitoring endothelial function in diabetic patients. Preliminary results indicate an overall endothelial dysfunction in diabetic foot ulcer patients at baseline. Additionally, an indication of improved endothelial function was found during thirty sessions of HBOT.

O-25 HYPERBARIC OXYGEN SIDE EFFECTS – RETROSPECTIVE ANALYSIS OF 2334 PATIENTS

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Introduction
Hyperbaric oxygen therapy (HBOT) is applied for a growing number of patients with wide diversity of co-morbid illness.The main side effects related to HBOT are barotraumas, oxygen toxicity, claustrophobia and anxiety and pulmonary and optic symptoms. Middle ear barotraumas, the most common complication, has a wide reported incidence of 2-82%. Seizures are reported in 1:10,000 but can increase up to 1:600 in hyperbaric pressure higher than 2.4 ATA. Previous studies usually excluded children and patients with neurologic diseases.

Objective
The aim of this study was to evaluate the incidence of side effects associated with HBOT and their risk factors in a single hyperbaric institute.

Methods
Retrospective analysis was performed on patients treated in Sagol Center of Hyperbaric Medicine and Research, Assaf Harofeh, Israelbetween June 2010 and December 2014. Data was collected from patients' medical files.
Each patient session was assigned to one of the following groups: A. Non healing wounds, non-neurological radiation injury, osteomyelitis, AVN, fractures, crohn's disease, idiopathic hearing loss.B.Stroke, Traumatic brain injury, cerebral palsy, autism andradiation injury to the brain. C-Acute indications including decompression sickness, CO intoxication, acute limb ischemia, central retinal artery occlusion.
Patients were treated five times per week in different protocols. Group A were treated with 2 ATA for 90 minutes with 5 minutes air breaks every 30 minutes. Group B were treated either by 1.5 ATA for 60 minutes with no air breaks or 2 ATA for 90 minutes with 5 minutes air breaks every 30 minutes. Group C were treated by either 2.4 ATA for 90 minutes with 5 minutes air breaks every 30 minutes or USN 5, USN 6, USN 6A as described.

Results
2334patients with a total of 62,614hyperbaric sessions were included in the analysis. The mean age was 52.3±22.5 and 240 (10.3%) were children under 16 years old.
The overall adverse event rate was 0.79%. The side effects incidence per group was 0.85% in group A, 0.72% in group B and 1.78% in group C.
The incidence of middle ear barotraumas was 0.4%.Multivariate analysis revealedincreased risk for middle ear barotraumas in females (OR=1.671 [1.256-2.224], p=0.0001) and age under 16 (OR=1.59 [1.050-2.408], p=0.028). The neurologic group (OR=0.674 [0.501-0.907], p=0.009) and urgent group (OR=0.221 [0.111-0.440, p=0.0001) had decreased risk for middle ear barotraumas compared to group A.

The incidence of seizures incidence was 0.011% (1:8954) and occurred in 7 (0.3%) patients. One patient had the seizure more than 20 hours after hyperbaric exposure. 5patients had known epilepsy prior to HBOT. Three patients that were treated urgently for air emboli suffered from seizures as part of their presenting symptoms, few minutes to hours prior to the hyperbaric exposure. They experienced similar seizures during the HBOT. The seizures were treated with intravenous benzodiazepines and phenytoin. Two patients, treated for traumatic brain injury and a non-healing wound, had a history of epilepsy prior to HBOT and their epilepsy was treated with anti-epileptic medications prior to HBOT initiation. During HBOT, they experienced similar seizures. The seizures were treated in the chamber using intravenous benzodiazepines.
The incidence of oxygen toxicity seizures was 1:62679. In hyperbaric pressure of 2.4 ATA or higher, the seizures incidence increased to 1:419, but none for oxygen toxicity.

Conclusion
In agreement with previous studies, HBOT is a safe treatment. Females and children (younger than 16 years old) should be properly educated as they are at increased risk for middle ear barotrauma. Chronic neurological diseases other than epilepsy do not increase risk for seizures.

O-26 COMPLICATIONS OF HBO TREATMENT, A MULTICENTER ANALYSIS OVER 18 YEARS IN 5801 PATIENTS

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Introduction
HBO treatment is considered a very safe modality with few complications. Most complications are related to pressure effects on the ear and acute oxygen toxicity.
The Institute for Hyperbaric Medicine (IvHG) is the largest HBO provider in the Netherlands with currently 4 multiplace facilities. Our institute uses the same session profile in every facility since 18 years. We conducted a retrospective analysis of complications in 5801 patients with a total of 146.849 sessions (mean 25,3 sessions per patient) between 1996 and 2013.

Materials and methods
All HBO treated patients received oxygen at 2.5 ATA (15 msw) for 80 minutes in a total session time of 115 minutes. Pressure increase/decrease is 1.5 m per minute to and from treatment depth. 100% oxygen is administered with BIBS for 20 minutes alternated with 5-minute air breaks, so a total of 200 bar.min-1 100% is administered per session. We retrospectively analyzed all complication forms in the patient files. We found 76 complications (rate is 1,31%).

Results
Complications were graded regarding seriousness as light, moderate or severe. Myopia and grade 1 or 2 middle ear squeeze were not recorded. We had acute oxygen toxicity in 50 cases, incidence of was 0,03% (1 in 2937 sessions). We had 7 cases of tympanic membrane rupture (incidence 0,004%), 6 cases of hypoglycemia (incidence 0,004%). Rare but serious were 2 cases of stroke, 1 myocardial infarction and 1 fracture due to a fall inside the chamber in acute oxygen toxicity. Severe complications are discussed.

Conclusions
To our knowledge this is the largest single institution retrospective analysis looking at complications of HBO treatment using 1 specific session profile.

O-27 HYPERBARIC OXYGEN THERAPY IN THE TREATMENT OF NECROTIZING SOFT TISSUE INFECTIONS ─ REVIEW OF 65 CASES

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Introduction
Necrotizing soft tissue infections are life-threatening infections that must be promptly treated. The treatment is based in combining surgical debridement, antibiotics and supportive care. Hyperbaric Oxygen Therapy (HBOT) is recommended as an adjuvant strategy, relying bacteriostatic and bactericidal effects and by optimizing tissue oxygen levels. Several studies report that applying HBOT in soft tissue necrotizing infections is related to improved survival and limb salvage. In this study, a review of 25 year experience of our center in treating necrotizing soft tissue infections with HBOT is performed.

Methodology
Retrospective and descriptive study. The clinical reports of patients diagnosed with necrotizing soft tissue infections treated with HBOT at our center were reviewed.

Results
A total of 65 patients (58 male and 7 female) with a mean age of 49 years were treated. Diabetes was the most common comorbidity condition (56.4%). Trauma was the most frequent etiology (30% of cases), followed by urological pathology. Most frequent anatomic location was perineum (53.8%) and lower limb (30.8%). Broad-spectrum antibiotics were used, namely metronidazole, clindamycin and meropenem, almost always in combination. Complications associated with HBOT were registered in 5 patients. Seven patients died (mortality rate: 15.6%), four of them had diabetes (57.1%). Surviving patients were submitted to an average of 20.8 sessions of HBOT, ranging from 6 to 100. The majority of patients were referred from hospital units in Lisbon area.

Conclusion
HBO is recommended as an adjuvant treatment in necrotizing soft tissue infections and should be considered whenever available. It was found that geographical area represents a limitation to referring these patients to our center. Due to the high level of care they require and logistical issues, it was clear that patients from outlying areas of Lisbon could not have access to the center without this interfering with other therapeutic strategies underway.

O-28 HYPERBARIC OXYGEN THERAPY FOR THE TREATMENT OF FOURNIER'S GANGRENE ─ A REVIEW OF 35 CASES

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Introduction
Fournier's gangrene is a serious necrotizing infection that can be fatal if it is not promptly attended. Treatment for this condition consists of a combination of surgical debridement, antibiotherapy and supportive care. Hyperbaric oxygen therapy (HBOT) is used as an adjuvant for the optimization of infected tissue oxygenation through its bactericidal and bacteriostatic effects. Several studies indicate that the use of HBOT in necrotizing soft tissue infections correlates with an increased survival. This study, reviews the experience of our center in treating Fournier's gangrene with HBOT.

Methods
Retrospective and descriptive study. Clinical records of patients diagnosed with Fournier's gangrene treated at our center were reviewed. This study encompass a period of 25 years.

Results
A total of 35 patients were treated. The majority of patients were males (94.3%) with a mean age of 53.8 years. Urinary tract was the most frequent source of infection (36.8%) followed by anorectal region (31.2%). All patients underwent surgical debridement and fecal diversion with colostomy was performed in 8. Most commonly used antibiotics were: metronidazol, clindamycin and meropenem, almost always in combination. Diabetes was the most common comorbidity (63.6%). The majority of deceased patients had diabetes (4 out of 5). Mortality rate was 17.9%. Surviving patients performed an average of 22.4 sessions (range 6 to 100). The majority of patients were referred from hospital units in Lisbon area.

Discussion and Conclusion
Although Fournier's gangrene is a rare condition, it is nevertheless a fatal illness, namely in patients with comorbidities like diabetes. HBOT is recommended as an adjuvant to conventional therapy and should be considered whenever available. It was also observed that the area of residence of patients may affect patients' referral to the center. Owing to the need for differential care and the logistics problems they pose, the access of patients that live furthest would not be possible without affecting other ongoing therapies. To further assess the role of HBOT in the treatment of this condition, additional studies must be carried out.

O-29 RESULTS OF HYPERBARIC OXYGEN TREATMENT (HBOT) IN PATIENTS WITH BONE MARROW EDEMA OR AVASCULAR BONE NECROSIS

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Introduction
Avascular bone necrosis (AVN) or bone marrow edema is an ischemia of the bone marrow with a lack of oxygen. There are surgical treatment options and conservative therapies, such as non-weight bearing, drug treatment e.g. prostaglandin or bisphosphonates, electromagnetic fields, shock waves or HBOT. We excluded patients with radiation treatment or treatment by bisphosphonates.

Materials and Methods
We treated 105 consecutive patients mean age 49.2 years (10-81) with a total of 118 AVN (73 AVN of the knee joint, 18 femoral head necrosis, 17 AVN of talar bone, and 10 with different localizations) up to 2012. Mean treatment number were 22 sessions (7-40). We used problem-wound tables (240 hPa/90 min). Follow-up time lasted up to 12 years.

Results
We treated 58 patients with 73 avascular necrosis of the knee. 36 patients (59%) had good results. MRI controls showed substantial amelioration or complete cure. Sixteen (26%) had a partial amelioration with residual pain and/or residual pathology in MRI. Three patients (5%) were unchanged. Six patients (10%) had to be operated despite less pain and better movement.

After the treatment of hip joint necrosis 6 patients (50%) were painless and could do sports without restriction. In 3 cases (25%) we found amelioration with less pain. One patient (8%) was unchanged six years after the treatment; two (17%) had no success.

Out of 12 patients with tarsal AVN five were painless and healed completely (42%), three patients improved but were not cured (25%), one stayed unchanged. Three patients had to be operated (25%).

Other localizations of avascular necrosis (tibia, head of humerus etc.) showed similar good results but the numbers were low.

Conclusions
Treatment results could be reconsidered in a minimum of three months after therapy by MRI. The majority of treatments of avascular bone necrosis or bone marrow edema of different localization and different stages showed amelioration, most of them complete cure (85% in patients with knee joint necrosis, 75% in patients with femoral head necrosis). The best results are found in stage 1 naturally, but even in ARCO stage 3 we could find complete cure in some cases. Our follow-up time lasted up to 12 years.

KEYNOTE LECTURE: THE PHYSIOLOGICAL EXTREMES OF BEING AN ASTRONAUT

André Kuipers is the first Dutchman with two space missions to his name. His second mission is the longest spaceflight in European history. In total the ESA astronaut spent 204 days in space: 11 days during mission DELTA in 2004 and 193 days during mission PromISSe.

After years of training in Houston, Moscow, Cologne, Montreal and Tokyo, a Russian Soyuz spaceship launched André and his two crew members from Russia and America on the 21st of December 2011 from Kazakhstan. Two days later he arrived at the International Space Station to live and work for six months. On board he was not only a medical doctor, scientist and flight engineer, but also handyman and ambassador for several charities. On the 1st of July 2012, André returned to Earth and landed in his space capsule in the Kazakh steppe.

Astronaut André Kuipers offers a unique look behind the scenes of international human spaceflight. He shares his story about the training, the mission and his exceptional view of our planet.

KEYNOTE LECTURE BOEREMA SESSION: HYPERBARIC OXYGEN THERAPY, THE PANACEA FOR RADIATION INJURY?

Marcel Stam, born in 1975, was trained as M.D. at the Free University medical center (VUMC) in Amsterdam from 1993 till 2000. After that, he was trained, as radiation oncologist, at the Radboud university medical center from 2000 till 2006. Since 2007 he is a staff member at the Radiotherapy group, location Arnhem (formerly known as the institute for radiation oncology Arnhem, ARTI). There, he has specialized in breast, lung and esophageal cancer. He is local (co-)investigator in several multicenter trials and partakes enthusiastically in the training of radiation oncologists. He is also project leader for the European electronic logbook for radiation oncology trainees. Furthermore, he is very active in developing the local electronic patient file and implementing many ICT solutions in daily work at the Radiotherapy group. Besides that, he is also member of the steering committee of ARTZ oncology (joint venture of Gelderse vallei hospital, Rijnstate hospital and Slingeland hospital).

O-30 LONG-TERM PATIENT REPORTED OUTCOME OF HYPERBARIC OXYGEN THERAPY FOR HAEMORRHAGIC RADIATION CYSTITIS

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Introduction
Haemorrhagic radiation cystitis (HRC) is a debilitating complication in 6.5-8% of patients after pelvic radiotherapy. Treatment of HRC is mostly symptomatic and evidence-based guidelines are lacking. Hyperbaric oxygen therapy (HBOT) has a different approach as it targets the origin of symptoms, i.e. local hypoxia. The objective of this study is to determine the effectiveness of HBOT to lessen or cure haemorrhagic cystitis in patients after radiotherapy of the lower pelvis

Materials and Methods
All living patients who had HBOT for HRC were retrospectively analysed. Effectiveness of HBOT was evaluated by patient-reported outcomes via a structured telephone interview. HBOT was given at 2.5 atmospheres for 115 min per session.

Results
Included were 74 patients (59 male, 15 female; mean age 72 years). Patients were referred for HBOT (median) 3.5 (range 0-30) years after radiotherapy and received (median) 40 (range 15-135) HBOT sessions. Telephonic interview was conducted median 5 years after start of haematuria. Of all patients, 44 (59%) reported complete resolution of symptoms, 19 (26%) reported partial relief, and 11 (15%) had no improvement of symptoms. After initial successful resolution of symptoms, 18 patients (24%) experienced recurrent symptoms of HRC.

Conclusion
HBOT can relieve or dissolute symptoms of HRC after radiotherapy of the pelvic area, especially in man after prostate cancer treatment. HBOT should be considered in patients suffering from mild to moderate HRC.

Remarks
Mean/median time interval of recurrence of symptoms (where applicable) remains unknown; most patients cannot reproduce when exactly they first experienced symptom recurrence.

O-31 TREATMENT OF LATE RADIATION TISSUE INJURY OF THE BLADDER; A RETROSPECTIVE VIEW OF EFFECTS ON HEMATURIA, CLOTHS AND QUALITY OF LIFE

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Introduction
Hyperbaric oxygen (HBO) therapy is known to be effective in treating symptoms of late radiation tissue injury (LRTI) of the bladder. To our knowledge there have been no reports on Quality of Life (QoL) after HBO. This retrospective study shows the effects as seen by the Institute for Hyperbaric Oxygen (IvHG) in the Netherlands, considering hematuria, cloths and QoL-scores pre- and post-treatment.

Materials and methods
Using a search in the institute's electronic database all patients treated for LRTI of the bladder between 2011 and 2013 in 4 facilities in the Netherlands were included. Patients receiving less than 20 treatments were excluded. Patient characteristics, effects on hematuria, cloths and QoL scores (EQ-5D VAS and parts of the QLQ-C30 and PR 25) were analyzed.

Results
106 patients were included, receiving on average 39 sessions of hyperbaric oxygen (daily sessions of 80 minutes of 100% oxygen at 2.5 atmosphere). 84 were male and 22 female, with cancer of the prostate being the most common reason for radiotherapy (64.2%). The mean time interval between radiotherapy and HBO was 4.9 years. 77 patients reported macroscopic hematuria at the start of their treatment, in 31 cases also with cloths. At the end of therapy 32 patients still had some form of macroscopic hematuria, and in 8 patients cloths persisted (differences between groups both $p<0.001$). Complaints of pain were resolved in 49% of patients ($p = < 0.001$). EQ-5D VAS scores went from 65.0 to 73.3 ($p=0.001$), a similar increase was seen in the global health score (64.8 to 74.7, $p = <0.001$) and quality of life score (67.6 to 75.6, $p = 0.02$) of the QLQ-C30 questionnaire. Scores for the urinary domain of the prostate cancer specific questionnaire QLQ-PR25 were 59.92 pre-treatment and 72.78 post-treatment ($p=0.002$). Follow-up ($n=14$) showed no difference in scores after three months. There were few complications, mostly concerning barotrauma of the ears.

Conclusions
HBO resolves hematuria and cloths due to LRTI of the bladder completely in respectively 58% and 74% of the cases. Quality of life scores increased significantly during treatment; three months follow-up showed no changes in these effects, but numbers were small. Data on partial resolution of complaints and extended follow-up were incomplete and could not be analyzed.

O-32 HYPERBARIC OXYGEN THERAPY FOR THE TREATMENT OF LATE RADIATION TISSUE INJURY OF THE BREAST: A RETROSPECTIVE ANALYSIS

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Introduction
Treatment of breast cancer with radiotherapy, can result in late radiation tissue injury (LRTI) of the breast in 6-15% of patients. It had been known that shown that hyperbaric oxygen (HBO) therapy can have beneficial effects on the complaints associated with LRTI of the breasts. To our knowledge there have been no reports on Quality of Life (QoL) after HBO. In this retrospective study we looked at the frequent symptoms of LRTI of the breast; pain, fibrosis, erythema and oedema, restriction of movement and skin ulceration. We analysed the effect of HBO on each symptom at the end of HBO therapy and at 3 months after HBO treatment. Also we analysed the changes in QoL in these patients.

Materials and methods
Using a search in the institute's electronic database all patients treated for LRTI of the breast between 2012 and 2014 in 4 facilities in the Netherlands were included. Patients receiving less than 20 treatments were excluded. Patient characteristics, effects on the main complaints (pain, oedema, erythema, fibrosis and restriction of movement) and QoL scores (EQ-5D and the QLQ-C30) were analysed, at the first and last day of HBO treatment and 3 months after HBO treatment.

Results
396 patients, all female, were included, with an average age of 56.8 years (range 35-85), receiving on average 37 treatments of hyperbaric oxygen therapy (daily sessions of 80 minutes of 100% oxygen at 2,5 ATA). 71,5% of patients received breast conserving therapy (BCT) and 19% underwent a mastectomy. 48% of patients underwent a sentinel node procedure (SNP) and 38.5% a full axillar lymph node resection. 64.2% received chemotherapy as well as radiotherapy. The average time between radiotherapy and the start of HBO therapy was 29.8 months, with a range from 1.6-710 months. 23.3% of patients smoked up to or during HBO treatment. 9.8% of our group had a form of diabetes.
We monitored the improvement of complaints and QoL between the first and last day of treatment. The patient reported complaints showed the following reduction: pain (61.8%), oedema (42.5%), erythema (28.2%), fibrosis (68%), motion restriction (36%) and skin ulceration (5.2%), all of which are significant ($p < 0.001$). EQ-5D VAS scores improved from 63.8 to 69.6 ($p < 0.001$). All these improvements were also reflected in the QoL score at the end of therapy (67.3 to 72.2, $p < 0.001$). There was a continued increase of QLQ-C30 scores at follow up (72.7, $p = 0.004$, $n = 145$). There were few complications during HBO treatment, the most important being barotrauma of the middle ear.

Conclusion
HBO significantly reduces the six main complaints women present with after radiotherapy treatment for breast cancer. QoL scores increased significantly during treatment. Numbers for follow-up were small, mostly because of missing data, and could not be completely analysed.

O-33 REDUCING SIDE-EFFECTS OF RADIATION THERAPY OF THE BREAST BY HYPERBARIC OXYGEN TREATMENT

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Introduction
Radiation is one of the main treatment modalities for breast cancer. Patient reported outcome (PRO) evaluation of breast cancer patients treated with hyperbaric oxygen treatment (HBOT) for delayed radiation injuries (DRI) will be the focus of this study. Radiation side-effects are encountered in 12-30% of patients treated for breast cancer.

Methods
For patients treated with HBOT for DRI in 2014, quality of life was assessed using validated European Organization for Research and Treatment of Cancer (EORTC) QLQ-C30, (specific cancer site-related) QLQ questionnaires, and the EQ-5D. HBOT treatment consisted of an average of 40 sessions, 5 days a week. In total 80 minutes of 100% O2 is administered to patients under increased pressure of 2.4 ATA during a 110 minutes hyperbaric oxygen session.

Results
A total of 67 patients were available for evaluation for the EORTC questionnaires. Before HBOT, patients had 52%, 55%, 69%, and 30% severe complaints of pain in the arm or shoulder, difficulty to raise arm or move it sideways, pain in the area of affected breast, and oversensitivity of the affected breast respectively. Post HBOT, the percentages of severe complaints were 12%, 8%, 16%, and 10% respectively. For the EQ-5D a total of 48 questionnaires were analyzed. Mobility, selfcare, activity, pain and anxiety improved with 31%, 100% (1 patient), 24%, 39%, and 71% respectively. Total EQ-5D score improved in 55% of the patients, also total health status improved in 55% of the patients. The VAS pain score improved in 77% of the patients.

Conclusion
PRO in breast cancer patients treated for DRI with hyperbaric oxygen treatment is positive, improvement in complaints of DRI were seen. HBOT is a well-tolerated treatment for DRI for breast cancer patients. Side-effects are minimal and reversible.

O-34 HYPERBARIC OXYGEN TREATMENT IN REDUCING SIDE-EFFECTS OF RADIATION THERAPY OF THE BREAST

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Introduction
To examine patient reported outcome (PRO) of breast cancer patients treated with hyperbaric oxygen treatment (HBOT). HBOT is a therapy used for delayed radiation injuries (DRI) in the Netherlands. HBOT improves among others oxygenation of the tissues, promotes formation of collagen matrix and angiogenesis by administering 100% oxygen to patients under increased pressure of 2.4 ATA. Published literature regarding HBOT and DRI of the breast is still scare.

Methods
Breast cancer patients treated with HBOT were interviewed (2009 - 2013) and quality of life was assessed using validated European Organization for Research and Treatment of Cancer (EORTC) QLQ-C30 and (specific breast-related) QLQ BR23 questionnaires, Numeric Rating Scale (NRS11), and Patient Global Impression of Change (PGIC) (2014). HBOT treatment consisted of on average 40 sessions, 5 days a week. In total 80 minutes of 100% O2 is delivered during a 115 minutes hyperbaric session.

Results
A total of 111 patients were available for evaluation. Regarding 82 interviewed patients, 66% were satisfied with HBOT results. For severe fibrosis, 55% scored >3 and for shoulder complaints 45% >3. In total 83% of these patients experienced improvement after HBOT. Regarding the 29 patient receiving the questionnaires postHBOT mild to no complaints were seen regarding “pain in arm” (59%), “swollen arm” (79%), “arm movements” (72%), “painful area” (76%), “Swollen area”(83%), “oversensitive area” (72%), “skin problems” (79%), NRS-11 (63%), and PGIC (85%).

Conclusion
PRO in patients receiving hyperbaric oxygen treatment is positive , on average 70-80% mild to no complaints of DRI. HBOT is a welltolerated treatment for DRI of breast cancer patients. Side-effects are minimal and reversible. A prospective trial regarding the optimal time frame of hyperbaric treatment is warranted and on the way in our medical center.

KEYNOTE LECTURE: 50 YEARS AFTER "PHYSIOLOGY OF BREATH-HOLD DIVING AND THE AMA OF JAPAN" ─ WHAT HAVE WE LEARNED?

Prof. Erika Schagatay, Research Director, Environmental Physiology Group, Department of Health Sciences, Mid Sweden University, Östersund, Sweden.

Erika Schagatay is professor of animal physiology at Mid Sweden University and has studied human freediving physiology for over 25 years. She finished a PhD at Lund University, Sweden, in 1996 where she became an Associate Professor in 2000. At Mid Sweden University, where she is professor since 2007, she leads the "Environmental Physiology Group" which studies human performance in extreme environments including apneic diving, high altitude and at extreme temperatures.

She has studied many groups of freedivers ranging from populations of Ama and Bajau living from diving in Asia to recreational divers and under water rugby players. The work is conducted both in the field and in traditional laboratory environments. During the past 10 years she has followed at close range the world elite in competition apnea, with measurements done both in and out of competition. This work was summarized in three reviews on predicting performance in competition freediving (Schagatay 2009, 2010 and 2011). Her written production comprises about 50 original journal papers and over 100 conference contributions and popular science papers and book chapters

Erika is also a certified freediving trainer, mostly for sub-elite, but with some of her students entering the World Championships. She has worked as a board member in the Swedish Diving Federation and been engaged in developing safety regulations and worked with establishing competitive freediving as a sport in Sweden under the official sports federation, which was accomplished during 2012. She has been internationally consulted in freediving safety matters by both AIDA and CMAS, and engaged in education of baromedic specialists in several European countries.

"The work published in 1965 "Physiology of freediving and the Ama of Japan" (Eds Rahn & Yokoyama) after a conference in Tokyo, is a cornerstone in freediving physiology research, and its 50 year anniversary deserves an update on what we have learned since then:" she says. "This is what I intend to cover in my presentation".

O-35 50 YEARS AFTER "PHYSIOLOGY OF BREATH-HOLD DIVING AND THE AMA OF JAPAN" ─ WHAT HAVE WE LEARNED?

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Introduction
In the classic book published after the 1965 Tokyo symposium "Physiology of Breath-Hold Diving and the Ama of Japan" (Rahn & Yokoyama 1965), the up-to-date knowledge of the field of apneic diving was reviewed. The history, activities, distribution, antropometrics and occupational problems of the Ama of Japan was presented, and the corresponding group in Korea, the Hae-Nyo, was described. The review of the physiology of breath-hold diving included that time´s knowledge of the limitations of human deep freediving, the basics of underwater alveolar gas exchange, physiological adaptations to diving, cardiovascular and renal responses, temperature regulation in water and the metabolic considerations of freediving, and it described the "Taravana syndrome" in Tuamutu pearl divers (decompression sickness: DCS). This work has been a cornerstone in the field and served as basis for numerous studies of apneic diving physiology, but what has half a centennium of continued research taught us?

Methods
While the groups of professional divers studied in 1965 were mainly the Ama and Hae-Nyo, later research has involved other groups of traditional divers, e.g. the SE Asian Bajau waterpeople, and most importantly, competition freedivers, which - trying to maximize time, distance or depth performance in a single dive - have taught us more about the limits and striking possibilities of human freediving. Studies of basic mechanisms have also been done on non-diving volunteers, with varying relevance for diving physiology, but with results interesting from a general physiology perspective. Technical development has enabled us to measure new things in both laboratory and field conditions.

Results
The Ama of Japan are, contrary to predictions 50 years ago, continuing their work into the 2020ties, still with good profit and hard-to-beat skills when it comes to total time spent underwater in a day. They are surpassed only by their SE counterpart the Bajau, which can spend 60% of their working time underwater. Both groups use submaximal lung volumes for this diving, probably to reduce buoyancy.
Diving depth has been extended from the 30-40 m considered the limit of safe diving in 1965, to beyond 120m in swimming competition dives, and to 214m in "no limit" weight- and flotation- assisted diving. Surprisingly many competition divers reach beyond 70 m without complications. However, physiological limitations in individual divers are becoming more obvious when better training, techniques and equipment make them reach greater depths, and the frequency of lung barotrauma increases. With high level of safety arrangements in competition serious accidents have been kept to a minimum, but in 2013 a no fins dive to 72 m resulted in death due to lung barotrauma. In static apnea the record duration is now 11 min 35s, and it can in fact be explained how this is possible in the most talented and trained divers. Expanding already large diver´s lungs by training and overfilling by positive pressure buccal breathing is part of increasing gas storage, while blood shift acts to diminish the effects of the shrinking lungs. Other ways discovered to add to total gas storage are increasing blood gas

storage by enhanced erythropoiesis and by spleen emptying, resulting in blood boosting, which prolongs apneic diving.
Further studies of the human diving response have shown the underlying mechanisms responsible and that the response effectively conserves oxygen in trained divers, who´s training may enhance the it to the level of semiaquatic mammals. The extraordinary cold adaptation of Ama/Hae-Nyo divers was found to disappear when wetsuits were introduced in the 1970ties, and the Tarawana and DCS/bubble formation described in the Ama has been observed to involve brain lesions, and bubbles have been observed to form after single apneic competition dives. Numerous scientists from the whole world have contributed to this increased knowledge about which factors make breath-hold diving possible, and how to improve safety while continuously extending durations and depths. Some factors determining the maximal performances in competition apnea are summarized in figure 1.

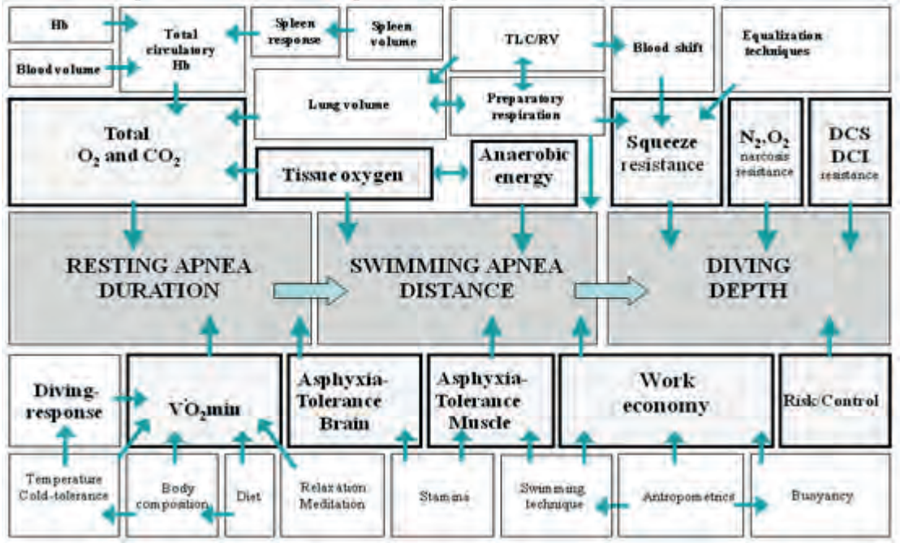

Figure 1. Overview of some major factors determining competition diving performance for maximal duration, distance and depth (modified from Schagatay 2011).

Discussion
While our knowledge about our physiology and performance when we do not breathe has now been remarkably increased, we still cannot explain why some individuals are responding to moderate pressure with pulmonary barotraumas while others seem immune, why some divers cope well with narcosis or how the DCS etiology differs from that associated with compressed air diving. We still don´t know if myoglobin is essential for oxygen storage in trained divers, or if their increased spleen volumes are a result of their training, and which other changes occur with the intense and well structured training taught in modern apnea diving schools worldwide.
Freediving is a rapidly growing sport in modern societies, as the central stress management skills so central in freediving are of great public interest. Freediving is still a way of making a living in many parts of the world, and in others´ it is being replaced by “modern” compressed air diving, often involving greater risks than natural diving. The breath-hold model is a useful tool to understand our body´s way to cope with a number of pathological conditions, e.g. OSAS, COPD and stroke. It is therefore essential that the research concerning the physiology and way of life connected to natural breath-hold diving continues, and it will be very interesting to follow it during the coming 50 years!

O-36 DETECTION OF VENOUS GAS EMBOLI AFTER REPETITIVE BREATH HOLD DIVES

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Introduction
Acute manifestations of neurological symptoms after Breath-Hold Diving (BHD-g) have been described since 1965, this complex syndrome is often called “Taravana”.
The majority of authors suggested the possibility of Taravana pathogenetic mechanism similar to DCI in SCUBA diving because of inert gas accumulation. Until today, however, nobody has clearly shown the presence of any gas embolism in BHD-g.
The aim of this experiment was to look for any bubble formation during BHD-g.
We also evaluate the theoretical application of modern decompression algorithms to BHD-g to the possible prevention of Taravana.

Materials and methods
Eight subjects were investigated by transthoracic echocardiography before and after a training session in a swimming pool allowing diving up to 40 m depth. All divers made a series of consecutive Breath hold dives: bottom time and surface intervals were freely determined by each diver.
We recorded echocardiographies before the dive series and every 15 minutes until 90 minutes after the dive series was completed.
The theoretical aspect of a possible accumulation of inert gas during repeated breath hold dives was investigated using DAN Europe’s original “ Diver Safety Guardian” (DSG) dive simulator, normally used for SCUBA diving, and modified to simulate the specific characteristics of BHD-g.

Results
We found high bubble grade in one subject and low bubble grade in another subject; both of them had previously suffered episode of Taravana. None of other six subjects with negative Taravana personal history, showed any bubble at echocardiography.
There was a significant difference in the computed inert gas accumulation between the two “bubblers” and the six “non bubblers” $p< 0.05$.

Conclusion
Our investigation showed for the first time that high bubble grades can occur in BHD-g. It appears reasonable that Taravana can be caused mechanism similar to those involved in Scuba Diving DCI.
More so if we consider that real spear-fishing sessions frequently imply more severe exposure than the ones studied in our pool tests.
This also confirms that the theoretical M-value based calculation approach can be used also for BHD-g decompression stress estimation.

Keywords
Taravana, Breath-Hold Diving, diving, DCI

O-37 MECHANISMS UNDERLYING SPLEEN CONTRACTION DURING APNEIC DIVING

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Introduction
It has been suggested that spleen contraction during short apneas is initiated by increased sympathetic stimuli from downloading of baroreceptors after a fall in MAP immediately after onset of apnea (Palada et al 2007). Injection of low-dose epinephrine revealed the same contractile pattern as short apneas, suggesting that spleen contraction is initiated by a general adrenergic stimulus (Bakovic et al 2013). However, in longer apneas, hypoxia and hypercapnia develop progressively. We did three studies aiming to evaluate the influence of chemoreception from hypoxia and hypercapnia on spleen volume.

Methods
Totally 30 elite freedivers and 8 non-divers participated in three experiments. Study A: Divers did 2min apneas followed by one maximal effort apnea, each spaced by 2min. Spleen volume was measured pre- and post-apneas. Study B: One maximal apnea was performed by divers. Spleen volume was measured every 15sec from pre- to post-apnea. Study C: Three separate trials were performed by non-divers with 2min apneas preceded by either 2min hypercapnic-, normocapnic- or hypocapnic breathing. A fourth trial involved eupneic hypercapnia. Spleen volume was measured pre-and post-apneas.

Results
A: After the submaximal apneas spleen volume was reduced by 21% (NS), and after maximal apnea of mean(SD) 4(1)min duration by 31% ($p<0.05$) from baseline. Hb increased by 5% ($p<0.05$) and SaO_2 decreased to 81% ($p<0.001$).
B: During the first 15sec the spleen contracted by 21% (NS) then returned to baseline volume within 1min. At the end of the maximal apnea of 4min 41(35)s duration spleen volume was reduced by 47% from baseline ($p<0.01$). This reduction occurred concomitant with a progressive decline in SaO_2.
C: Pre-apneic hypercapnia led to the strongest spleen derived Hb increase by 4 % ($p<0.002$) and 33 % decrease in spleen volume, with in the other trial´s responses decreased with falling hypercapnic order.

Conclusions
The massive spleen contraction seen during long apneas results mainly from chemoreceptor input from both O_2 and CO_2. While a general adrenergic stimulus may initiate spleen contraction during apnea onset, and possibly in other situations evoking adrenergic output, this response is transient and not the main response associated with prolonged apnea.

O-38 THE EFFECT OF DIETARY NITRATE ON SPLEEN CONTRACTION AND DIVING RESPONSE DURING APNEA

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Introduction
Dietary nitrate supplementation has been reported to increase dry apnea duration (Engan et al. 2012; Collofello et al. 2014) and to reduce arterial oxygen saturation (SaO_2) during fixed duration apneas (Engan et al. 2012). However conflicting results have also been shown (Schiffler et al. 2013) and the mechanisms responsible are not known. Our aim was to determine if two physiological responses evoked by apnea – (1) the cardiovascular diving response and (2) spleen contraction with associated increase in hemoglobin concentration (Hb), are affected by dietary nitrate.

Materials and Methods
Five men and three women aged 24±2 years performed a 2min apnea during prone rest 2.5h after ingesting either 70ml concentrated beetroot (BR; 5mmol nitrate) or placebo (PL) juice. Tests occurred on separate days in weighted order. Mean arterial pressure (MAP), heart rate and SaO_2 were measured continuously. Spleen size was measured via ultrasonic imaging for volume calculations, and capillary Hb was measured before and after the apneas. Heart rate was recorded to determine the magnitude of the diving response.

Results
Before the apnea, MAP and spleen volume were reduced and Hb was increased after ingesting BR. ($P<0.05$; Table 1). During the apnea, heart rate and SaO_2 reductions were the same with BR and PL (Table 1). After the apnea, there were no differences between BR and PL in MAP, spleen volume or Hb.

Variable	Placebo	Beetroot
Spleen volume before apnea (mL)	287±103	219±78*
Hb before apnea (g/L)	145±10	150±8*
MAP before apnea (mmHg)	90±1	84±2*
Heart rate reduction during apnea (%)	27±14	23±14
SaO_2 reduction during apnea (%)	5.0±2.7	4.9±3.4

Table 1. Mean±SD spleen volume, hemoglobin concentration (Hb), and mean arterial pressure (MAP) before the apneas, and the 2 min apnea induced heart rate and SaO_2 reductions with and without nitrate. *$P<0.05$.

Conclusions
The spleen was already contracted with BR before the apnea. However BR did not affect the oxygen conserving diving response. Further investigation is needed to understand the effect of dietary nitrate on spleen contraction and whether it could contribute to the conflicting SaO_2 and apneic duration results with BR found in previous studies.

Abstracts of Poster Presentations

P-01 SURVEY ON THE USE OF HYPERBARIC OXYGEN THERAPY FOR SUDDEN SENSORINEURAL HEARING LOSS IN EUROPE

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Introduction
Hyperbaric oxygen therapy (HBO) is frequently used in the treatment of sudden sensorineural hearing loss (SSNHL). A recent Cochrane review concluded that HBO therapy was useful in acute but not chronic hearing loss and tinnitus. The Undersea and Hyperbaric Medical Society recommends the use of 10 to 20 sessions of HBO therapy in patients with SSNHL who present within 14 days of disease onset. The aim of this survey was to assess the compliance of HBO centers in Europe with current evidence based guidelines in the treatment of SSNHL and to identify practice differences in HBO protocols used in these centers.

Materials and Methods
A questionnaire comprising 9 questions was built using surveymonkey.com website. The medical directors of hyperbaric centers in Europe were invited by email to fill the survey. The percentages were calculated by using the number of centers answered for that particular question as dominator.

Results
A total of 179 centers were invited. Eighty centers from 25 countries responded. Of these, 86,3% (69/80) were using HBO for SSNHL. The majority of centers [73.3% (44/60)] were accepting patients if they applied within 30 days of SSNHL. Surprisingly, 43,3 % (26/60) of centers were treating patients with tinnitus alone. The average of total number of treatments were 19.1±7.9 (min-max: 5-40) sessions. The frequency of HBO sessions varied between centers. While 46/56 (82.7%) centers used one session a day, 10 (17, 9%) centers used twice daily sessions. Treatment duration varied between 60 to 140 minutes and treatment pressure between 1, 5 to 2, 5 ATA. Number of patients treated with SSNHL in the past year ranged from 2 to 150, with a median of 18 and mean of 33,9±40,8.

Conclusion
HBO centers in Europe displayed a wide deviation from current evidence based guidelines and HBO protocols used for SSNHL at these centers varied significantly.

P-02 EXPOSURE CIRCUMSTANCES AND CHARACTERISTICS OF CARBON MONOXIDE POISONED PATIENTS TREATED WITH HYPERBARIC OXYGEN THERAPY: ANALYSIS OF 259 CASES

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Introduction
Carbon monoxide (CO) poisoning is the most frequent cause of poisoning related deaths in Turkey. Oxygen therapy is the main treatment of CO poisoning and hyperbaric oxygen therapy is recommended in cases with severe poisoning. The aim of this study was to investigate the characteristics of CO poisoned patients treated with hyperbaric oxygen therapy in our department in 2013.

Methods
We retrospectively reviewed hospital records to identify adult patients (>18 years) who received HBO therapy for CO poisoning between January 1st, 2013 to December 31st, 2013.

Results
Two hundred and fifty nine CO patients received HBO therapy during the study period. Of these patients, 166 were female (64%) and 14 of them were pregnant. Mean age of the patients was 40.9±16.1 years. Mean carboxyhaemoglobin level at admission to emergency services was 31.8±9.1%. While 52 patients (20%) admitted to our hospital, 203 patients were referred from other hospitals. Most frequent CO sources were stove (37.8%), combination boiler (34.3%) and water heater (20%). CO poisoning was highest between December to March. Nine patients were in coma while receiving HBO therapy. History of syncope was in 112 (43%) patients. Thirty-four patients had ECG abnormalities. While most of the patient received a single HBO therapy, the total number of HBO treatments varied between 1 to 20.

Conclusion
CO poisoning is common in winter. Most of the patients received only 1 HBO treatment. However, long term outcome of patients should be investigated.

P-03 THE DAMOCLES TRIAL, AN ONGOING DUTCH MULTICENTRE RANDOMIZED CLINICAL TRIAL ASSESSING THE COST-EFFECTIVENESS OF HYPERBARIC OXYGEN THERAPY IN THE TREATMENT OF ISCHEMIC DIABETIC ULCERS

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Introduction
The value of hyperbaric oxygen therapy (HBOT) in the treatment of diabetic ulcers is still under debate. Available evidence suggests that HBOT may improve the healing of diabetic ulcers, but it comes from small trials with heterogeneous populations and interventions. To clarify the costs and effectiveness of HBOT in addition to standard of care, the 'DAMOCLES' trial was initiated, sponsored by the Netherlands Organisation for Health and Development.

Methods
All Dutch HBOT centres and 35 hospitals agreed to collaborate. The hyperbaric medicine physicians agreed upon a standard HBOT-protocol for these patients. Patients with Type 1 or 2 diabetes, a Wagner 2, 3 or 4 ulcer of the leg present for at least 4 weeks, and concomitant leg ischemia, defined as an ankle systolic blood pressure of <70 mmHg, a toe systolic blood pressure of <50 mmHg or a forefoot transcutaneous oxygen tension (TcpO2) of <40 mmHg are eligible for inclusion. Patients are randomised to standard care (vascular reconstruction when possible and wound care according to local best practice) with or without 40 HBOT-sessions.
Primary outcome measures are freedom from major amputation after 12 months and achievement of, and time to, complete wound healing. Secondary endpoints include freedom from minor amputations, ulcer recurrence, TcpO2, quality of life, and safety. In addition, we will assess the cost-effectiveness of HBOT for this indication.

Results
Patient inclusion started July 2013. After 1,5 year of inclusion, 85 patients have been enrolled in this clinical trial and we plan to include another 35 patients. Most of the excluded patients have end-stage renal disease. So far, inclusion has been hampered by several factors: few patients actually have a diabetic and ischaemic ulcer. Many vascular surgeons are reluctant to include patients when vascular reconstruction is still an option. Also, some patients do not like the idea of travelling and undergoing the HBOT treatment regimen for 40 times. Only few of those who were randomised to HBOT suffered reversible complications. Final results are expected in 2016.

Conclusion
The DAMOCLES trial will be the largest trial ever performed in the realm of HBOT for ischemic diabetic ulcers, and it is unique for addressing patients with ischemic diabetic foot ulcers who may also receive vascular reconstructions. This may solve the treatment dilemma in current clinical practice.

P-04 VERY DELAYED TREATMENT OF FROSTBITE WITH HBO

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Introduction
Frostbite results from the freezing of tissue, causing invalidating tissue damage and necrosis. Case reports have shown a positive effect of hyperbaric oxygen in such injuries, in immediate as well as delayed (up to 21 days) intervention.

Materials and methods
Using hyperbaric oxygen (HBO) we treated two siblings (age 58 and 62) that obtained frostbite injuries to both feet 28 days earlier while hiking in the Himalayas. They were initially treated in Nepal following local protocol, afterwards their primary care in the Netherlands was managed by the Burn center at Maasstad Hospital in Rotterdam. Their progress was monitored by regular photographs and EQ-5D VAS scores.

Results
Both patients were treated with daily sessions of in total 80 minutes of 100% oxygen at 2.5 ATA.
The female sibling (age 62) underwent 25 sessions and showed a remarkable preservation of tissue and quick demarcation. No surgical intervention was needed. Her EQ-5D VAS score went from 5.5 to 8.4.
In the male sibling (age 58) both front feet were already mummified to a larger extent before start of HBO, during HBO (30 sessions) demarcation progressed quickly resulting in early, more distal amputation. His EQ-5D VAS scores went from 6 to 7.
Both patients experienced no side effects.

Conclusions
Both patients showed a quick progress and demarcation of their wounds, even 28 days after sustaining their injuries. Based on this case report and earlier publications on the effects and mechanisms of hyperbaric oxygen in frostbite we suggest that this therapy should also be considered in treating delayed frostbite injuries, even 4 weeks after initial injury.

P-05 HYPEROXIA AND MITOCHONDRIAL RESPIRATION – EVALUATION OF MITOCHONDRIAL RESPIRATION AND ROS PRODUCTION IN AN ANIMAL MODEL OF DIVING

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Introduction
Divers are exposed to an elevated partial pressure of oxygen as they breathe compressed gas while diving, and several studies point in the direction of adverse effects generated as a consequence of the hyperoxic period and subsequent oxidative stress. Mitochondria generate reactive oxygen species (ROS), and this production is known to increase when exposed to elevated concentrations of oxygen. As mitochondria are targets for the potentially detrimental actions of reactive species, the generation of ROS and oxidative stress is linked to mitochondrial dysfunction. The aim in the present PhD project is to investigate the role of hyperoxia on mitochondrial respiration and ROS production by using a rat model of barophysiology.

Methods
Dives will be simulated in a small hyperbaric chamber where rats will be compressed (200 kPa/min) to 500 kPa (40 msw) breathing a heliox (80:20) gas mixture for 60 minutes followed by a 50 kPa/min decompression to the surface. Blood samples will be collected for later analysis using biomarkers for oxidative stress. Heart tissue will be harvested, and mitochondrial respiration will be investigated by the use of high-resolution respirometry (HRR) (Oxygraph-2k, Oroboros Instruments). A substrate-inhibitor titration protocol will be used to stepwise increase and inhibit oxygen consumption of the mitochondria by different substrates and specific blockers in order to assess information about complex I and complex II linked respiration. Fluorometric detection of H2O2 production for indication of oxidative stress will be done simultaneously by integrating an O2k-fluorescence LED2-module into the Oxygraph-2k.

Outcome
At least three studies will be performed during this PhD project where the main aim is to investigate the effects of hyperoxic exposure on mitochondrial respiration and ROS production after simulated dives using a rat model. The studies will be completed by the end of 2017.

P-06 18 MONTH OLD TODDLER BENEFITS FROM HBOT IN CASE OF A SEVERE SOFT TISSUE INFECTION

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Introduction
Severe soft tissue infections profit from supportive hyperbaric oxygen therapy (HBOT). In our case a vast Ecthyma gangraenosum in the perianal and gluteal region of a 18 month old toddler was treated to achieve the best possible result.

Materials and Methods
A toddler aged 18 months was admitted to our hospital with severe perianal and gluteal Ecthyma Gangraenosum reaching the deep fascia. Two weeks prior the toddler had developed a rapidly progressive sepsis and subsequent local infection of said region. Initial treatment for Dermatitis ammoniacalis had been insufficient and no wound debridement had been carried out. Surgical therapy consisting of deep and radical necrectomy was immediately performed at our hospital and repeated frequently. Antibiotic therapy was administered intravenously and adjusted according to the antibiograms in the course of treatment.

Due to the severe extent of soft tissue damage HBOT was initiated immediately after the first necrectomy. In preparation paracentesis had been performed and tympanic tubes implanted. HBOT was conducted in a multiplace chamber (Sayers/Hebold, modified HAUX Germany). The chamber was pressurized with air. During the first treatment he was ventilated with 100% oxygen. The following 18 treatments in sedation with Propofol he breathed 100% oxygen spontaneously in a head tent. Spontaneous breathing was always sufficient. Each chamber session lasted 68 minutes: 60min at 2,0 atmospheres absolute (ATA), 3min for decompression and no decompression stop. The treatments were given once a day, 5 times a week. The patient was monitored by the doctor and nurse inside the chamber.

Results
Eventually, after five weeks, it was possible to close the wound cavity without the need of skin grafts or other complex reconstructive procedures. The cosmetic and functional long term results are excellent.

Conclusions
Although there are no established treatment tables for children HBOT is safe, even for young toddlers, at a suited hyperbaric medical center. In cases of severe soft tissue infections prompt supportive HBOT should be considered next to surgical and antibiotic therapy for young toddlers.

P-07 BILATERAL IDIOPATHIC SUDDEN SENSORONEURAL HEARING LOSS AND HYPERBARIC OXYGEN THERAPY: A CASE REPORT.

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Introduction
Bilateral idiopathic sudden sensorineural hearing loss (ISSHL) is relatively rare and should raise concern for certain specific causes such as metabolic, infectious, neoplastic, toxic, or inflammatory. Prompt diagnosis and management of ISSHL may improve hearing recovery and patient quality of life. Clinicians may offer different treatment modalities including corticosteroids as initial therapy to patients with ISSNHL and hyperbaric oxygen therapy within one month of diagnosis of ISSNHL.

Materials & Methods
While a 46-year-old woman was taking her medication for flu-like symptoms, she was admitted to the Otolaryngology department with complaints of hearing loss in the both ears, without tinnitus, vertigo and otalgia. Otoscopic examination of the left ear did not show any lesion or bleeding in the external auditory canal. But her right tympanic membrane had a 2 mm central perforation in the anterior inferior quadrant. The rest of the physical examination was unremarkable. The patient had no significant history for past medical conditions. She underwent an acoustic canal MRI which revealed no pathology. Her laboratory work-up, including complete blood cell count, chemistry panel and urine analysis were unremarkable. Following her admission to the Otolaryngology department, her pure tone audiometry suggested the presence of bilateral ISSHL. For this sudden hearing loss she started a 12-day treatment with oral methylprednisolone. A few days later her pure tone audiometry showed a bilateral and symmetrical severe sensorineural hearing loss, affecting all frequencies. Following the suggestion of the otolaryngologist, the patient underwent hyperbaric oxygen therapy (HBOT).

Results
HBO treatment was started 15 days after the start of her symptoms and was administered once daily for 24 days. The patient received oxygen at 2.4 atmospheres absolute pressure for 90 minutes. She reported recovery of hearing and pure tone audiometry confirmed complete improvement of hearing loss affecting all-frequencies.

Conclusions
Here we report a case of sudden hearing loss after flu-like symptoms. To our knowledge, this is a rare report of bilateral ISSHL which was successfully treated with hyperbaric oxygen therapy.

P-08 HIGH PRESSURE PAINT GUN INJECTION INJURY TO THE PALM AND HYPERBARIC OXYGEN THERAPY: A CASE REPORT

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Introduction
High-pressure injection injuries to the upper limb are uncommon, but require prompt surgical intervention due to the high risk of digital ischemia, necrosis, and permanent deficits of hand function. There are only limited clinical data concerning hand injury with paint gun and use of hyperbaric oxygen therapy (HBOT). The aim of this case report was to emphazise the clinical characteristics and the results of additional treatment with HBOT.

Materials & Methods
A 32-year-old industrial labourer presented to the plastic and reconstructive surgery department with a history and clinical examination findings consistent with a high-pressure injection injury to his left hand. His wound had been promptly explored, irrigated, and debrided. Plain radiographs demonstrated paint within the soft tissue spaces of the hand. After surgical intervention and negative pressure wound therapy, the hand did not improve satisfactorily with wound dressings over a period of 5 weeks. The patient was referred to the Hyperbaric Oxygen Treatment Center by a plastic surgeon for adjunctive hyperbaric oxygen therapy. He presented with complaints of severe tenderness distally over the fingers. On examination, swelling extended down to the fingers and up to the elbow, there was discoloration and infected discharge from the wound sites. The worsening pain, increasing edema, limited joint mobility were interpreted as signs of vascular compromise and soft tissue infection.

Results
The patient was treated using a standard 2.4 atmospheres absolute (atm abs) 90-minute protocol with two five-minute air breaks. The outcome was positive and the clinical condition of the patient improved rapidly after a total of 24 treatment sessions.

Conclusions
High-pressure injection injuries of the hand are relatively rare. Wounds can be contaminated and progressively infected due to the injected material. Prompt treatment of these injuries helps to reduce extremity loss and morbidity. This case report illustrates the clinical efficacy of an interdisciplinary approach for the enhancement of healing in such cases. HBOT may have a significant impact on the satisfactory outcome of these injuries.

P-09 ADJUNCTIVE HYPERBARIC OXYGEN THERAPY EFFECTIVENESS TO REDUCE MORTALITY RATE FOR NECROTIZING SOFT TISSUE INFECTION - THREE YEAR RETROSPECTIVE REVIEW OF CLINICAL OUTCOME

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Introduction
Necrotizing fasciitis (NF) is a serious lethal skin and soft tissue infectious-necrotizing process. The treatment of necrotizing fasciitis consists of aggressive debridement, broad-spectrum antibiotics, hemodynamic support and nutritional support. In this study, we present the effects of quick open fasciotomy debridement, drainage and adjunctive hyperbaric oxygen therapy in necrotizing fasciitis patients during a 3-year period.

Materials and Methods
Necrotizing fasciitis patients who were hospitalized in Show Chwan Memorial Hospital between January 2012 and January 2014, were retrospectively analyzed. The diagnosis of necrotizing fasciitis was established clinically on the basis of clinical history, physical examination, laboratory data, radiological imaging and pathology. All patients received early resuscitation and broad-spectrum antibiotics. Following aggressive debridement, tissue specimens were sent for microbiological and pathological examination. Besides, quick open fasciotomy debridement drainage and urgent hyperbaric oxygen therapy as adjunctive therapy was applied in all patients.

Results
Of the 48 necrotizing fasciitis patients, 32 were male and 16 were female. Average age was 55.5 years. The major underlying disease was diabetes mellitus (n=32, 66%). All the patients received quick open fasciotomy debridement, even at the emergency room; all the patients received the adjunctive hyperbaric oxygen therapy. All patients received fasciotomy and debridement (n=48, 100%), 6.3% (n=3) patients received major amputation. The mortality rate of all patients in this group was 0% (n=0).

Conclusion
Necrotizing soft tissue infection is associated with considerable mortality and morbidity, even with optimal therapy. Early correct diagnosis will affect the results of mortality and morbidity. The standard treatment of necrotizing fasciitis consists of aggressive radical debridement, broad-spectrum antibiotics, hemodynamic support and nutritional support. The findings of our clinical analysis is that standard treatment and added quick open fasciotomy debridement with drainage and urgent hyperbaric oxygen therapy can provide effective excellent outcomes in mortality and limb salvage in necrotizing fasciitis patients.

P-10 DIABETIC HAND INFECTIONS TREATED WITH HYPERBARIC OXYGEN THERAPY: A CASE SERIES

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Introduction
Hand infections in diabetic patients may cause significant morbidity and mortality. Micro-angiopathy and neuropathy are involved in the pathogenesis of diabetic hand infections. The outcome of diabetic hand infections are rarely reported in the literature. The aim of this study was to evaluate the outcomes of patients received hyperbaric oxygen (HBO) therapy for diabetic hand infections.

Methods
We reviewed hospital records to identify the patients who received HBO therapy between January 2013- December 2014. The demographic data, clinical and laboratory findings, medical and surgical treatments, length of hospitalization and outcomes of patients were recorded.

Results
We identified 7 patients (4 male and 3 female) with diabetic hand infection. Mean age of patients was 59,4±13,8 years. Four patients (57%) were hospitalized. Mean number of HBO treatments was 6,2 (1 to 12). Two patients received only 1 HBO treatment. Since there is not a specific grading system for diabetic hand infections, we used Wagner classification. There were one patient with Wagner 0 lesion, 2 patients with Wagner 1 lesion, 1 patients with Wagner 2 lesion, and 3 patients with Wagner 4 lesion. The mean duration of hospital stay was 15,7 (6 to 23) days. Mean WBC, ESR and HbA1c levels were 13000/ mm^3 , 79/h and 7,9% respectively. The most prevalent comorbid condition was hypertension. There was chronic renal failure in two patients as their wounds were located on the arm with hemodialysis fistula. Four patients recovered without amputation. One patient which chronic renal failure underwent finger amputation. One patient with Wagner 4 wound and Doppler monophasic flow in the right subclavian, axillary, ulnar and radial artery recovered after finger amputation and dialysis fistula was revised, but died due to subdural haematoma in the seventh month follow-up. One patient, who had arterial thrombosis and polimicrobial infection, died at the 23th day of hospitalization (Wagner 4).

Conclusions
Diabetic hand infections are associated with high risk of mortality and morbidity. Multidisciplinary approach is required to manage hand infections. HBO therapy may be beneficial in selected cases such as those with compromised arterial circulation of upper extremity or with necrotizing progressive infection.

P-11 EMERGENCY HYPERBARIC OXYGEN THERAPY REQUESTS FOR CARBON MONOXIDE POISONING

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Introduction
Carbon monoxide (CO) poisoning is very common during winter in Turkey. Our department is the main provider of emergent hyperbaric oxygen therapy (HBOT) in Ankara and neighboring cities. We have an on-call team for emergencies 24 hours a day. In this study, we analyzed the characteristics of CO poisoned patients that were consulted by phone to our department for emergent HBOT.

Material and Method
We analyzed CO intoxication consultation records between January 14, 2014 and January 14, 2015. Patients' age, gender, consultant hospitals, elapsed time between admission and consultation, COHb levels, exposure sources and durations, symptoms, electrocardiograms (ECG), cardiac enzymes, pregnancy, HBOT decisions and the relationship among them were evaluated.

Results
Over a-year period, 562 patients (58% females and 42% males) have been consulted from 25 different cities. The mean age of the patients was 28.6±22.4 years (ranging from 2 months to 88 years). Among all consultations, 68,5% were from Ankara and 31,3% were from other cities. We recommended HBOT for 289 patients (51,4%). 267 of them (96,1%) whose average COHb level was 30,65%, were treated in our clinic and 22 of them (3,9%) whose average COHb level was 27,61%, were directed to other hyperbaric centers because of full occupancy in our clinic. The average COHb level of patients, who were not recommended HBOT, was 24,8%. We treated 57,9% of patients who were consulted from Ankara, and 37,3% of patients, who were consulted from other cities, in our clinic. Among all consultations, 34,7% were consulted at 08:00-16:00, 18,7% were consulted at 16:00-21:00, 25,6% were consulted at 21:00-03:00 and 47,7% were consulted at 03:00-08:00. HBOT recommendation ratios were 51,3%, 42,9%, 43,8% and 47,7%, respectively. A history of syncope was 40% of the patients and 72,4% of them received HBOT. Besides, 67,3% of patients who had ECG abnormalities, have been treated with HBOT whereas 47,3% of patients who had normal ECG, have been treated with HBOT. Among pregnant patients, 66,7% were recommended HBOT.

Conclusion
According to this study, distance between hospital and HBOT center, pregnancy, syncope and ECG are identified as the major factors, which have influence on our HBOT decision.

P-12 EFFECTS OF HYPERBARIC THERAPY ON RAT SKELETAL MUSCLE MITOCHONDRIAL SWELLING INDUCED BY CONTUSION

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Introduction
Hyperbaric Oxygen environments are known to help muscles recover from damage induced by contusions. However the role of mitochondrial in this process is yet not fully understood. We aim to analyze the influence of hyperbaric environments with different oxygen contents on rat skeletal muscle mitochondrial swelling during mitochondrial permeability transition pore (MPTP) induction after muscle damage induced by contusion.

Material and Methods
Twelve female Wistar rats were randomly assigned into three groups. All rats were submitted to muscle contusion in the right *gastrocnemius*. The control group (C) had no intervention, while the hyperbaric group (HB) and the hyperbaric oxygen (HBO) group were submitted to a four 60 minutes session of hyperbaric therapy at 253.25 kPa (2.5 ATA), receiving normal air or 100% oxygen, respectively. The animals were sacrificed 48h after muscle injury and both muscles (injured and non injured) were analyzed. After isolating mitochondria, mitochondrial osmotic volume changes were followed by monitoring the classic decrease of absorbance at 540 nm with a Jasco V-560 spectrophotometer. Swelling amplitude and time until maximal absorbance decrease upon Ca^{2+} addition were considered as MPTP susceptibility indexes. The swelling amplitude was calculated as the difference between the suspension absorbance before Ca^{2+} and the absorbance at the end of the experimental measurement, and the time to V_{max}, was the time (in seconds) that elapsed until the faster swelling kinetics starts. A Bonferroni post-hoc test was used to compare groups. In order to analyze the internal control, between the right and the left *gastrocnemius*, Student's test for paired samples was used. Statistical Package for the Social Sciences (SPSS Inc, version 20.0) was used for all analysis. The significance level was set at 5%.

Results
The swelling experiments demonstrated that the injured *gastrocnemius* of HBO group developed significantly smaller swelling amplitude comparing to other groups and also exhibited the biggest time to V_{max} ($p<0.05$). In HB group it was also observed better results, on the injured side, only compared to C group, however not significant.

Conclusions
HBO group showed a lower susceptibility to MPTP opening when compared with other groups.

P-13 EFFECT OF HYPERBARIC OXYGEN THERAPY ON THE RECOVERY OF ANTERIOR CRUCIATE LIGAMENT RUPTURE IN RABBITS

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Introduction
The anterior cruciate ligament (ACL), the major intra-articular ligament of the knee, is the most commonly injured ligament of the knee and is critical to normal kinematics and stability. After injury, ligament healing can be divided in three phases: inflammation, matrix repair and remodeling. The poor wound-healing response of the ligament is due to many causes including the poor vascularization of the area. The goal of this study was to investigate the effect of HBO in the recovery from ligament ruptures.

Material and Methods
Ten Rabbits, White New Zealand, were induced a transcapsular rupture in ACL and randomly assigned in to a control and a treatment group. Treatment group was submitted, daily, for a period of 21 days, starting 24 hours after injury to 60 minutes of HBO at 2.5 ATA. After that period animals were sacrificed, blood samples were collected and ACL was harvested and cryopreserved for a subsequent western blots analysis for VEGF and Collagen I. Previously the Lachman-test was performed and compared to the contralateral side. Cartilage thickness was measured in situ using a precision caliper.

Results
In the treatment group it was observed a decrease in CPK and lymphocites levels, while VEGF factor increased. Sedimentation velocity was significantly higher for the control group. However Type I collagen seems to have disappeared in the treatment group even though a macroscopical analysis of the capsule revealed that the treatment group had significantly thicker capsules that could be responsible for an increase of joint stability and mobility.

Conclusions
HBO plays an importante role in ligaments injury recovery, namely by increasing neovascularization, decreasing inflammation and contributing for the increase of capsule thickness and joint stablity. Collagen type I was substituted for another type, in a process whose consequences need to be further studied.

P-14 HBO IN THE TREATMENT OF IATROGENIC MANDIBULAR OSTEOMYELITIS – CASE REPORTS

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Introduction
Mandibular osteomyelitis resulting from tooth extraction is very rare complication, with a prolonged and complicated treatment. It is usually caused by anaerobic bacterial strains, which suggests that osteomyelitis should be treated as an anaerobic infection. Considering its polymicrobial flora, hypoxia caused by infection, the possibility of pathological fracture and its chronical nature, this condition is indication for the timely use of HBO as a therapy of choice, together with surgical and antibiotic therapy, in order to reduce infection and to stimulate osteogenesis.
The aim of this study was to present the effects of HBO in the treatment of mandibular osteomyelitis following uncomplicated extraction of third molar and to show that the HBO is an unmatched treatment in this field also.

Materials and methods
Two patients with mandibular osteomyelitis resulting from an uncomplicated extraction of third molar were admitted in Centre for hyperbaric medicine, Belgrade in January 2015. They were referred by oral surgeon, two months after surgical intervention, because of complication development: soft tissue infection, swelling, second degree trismus and mandibular osteomyelitis. Intensive antibiotic therapy was conducted for over a month, together with local debridement and sequestrectomy but with no adequate therapeutic response.
HBO treatment was introduced , together with existing antibiotic therapy and regular control by the oral surgeon. Treatment protocol included 100% oxygen at 2.5 ATA for 70 minutes. 25 exposures in total were conducted.

Results
Full recovery from infection and trismus occurred in both patients. The pain and swelling were completely reduced. After a month of HBO therapy the x-ray already showed initial signs of the bone formation. HBO retreatment aimed on stimulation of fibroblastic and osteoblastic activity was planned in 3 months.

Conclusion
Severity of mandibular osteomyelitis is the reasons for the early introduction of HBO together with antibiotics and surgical debridement. The failure of conservative therapy and clinical examples from our practice show the importance of HBO in the treatment of osteomyelitis regardless of localization and etiology. It is very important to include the HBO as soon as possible. Multidisciplinary approach and cooperation with other specialists are necessary, given the complexity of treatment.

Key words
HBO, Mandibular osteomyelitis

P-15 THERMAL IMAGING OF NON-HEALING WOUNDS

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Introduction
Blood flow can be assessed by many methods including laser doppler flowmetry and medical infrared thermal imaging. Of these, infrared thermography has the advantages of being noninvasive, fast, reliable, capable of producing multiple recordings at short time intervals, and absolutely safe for patients and doctors. It has been used to evaluate inflammatory arthritis, soft tissue rheumatism, enthesiopathies, hand-arm-vibration syndrome and to evaluate burns and skin grafts. Thermal imaging can be used either as a diagnostic test or as outcome measure for clinical trials.

Materials and Methods
The thermal imaging was carried out using a FLIR Lepton thermal camera core, with ability to detect temperature differences as small as 0.18 °F (0.1°C). A high-resolution color image was provided in real time, viewed on a miniature screen and stored in a wound assessment software system. Images were collected from the wound area as well as of the vascular system supplying the wound area. The thermal profile of the area of examination was compared with the surrounding tissues and the counterpart region of the same subject. The thermal image was then compared with a high resolution photo of the wound by using an overlay function in the software system.

Results
The thermal imaging was also used to show, that for these patients, there was no significant proximal stenosis in the vascular system of the examined extremity. The temperature in most of the examined non-healing wounds of lower extremities were examined was lower than the surrounding tissue and the counterpart region. However, in some areas it showed 0.7 to 1°C higher temperature than the normal areas due to inflammation and venous flow alteration. Only patients with low-temperature (and thus non-inflammatory) wounds were selected for hyperbaric oxygen treatment (HBOT).

Conclusions
Thermal imaging has been successfully used for medical diagnosis of vascular disorders. In general the thermal image findings were in good agreement with the clinical findings. This study demonstrates the usefulness of thermal imaging for medical diagnostics, as a simple tool to find patients with ischemic non-healing wounds that would benefit from HBOT.

P-16 HYPERBARIC OXYGEN TREATMENT OF TROMBOANGIITIS OBLITERANS: A CASE REPORT.

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Introduction
Thromboangiitis obliterans (Buerger disease) is caused by small blood vessels that become inflamed and then completely blocked by thrombosis. Blood vessels of the hands and feet are especially affected and arteries more than veins. There is no definite cure. The goal of treatment is to control symptoms and to prevent the disease from getting worse. Aspirin and vasodilators may help. In severe cases, surgical sympathectomy can help control pain. Some patients develop nonhealing wounds that might require amputation. To select the best and most cost-effective treatment is difficult for patients with this serious complication. Hyperbaric oxygen treatment (HBOT) is often used as an adjuvant treatment. We selected to use HBOT as the primary treatment procedure. In this case, the patient was a 50 years old man with tromboangiitis obliterans and colitis ulcerosa. In 1996 the 1st and 2nd phalanx of the left foot and in 2000 the 3rd phalanx of the right foot were amputated. This time, the patient was quickly referred to our center with two painful wounds 3x2 cm and 4,5 x3 cm wide painful infected wounds on the dorsal part of metatarsus of the right foot. The wounds had developed in only 2 weeks.

Material and Methods
These treatment protocols were used:
Daily change of the dry dressing
Hyperbaric Oxygen Treatment (HBO) 30 daily sessions of %100 oxygen at pressure of 2.5 ATM for 120 minutes.

Results
After treatment: Total healing. No pain. No side effects.
Control at one month post treatment: Wounds still healed.

Conclusion
For a tromboangiitis obliterans patient it is important to treat and heal the wounds quickly. Traditional treatment procedures such as debridations often worsen the wounds. Quick wound treatment with dry dressings and HBOT an effective treatment and definitely more cost-effective than debridements and any type of amputation.

P-17 HYPERBARIC OXYGEN AND ELECTRICAL STIMULATION TREATMENT OF SYSTEMIC SCLEROSIS NON HEALING ULCERS: A CASE REPORT

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Introduction
Systemic sclerosis is a rare autoimmune disorder resulting from a cycle of inflammation, vascular destruction, fibroblast proliferation, thrombosis, vasospasm and ischemia, ultimately leading to tissue fibrosis and target organ damage. As a result of this 35-50% of all systemic sclerosis patients have ulcers. The treatment of these patients can be divided into three main categories: non-pharmacologic, pharmacologic, and surgical or interventional. Hyperbaric oxygen treatment (HBOT) has been reported to improve the ischemic ulcers. Our patient was a 36 years old female with systemic sclerosis and Raynauds disease. She had been hospitalized for months and had a VAS pain score of 7 and did not seem to respond to the “conventional” treatment with salicylic acid, calcium channel blockers, corticosteroids, heparin, ilioprost and bosentan. The distal parts of the left hand 2th and 5th and the right hand 3th digits had become necrotic. During a consultation at the University Clinic it was decided to amputate these 3 digits. The patient was referred to the hyperbaric center for preadjuvant treatment.

Material and Methods
The treatment protocol included:
ES. Electrical stimulation with PBK technique employs low voltage electric impulses, administrated by means of skin electrodes, with the aim to get a bio-humoral reaction. The ES treatment was applied in 40 sessions, approximately 20 minutes each, 6 days per week.
Hyperbaric Oxygen Treatment (HBOT). Daily sessions of 100% oxygen inhalation during 2 hours at pressure of 2.5 ATM, 6 days per week,

Results
The left hand digit ulcers healed after 25 sessions of HBO and ES treatment. The patient was free from pain after 29 sessions. All ulcers were healed after 60 sessions. No side effects. The control at six months post treatment showed that all wounds were still healed.

Conclusions
Patients with some autoimmune disorders, such as scleroderma, have poor wound healing. The optimally effective healing of these complex wounds often require combinations of treatments, so these patients should be referred to a wound center as soon as possible. One of the preferred treatments, as in the described case, is the ES treatment combined with HBOT.

P-18 HYPERBARIC OXYGEN FOR THE TREATMENT OF ENTEROCUTANEOUS AND PERIANAL FISTULAS

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Introduction
Enterocutaneous and perianal fistulas pose a serious therapeutic challenge and cause considerable effect on patients' quality of life. Hyperbaric oxygen therapy (HBOT)'s use as an adjuvant to conventional therapy for cases of fistulizing Crohn's disease (CD) has been a topic of discussion over the past years. It is presently considered when patients are unresponsive to conventional treatment. In post-radiotherapy fistulae, the role of HBOT is not cleary defined. HBOT acts in several ways: mediation of both inflammatory and immunological responses through the inhibition of pro-inflammatory cytokines, stimulation of collagen production by fibroblasts, angiogenesis stimulation and bactericide action. In this study, the possible benefits of HBOT in fistulas treatment are assessed.

Methodology
Retrospective and descriptive study. The clinical reports of patients diagnosed with enterocutaneous and/or perianal fistulas treated with HBOT at our center were studied. Patients were administered O_2 at 100% and 2.5 atm for 70 minutes five times per week.

Results
A total of 7 patients (4 male and 3 female) with an average age of 53.7 years were considered in this study. Three patients had fistulizing CD that was unresponsive to medical and surgical therapy and four patients presented post-radiotherapy fistula (one had a perianal fistula and a rectal ulcer, a second had enterocutaneous and perianal fistula, another presented a rectovaginal fistula and the last one had a vesicorectal fistula). The average number of treatment sessions was 57 (range: 10 to 120 sessions), ranging from 1 to 16 months. Patients with CD were being treated with tumor necrosis factor inhibitors before and continued during HBOT. All patients improved after treatment: fistula closure or leakage reduction and pain improvement. No side effects were observed and all patients completed the proposed treatment.

Conclusions
There was a significant improvement in all cases, supporting the satisfying results from previous reports. In patients that are unresponsive to conventional treatment, HBOT should be considered. More studies are required to further assess the role of HBOT in these area.

P-19 RADIATION INDUCED HEMORRAGIC GASTRITIS TREATMENT: SUCCESS CASE WITH HYPERBARIC OXYGEN THERAPY

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Introduction
Radiation- induced gastritis constitutes an uncommon disorder, with a substantial morbility, that may trigger an upper gastrointestinal bleeding. A consensus regarding the most suitable therapy is yet to be achieved, mainly due to the correlated lack of success.

Case Report
A 77–year-old women diagnosed with plasmacytoma, who went through radiotherapy 2 years before, denoting recurrent hematemesis with hemodynamic instability and severe anaemia (Hb 5,8 g/dL), requiring 20 units of blood transfusion. The patient underwent an esophagogastrodudenoscopy (EGD), which revealed diffuse oedematous and hyperemia, oozing blood, suggestive of haemorrhagic gastritis. Several argon plasma coagulation endoscopic sessions were performed, with no success. Patient was referred to our Centre, in order to start hyperbaric oxygen treatment (HBOT). The HBOT was delivered with 100% oxygen for 90 minutes at 2,5 atmospheres (ATA), 5 days a week with initial prescription of 20 treatments, resulting in an asymptomatic state. A control EGD confirmed the improvement of initial lesions. Upon the third month after treatment, hematemesis were once again observed, resuming an HBOT treatment of 40 sessions resulting in a substantial improvement in her medical state, which was once again worsened 2 months later, when the patient had to return to a 40 sessions' treatment. 1 year after the end of HBOT therapy, our patient remains asymptomatic.

Conclusion
Radiation-induced gastritis is due to thrombosis of small vessels, causing ischemia and leading to cell death. Severe gastric complications due to radiotherapy uncommon, particularly for haemorrhagic gastritis. Treatment options for digestive haemorrhage include aminocaproic acid, argon plasma coagulation, corticoids and hyperbaric oxygen therapy. Unfortunately, no substantial data based on a considerable magnitude of case reports is available, which therefore disables robust and validated therapy. Patients with this diagnostic are usually associated with a considerable consumption of hospital resources, with multiple internments, blood transfusions and recurrent therapeutic endoscopies. HBOT is to be considered in conventional therapy refractory cases, amending the damaged tissues, reducing correlated bleeding and improving patients' quality of life.

P-20 CALCIPHYLAXIS – AN UPCOMING INDICATION FOR HYPERBARIC OXYGEN TREATMENT

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Introduction
Calciphylaxis is a rare and serious lethal disorder mostly in patients with end-stage renal disease who are on hemodialysis characterized by systemic medial calcification of the arterioles that leads to ischemia and subcutaneous necrosis progressing to ischemic/necrotic ulcers that often become superinfected. Infection is the primary cause of the high mortality associated with this condition (up to 58%). The optimal therapy is not known, a multifactorial approach appears to be the best approach. Hyperbaric Oxygen Treatment (HBO) is recognized as a treatment approach to chronic wounds but data concerning the treatment of calciphylaxis-associated wounds is still rare.
The objective of this study is to demonstrate the benefit of HBO for the treatment of calciphylaxis-associated wounds using a case series.

Materials and Methods
We reviewed and retrospectively analyzed the data from the medical files of all patients with calciphylaxis treated between 1996 and 2011 in the hyperbaric chamber of the Academical Medical Center, Amsterdam, The Netherlands.

Results
All 15 patients had end stage renal disease, 13 needed either peritoneal- or hemodialysis and seven had even undergone kidney transplantation. Most of them had accompanying arterial hypertension, diabetes mellitus type 2 and adipositas. All suffered from relevant pain and a mean of 4.6 wounds (SD ± 2.5, range 2 – 10) with a total diameter of mean 15.8cm (SD ± 8.2cm, range 7 – 39cm). 11 patients completed the HBO course of a minimum of 20 sessions (mean 51.2, SD ± 29.7, range 20 – 126). 10 patients (91%) experienced complete resolution of their wounds and 9 patients (82%) were pain-free after completing the HBO course.

Conclusions
Superinfection of wounds is the major cause of mortality associated with calxiphylaxis and the optimal therapy is not known yet but appears to be multifactorial. Our data shows that HBO is capable to heal calciphylaxis-associated wounds and therefore HBO appears to be one of the factors of optimal calciphylaxis-therapy. We suggest that calciphylaxis should be recognized as an indication for Hyperbaric Oxygen Treatment.

P-21 IMPLEMENTATION OF HFMEA AS PART OF THE CERTIFIED PATIENT SAFETY SYSTEM IN A MULTIPLACE HBO FACILITY

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Introduction
Prospective identification of potential risks in a hyperbaric facility is necessary to ensure patient safety. As part of the safety system is examined whether the Health Failure Mode and Effect Analysis (HFMEA) is an effective method to analyze, evaluate and eliminate risks in the primary healthcare process in a hyperbaric facility. The HFMEA is a valid, proactive method to identify risks. We used this method to determine the (potential) risks during the process.

Methods
We established a working group in which different disciplines are represented. We have analyzed the different sub-processes in the primary process and reported the potential risks. The potential failure mode for each process step is recorded in a scoring matrix to give an estimate of the (possible) risks. Using a decision tree we identified the risks that should be further analyzed.

Results
The primary process was divided into the following sub-processes: referral, intake, treatment and aftercare. The oxygen supply is an essential part in the treatment of patients this sub-process is also included. In applying the HFMEA-method three potential risks were classified as high risk, nine as low risk, and six as very low risk. The three critical processes with high risk are discussed. The recommendations of the working group have been implemented by the organization.

Conclusion
A multidisciplinary approach with HFMEA provides a systematic method for identifying potential risks in critical processes that may occur in the treatment of hyperbaric oxygen therapy. The method gives the possibility to make potential risks visible at an early stage, so it is possible to eliminate risks before they can arise. If the recommendations of the working group are implemented by the management of the organization it is a useful method for detecting potential risks and this improves the quality of healthcare.

P-22 EVOLUTION OF HYPERBARIC MEDICINE IN THE INDIAN SUBCONTINENT - CURRENT CHALLENGES AND SOLUTIONS

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Introduction
Indian healthcare sector is growing rapidly with a CAGR of 17 per cent and is likely to touch US$ 280 billion by 2020. Private healthcare accounts for 72 per cent of this growth as per capita healthcare expenditure increases at a CAGR of 15.4 per cent on the back of rising incomes, access to high-quality healthcare facilities and awareness.
There is a recent thrust by international and indigenous hyperbaric equipment manufacturers to enter the market. While this had led to a desirable recognition of hyperbaric medicine, however unregulated growth is throwing up many challenges.
The paper discusses the evolution of this science of medicine in the Indian subcontinent, its current status, challenges and some thought of the proposed path for its future development.

Materials and Methods
"Hyperbaric Medicine" includes Clinical Hyperbaric Oxygen Therapy, Diving Medicine and Compressed air works. Our method of assessing evolution is by tracing the growth of various centers in the country.
The Indian Navy installed a "Galeazzi chamber" in Mumbai in the sixties and the first private multiplace hyperbaric chamber as part of hospital services came in the year 2000 at New Delhi.
Over the past three years, ten new private centers have come up.
The "occupational " part of hyperbaric medicine is growing with increase in underground metro rail projects and "diving medicine " is restricted to medical examination of professional divers.
The experience of other countries in the region will be briefly reviewed as also the growth of societies such as the AHDMA and APUHMS.

Results
A "National Society " has been formed to promote interaction and develop guidelines in these areas. Implementation will be a challenge but with support from government it is hoped that this will be adopted.
Teaching and training programs are being developed and will be in place in near future.

Conclusions
Hyperbaric medicine is gaining acceptance and momentum in the subcontinent. It is a moment of great satisfaction for many who have worked to establish its rightful place in mainstream medicine. However the onus of guiding this growth also lies with these pioneers and this may be as daunting a task.

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P-23 ORAL MICROCIRCULATORY RESPONSE TO NORMOBARIC AND HYPERBARIC HYPEROXIA

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Introduction
The propensity of oral tissues to succumb to cellular distress and avascularity as a result of head and neck irradiation procedures remains a difficult challenge in the management of radiotherapy-related complications. Hyperbaric oxygen (HBO) therapy can restore oxygen tensions in tissues distressed by ischemic injury and it is believed that it can also yield angiogenesis and regulate vascular physiology.

Aim
The aim of this study was to develop a model in which hyperoxia-driven functional anatomic changes measured in the microcirculation could be quantified in response to both normobaric (NB) and hyperbaric (HB) hyperoxic maneuvers.

Materials and Methods
Sublingual microcirculation (perfused vessel density [PVD, vessels <25µm, %] and microvascular flow index [MFI, AU]) was examined by sidestream dark-field imaging (SDFI) in 6 male New Zealand White rabbits (3.4±0.4kg) while breathing O_2/air mixtures of 21%, 55%, 100%, and back to 21% during NB (40min) and HB (40min) (2.5atm [2.5bar]) conditions. Basic hemodynamic parameters (HR and MAP) and arterial blood gas samples (paO_2, $paCO_2$, pH) were obtained at each time point corresponding with measurements of the microcirculation at the specified atmospheric and oxygen settings.

Results
No significant differences were observed in HR or MAP. All blood gas measurements remained unremarkable except paO_2, which rose significantly from baseline at NB55% and NB100% ($p<0.01$, respectively), and all time points under HB conditions ($p<0.01$, respectively), paO_2 returned back to normal after ascending back surface (1atm). PVD decreased significantly by 15% at NB55% ($p<0.05$) and 25% at NB100% ($p<0.01$) and returned back to normal at NB21% (ns). Under all HB conditions PVD data decreased at HB21% by 16% ($p<0.05$), at HB55% by 24% ($p<0.01$), at HB100% by 28% ($p<0.01$), and return to HB21% by 22% ($p<0.01$). There was no significant difference in PVD at the conclusion of these experiments after ascending back to the surface (1atm). No significant difference in MFI was observed for any time point.

Conclusions
The results demonstrate that microcirculation measurements can be successfully obtained using SDFI during HB conditions and that changing barometric and hyperoxic conditions elicit reversible physiological control of oral blood perfusion in healthy subjects.

Keywords
Animal model, hyperoxia, hyperbaric oxygen, intrabarochamber, microcirculation

DP-01 10 YEARS OF OXYGEN DIVING IN A MILITARY POPULATION: CHANGES IN SPIROMETRY AND DIFFUSION CAPACITY

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Introduction
Regular diving may elicit adverse long term health effects on the lungs. n professional and sports diving it is not uncommon to use breathing gases containing higher percentages of oxygen, which can induce a pathological process known as pulmonary oxygen toxicity (POT) resulting in the alteration of lung functions parameters.
The objective of this study was to assess the changes in spirometry and diffusion capacity after 10 years of oxygen diving in a military population.

Methods
50 healthy, military oxygen divers were followed during their annual assessments. Spirometry (VC, FEV1, PEF and FEF) and diffusing capacity (DLco, VA and KCO) were measured at baseline (pre) and after a follow up period of 5 and 10 years (post). The cohort was divided in two groups. In group 1 (n=50) we assessed the spirometrical data while in group 2 (n=10) we also assessed the diffusion data. Smoking history was assessed as nominal data. A paired t-test was used for statistical analysis.

Results
In group 1 50 divers were included (29.8 ± 5.3 yrs, 183.1 ± 6.4 cm, 83.5 ± 7.5 kg, 28% smokers). Group 2 consisted of 10 divers (26.5 ± 2.9 yrs, 184.0 ± 6.0 cm, 83.0 ± 9.0 kg, 50% smokers). At baseline spirometry (group 1) and diffusion capacity (group 2) were within normal limits. In group 1 a significant increase in VC and PEF was found after 5 and 10 years, whereas FEV1/VC and FEF75% decreased. FEV1 increased only after a follow up period of 10 years and FEF50% decreased only after 5 years. In addition, in group 2, the KCO (DLco /VA) decreased after 5 years while the VA increased after both 5 and 10 years, DLco remained unaffected.

Conclusion
In this study, diving with hundred percent oxygen has similar effects on lung functions parameters compared to other breathing gases. Therefore, hyperoxic exposure is likely to be a contributing factor for the expiratory flow limitation at low lung volumes.

DP-02 ACHIEVEMENTS IN BREATH HOLD DIVING PHYSIOLOGY USING UNDERWATER BIOMEDICAL MONITORING DEVICES

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Introduction
Available clinical devices used in everyday clinical practice for assessing health status cannot be used underwater because of the problems related to the liquid environment and hydrostatic pressure environment. Then, physiological models of underwater diving are commonly adopted, although related to the knowledge of the clinical world as valid surrogate and inferences. This approach results in a scanty knowledge and even in producing true blunders in the study of diving. The only monitoring of vital parameters during diving may assure the correct procedure to investigate the human physio-pathological response underwater. The Authors used a set of special instrumentation developed in their Institute to monitor cardiac and hemodynamic functions during diving, confirming some of the previous hypothesized physiological responses to dive, discovering news and refuting other ones.

Method and materials
Devices for cardiac and hemodynamic function monitoring has been developed to be used underwater: instruments for holter ECG registration of two ECG leads (at present a 12 leads holter is in testing), an echo-doppler echography device (to be used with a complete set od US probes), a pulse oxymeter and an oscillometric measurement blood pressure device for systolic and diastolic intermittent readings.
A set of experimental protocols for underwater research during breath-hold and SCUBA diving has been designed, in order to investigate the response to diving in humans.

Results and Conclusions
Underwater 2D-Doppler echocardiography was used to evaluate cardiovascular changes induced by breath-hold diving. Diving humans showed circulatory changes qualitatively similar to marine mammals (i.e. reduction of cardiac output due to both a reduction in heart rate and in stroke volume), but with different physiologic mechanism. In fact, cardiac output reduction in humans was strictly dependent on the constrictive effect exerted on the heart by the increased environmental pressure. Another important achievement obtained by underwater instrumentation was the documentation of only a mild increase of arterial blood pressure (while previous studies performed during simulated dives showed sharp increase of blood pressure).
In conclusion, the realization of an "underwater lab" to study humans adaptation to dive, resulted important to confirm, and sometimes to refute, previous data obtained by simulated diving studies.

DP-03 COMPARISON OF TWO METHODS POTENTIALLY REDUCING METABOLISM DURING APNEA

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Introduction
Ever since Paul Bert (1870) showed that diving birds react with bradycardia upon submersion, a number of studies have investigated the diving response, characterized by bradycardia and peripheral vasoconstriction, that results in an conservation of O_2 during apnea (Gooden 1994). Fasting , meditation and yoga-techniques are other methods known to enhance diving performance with effects on metabolic rate (Schagatay 2009). Resting metabolic rate may also be reduced by ingestion of dietary nitrate acting as a nitric oxide-donor (Larsen, Schiffer et al. 2014). This study compared the effects of training of the diving response with those derived from nitrate ingestion.

Materials and methods
The study had two parts involving different subjects:
A: 10 subjects (6 males, 25±6 yrs, 72±9kg, 175±11cm) performed apnea training for two weeks and were tested before and after training.
B: 12 subjects (9 males, 32±7yrs, 77± 10kg, 177±7cm) ingested dietary nitrate in a double-blinded placebo-controlled study.
In both studies subjects were tested for maximal apnea performance, diving response and the effects on SaO_2 during fixed duration apneas.

Results
A: After training, maximal apnea duration increased by 15 %. SaO_2 after apnea of fixed durations was 4.2 (4.8)% higher after training, and the diving response occured earlier and was more pronounced after training ($P<0.05$).
B: After dietary nitrate ingestion, maximal apnea duration increased by 11 %. SaO_2 after apnea of fixed durations remained 1.4 (1.9) % higher with dietary nitrate ($P<0.05$), and the diving response was unchanged.
Maximal apneic duration tended to be more increased with training (A) than from nitrate ingestion (B; $P=0.07$).

Conclusions
Both apnea training and ingestion of dietary nitrate can prolong apnea duration by restricting metabolism. The effect of apnea training tended to be greater than from nitrate ingestion. Apnea training reduces metabolic rate by inducing a more efficient diving response, while dietary nitrate likely improves O_2 utilization in tissues while not affecting the diving response.

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DP-04 REAL-TIME UNDERWATER GLYCAEMIA MONITORING AND RECORDING DURING SCUBA DIVING.

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Introduction
The numbers of diabetic divers affect by Mellitus type 1 is steadily increasing since this disease is no longer considered an absolute contraindication to scuba diving. The scope of this work is to develop a continuous underwater real time blood glucose monitoring system.

Materials and methods
Two diabetic divers were monitored by a dedicated Continuous Glucose Monitor (CGM), hosted in a waterproof case, and a Subcutaneous Glucose Sensor (Dexcom G4). Data were recorded every 5 minutes during the dive and for 1 hour before and after the dive.
Dives were made using a dry-suit during a multiday diving week in tropical waters.
To assure underwater (hyperbaric) measurement of interstitial glycaemia reliability a comparison between capillary blood glucose (OneTouch® Verio®IQ ") and subcutaneous interstitial glycaemia (Dexom G4) in normobaric and hyperbaric conditions was affected.
The mean absolute relative difference (MARD) between CGM and CBG was calculated as to accuracy according to the International Organization for Standardization (ISO guideline 15197)
The Clarke error grid (CEG), was also used to confirm data validity

Results
Two diabetic divers N.B. 29 Female, 53 Kg, 157 cm, BMI 21.5 and R.D.36 Male 72 Kg, 167 cm, BMI 25.8 were investigated during an intensive scuba diving period (18 and 10 dives respectively).
Both divers showed a gradual BG decrease during diving and occasional borderline hypoglycaemia (<70mg/d).
We found a statistically significant difference between CBG (Verio IQ) and CGM Dexom G4 data both normobaric ($p=0.0001$ and hyperbaric conditions ($p=0.0002$) but this difference was consistent and not significant as to the different environment ($p=0.35$).
The overall MAD was 7.03 +/- 6.05 in normobaric and 9.9 +/- 10.7 in hyperbaric conditions.
The combined Clarke error grid analysis confirmed data consistency and reliability in both normobaric and hyperbaric conditions

Discussion
Continuous underwater real time monitoring system can be very important for diabetic divers, as it allows for continuous monitoring and if necessary adjustment of Blood Glucose Levels during diving.
Additional our data (even if referred to only two subjects at the moment) are in agreement with the current literature and confirm that diving does not imply significant risks of hypoglycaemia.
The accuracy tests affected confirm that data recorded under pressure are correct and reliable in agreement with previous observations by Adolfsson et al.

DP-05 A SIMULATED HELIOX DIVE TO 65 METERS AND BLOOD-BRAIN BARRIER PERMEABILITY IN RATS

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Introduction
Saturation divers working on the Norwegian continental shelf since the beginning of the North Sea oil-drilling era have drawn much attention to long-term health effects of diving. Much of the debate has been related to the safety of the job performed, but concern is also raised about the physical environments under which they worked. Long-time exposures to enriched oxygen atmospheres have been suggested as one of the risks for adverse effects affecting the central nervous system (CNS).
In a previous study, we have observed altered brain perfusion and temporary permeability of the blood-brain barrier (BBB) after decompression, but histology revealed no structural changes. Therefore, we hypothesize that hyperbaric exposure causes altered brain perfusion and BBB physiology that may increase the risk for subsequently injury to the brain.
In the present study, the effects of simulated diving on the BBB have been investigated using rats.

Materials and methods
Sprague Dawley rats (n=8) were compressed to 750 kPa at a rate of 200 kPa/min in a 22 L steel chamber breathing Heliox (20:80) for 60 min. Decompression rate was 50 kPa/min. After the simulated dive, rats were anesthetized with Haldol 0,33mg/Fentanyl 0,05mg/ Midazolam and injected with Evans blue (4%, 2 ml/kg) or Sodium Fluorescein (2%, 5 ml/kg body weight) in the tail vein and allowed to circulate for 30 minutes before sacrificed with a lethal dose of pentobarbital. Rats were then perfused transcardially through left ventricle with 150 mL physiological saline. Following the perfusion, the rats are decapitated and brains were removed. Brains are homogenized in 5 ml of PBS, added 5 ml of 60% trchloroacetic acid and mixed with vortex for 2 min. Homogenized samples were kept on ice for 30 min and centrifuged at 18000 g at 4 C for 10 min. Supernatants were put in microplate containers spectrophotometrically detection of Evans blue (620 nm) and Sodium Fluorescein (excitation at 480nm and emission at 525nm).

Results
Neither Evans blue nor Sodium Fluorescein were detected in the supernatants from the homogenized brains.

Conclusions
The simulated heliox dive in the present study did not seem to affect the BBB permeability in the rats.

DP-06 REVERSIBLE CEREBRAL VASOCONSTRICTION SYNDROME AFTER SCUBA DIVING: A CASE REPORT

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Abstract
Reversible cerebral vasoconstriction syndrome (RCVS) is a rare neurological but important diagnosis that clinically appears in mild to severe neurovascular complications ranging from no symptoms or mild headache to thunderclap headache, hemorrhage, brain ischemia or seizures**.** Recognition of RCVS is increasing in the last years but still there might be many undetected cases. Headache is a frequent problem associated with scuba diving, but the underlying cause may not be clear in many cases. Here we report about a working diver, who was admitted to our department because of persisting and severe headaches after a scuba dive with heavy work at 5 msw. The headache was right-sided occipital located and had an uncommon pulsatile character. The patient's history was negative for headache, medication or relevant previous conditions. No neurological deficit was found at any time. An initial CT-scan and CT-angiography was normal, but the routine diagnostic workup revealed a segmental constriction of the basilar artery in MR-angiography. Thus, a RCVS was assumed and the patient was treated with nimodipine. Both the vasoconstriction and headaches were completely regressive within 3 weeks under this medication. No symptoms remained on long term follow up. Though it might be a rare complication after scuba diving, RCVS should be considered as differential diagnosis in patients with severe, atypical or persisting headache after diving. Thus, if a patient presents atypical or persisting headaches after scuba diving, MR- or CT-angiography and transcranial sonography are useful to detect cerebral vasoconstriction.

Key words
Cerebral blood flow, Vasoconstriction, Diving, Headache

DP-07 A PORTABLE RESPIRATORY MONITORING SYSTEM WITH SELECTABLE WORK LOAD, BREATHING RESISTANCE AND HYDROSTATIC IMBALANCE FOR DIVERS

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Introduction
It is often desirable to monitor a divers' breathing in the water. A monitoring system should allow measurements of breathing frequency, tidal volume, pressures required to breathe, gas composition at the mouth, (O_2 and CO_2) and heart rate. It also should deliver any chosen breathing mixture to the diver with selectable breathing resistance, hydrostatic imbalance and elastance, all without breath-by-breath adjustments by an investigator. During monitoring, whole-body exercise should be possible.

Materials and Methods
In the portable monitoring system (MS) described here, a diver in a full face mask with alternate gas supply inhales from a breathing bag supplied with premixed gas at a constant, investigator-set flow chosen to fill the bag before the end of expiration; gas bubbles out before every inhalation. Expired gas passes to another bag from which it bubbles into the water. Flow meters and pressure transducers are mounted in two dry compartments (acrylic cylinders with metal ends) one each on the inspiratory and expiratory sides. Gas is sampled continuously from the oronasal mask for analysis with a fast O_2 and CO_2 analyzer. A Polar heart rate receiver hangs on the unit. During set-up, breathing resistance can be increased by inserting calibrated elements in the hoses. Hydrostatic imbalance can be imposed by adjusting the depths of the bags' individual exhaust ports.

An electrically braked cycle ergometer has its workload adjusted from the surface. A diver with his head aligned with the MS lies chest down on support mounted at the depth of the monitoring unit to maintain constant depth. Shoulder supports and hand holds prevent forward motion during cycling. The pedal box is moved relative to the MS to adjust for diver height.

Results
This monitoring system has been used in almost 100 dives at a depth of about 3 m in a pool without any problems. Divers breathed between 10 and 140 l/min.

Discussion
This system has shown itself capable of working well with divers. With a stand-by diver present it should be useable at various depths in the ocean.

DP-08 MEASURING PULMONARY FUNCTION IN MILITARY DIVER CANDIDATES USING THE 90% CONFIDENCE INTERVAL OF PREDICTED PULMONARY PARAMETERS, COMPARED TO DIVING GUIDELINE STANDARDS

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Introduction
During the first assessment military diver candidates undergo pulmonary function tests to determine pulmonary health. The following spirometric parameters are included: Forced Expiratory Volume at one second (FEV1), Forced Vital Capacity (FVC) and the FEV1/FVC ratio. The predicted pulmonary volumes are used as reference. Commercial diving guidelines of the Association of Diving Contractors (ADC), the European Diving Technology Committee (EDTC) and the Health and Safety Executive (HSE) use a fixed percentage of the predicted pulmonary volumes, which are dependent of age, height, gender and ethnicity, to calculate cut off values for pulmonary fitness.
As deterioration of pulmonary function during ageing is a physiological process, using fixed cut off values might result into disqualification of healthy ageing divers. Using the 90% confidence interval (90% CI) of pulmonary parameters instead of a fixed value may improve the assessment of pulmonary health, resulting into less false disqualifications. Using this method is in accordance with the current standard of practice in clinical settings. The aim of this study is to see whether adapting the 90% CI as a cut off value will disqualify less divers.

Materials and Methods
We included 193 military diver candidates who received their first medical assessment between January 1st 2012 and October 31st 2014. All candidates underwent spirometry. The predicted values of the pulmonary volumes were calculated using the formulas of the European Respiratory Society (ERS). The 90% CI was calculated for the pulmonary parameters. For comparison between the guidelines the McNemar's test was used.

Results
Using the 90% CI method did not lead to significantly more disqualifications for diving compared to HSE guidelines. Using the 90% CI method 18 divers were found unfit for diving. Using the HSE guidelines 13 divers were disqualified. The ADC and EDTC guidelines had significantly less disqualifications compared to the HSE guideline and when applying the 90% CI method.

Conclusions
Using the 90% CI of pulmonary parameters does not lead to more disqualifications compared to the HSE guideline. The Diving Medical Center of the Royal Netherlands Navy has adopted the 90% CI method and will evaluate disqualifications in a prospective way.

DP-09 INNOVATIVE METHODOLOGY: MODIFYING PORTAPRES® TECHNOLOGY FOR CONTINUOUS NONINVASIVE BLOOD PRESSURE MEASUREMENTS IN THE HYPERBARIC CHAMBER

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Introduction
For various (patho-)physiological human study designs it would desirable to have a safe, noninvasive continuous blood pressure measurement for use under hyperbaric conditions. For this purpose we present the modifications to the commercially available Portapres® (Model 1, Finapres Medical Systems, Amsterdam, The Netherlands) system and its preliminary validation.

Methods
Based on the specifications provided by the manufacturer, the Portapres® system was systematically analyzed according to "failure mode and effects analysis" (FMEA) principles. We identified possible failure modes related to pressure resistance and fire hazard in a hyperbaric and oxygen enriched environment, and adapted the device accordingly. Adaptations included 1. replacement of the carbon brush motorized pump by a pressure reducing valve to be connected to a pressurized air supply, 2. replacement of all gas-filled electrolytic capacitors for solid equivalents, 3. modification of the 12 V power supply connection in the hyperbaric chamber.

Results
Normobaric validation of the modified system was performed in 5 healthy volunteers: against a standard Finapres® device (n=5) there was concurrence between measurements in normobaric conditions, with non-significant ($p > 0.2$) mean differences of 1.03 and 4.93 mmHg in systolic and diastolic blood pressure. Hyperbaric measurements proceeded without problems in two of the healthy volunteers and two patients.

Conclusion
The modified system provides safe and reliable continuous non-invasive blood pressure measurements both under normo- and hyperbaric conditions in humans.

DP-10 A RED ORANGE EXTRACT MODULATES VASCULAR RESPONSE TO A RECREATIONAL UNDER-WATER DIVE EVENT: A PILOT STUDY ON THE EFFECT OF ANTHOCYANIS ON THE PHYSIOLOGICAL CONSEQUENCES OF HIGH OXYGEN

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Introduction
Scuba diving, breathing either compressed air or specific gas mixtures, at recreational or professional level, has been reported to affect endothelial function, and to impair flow mediated dilation (FMD) and heart function. These effects have been frequently attributed to an "alleged" increased generation of reactive oxygen and nitrogen species. Accordingly, nutritional antioxidants have been proposed as an expedient strategy to reduce endothelial adverse effects of diving.

Results
16 volunteer subjects (12 males and 4 females, 40,1 ± 5,8 yrs) certified experienced scuba divers, were enrolled in the study and randomly assigned to 2 groups. One group was administered with two doses of 200 mg of an anthocyanins (AC) rich extract from red oranges (Red Orange Complex-ROC™), consumed 12 hrs and 4 hrs before the dive, respectively (the pills were swallowed drinking one glass of water); the other group received a placebo with the same amount of water. All subjects reported to a specifically designed indoor pool (Nemo 33, Brussels, Belgium) and performed a single "standard dive" at 34 m depth (4 Atmospheres Absolute-ATA) for 20 minutes observing the US Navy diving procedures. Blood samples were collected, FMD, and multi-frequency body impedance assessed just before diving and just after surfacing. The decrease (reduction) of Hematocrit, extracellular water measured by whole body impedance and the decrease of FMD associated with dive was significantly countered by AC supplementation.

Conclusions
Our data indicate that AC administration significantly prevents the potentially harmful endothelial effects of a recreational single dive. The mechanism underlying this protective activity can only in part be explained by the antioxidant capacity of AC and possibly involves the modulation of signaling in cellular response to high oxygen including some fluid balance changes responsible of the hematocrit decrease.

DP-11 CHANGE IN RELAXATION PATTERN OF THE LEFT AND RIGHT VENTRICLE AFTER FREEDIVE TRAINING

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Introduction
Freediving becomes a popular sport activity which requires good mental and physical training. During the dive, the cardiovascular system has to face up to water environment (temperature, significant pressure changes), breatholding (hypoxia, hypercapnia), and physical activity. Little is known about the reaction of cardiovascular system to these factors. The aim of the study was to assess the effect of freedive training on the functional parameters of the left and right ventricle.

Methods
The study group consisted of the 19 well-trained competitive freedivers (37.2 ± 7.6 years, 2 women, and 17 men). Echocardiography was performed just before and immediately after freedive training. All freedivers completed at least 20 dives into the depth of 20 m (constant weight discipline, 5mm neoprene wet suits, water temperature 12°C).

Results
We observed significant changes in pulse-waved Doppler parameters of left ventricle diastolic function (E/A: 1.5±0.3 vs. 1.2±0.2, p<0.001; E: 92.1±16.2 vs. 70.3±10.5 cm/s, p<0.001; A: 62±14.3 vs. 58.5±10.1cm/s, p ns; E-wave deceleration time: 129.8±34.2 vs. 157.8±38.6 ms, p<0.01). Similarly, tissue Doppler imaging-derived early diastolic myocardial velocities measured at the mitral annulus were decreased after the training (e'septal: 14.5±3.2 vs. 11.2±2.8cm/s, p<0.01; e' lateral: 16.8±3.0 vs. 14.5 ± 3.1cm/s, p<0.05). Systolic parameters of the left ventricle (EF and FS) were not affected. Right ventricle parameters: TAPSE showed significant decrease (26.8±2.8 vs. 21.1±2.7 mm, p<0.001), tissue Doppler imaging-derived early diastolic velocities measured at the tricuspid annulus were decreased after the dive (e': 15.8±3.1 cm/s vs. 12.7±2.2, p<0.05). Also right ventricle myocardial performance index decreased (0.51±0.07 vs. 0.46±0.07, p<0.01). Peak gradient of the tricuspid regurgitation significantly increased (6.52±4.8 vs. 15.3±6.2 mmHg, p<0.01).

Conclusion
For the first time, the echocardiography was used to detect changes in diastolic function induced by freedive training in fresh water. The study showed decrease in diastolic characteristics of the left ventricle, which can be attributed to the change in relaxation pattern of the left ventricle. Similar changes were observed in right ventricle, where additional factor can play important role (increase in pulmonary artery pressure). We consider these changes as reactive to changes in ambient pressure and temperature. This study underlines the necessity of good physical condition of competitive freedivers.

DP-12 PREDICTING STATIC AND DYNAMIC APNEA PERFORMANCE IN ELITE DIVERS USING A 2-MINUTE STATIC APNEA TEST

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Introduction
Large lung volume, high hemoglobin concentration (Hb), enhanced spleen volume and contraction, and low metabolic rate have been described as predictive factors for apneic diving performance (Lemaître, 2010; Schagatay, 2010; Breskovic, 2011). Tolerance to lactate and an enhanced buffering system may also be useful (Schagatay, 2010). The purpose was to determine if a 2-minute static apnea (STA) test with measurement of these variables would provide an indication of competition performance.

Materials and Methods
Fourteen male freedivers aged 38±11 years, with 4.2±2.3 years of training apnea and 2.8±0.9 hours/week apnea training during the last month volunteered. They performed a 2-minute dry static apnea while sitting, preceded by a vital capacity (VC) test and ten minutes of rest. Capillary hemoglobin and lactate were measured before and after the apnea, while heart rate and arterial oxygen saturation (SaO_2) were measured continuously via pulse oximetery. For "O_2-cost" we observe the SaO_2 minimal value, considering a higher value as reflecting a better O_2 conservation. A Pearson correlation analysis was conducted between measurements and performances at the Swedish national pool freediving championship.

Results
There was a positive correlation between VC and performance in all disciplines, highest in STA performance (P<0.05; Table 1). Moreover, a positive correlation between O2-cost and STA performance was found (P<0.05; Table 1), while other variables did not correlate with performance. All variables combined were also correlated to STA, and correlation increased further with a combination of VC and O_2-cost (P<0.05). Dynamic discipline scores did not correlate with combined variables.

	Static apnea	Dynamic apnea	Dynamic apnea no fins	Overall Results
VC	.756 *	.435	.533*	.430
O2-cost	.702*	.034	.149	.261
Hb basal	.379	.088	.031	.127
Hb increase	.248	.033	.043	.008
Lactate	-.06	-.317	-.173	.057
Total Score	.555*	.283	-.090	.236
VC and O_2-cost	.831*	.331	.185	.364

Table1. Predictors and Performance by R from Pearson analysis. *P<0.05.

Conclusions
The variables VC and O_2-cost predicted STA performance well, but is appears insufficient to predict dynamic apnea performance in elite divers. Work economy is essential in dynamic disciples (Schagatay, 2010) which likely accounts for the lack of correlation.

DP-13 POST-DIVE DETECTION OF BUBBLES IN SCUBA DIVERS EMPLOYING ELECTRICAL IMPEDANCE SPECTROSCOPY MEASUREMENTS

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Introduction
Bubbles formation in the human body due to decompression may cause a clinical syndrome known as Decompression Sickness. Bubbles form and increase in size when the sum of the dissolved gas tensions (oxygen, carbon dioxide, nitrogen, helium) and water vapour pressure exceeds the local absolute pressure. It is vital to detect the presence of bubbles in the human body as early as possible. Currently, only acoustic devices can do so but they are bulky, expensive, require trained personnel and are motion sensitive so they cannot be used as portable on-line bubble sensing devices in the field without significant compromises.

Materials and methods
Herein, bubbles in the human body are detected non-intrusively by I-VED (In-Vivo Embolic Detector) technology. I-VED is a patented electrical impedance spectroscopy technique of exceptional high spatial and temporal resolution (*European Patent Office, Application Number: EP14188200.1*). The innovative hardware and signal analysis/processing of I-VED allow capturing slight impedance changes in the human body like those encountered during decompression incidents. A test campaign for bubbles detection in divers is performed in the NEMO 33 swimming pool in Brussels, Belgium. After ethical approval and informed consent, 17 volunteer divers are subjected to a well-defined dive profile at 33m depth for 20 minutes with water at 31^{o}C, while the evolution of bubbles formation in their body is studied for 2h post-dive. Electrical measurements are conducted applying self-adhesive ECG pads at the forearm site of divers and are validated against ultrasound measurements.

Results
Acquired electrical signals are fragmented to three distinct frequency band components: LPF (0-0.5 Hz), BPF (0.5-10 Hz) and HPF (10-250 Hz). LPF and BPF components capture impedance variations in the scale of breathing and heart beat operations, respectively, while HPF component is considered chiefly as noise. Advanced statistical (time-series) analysis of the acquired signals demonstrates the effect of bubbles presence as a function of (post-dive) time.

Conclusions
I-VED delivers promising results concerning early bubbles detection in humans. Further signal processing is currently carried out employing advanced algorithms (such as FFT/STFT, wavelets, spectrograms, HHT) in an effort to enhance bubbles detection, identify the detection limits and quantify obtained results.

DP-14 TOBACCO AND SCUBA DIVING, A PILOT STUDY

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Introduction
Tobacco usage alters the respiratory physiology. Lungs has to be in an healthy state for safe diving. This pilot study aim to investigate the impact of tobacco as risk factor in a diving population.

Materials and methods
An epidemiological questionnaire about tobacco and diving history was submitted to all divers in the Royal Wolu Plongée Club, Brussels.

Spirometric tests were performed in smokers and ex-smokers (tobacco smoking history ≥ 10 years) versus non-smokers before and after a standardised swimming pool training session. Bronchial obstruction reversibility testing were performed in order to exclude asthmatics.

Results
The divers (n=48) replying to the questionnaire had a mean age of 50 (±13) years with a sex ratio M/F=4,33 and performed 26 (±23) dives/year. 13% were active smokers (vs 26% in Belgium – Fondation contre le Cancer – 2014 Report) with an average of 17 pack/years (±13) or 14 (±8) cigarettes/day (vs 15 in Belgium). 10% were passive smokers, 35% ex-smokers (vs 23% in Belgium) and 42% were non-smokers. 67% of smoking divers were encouraged to stop smoking (vs 37% in Belgium) by their physcian and 83% (vs 61% in Belgium) whished to stop smoking. The absolute risk of reported decompression illness (DCI) was 0.035 % in all divers (incidence rate : 1 DCI per 2829 dives) without significant differences between smokers (n=6), passive smokers (n=5), ex-smokers (n=17) and non-smokers (n=20). Occurance of a breathlessness episode was only reported by 67% of active smokers, 20% of passive smokers and 18% of ex-smokers during open water dives. The seriousness of breathlessness was significantly increased in active ($p<0.01$) and passive smokers ($p<0.05$) versus non-smokers.

A standardised swimming pool training session leaded to a small but significant decrease in values of FEV1, PEF, FEF25-75, FEF25, FEF50, FEF75. There was no difference in decrease of values between smokers/ex-smokers (n=5) versus non-smokers (n=5). 1 smoking divers was diagnosed COPD grade 1.

Conclusion
This study reported less smokers in divers versus a general population. Divers and their physicians were more aware of the harmfull impact of tobacco. In this sample there was no relation between DCI and tobacco. Nevertheless breathlessness may present a important safety issue for smoking divers.

Swimming pool sessions leaded to a small asymptomatic, significant decrease in spirometric values which are still within normal range in all divers. Spirometry can give usefull additional safety information regarding smokers and scuba diving.

DP-15 DEVELOPMENT OF HELIOX DECOMPRESSION TABLES FOR USE WITH THE INTERSPIRO SEMI-CLOSED REBREATHER IS-MIX

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Introduction
The Interspiro IS-MIX is a re-circulating semi-closed breathing apparatus that provides a breathing mixture with a constant O_2 fraction. It has been hypothesized that using Nitrox to decompress during Heliox (16% O_2 and 84% He) diving could be logistically simpler and advantageous in terms of decompression requirements, operational requirements and safety.

Methods
After a successful pilot study to assess the feasibility of using Nitrox (60% O_2 and 40% N_2) as a decompression breathing medium from a depth of 24 msw and shallower, an in-water Heliox-Nitrox decompression table for depths between 54 and 81 msw has been calculated using the DCIEM™ Decompression Model and is being evaluated at the Royal Netherlands Navy's Diving Medical Center. Each dive included two wet-working divers on bicycle ergometers (at 50 W) wearing dry suits in 8-10°C water and breathing from the IS-MIX, and two dry resting divers, acting as standby diver and Team Leader, at 3 msw shallower and breathing from the chamber's BIBS. To evaluate decompression stress, all divers were monitored post-dive for venous gas emboli with Doppler ultrasound (Kisman-Masurel method) at the precordium and subclavian vein sites. The inhaled PO_2 and heart rate were monitored.

Results
Ten dive profiles using 19 volunteer military divers were tested for a total of 127 man-dives (56 wet and 71 dry). Of the dry divers, 54 were at 3 msw shallower than the wet divers on the same dives. The other 17 dry divers were tested on three of the 10 profiles for comparison with the wet divers. One incident of DCS and one case of sudden deafness occurred after two dives to 81 msw/20 min. Hyperbaric treatment was used in both cases with complete resolution for the DCS case. Bubble Grades (BG) of wet divers were high in most of the profiles, especially at the precordial site after movement. The dry resting divers, including those at the shallower depth, produced significantly lower BG. This may result in a modified decompression schedules and revised operational procedures for the remainder of the trials.

Conclusions
The incidence of DCS for this study was 0.79% (0.02-4.32 95% CL). Based on previous studies, schedules calculated using the DCIEM™ Decompression Model are expected to have low DCS incidence[a]. However, the proposed decompression table should be modified for deep IS-MIX dives at relatively high workloads and realistically cold water temperatures.

References
[a] Nishi RY, Tikuisis P, Weathersby PK. Comparison of helium-oxygen decompression procedure safety using the principle of maximum likelihood. Abstract presented at the Joint Meeting on Diving and Hyperbaric Medicine, Aug 1990, Amsterdam, The Netherlands.

DP-16 SUDDEN DEAFNESS AFTER DEEP DIVES IN MILITARY DIVERS

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Introduction
We present and discuss three cases of military divers with sudden perception deafness after deep decompression dives. All divers were fit to dive according military standards and had no problems with Valsalva during the actual dive. Their dives were in the depth range of 51-72 mt both on air or heliox. All dives were performed with in-water decompression on oxygen according DRDC/DCIEM diving tables in a controlled situation in the chamber of the Diving Medical Center, Royal Netherlands Navy. Symptoms occurred in the range of directly after surfacing up till several hours after the decompression dive. Otoscopy had not revealed any alterations like rupture of the tymphanic membrane.

Method
All three divers had been admitted at the military ENT department and treated with prednison (50 mg per day for 1 week) and HBO (10 sessions: 2.4 bar, 120 min on a daily base). The demography of these three divers, decompression dives, time of presenting symptoms are presented as well both baseline and post dive audiometry.

Results
The results of the treatment were adequate; two divers recovered fully and are fit for diving. One diver is still recovering, his audiometry improved but not until baseline.

Discussion
The pathophysiological cause of sudden perception is subject for debate. After diving it is an additional interesting and challenging diagnosis. Deafness as a solitary symptom for decompression sickness is not plausible when there are no other signs or symptoms as vertigo, ataxia or other subtile neurological symptoms. Considering these three cases perilymphatic fistula, spasm of the arteria cochlearis or obstruction by nitrogen of helium bubbles are possible explanations. CT scan of the middle ear showed no cochlear bubbles and fistula tests excluded the perilymphatic fistula. Hyperbaric oxygen might be a therapeutic option if no other cause for the deafnes is apparent.

DP-17 BUBBLES QUANTIFIED IN VIVO BY ULTRASOUND RELATES TO AMOUNT OF GAS DETECTED POST-MORTEM IN RABBITS DECOMPRESSED FROM HIGH PRESSURE

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Introduction
The pathophysiological mechanism of decompression sickness is not fully understood but there is evidence that it can be caused by intravascular and autochthonous bubbles. Doppler ultrasound at a given circulatory location is used to detect and quantify the presence of intravascular gas bubbles as an indicator of decompression stress. We studied the relationship between presence and quantity of gas bubbles at the pulmonary artery of compressed and decompressed New Zealand White Rabbits (NZWR) using Doppler ultrasound, the presence and quantity of gas bubbles found postmortem elsewhere in the body, and mortality rate.

Material and methods
Twenty anaesthetized NZWR were compressed in pairs, in a dry hyperbaric chamber to 8 atmospheres absolute with 45 minutes bottom time followed by a fast decompression (0.33m/s). After decompression, the pulmonary artery and the aorta of the rabbits were monitored by ultrasound for *in vivo* bubble detection. The number of gas bubbles was evaluated using the Eftedal and Brubakk grading scale from 0 to 5. Ultrasound monitoring was repeated every 15 minutes for 1 hour, or until death of the animal. Animals that survived for 1 hour after decompression were euthanized with an intraperitoneal injection of pentobarbital (200 $mg \cdot Kg^{-1}$). Animals were carefully dissected and the presence of gas within different veins (subcutaneous, mesenteric, femoral and coronary veins as well as the right atrium) and tissues at different locations (abdominal adipose tissue and capsule of all the organs) were evaluated using a gas score index. Results were compared with a control group. Experimental protocols were done following EU regulations and approved by the corresponding ethical committee.

Results
We found a strong positive relationship between high ultrasound bubble grades (4-5) in the pulmonary artery, sudden death, and high amount of intra and extra vascular gas bubbles widespread throughout the entire organism. In contrast, animals with lower bubble grades (0-3) survived for at least one hour and showed no gas bubbles during dissection.

Conclusions
In vivo ultrasound measurements are related to quantity of gas observed macroscopically post-mortem. High bubble grades were related to high gas score causing death within 35 minutes after decompression.

DP-18 OPTIMIZING MIXED GAS REBREATHERS FOR HELIUM CONSERVATION

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Introduction
Deep diving requires large quantities of helium as diluent in the breathing gas mixture. Helium availability is decreasing due to its use in research, in manufacturing semiconductors and magnetic resonance imagers, and its cost is rising dramatically. The U.S. manages a third of the world supply and at the urging of businesses and universities, Congress recently passed HR 527, the "Responsible Helium Administration and Stewardship Act". Conservation of helium is critical as cost already impacts diving research and operations.

Typical surface supplied diving systems are demand open circuit , meaning all of the diver's exhaled breath is exhausted into the water even though only a small portion of breathing gas oxygen was usefully metabolized by the diver. A semi-closed circuit rebreather exhausts only a portion of the exhaled breath while scrubbing carbon dioxide from the remaining breathing gas and reusing it. While not as thrifty with breathing gas as an electronic closed circuit rebreather, a rugged fully mechanical semi-closed rebreather is a robust choice for surface supplied salvage divers. However, such a rebreather has not been interfaced with a commercial life support helmet to optimize gas conservation while also improving life support characteristics.

U.S. Navy research indicates it is possible to integrate a commercial diving helmet and mechanical rebreather to greatly reduce helium consumption while improving life support.

Materials and methods
Numerical modeling and hyperbaric breathing simulator testing were conducted to optimize a prototype integrated system comprised of a modified Kirby Morgan KM97 helmet and a modified U.S. Navy mechanical semi-closed circuit rebreather.

Results
Analysis indicated that a mechanical semi-closed circuit rebreather with practical gas mixtures can maintain acceptable oxygen and carbon dioxide partial pressures for surface supplied diving while conserving up to 80% of the helium.
Tests indicated that the predicted gas conservation is achievable, with simultaneous decreases in work of breathing, inspired CO_2, flow noise, and faceplate fogging.

Conclusions
Helium is a non-renewable resource and conservation is becoming urgent. Novel integration of contemporary diving equipment can produce hybrid systems that conserve helium and reduce the logistics footprint without sacrificing life support performance.

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