# EUBS 2012

European Underwater and Baromedical Society

## Abstracts and Proceedings from EUBS Annual Scientific meeting 2012

Belgrade, SERBIA

September 12th – 15th 2012

Editors:

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# Scientific Programme

## 38th EUBS Annual Scientific Meeting

*September 12th – 15th 2012*

*

## Satellite meetings:

EUBS Workshop:
"Research in Hyperbaric Medicine – is it possible,
And how can we do it better?"
*Wednesday, September 12th 2012*

8th International DAN Divers Day
"New Perspectives in Diving Medicine"
*Sunday, September 16th 2012*

# SCIENTIFIC PROGRAMME

## Thursday, 13th September 2012

Opening Ceremony: 08:30 – 09:00

| | | |
|---|---|---|
| 09:00-09:30 | **INVITED SPEAKER** | **"Life-threatening necrotizing soft-tissue infections: The role of hyperbaric oxygen"** ***Folke Lind (Sweden)*** |

## SESSION 1 - Research in Hyperbaric Medicine

**Chairmen:** ***Daniel Mathieu, Peter Germonpré***

| | | |
|---|---|---|
| 09:30-09:45 | OP-1 | HYPERBARIC OXYGEN TREATMENT IMPROVED COGNITIVE PERFORMANCE IN LONG TERM BRAIN TUMOR SURVIVORS AFTER NEUROSURGERY AND RADIOTHERAPY<br>*N. A. M. Schellart , A. J. van der Kleij, L.J.A Stalpers* |
| 09:45-10:00 | OP-2 | NORMOBARIC HYPEROXIA INDUCES MORPHOLOGY DIFFERENCES IN LEUKEMIA LINE CELLS: A FRACTAL ANALYSIS<br>*G.K. Orman, F. Tillmans, F. Corazza, D. De Bels, C. Balestra* |
| 10:00-10:15 | OP-3 | HYPEROXIA INDUCES DOUBLE STRAND-BREAKS IN THE DNA DIRECTLY DOSE-DEPENDENT IN ISOLATED LYMPHOCYTES<br>*W.Kähler, J.Witte, A.Koch* |
| 10:15-10:30 | OP-4 | HYPERBARIC OXYGEN THERAPY IN THE TREATMENT OF CALCIPHYLAXIS<br>*J.De Sanctis, R. Hodgsdon, J.Pisarello* |
| 10:30-10:45 | OP-5 | AFFERENT AUTONOMIC ACTIVATION IMPROVES CARDIO-VASCULAR FUNCTION IN $HBO_2$ AND MITIGATES CNS AND PULMONARY OXYGEN TOXICITY<br>*I.T. Demchenko, B.W. Allen, C.A. Piantadosi* |
| 10:45-11:15 | | **COFFEE BREAK** |

## SESSION 2 – Research in Diving Medicine

**Chairmen:** ***Costantino Balestra, François Guerrero***

| | | |
|---|---|---|
| 11:15-11:30 | OP-6 | PLATFORM FOR UNDERWATER MONITORING OF PHYSIOLOGICAL PARAMETERS<br>*A. Sieber, A. Schuster, S.Reif, M. Ljubkovic, Z. Dujic* |
| 11:30-11:45 | OP-7 | NOVEL OSCILLOMETRIC METHODOLOGY FOR UNDERWATER BLOOD PRESSURE MONITORING<br>*A. Schuster , M. Ljubkovic, Z. Dujic, A. Sieber* |
| 11:45-12:00 | OP-8 | NEUROPROTECTIVE EFFECT OF FLUOXETINE IN DECOMPRESSION SICKNESS<br>*J. E. Blatteau, S.Barre, O.Castagna, A. Pascuale, J.J. Risso, N. Vallée* |
| 12:00-12:15 | OP-9 | DYNAMICS OF GAS MICRONUCLEI FORMED ON A FLAT HYDROPHOBIC SURFACE, THE PREDECESSORS OF DECOMPRESSION BUBBLES<br>*R. Arieli, A. Marmur* |
| 12:15-12:30 | OP-10 | DARK CHOCOLATE IMPROVES ENDOTHELIAL FUNCTION IN BREATH-HOLD DIVING<br>*S. Theunissen, J. Schumacker, F. Tillmans, W. Hemelryck, A. Boutros, K. Lambrechts, A. Mazur, M. Pieri, F. Guerrero, P. Germonpré, C. Balestra* |
| 12:30-14:00 | | **LUNCH BREAK / POSTER EXHIBITION** |

## SESSION 3 – Hyperbaric Medicine - Clinical

**Chairmen:** ***Yehuda Melamed, Marko Bumbaširević***

| | | |
|---|---|---|
| 14:00-14:15 | OP-11 | HYPERBARIC OXYGEN INDUCES LATE NEUROPLASTICITY IN POST STROKE PATIENTS<br>*S. Efrati, G. Fishlev, Y. Bechor, O. Volkov, J. Bergan, K. Kliakhandler, I. Kamiager, M. Friedman, E.Ben-Jacob, H.Golan* |
| 14:15-14:30 | OP-12 | HYPERBARIC OXYGENATION IN RADIATION HEMORRAGIC CYSTITIS<br>*C. Pinto, T. Oliveira, C. Amaro, A. Alves, F. Guerreiro* |
| 14:30-14:45 | OP-13 | INFLAMMATORY EFFECTS IN THE HUMAN NASAL MUCOSA IN PATIENTS PERFORMING CHRONIC HYPERBARIC OXYGEN THERAPY<br>*P. Vera-Cruz, M. Ferreira, C. Zagalo, J. M. Santos, A. P. Águas, F. Guerreiro* |
| 14:45-15:00 | OP-14 | SUDDEN DEAFNES TREATED WITH HYPERBARIC OXYGENATION IN CRIS-UTH DURING THE PERIOD 1986-2011. DESCRIPTIVE ANALYSIS OF 190 CASES<br>*J. Desola, L.I.Garcia, P. Martos, E.Poputsidakis* |
| 15:00-15:15 | OP-15 | HBOT OF CARBON MONOXIDE POISONING IN BUENOS AIRES, ARGENTINA, ANALYSIS OF 2101 CONSECUTIVE CASES<br>*N.Subbotina, H.O. Campos* |
| 15:15-15:30 | OP-16 | TREATMENT OF BONE AVASCULAR NECROSIS WITH HBO : THE TRUTH EMERGES<br>*L. De Fina, P.Tanasi, M.Brauzzi* |
| 15:30-16:00 | | **COFFEE BREAK** |

## SESSION 4 – Diving Medicine - Clinical

**Chairmen:** ***Adel Taher, Jürg Wendling***

| | | |
|---|---|---|
| 16:00-16:15 | OP-17 | PULMONARY SYMPTOMS AMONG PARTICIPANTS IN THE "NORWEGIAN DIVER 2011" PROJECT<br>*E. Thorsen, Å. Irgens, K. Troland, M. Grønning* |
| 16:15-16:30 | OP-18 | WHY OCCUPATIONAL INSHORE DIVERS END THEIR DIVING CAREER - DATA FROM THE "NORWEGIAN DIVER 2011" PROJECT<br>*Å. Irgens, K. Troland, E. Thorsen, M. Grønning* |
| 16:30-16:45 | OP-19 | DECOMPRESSION THEORY-CHINESE PRACTICE<br>*S. Yan, W.B.Xiao, M. Zhang* |
| 16:45-17:00 | OP-20 | DECOMPRESSION ILLNESS IN RECREATIONAL, PROFESSIONALLY TRAINED AND SHELLFISH DIVERS – RESPONSE TO TREATMENT SUGGESTS MORE THAN ONE DISEASE ENTITY<br>*J.A.S. Ross, M.D.J. Sayer, C.M. Wilson* |
| 17:00-17:15 | OP-21 | TECHNICAL ASPECTS OF ICE DIVING FOR A GROUP OF DIVERS WITH SCI<br>*B. Ravnak, A. Fidler* |
| 17:15-17:30 | OP-22 | 24 CASES OF NEUROLOGICAL DECOMPRESSION ILLNESS (NDCI) - 14 MONTHS OF A SINGLE CENTER EXPERIENCE<br>*J. Calderon, A. Reccius* |

## Friday, 14th September 2012

| | | |
|---|---|---|
| 08:30-09:00 | INVITED SPEAKER | **"The impact of Technical Diving on recreational diving safety in today diving tourism destinations"** ***Adel Taher (Egypt)*** |

# SESSION 5 - Research in Diving Medicine

**Chairmen:** ***Ole Hyldegaard, Yoram Grossman***

| | | |
|---|---|---|
| 09:00-09:15 | OP-23 | THE INFLUENCE OF BODY FAT ON BUBBLE FORMATION IN RECREATIONAL DIVERS MEASURED BY DOPPLER MONITORING AFTER DIVING<br>*N. A. Schellart, T.P. van Rees Vellinga, F.J. van Dijk, W.Sterk* |
| 09:15-09:30 | OP-24 | PREVALENCE AND GENETIC PREDISPOSITION TO ACUTE RESPIRATORY SYMPTOMS IN BREAT-HOLD DIVERS<br>*D. Cialoni , M. Pieri, N. Sponsiello, C. Marabotti, F. Garoia, P. De Cristofaro, E. Pisciotti, A. Marroni* |
| 09:30-09:45 | OP-25 | VENOUS GAS EMBOLI AFTER COMPRESSED-AIR DIVING: IDENTIFICATION OF PREDICTIVE BIOPHYSIOLOGCAL FACTORS<br>*W.Hemelryck, P. Germonpré, P.Lafère, C. Balestra, S.Theunissen, F. Tillmans* |
| 09:45-10:00 | OP-26 | EFFECT OF DIVING ON HUMAN CUTANEOUS VASCULAR ENDOTHELIAL FUNCTION<br>*K. Lambrechts, J. M. Pontier, A. Mazur, Q. Wang, M. Theron, F. Guerrero* |
| 10:00-10:15 | OP-27 | EFFECT OF OXYGEN-STOP DECOMPRESSION ON BUBBLE FORMATION AND CELL-DERIVED MICRO-PARTICLE RELEASE AFTER AN OPEN-SEA AIR DIVE<br>*J-M Pontier, K. Lambrechts, F Guerrero* |
| 10:15-10:30 | OP-28 | THE EFFECT OF ICE DIVING ON PERIPHERAL SKIN TEMPERATURE ON DIVERS WITH SPINAL CORD INJURY- A PRELIMINARY REPORT<br>*U Gajsek, Z. Finderle* |
| 10:30-11:00 | | **COFFEE BREAK** |

# SESSION 6 – Research in Hyperbaric Medicine

**Chairmen:** ***Erik Jansen, Ian Millar***

| | | |
|---|---|---|
| 11:00-11:15 | OP-29 | TRANSIENT NORMOBARIC HYPEROXIA INHIBITS LEUKEMIA CELL LINE PROLIFERATION SECONDARY TO A CELL CYCLE BLOCKING IN S-PHASE<br>*F. Tillmans, F. Maquerlot, F. Corazza, G.K. Orman, P. Radermacher, C. Balestra, D. De Bels* |
| 11:15-11:30 | OP-30 | HYPERBARIC OXYGENATION IN RESTORATION OF THE COGNITIVE FUNCTIONS IN CHILDREN<br>*N.Jovanovic Simic, T.Jovanovic, P.Brkic, A. Mitrovic* |
| 11:30-11:45 | OP-31 | CHANGES IN MITOCHONDRIAL RESPIRATORY RATE IN LEUKEMIC CELL LINE AFTER TRANSIENT NORMOBARIC HYPEROXIA<br>*M. Theron, F. Tillmans, Q. Wang, P. Radermacher, C. Balestra* |
| 11:45-12:00 | OP-32 | HYPERBARIC OXYGENATION REDUCES NEURONAL DEGENERATION IN THE RAT BRAIN TISSUE AFTER CORTICAL INJURY<br>*P. Brkic, T. Jovanovic, M. Stojiljkovic, S. Dacic, I. Lavrnja, A. Parabucki, A. Mitrovic, I. Bjelobaba, D.Stojkov, S.Pekovic* |
| 12:00-12:15 | OP-33 | IMPACT OF NORMOBARIC HYPEROXIA ON VASCULAR ENDOTHELIAL GROWTH FACTOR DOWN REGULATION IN LEUKEMIA CELLS<br>*M. Legout, F. Corazza, D. De Bels, I. Heninger-Favier, C. Balestra, P. Radermacher, F. Tillmans* |
| 12:15-12:30 | OP-34 | TIME COURSE OF CHANGES IN EXPIRED NITRIC OXIDE AND CARBON MONOXIDE DURING ACUTE NORMOBARIC HYPEROXIC EXPOSURES<br>*D.M. Fothergill, H.G. Gasier* |
| 12:30-14:00 | | **LUNCH BREAK / POSTER EXHIBITION** |

## SESSION 7 – Hyperbaric Medicine - Clinical

**Chairmen:** ***Marco Brauzzi, Milica Dekleva***

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|---|---|---|
| 14:00-14:15 | OP-35 | SYSTEMIC SCLERODERMA: QUALITY OF LIFE OF THE PATIENTS TREATED WITH HYPERBARIC OXYGENATION<br>*L. Polyakova, E. Voronenkova* |
| 14:15-14:30 | OP-36 | LYMPHEDEMA: THE EFFECTS OF COMBINED HYPERBARIC OXYGEN THERAPY (HBOT), COMPRESSION- DECONGESTION PHYSICAL THERAPY (CDPT) AND VACUSAC THERAPY<br>*D. Vujnovic, R. Kostic, D. Rondovic, Z. Damjanovic* |
| 14:30-14:45 | OP-37 | ULCUS CRURIS: THE PLACE OF HBOT AS IMPORTANT COMPONENT IN THE TREATMENT<br>*D. Vujnovic, R. Kostic, D. Rondovic, D. Ivkovic, B. Suzic-Todorovic* |
| 14:45-15:00 | OP-38 | SIGNIFICANCE OF IMMUNOHISTOCHEMICAL IDENTIFYING OF VASCULAR ENDOTHELIAL FACTOR AND ITS RECEPTOR $R_2$ DURING HYPERBARIC OXYGEN THERAPY IN DIABETIC FOOT TREATMENT<br>*M. Vojinovic, S. Milenkovic* |
| 15:00-15:15 | OP-39 | EFFECTS OF HYPERBARIC OXYGENATION ON PROSTHETIC REHABILITATION OF PATIENTS WITH UNILATERAL LOWER LIMB AMPUTATION<br>*I. Simanic, M. Teofilovski, P. Brkic, G. Izquierdo Pinedo, T. Jovanovic* |
| 15:15-15:30 | OP-40 | MONITORING CARDIAC OUTPUT DURING HYPERBARIC OXYGEN THERAPY OF HEMODYNAMICALLY UNSTABLE PATIENTS<br>*M.B. Hansen, F. Treschow, M. Skielboe, O. Hyldegaard, E.C. Jansen, J.B. Nielsen* |
| 15:30-16:00 | | **COFFEE BREAK** |

## SESSION 8 – Hyperbaric Medicine - Clinical

**Chairmen:** ***Jordi Desola, John Ross***

| | | |
|---|---|---|
| 16:00-16:15 | OP-41 | THE INTERNATIONALISATION OF CLINICAL HYPERBARIC FACILITY ACCREDITATION: QUALITY IMPROVEMENT AND RISK MANAGEMENT IN ACTION<br>*W. Workman* |
| 16:15-16:30 | OP-42 | CHAMBER PERSONNELS' USE OF NITROX DURING HYPERBARIC OXYGEN TREATMENT – A QUALITY STUDY<br>*M.B. Hansen , T. Jansen, O. Hyldegaard, E.C. Jansen* |
| 16:30-16:45 | OP-43 | REVERSE ENGINEERING AS A TOOL FOR THE DEVELOPMENT OF SATURATION INSTRUCTIONS<br>*J.P. Imbert* |
| 16:45-17:00 | OP-44 | SUBAQUATIC AND HYPERBARIC MEDICINE CENTER OF THE PORTUGUESE NAVY: EXTENDED MEDICAL CORE TEAM SWITCHING CHALLENGE<br>*A. Alves, A. Anão, F. Guerreiro* |

**17:00-18:00** **EUBS GENERAL ASSEMBLY**

## Saturday, 15th September 2012

| | | |
|---|---|---|
| 08:30-09:00 | INVITED SPEAKER | **"Rebreather Primer: Opening the Loop"** ***Michael Lang (USA)*** |

# SESSION 9 - Diving Medicine – Clinical

**Chairmen:** ***Jacek Kot, Theodoros Mesimeris***

| | | |
|---|---|---|
| 09:00-09:15 | OP-45 | PROGNOSTIC FACTORS OF SPINAL CORD DECOMPRESSION SICKNESS: RETROSPECTIVE ANALYSIS OF 36 CASES<br>*M. Brauzzi, A. Mambro, S. Falini, P. Tanasi, L. De Fina* |
| 09:15-09:30 | OP-46 | A PROSPECTIVE EVALUATION OF MALE FERTILITY CHANGES IN SATURATION DIVERS<br>*M. Kharb, WAJ Meintjes* |
| 09:30-09:45 | OP-47 | COGNITIVE SYMPTOMS AND WELDING FUME EXPOSURE<br>*J.A.S. Ross, J.I. Macdiarmid, S. Semple, S.J. Watt, G. Moir, G. Henderson* |
| 09:45-10:00 | OP-48 | ENT PROBLEMS SUFFERED BY SCUBA DIVERS DURING PARTICIPATION IN DIVING ACTIVITIES, A CROSS SECTIONAL STUDY FROM 2009 TO 2011 USING THE DAN EUROPE INSURANCE CLAIMS DATABASE<br>*A.Gerges, R. van den Berg ,T.Berghout,C.De Iuliis, A.Marroni* |
| 10:00-10:15 | OP-49 | EFFICACY OF VENTILATION AND VENTILATION UTILITIES DURING IN WATER RESUSCITATION<br>*B. E. Winkler, A. M. Eff, S. Eff, U. Ehrmann, A. Koch, W. Kähler, C. M. Muth* |
| 10:15-10:30 | OP-50 | INFLUENCE OF DECOMPRESSION SICNESS ON THE ENDOTHELIUM DEPENDENT AND INDEPENDENT RELAXATION IN ISOLATED RAT VESSELS<br>*A. Mazur, Q. Wang, K. Lambrechts, M.Belhomme, M.Theron, F. Guerrero* |
| 10:30-11:00 | | **COFFEE BREAK** |

# SESSION 10 – Research in Diving Medicine

**Chairmen:** ***Petar Denoble, Dragana Ivković***

| | | |
|---|---|---|
| 11:00-11:15 | OP-51 | COMPRESSION EFFECT OF DIVING WET SUIT : A STEP TOWARDS IMMERSION EFFECTS ON WATER BALANCE<br>*O. Castagna, J. E. Blatteau, N. Vallée, B. Schmid, J. Regnard* |
| 11:15-11:30 | OP-52 | PRELIMINARY ANALYSIS OF DAN EUROPE DSL DB AND GRADIENT FACTOR EVALUATIONS. PHYPODE PROJECT<br>*C.Bonuccelli, M. Pieri, D.Cialoni, A.Gerges, G.Orman, C. Balestra, A. Marroni* |
| 11:30-11:45 | OP-53 | EFFECTS OF 2H FIN SWIMMING IN 29°C WATER ON WATER BALANCE<br>*O. Castagna, J.E. Blatteau, N. Vallée, C. Jimenez, J. Regnard* |
| 11:45-12:00 | OP-54 | MECHANISMS THAT ALTER BODY FLUID BALANCE DURING IMMERSION<br>*J. Regnard, L. Mourot, O. Castagna, C. Jimenez, J.E. Blatteau, M. Bouhaddi, JP Wolf, A. Boussuges, JL Méliet, B. Melin, C. Robinet* |
| 12:00-12:15 | OP-55 | INTRINSIC AEROBIC CAPACITY AND SUSCEPTIBILITY FOR DECOMPRESSION SICKNESS<br>*A. Møllerløkken, M.B. Havnes, A. Hjelde, S.E. Gaustad, A. Jørgensen, K.V. Rasdal, A.O. Brubakk, I. Eftedal* |
| 12:15-12:30 | OP-56 | COMPARISON OF DECOMPRESSIONS USING ULTRASOUND DOPPLER<br>*M. Gennser, S.L. Blogg* |
| 12:30-12:45 | OP-57 | INCREASED RELATIVE SIGNAL INTENSITY ON DYNAMIC CONTRAST ENHANCED MAGNETIC RESONANCE IMAGING IN THALAMUS AND FRONTAL CORTEX IN DIVED RATS<br>*M.B. Havnes, M. Widerøe, M. Thuen, AM. Brubakk, A. Brubakk, A. Møllerløkken* |
| 12:45-13:15 | | **CLOSING CEREMONY** |

# LIST OF POSTER PRESENTATIONS

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*K. Vaskin, I. Gruzdeva*

PP-02 CLINICAL EXAMPLE OF SUCCESSFUL APPLICATION HYPERBARIC OXYGENATION TO THE CHILD IN REMOTE PERIOD AFTER CARBON MONOXIDE POISONING
*K. Vaskin, I. Serdeshnova, E. Koreneva*

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*G. Grigorieva, L. Polyakova, N. Meshalkina*

PP-04 EFFECT OF HYPERBARIC OXYGENATION ON THE QUALITY OF LIFE OF PATIENTS WITH INFLAMMATORY BOWEL DISEASE
*S. Golysheva, L. Polyakova, G. Grigorieva*

PP-05 A CURRENT OVERVIEW TO THE DANGERS AND MEASURES IN HYPERBARIC CHAMBER
*E. Karakuzu, S. Yildiz*

PP-06 THE CLINICAL EXAMPLE OF SUCCESSFUL APPLICATION OF HYPERBARIC OXYGENATION, IN THE TREATMENT OF PATIENTS WITH SEVERE RESPIRATORY DISTRESS SYNDROME
*K.Vaskin*

PP-07 CHRONIC WOUNDS IN CALCIPHYLAXIS TREATED WITH HYPERBARIC OXYGEN: A CASE SERIE REPORT AND A BRIEF REVIEW OF LITERATURE
*V. A Zieren, F. Yildirim, A. van den Brink, R. A van Hulst*

PP-08 THE EFECT OF HYPERBARIC OXYGENATION ON NEURONAL PLASTICITY AFTER EXPERIMENTAL CORTICAL INJURY IN RATS
*P. Brkić, T. Jovanović, M. Stojiljković, S. Dacić, I. Lavrnja, A. Parabucki, A. Mitrović, I. Bjelobaba, D. Stojkov, S. Peković*

PP-09 THE COMBINED USE OF HBOT AND OTHER WOUND CARE INSTRUMENTS IN CHRONIC WOUNDS WITH DIFFERENT ETHIOLOGIES: A CASE SERIES OF 41 PATIENTS
*M. Cimsit, A. Cakkalkurt*

PP-10 CICATRISATION IN THE POST-AMPUTATION DIABETIC FOOT WOUND, WITH A HUGE TISSUE LOSS, TREATED WITH SMALL NUMBER OF REPEATED HBOT: CASE REPORT
*B. Suzić Todorović, D. Ivković, D. Vujnović, R Kostić*

PP-11 HYPERBARIC OXYGEN THERAPHY AND CHELATION : AN EFFECTIVE COMBINATION FOR TREATMENT OF NEUROINFLAMATION IN CHILDREN WITH AUTISM
*N. C. Kinaci*

PP-12 CLINICAL AND MICROSCOPIC EFFECTS OF HYPERBARIC OXYGEN IN DIABETIC FOOT ULCERS
*D. Mendes, M. Monteiro-Soares, E. Lemos, A. Távora, J. Sobral, I. Duarte, D. Brandão, J. Campos-Lemos, M. Madureira, M. Ribeiro, T. Fernandes, O. Camacho, J. Lima, R. Soares*

PP-13 HYPERBARIC OXYGEN THERAPY FOR NONARTERITIC ANTERIOR ISCHEMIC OPTIC NEUROPATHY: A CASE REPORT
*D. Cavalheiro, C. Pereira, C. Pinto, F. Guerreiro*

PP-14 HYPERBARIC OXYGEN THERAPY IN ACUTE AND CHRONIC SUDDEN DEAFNESS
*B.Markuš, J.Milošević*

PP-15 POLYNEUROPATHY AS A CHALLENGE IN HYPERBARIC MEDICINE
*J. Milošević, B. Markuš*

PP-16 EFFECT OF HYPERBARIC OXYGEN THERAPY ON PULMONARY FUNCTION IN PATIENTS WITH CHRONIC SYSTEMIC VASCULITIS AND DIABETES MELLITUS
*S. Kutlešić-Stević*

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*T. Jovanović, P. Brkić*

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*T. Jovanović, P. Brkić, D. Ninković*

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*T. Jovanović*

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*T .Jovanović, P. Brkić, A. Mitrović*

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*H. Stipančević, G. Gošović*

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*A. Sieber, A. Schuster , P. Enoksson*

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*A. Sieber, M.Stoianova-Sieber, D. Bachmaier, B.Kuch, P. Enoksson*

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*J. Calderon*

PP-28 NEUROLOGICAL DECOMPRESSION ILLNESS: BRAIN AND SPINAL CORD RESONANCE IMAGENOLOGY FINDINGS
*J. Calderón, M. Peldoza, A. Vidal*

PP-29 HEART RATE VARIABILITY DURING A STANDARD DIVE: POSSIBLE INFLUENCE OF INSPIRED OXYGEN LEVEL?
*P. Lafère, W. Hemelryck, F. Tillmans, P. Germonpré, C. Balestra*

PP-30 COMPARISON BETWEEN AN ACTIVE AND PASSIVE SEXUAL INTERCOURSE WORKLOAD : "EFFORT AFTER DIVING?"
*M. Ezquer, T. Snoeck, S. Provyn, J. Marteau, V. Oboeuf, F.Tillmans, P. Lafère, C. Balestra*

PP-31 IN VITRO CONSTRUCTION OF COMPRESSION AND DECOMPRESSION MODEL SYSTEM
*Q. Wang , M. Belhomme, F. Guerrero, A. Mazur, K. Lambrechts, H. Ollivier, M. Theron*

PP-32 DECOMPRESSION SICKNESS IN CAISSON WORKERS IN A TUNNEL PROJECT IN AMSTERDAM
*X Vrijdag, A. van den Brink, P van Ooij, R van Hulst*

PP-33 A CROSS-SECTIONAL STUDY DESCRIBING ALL DIVERS SEEN AT A PRIVATE MEDICAL PRACTICE IN DUBAI, UAE
*B. Karin Vela, W.A.J. Meintjes*

PP-34 A SURVEY OF ANTIMALARIAL MEDICATION USE AND ITS EFFECTS IN RECREATIONAL SCUBA DIVERS
*T. Mandic, W.A.J. Meintjes*

PP-35 OXIDATIVE STRESS IN BREATH-HOLD DIVERS AFTER SUCCESSIVE DIVES
*S. Theunissen, N. Sponsiello, F. Tillmans, F. Guerrero, P. Germonpré, W. Hemleryck, C. Balestra*

PP-36 REDUCTION OF VENOUS GAS EMBOLI LOAD AFTER BREATHING NORMOBARIC OXYGEN
*S.L. Blogg, M. Gennser*

PP-37 DESTRUCTION OF A PROPTOSIS, A POSSIBLE CAUSE OF PULMONARY BAROTRAUMA
*L. Bense, G. Eklund, H. Jorulf, Á. Farkas, I. Balásházy,B. Madas , J. Eden Strindberg, M Gennser, J. Douglas*

PP-38 DECOMPRESSION MODELLING: A PROJECTION PROCEDURE FOR DISSOLVED PHASE TRACKING SIMULATIONS
*V. Papadopoulou, R. Eckersley, M. Tang*

PP-39 ACUTE MEDULLARY SYNDROME PROVEN BY MRI AFTER STRENUOUS EXERCICES UNDERWATER, TREATED SUCCESSFULLY BY HBOT PROVE BY REPEATED MRI
*H. Foreid, C. Araújo, C. Pinto, A. Alves, A. Ação, F. Guerreiro*

PP-40 BODY COOLING IN COLD WATER IMPROVES DYNAMIC FUNCTIONAL NASAL PARAMETERS
*B. Schmidt, W. Kähler, T. Wunderlich, J. Witte, B. Winkler, J. Kowalski, I. Koch, A. Koch*

PP-41 EXHALED NITROUS OXIDE AND LUNG FUNCTION AFTER PROVOCATION WITH COLD DRY AIR IN HEALTHY AND ASTHMATIC SUBJECTS
*P. Yannick Lungwitz, C. M. Muth, M. Gröger, W. Kaehler, A. Koch, K. Tetzlaff, B. E. Winkler*

PP-42 EFFECTS OF COLD WATER SCUBA DIVES WITH FULL-FACE-MASK OR DIVING MASK AND MOUTHPIECE REGULATOR ON BODY TEMPERATURE, HEART RATE AND LUNG FUNCTION
*F. Uhlig, C.M. Muth, K. Tetzlaff, A. Koch, W. Kaehler, R. Leberle, B.E. Winkler*

PP-43 AFTER IMMERSION PULMONARY OEDEMA OF A COMMERCIAL DIVERS: MORE THAN PULMONARY HRCT NEEDED IN THE FTD-EXAMINATION?
*C. Fabricius*

Wednesday, 12th September 2012
(09:00 - 12:35, Conference Room1 Annex B)

# EUBS Workshop:
# Research in Hyperbaric Medicine - is it possible, and how can we do it better?

Co-sponsored by:
Centre for Hyperbaric Medicine, Serbia
OxyHeal Health Group, USA

Moderators: Philip Bryson, Tomislav Jovanović

09:00-09:10 **Introduction**

## SESSION 1 – HBO and Calcaneal Fractures

09:10-09:20 *Karin Hasmiller*:
RESULTS OF THE BG-UNFALLKLINIK (MURNAU, GERMANY) EXPERIENCE TO DATE

09:20-09:40 *Johannes Gabel:*
WHY HBO SHOULD BE USED IN FOR CALCANEAL FRACTURES AND THE EVIDENCE FOR THIS

09:40-10:00 *Alan Johnstone:*
WHY HBO IS NOT USED IN THIS CONDITION IN THE UK

10:00-10:30 *Ruth Stephenson:*
DIFFERENT RESEARCH PROTOCOLS, MODALITIES AND THEIR APPROPRIATENESS

10:30-11:00 **COFFEE BREAK**

## SESSION 2 – Clinical Trials?

11:00-11:15 *Erik Jansen:*
PROBLEMS AND IMPORTANCE OF CLINICAL TRIALS IN HYPERBARIC MEDICINE

11:15-11:35 *Henrik Eckardt:*
DISCUSSION ON AN ONGOING CALCANEAL FRACTURE AND HBO STUDY AND ITS DESIGN

11:35-11:55 **DEBATE**

11:55-12:05 *Philip Bryson:*
TRANSLATIONAL RESEARCH AS AN ADDITIONAL TOOL IN CLINICAL RESEARCH

12:05-12:25 AUDIENCE opinion and discussion

12:25-12:35 *Alan Johnstone:*

WRAP UP AND CONCLUSIONS

12:35–14:00 **LUNCH**

Sunday, 16th September 2012
(10:00 - 15:30, Conference Room1 Annex B)

# 8th International DAN Divers Day
# "New Perspectives in Diving Medicine"

## MORNING SESSION

10:00-10:15 *Alessandro Marroni (IDAN)*:
WELCOME AND INTRODUCTION

10:15-10:30 *Cristian Pellegrini (Italy):*
THE DIVERS ALERT NETWORK AND ITS MISSION

10:30-11:00 *Jacek Kot (Poland):*
OXYGEN IN DECOMPRESSION

11:00-11:30 *Dragana Ivković (Serbia):*
RESPIRATORY PROBLEMS IN DIVING

11:30-12:00 *Costantino Balestra (Belgium):*
RECENT ADVANCES OF DAN EUROPE RESEARCH ON THE PATHOPHYSIOLOGY OF BREATH-HOLD AND SCUBA DIVING

12:00-13:15 **LUNCH BREAK**

## AFTERNOON SESSION

13:15-13:45 *Adel Taher (Egypt):*
TECHNICAL AND REBREATHER DIVING IN POPULAR DIVING DESTINATIONS: LIGHTS AND SHADOWS

13:45-14:30 *Francois Burman (South Africa), Guy Thomas (Italy):*
DAN`s DIVING MEDICINE AND SAFETY PROGRAMS: BETTER AWARENESS MAKES SAFER DIVING

14:30-15:00 *Petar Denoble (USA):*
EFFECT OF DELAY TO RECOMPRESSION ON OUTCOME OF DCS

15:00-15:30 *Alessandro Marroni (Italy):*
PARTICIPATED FIELD RESEARCH IN DIVING MEDICINE AND PHYSIOLOGY. A POWERFUL DATA COLLECTION SYSTEM TO COMPLEMENT CLASSICAL LAB RESEARCH. METHODOLOGY AND RECENT ACQUISITIONS

# ORAL PRESENTATIONS

OP-01

# HYPERBARIC OXYGEN TREATMENT IMPROVED COGNITIVE PERFORMANCE IN LONG TERM BRAIN TUMOR SURVIVORS AFTER NEUROSURGERY AND RADIOTHERAPY

N. A. M. Schellart[1] , A. J. van der Kleij[2], L.J.A Stalpers[3]

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Keywords: Brain tumor survivors, Cognitive impairment, HBOT, qEEG, Late event-related components

*Introduction/background/objectives*

Cognitive performance is often permanently impaired in long-term brain tumor survivors after neurosurgery and radiotherapy. Hyperbaric oxygen treatment (HBOT) stimulates neovascularization of hypoperfused tissue that may result in improved functionality of damaged tissue. In this study, clinical neurophysiological and neuropsychological tests were used to assess the effect of HBOT on brain performance.

*Methods*

Ten patients (6 males), age 32-75 years, obtained HBOT for severe cognitive deficits after neurosurgery and radiosurgery. Patients were tested before HBOT (29-52 sessions), and at 6 weeks and 4 months after HBOT. The tests comprised a quantitative electro-encephalographic (qEEG) examination, the number connection test (NCT), the continuous reaction time test (CRTT) and the Informant Questionnaire on Cognitive Decline in the Elderly (IQCOD) for memory performance. Late event-related components (LERCs; N200, P3a and P3b, ordered according to increasing latency) of averaged evoked EEG responses to a visual odd-ball stimulus were analyzed from whole-head activity maps obtained with 64 electrodes (10-10 configuration). For comparison, healthy control subjects (no HBOT) were also investigated.

*Results*

After HBOT, the amplitude of the cognitive most important LERC, P3b (involved in object interpretation) was significantly improved (P=.02). The amplitudes of N200, the intermediate P3a and the preceding visual CI component did not change. Neither latencies nor reaction times changed after HBOT. However, P3a and P3b latencies were longer than in healthy subjects. The NCT showed inconclusive results, but the IQCODE questionnaire answers showed improvement. When the outcomes of NCT, CRTT, IQCODE and P3b amplitudes are evaluated in common tests, HBOT appears to provide substantial improvement (P<.006).

*Summary/conclusions*

It is tentatively concluded that HBOT improves cognitive performance in long-term brain tumor survivors on the basis of the analyses of a variety of tests. Part of this study has been published (Schellart et al., Cancer, 117, 2012).

OP-02

## NORMOBARIC HYPEROXIA INDUCES MORPHOLOGY DIFFERENCES IN LEUKEMIA LINE CELLS: A FRACTAL ANALYSIS.

G.K. Orman[1], F. Tillmans[1], F. Corazza[2], D. De Bels[1,2], C. Balestra[1]

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*[2] Brugmann University Hospital, Brussels, Belgium.*

This study is part of the Phypode Project, financed by the European Union under a Marie Curie Initial Training Network programme

Keywords: Fractal dimension, Box-counting, Image processing

*Objectives*

The aim of this study was to determine if normobaric hyperoxia (18 h) compared to normoxia induces morphology differences in U937 and Jurkat leukemia line cells by quantitatively measuring through a mathematical morphometric approach based on fractal geometry.

*Methods*

Before detecting fractal dimensions, we applied two pre-processing; (1) equalizing the color histogram of images by enhancing operation (between 0 and 255). (2) Applying thresholding at 80 to have black-white images. Then, we used the Harfa software to calculate the fractal dimension of these images. This tool uses a very extensive box-counting algorithm. This algorithm allows denoting several different fractal dimensions as black, black & white or white parts of boxes. It gives the opportunity to use continuous or discrete increasing box sizes. The difference between discrete and continuous spectrum is in distance of adjacent data points (Continuous - step one, discrete - logarithmical step).

*Results*

Fractal dimensions significantly increased in U 937 and Jurkat cells after hyperoxia. For Jurkat cells, discrete increasing box sized fractal dimension for normoxia and hyperoxia is around 1.43 and 1.54 respectively. Continuous increasing box sized fractal dimension for same type of cell lines are 1.47 and 1.56. For U 937 cells, discrete increasing box sized fractal dimensions are 1.24 and 1.39 while they were 1.28 and 1.42 for continuous increased box sized fractal dimension for normoxia and hyperoxia respectively.

*Conclusion*

In this work, we used fractal dimension to determine the morphological changes of leukemia cells. The increase in fractal dimension addresses a parallel increase in cell shape complexity. It is likely that early membrane fragmentation processes, associated with precocious apoptosis, will result in a more “spindle” cell profile, therefore mimicking an increase in shape complexity.

# HYPEROXIA INDUCES DOUBLE STRAND-BREAKS IN THE DNA DIRECTLY DOSE-DEPENDENT ISOLATED LYMPHOCYTES

W.Kähler, J. Witte, A. Koch

*German Naval Medical Institute – Section for Maritime Medicine of the Christian-Albrechts-University, Kiel, Germany*

*Objective*

It has been shown that hyperoxia can induce DNA-damage in living cells, visualizable as “comets” in the single cell gel-electrophoresis. It is not clear, how far the occurrence of these double-strand breaks in the DNA is directly dose-dependent from oxygen partial pressure (pO2) and exposure time to hyperoxia and therefore from the amount of free radicals inside the cells.

*Methods*

Isolated lymphocytes from healthy non-diving persons were exposed to hyperoxia in a hyperbaric pressure chamber at 38°C ambient temperature in 96-well plates with RPMI-buffer. Samples of cells were exposed to either ambient air (controls; 0.21 bar pO2) or different levels of hyperoxia, ranging from 1 bar pO2 to 6 bar pO2 and up to 6.5 hours exposure time. Each thirty minutes an aliquot of cells was removed from the chamber for the alkaline comet–assay. From each sample a total of 200 cells were analyzed for either the mean tail moment in relation to the maximum found tail moment (Comet Assay IV-software) or for calculating the percentage of cells with any visible comets as signs of DNA-damage (comet+-cells).

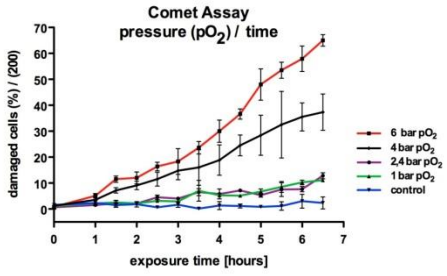
*Results*

Data show that the method of calculating the percentage of comet+-cells out of 200 cells in the view field revealed a good overall correlation between pO2 and exposure time on one side and percentage of comet+-cells on the other. Even exposures to clinically used pO2-values induced a significant elevated percentage of comet+-cells (figure). Calculation of the tail moments showed comparable but less accurate results.

*Conclusions*

Hyperoxia seems to induce double strand-breaks in the DNA directly dose-dependent in isolated lymphocytes. The calculation of the percentage of comet+-cells out of 200 cells gives more accurate results than the tail moment-method.

Figure:



OP-04

## HYPERBARIC OXYGEN THERAPY IN THE TREATMENT OF CALCIPHYLAXIS

J. De Sanctis[1]; R. Hodgsdon[2]; J. Pisarello[3]

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Keywords: Calciphylaxis, End stage renal disease, HBOT, Parathyroidectomy

*Introduction*

Calciphylaxis is a rare, potentially devastating ulcerative cutaneous disease. It has been recognized in patients with chronic renal failure, recent renal transplant, hypercoagulable states and chronic liver disease. Associated mortality is extremely high (up to 60-80%) and death is usually secondary to sepsis. Hyperbaric oxygen therapy (HBO) has been proposed as adjunctive treatment in calciphylaxis.

*Methods*

We reviewed 14 consecutive patients between March 1999 and October 2003. There were twelve females, 2 males, mean age 56 (32-81), with end stage renal disease (ESRD) 13/14 and one female with chronic liver disease. Diagnosis of calciphylaxis was made according to established clinical criteria and in 6 cases with histological confirmation. All patients received local wound therapy and surgical debridement as indicated.

*Results*

10 patients completed therapeutic courses of HBO, defined as 10 or more daily sessions at 2.0 ATA for 90 minutes. Of the four remaining patients, one never received HBO due to insurance issues, one initiated therapy and discontinued after 3 sessions and the other two patients died while receiving HBO. Parathyroidectomy was performed in 4/14, including three of the patients from the HBO group. At a 6 to 60 month follow up, in the HBO group there was one death due to calciphylaxis and sepsis. The 9 remaining patients experienced documented wound healing. Three of these patients died later of unrelated causes (two from cerebrovascular disease and one from gastrointestinal bleeding). In the non-HBO group there were 2 deaths for sepsis, one resolved wounds after parathyroidectomy and one was lost to follow up.

*Conclusion*

In our experience, HBO significantly reduces mortality associated with calciphylaxis. HBO should be considered as the first line therapy for calciphylaxis more than adjunctive as it was proposed in the past. In addition, our data suggests that HBO is more effective in the early stages of the disease.

# AFFERENT AUTONOMIC ACTIVATION IMPROVES CARDIO-VASCULAR FUNCTION IN $HBO_2$ AND MITIGATES CNS AND PULMONARY OXYGEN TOXICITY

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Keywords: Hyperbaric oxygen, CNS O2 toxicity, Cardiovascular function

*Background*

$HBO_2$ (above 3 ATA) causes a biphasic autonomic nervous system (ANS) response. There is initial efferent parasympathetic hyperactivity followed by sympathetic overdrive. The sympathoexcitation is associated with oxygen seizures, depressed left ventricular function and acute lung injury. Bilateral vagotomy or baroreceptor denervation abolishes parasympathetic overdrive and hastens the onset of seizures in $HBO_2$. Thus, in addition to efferent outflow, afferent ANS activity is critical to the development of seizures and pulmonary injury in $HBO_2$. This study investigated the impact of enhancing autonomic afferents (achieved through aortic depressor nerve (ADN) or vagus nerve (VN) electrical stimulation) on cardiovascular function and CNS and pulmonary $HBO_2$ toxicity.

*Methods*

In anesthetized rats, central and cardiac hemodynamics, EEG, ECG and renal sympathetic nerve activity were recorded at 3 or 6 ATA $O_2$ with and without ADN stimulation. Heart rate intervals, sympatho-vagal imbalance, baroreceptor sensitivity, and left ventricular dysfunction indices were computed. In conscious rabbits, EEG, ECG and respiration were recorded at 5 ATA $O_2$ with and without VN stimulation. Prodromal signs of CNS $O_2$ toxicity and convulsion latency were determined, and lung injury was assessed.

*Results*

In rats, sympatho-excitation and vagal withdrawal preceded $HBO_2$ related seizures (EEG spikes), accompanied by acute cardiogenic pulmonary hypertension and reductions in left ventricular contractility. ADN stimulation prolonged vagal inhibition, prevented sympatho-excitation, diminished pulmonary hypertension, improved cardiac function and delayed EEG spikes. In rabbits at 5 ATA, sympathetic overdrive and specific patterns on the EEG, ECG and respiration preceded motor convulsions. Vagal stimulation increased the parasympathetic component of autonomic drive and delayed both prodromal signs of oxygen toxicity and seizure latency. Severe lung injury observed in untreated animals was markedly attenuated by VN stimulation.

*Conclusion*

Activation of afferent autonomic by electrical stimulation of ADN or VN improves cardiac autonomic control, significantly lengthens seizure latency and prevents lung injury in $HBO_2$.

OP-06

## PLATFORM FOR UNDERWATER MONITORING OF PHYSIOLOGICAL PARAMETERS

A. Sieber[1,2], A. Schuster[1,2], S.Reif[1], M. Ljubkovic[3], Z. Dujic[3]

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[3] *University of Split, School of Medicine, Split, Croatia*

Keywords: Diving computer, Physiological data monitoring, ECG, SO2, Blood pressure

*Introduction / Background / Objectives*

Underwater assessment of physiological parameters requires ad hoc instrumentation. Clinical instruments cannot simply be put into water and pressure proof housings, mainly as during measurements also ambient factors – high pressures, water, salinity, etc - have to be taken into account, which clinical instruments usually do not do. In the past the authors have already presented such instrumentation for measurement of single physiological parameters (Sieber A et. al, Undersea and Hyperbaric Medicine. 2010; 37(5)).

*Methods*

The target of the current work was to develop a platform that allows recording of a variety of physiological parameters in a synchronic way together with diving profile. Core component is a novel type of diving computer, which is equipped with an analog and a digital interface to which a variety of sensor nodes can be connected. First sensor nodes include an ECG board which is mounted into a water tight port for a dry suit, a SO2 sensor board and a novel type of blood pressure meter.

*Results*

Three prototypes were manufactured. It features TRIMIX decompression calculation, a tilt compensated compass, a high contrast OLED screen and a patent pending touch display that can be used even underwater. A binary critical flicker fusion frequency test was integrated as well .Dive relevant data and physiological data are store on an internal FLASH memory. ECG is recorded with 250Hz. A graphical user interface allows detailed post dive analysis of all the parameters. The prototypes were tested in water at 50msw and in a pressure chamber to 100mfw.

*Acknowledgment*

This work relates to Department of the Navy Grant N62909-11-1-7044 issued by Office of Naval Research Global. The work was co-funded by the Marie Curie ITN PHYPODE.

# NOVEL OSCILLOMETRIC METHODOLOGY FOR UNDERWATER BLOOD PRESSURE MONITORING

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[2] *SEABEAR Diving Technology*
[3] *University of Split School of Medicine (USSM)*

*Introduction / Background / Objectives*

The assessment of blood pressure (BP) of divers underwater requires special instrumentation that is water- as well as pressure-proof. Previous work in this field is limited to a few research studies, where either BP devices in a laboratory set up were used in simulated dives in a hyperbaric chamber (Ferrigno et.al. 1997) or a prototype of an underwater BP measurement was used in field conditions (Sieber et.al, 2008). The later oscillometric device worked well in the initial studies, but required user training and manual adjustments underwater after each depth change.

*Methods*

The approach followed in this work is based on an oscillometric measurement methodology. Instead of detecting the pressure oscillations during deflation of the cuff, measurements take place during cuff inflation. In order to avoid disturbances caused by pressure spikes, the cuff is inflated in a stepwise manner, which is synchronized with the pulse.

*Results*

A first prototype (Figure 1) was assembled. The electronics are encapsulated in a silicon gel. First laboratory verification showed that oscillations can be detected and the BP measurement is possible. The device was tested in a wet pressure chamber to 50 mfw.

*Acknowledgments*

This work relates to Department of the Navy Grant N62909-11-1-7044 issued by Office of Naval Research Global and Marie Curie ITN PHYPODE.

OP-08

## NEUROPROTECTIVE EFFECT OF FLUOXETINE IN DECOMPRESSION SICKNESS

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*Introduction*

Nitrogen supersaturation and bubble formation can occur in the vascular system after diving leading to death and nervous disorders from decompression sickness (DCS). Bubbles alter the vascular endothelium; activate platelets, leukocytes and immuno-inflammatory processes, leading to focal ischemia with neurological damage mediated. Fluoxetine (Prozac™), a well-known and commonly prescribed antidepressant, is recognized to have anti-inflammatory effects in the setting of cerebral ischemia. We report a neuroprotective effect associated with fluoxetine in DCS.

*Methods*

91 C57Bl6 mice were subjected to a simulated dive at 90 msw for 45 minutes before rapid decompression. The experimental group received a per os 50 mg/Kg fluoxetine solution 18 hours before hyperbaric exposition (n=46) while the control group had a similar saccharine solution without fluoxetine (n=45). Clinical assessment, including grip tests, was realized during a period of 30 min after surfacing. At the end, blood samples were collected for blood cells counts and cytokines detection.

*Results*

There were significantly fewer manifestations of DCS in the fluoxetine group compared to controls: 75.5% of the controls were symptomatic versus 43.5% of the treated animals. Survival mice showed a better and significant neurological recovery, according to grip tests, in the fluoxetine group but not in controls. Platelets and red-cells counts were significantly decreased after decompression in controls but not in treated mice. Fluoxetine reduces circulating IL-6, a relevant proinflammatory marker in DCS and restores chemokines levels of MIG/CXCL9 and MIP-1α/CCL3.

*Conclusion*

Fluoxetine reduces DCS incidence and enhances motor recovery in mice by limiting inflammation processes.

# DYNAMICS OF GAS MICRONUCLEI FORMED ON A FLAT HYDROPHOBIC SURFACE, THE PREDECESSORS OF DECOMPRESSION BUBBLES

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[2]*Department of Chemical Engineering, Technion-Israel Institute of Technology, Haifa, Israel*

*Introduction*

It is a long-standing hypothesis that the bubbles which evolve as a result of decompression have their origin in stable gas micronuclei, possibly produced by tribonucleation and lodging in hydrophobic crevices and micelles of surface-active molecules. Recent findings supported by atomic force microscopy have indicated that tiny, flat nanobubbles form spontaneously on smooth, hydrophobic surfaces submerged in water. The purpose of the present study was to examine the kinetics of bubble evolution. Propose that these nanobubbles may be the gas micronuclei responsible for the bubbles that evolve to cause decompression sickness. The purpose of the present study was to examine the kinetics of bubble evolution.

*Methods*

We used hydrophilic and monolayer-covered hydrophobic smooth silicon wafers to show that nanobubbles formed on a flat hydrophobic surface may be the gas micronuclei responsible for the bubbles that evolve to cause decompression sickness. On decompression, bubbles appeared only on the hydrophobic wafers.

*Results*

Bubble density after decompression was greater with increasing hydrophobicity. Bubbles appeared after decompression from 150 kPa, and their density increased with elevation of the exposure pressure (and supersaturation), up to 400 kPa. The normal force of attraction between the hydrophobic surface and the bubble, as determined from the volume of bubbles leaving the surface of the wafer, was $38 \times 10^{-5}$ Newtons and the tangential force was $20 \times 10^{-5}$ Newtons.

*Conclusions*

Our results correlate with previous reports of experimental decompression and bubble formation, and suggest, on the basis of the present findings, that there is a need for the modification of decompression models.

OP-10

## DARK CHOCOLATE IMPROVES ENDOTHELIAL FUNCTION IN BREATH-HOLD DIVING

S. Theunissen[1,2,3], J. Schumacker[1], F. Tillmans[1,3], W. Hemelryck[1,3,4], A. Boutros[1,3], K. Lambrechts[2], A. Mazur[2], M. Pieri[3], F. Guerrero[2], P. Germonpré[3,4], C. Balestra[1,3]

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This study is part of the Phypode Project, financed by the European Union under a Marie Curie Initial Training Network programme

Keywords: Nitric oxide, Free radicals, Flow Mediated Dilation, Photoplethysmography

*Objectives*

The aim of the study was to observe the effect of dark chocolate on breath-hold diving by measuring flow mediated dilation (FMD) and photoplethysmography.

*Methods*

20 breath-hold divers were divided into a control group (8 males and 2 females; 47,3 +/- 12,48 years, 178,4 +/- 7,6 cm, 76,1 +/- 11,5 kg) and a chocolate group (9 males and 1 female; 49,7 +/- 8,3 years, 179,8 +/- 6,1 cm, 77,3 +/- 7,6 kg). The control group was asked to perform a series of dives to 20 m adding up to 20 minutes in the quiet diving pool of Conflans-Ste-Honorine (Paris, France). The chocolate group perfomed the same dives in the same conditions 1h after ingestion of 30g of dark chocolate (70% of cocoa). FMD and digital photoplethysmography were measured before and after each series of breath-hold dives.

*Results*

A significant decrease in FMD was observed in the control group after the series of dives (95,28 +/- 2,9% of predive values, p = 0,0006) while it was increased in the chocolate group (104,1 +/- 2,9% of predive values, p = 0,0017). No difference was observed in photoplethysmography between the two groups (respectively 103,1 +/- 20,9 vs 96,22 +/- 20,57).

*Discussion*

Antioxidants contained in dark chocolate are able to scavenge free radicals produced during breath-hold diving. Physical exercise associated with this type of dive leads to a production of nitric oxide leading to a vasodilation. The ingestion of 30g of dark chocolate 1 hour before the dive can thus prevent endothelial dysfunction observed after a series of breath-hold dives to 20m adding up to 20 minutes.

*Acknowledgments*

The authors want to thank C. Furet for the access granted to his diving facility.

## HYPERBARIC OXYGEN INDUCES LATE NEUROPLASTICITY IN POST STROKE PATIENTS

S. Efrati [1,2], G. Fishlev[1], Y. Bechor[1], O. Volkov[3], J. Bergan[1], K. Kliakhandler[4], I. Kamiager[5], M. Friedman[1], E. Ben-Jacob[4], H. Golan[3].

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*Background*

Recovery after stroke correlates with non-active (stunned) brain regions, which may persist for years. The current study aimed to evaluate whether increasing the level of dissolved oxygen by Hyperbaric Oxygen Therapy (HBOT) can induce neuroplasticity in patients with chronic neurological deficiencies due to stroke.

*Methods*

A prospective, randomized, controlled, crossover trial including 74 patients who suffered a stroke 6-36 months prior to inclusion. Patients had at least one motor dysfunction. After inclusion, patients were randomly assigned to "treated" or "cross" groups. Brain activity was assessed by SPECT imaging; neurological functions were evaluated by NIHSS, ADL, and life quality. Patients in the treated group were evaluated twice: at baseline and after HBOT. Patients in the cross group were evaluated three times: at baseline, after a 2-month control period, and after subsequent 2-months of HBOT. HBOT protocol: 40 daily sessions, 90 minutes, 100% oxygen at 2ATA, 5 days/week.

*Findings*

Neurological functions and life quality of both groups significantly improved following HBOT but remained unchanged during the control period of the cross group. SPECT imaging was well correlated with clinical improvement. Elevated brain activity was detected mostly in regions of a noticeable discrepancy between anatomy and physiology – live cells (as confirmed by CT) with low activity (based on SPECT).

*Conclusions*

The results indicate that HBOT can lead to significant neurological improvements in post stroke patients even at chronic late stages. The observed clinical improvements demonstrate that neuroplasticity can still be activated long after damage onset in regions where there is a brain SPECT/CT mismatch.

OP-12

## HYPERBARIC OXYGENATION IN RADIATION HEMORRAGIC CYSTITIS

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Keywords: Hyperbaric oxygenation, Cystitis, Hematuria, Radiotherapy.

*Objective*

Due to its morbidity and mortality, radiation-induced hemorrhagic cystitis is an important complication of pelvic radiotherapy and is frequently refractory to conservative techniques. Hyperbaric oxygen therapy has showed to be effective in the management of late radiation injuries, including radiation-induced cystitis. Our aim was to analyze the efficacy of hyperbaric oxygen for the treatment of radiation-induced hemorrhagic cystitis and the influence of some external variables.

*Methods*

Clinical records from 176 patients with refractory radiation-induced hemorrhagic cystitis treated at our institution in the last 15 years were retrospectively analyzed. Patients received daily 90 minute sessions, with 100% oxygen at 2,5 atmospheres. Evolution of macroscopic hematuria was used to analyze treatment efficacy.

*Results*

From a total of 176 treated patients, 23,9% showed other radiation-induced soft tissue lesion. After an average of 37 sessions, 89,8% of patients showed resolution of hematuria. Hematuria resolution rates were lower when time from the beginning of symptoms to institution of hyperbaric oxygen therapy increased (p=0,199). Patients that underwent 20 sessions or less had 90% resolution rate, whereas patients receiving 21 to 40 sessions had 96,5% (p=0,042).

*Conclusion*

In concordance to previous reports, radiation-induced hemorrhagic cystitis was successfully treated with hyperbaric oxygen. Our results show that, in order to have maximum results, hyperbaric oxygen treatment should be established as soon as possible. Treatment efficacy was higher in patients that underwent more than 20 sessions, but there was no greater benefit after 40 sessions. A prospective study is in progress in order to confirm these results.

# INFLAMMATORY EFFECTS IN THE HUMAN NASAL MUCOSA IN PATIENTS PERFORMING CHRONIC HYPERBARIC OXYGEN THERAPY

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Keywords: Hyperbaric Oxygen Therapy, Nasal Mucosa, Basement Membrane, Neutrophils, Cilia.

*Objective*

We aimed at the identification of putative morphologic changes induced in the nasal mucosa by hyperbaric oxygen (HBO) treatment.

*Material and Methods*

Biopsies were obtained from two groups of 9 individuals: the first group had a diagnosis of tinnitus and was submitted to 15 sessions of 100 min-long HBO treatments, and the latter group was made of healthy volunteers not submitted to HBO therapy.

Small biopsies of the anterior portion of the lower nasal turbinate were collected with the help of a Hartmann forceps under direct visual inspection. The samples were processed for light microscopy and morphometric analysis and electron microscopy. Inflammatory infiltration (neutrophils and lymphocytes) was evaluated by a semiquantitative method. Unpaired *t* test and Bernoulli distribution were applied to evaluate statistical differences between data from the two groups of samples.

*Results*

Samples of the turbinate mucosa of the HBO-treated group showed a significant increase in the thickness of the epithelial basement membrane to 12,1±4,1µ ($p<0,05$) and a moderate enhancement in infiltrating neutrophils, presented in 8 patients ($p<0,05$). By transmission electron microscopy (TEM), we observed that only a minority of the nasal epithelial cells presented alterations due to the HBO treatment; these alterations were focal and restricted to cilia.

*Discussion / Conclusion*

Chronic HBO treatment causes only minor changes in the architecture of the nasal mucosa that may represent the response of the respiratory tract to the increase in pressure and in oxygen content induced by this type of therapy.

OP-14

## SUDDEN DEAFNES TREATED WITH HYPERBARIC OXYGENATION IN CRIS-UTH DURING THE PERIOD 1986-2011. DESCRIPTIVE ANALYSIS OF 190 CASES

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*Background*
Sudden deafness (SD) is a non solved problem with a relatively high prevalence. Several drug therapies have been empirically tried but no one has ever given valuable results. Hyperbaric Oxygenation (HBO) has been applied from a long time.

*Methods*
Descriptive analysis of patients suffering from SD during the period 1986-2011, focussed in personal data (age, gender, origin), the single description of the disorder, latency, delay in HBO, and outcome. Results were qualified as healing, partial ameliorance, no change, or worsening, in base of the subjective validation of the patients or the reports given by ENT specialists when available.

*Results*
One-hundred and ninety patients where sent to CRIS-UTH; from these 190 patients, 149 (78.4%) accomplished criteria for hyperbaric treatment and received a minimum of 15 HBO sessions applied in less than 20 days. Eighteen patients (12.2%) had a full recovery with total restitution of their hearing function. Seventy-eight (52.7%) experienced a partial improvement. Thirty five patients (23.6%) did not experience any change. No patient ended in a worse condition than when HBO was started.

*Discussion*
Near to two third part of the patients (64.9%) experienced a favourable outcome, which apparently had no relation with the delay in starting HBO. There was no clear difference between those starting the treatment within the first 10 days, and those received after some months after the sudden episode.

*Conclusions*
HBO is by so far the best studied, and the more consistently reported, of all therapies of any kind that have been applied to patients suffering from sudden deafness. These results encourage us to continue working in this field and to endorse a randomized controlled study. We hypothesize that the requirement of a Sudden Origin as inclusion criterion should be replaced by the HBO treatment of Neurosensorial Hearing Disorders, independently of their latency.

This abstract still contains preliminary data that will be enhanced in the oral presentation during the Congress.

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# HBOT OF CARBON MONOXIDE POISONING IN BUENOS AIRES, ARGENTINA, ANALYSIS OF 2101 CONSECUTIVE CASES

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Keywords: Carbon monoxide poisoning, Carboxyhemoglobin

*Introduction*

Carbon monoxide (CO) poisoning continues to be a significant public health issue. Approximately 50,000 cases occur annually in the United States. There is no agreement among the medical community about the specific indication and efficacy of HBO in the treatment of this condition.

*Materials & Methods*

Clinical and demographic data and clinical outcomes of 2,101 victims of unintentional CO-poisoning treated in hyperbaric chambers in Buenos Aires from 1998 to 2011 are analyzed. Treatment goals included resolution of symptoms persisting after prolonged surface oxygen therapy and normalization of carboxyhemoglobin (COHb).

*Results*

2030 patients (94%) showed resolution of symptoms and normalization of COHb after one HBO session at 2.8 ATA for 90 minutes. 63 patients presenting with more severe symptoms, received from 2 to 10 sessions with complete to partial improvement. Eight severely affected patients did not respond to HBOT. The main indication of HBOT was history of loss of consciousness, neurological symptoms and persistent headaches. 59% of patients had COHb levels from 20 to 39%. Rabdomyolisis confirmed by CPK test was observed in 21 patients (from 332 registered data). 95% of patients were treated during the first 12 hours after rescue, but 18 patients still symptomatic after 24 hours of NBO, showed symptom resolution with HBOT. The highest incidence of CO poisoning was observed in June, July and August (winter) (73%) with moderate incidence in May and September (19%). The majority of patients were treated during the night and pre-dawn hours. The socio-economic level of CO victims was heterogeneous; that correlates with the general sources of poisoning: charcoal briquettes, water heaters, furnaces or gas-powered boilers.

*Conclusion*

A single HBOT was effective for resolution of symptoms in the vast majority of CO poisoned victims. A significant number of patients with more severe symptoms demonstrate improvement after continued HBOT.

OP-16

## TREATMENT OF BONE AVASCULAR NECROSIS WITH HBO: THE TRUTH EMERGES

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Keywords: Avascular bone necrosis, Hyperbaric oxygenation

*Introduction*

The bone avascular necrosis (BAN) in adults is a constantly increasing phenomenon. It has a strong social importance since it primarily involves the working population. We have used treatment with HBO (Hyperbaric Oxygenation) to prevent or to significantly delay the surgical procedure.

*Methods*

Since 2008 to March 2011 we have treated 169 patients affected by BAN with HBO. Mean age 46 years. The diagnosis was based on X-ray imaging (CT SCAN,MRI or standard x-ray). The protocol was based on a 20 sessions of HBO at 2.5 ATA followed by a stop of 30 days and 10 more sessions and so on with the same timing for a total number of sessions of 70-100. The follow up was based mainly on MRI and specialist's judgment.

*Results*

Data from 169 patients (95 male and 74 female) were analyzed. Mean age of the patients were 46 years (range: 35-60 years). All patients were affected by BAN (Stage 0 or 1) HBO started in the first 3 months after the diagnosis of BAN in all patients.. Mean number of HBOT sessions were 70 ± 30 (range: 20-92). Clinical improvement was observed in 155 patients (91,71%). No improvement was observed in 6 patients (3,56 %). 8 patients (4,73 %) required surgery.

*Conclusions*

BAN leads to a destruction of the affected bone, making a prosthetic replacement necessary in most cases. Avoiding an early surgical procedure is very important and induces a significant saving of money for the National Health system. We think that our results are very encouraging.

# PULMONARY SYMPTOMS AMONG PARTICIPANTS IN THE "NORWEGIAN DIVER 2011" PROJECT

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Keywords: Divers, Lung, Long term health effects

*Introduction*

Occupational divers are exposed to increased ambient pressure, and the associated hyperoxia, increased gas density and venous gas microembolism have short and long term effects on the lung. Epidemiological studies show reduced lung function that is related to cumulative diving exposure. The aim of this study was to estimate the prevalence of pulmonary symptoms among active and former inshore divers.

*Methods*

The Registry of Divers by The Norwegian Labour Inspection Authority comprises all occupational inshore divers that have ever held a diving certificate since 1980. Ninety percent of the 6151 male divers born 1950-90 could be identified. A comprehensive questionnaire was mailed, and pulmonary symptoms were registered by a modified version of the British Medical Research Council questionnaire. The divers were categorized into previous divers, present divers and references based on diving exposure and time for ending their career. References were divers with present or former S-certificate (SCUBA diving to 30m.). The response rate after one reminder was 47.8 %.

*Results*

The cumulative number of dives in each group were 1577, 588 and 477 in previous divers, present divers and references. After adjusting for age and smoking status the prevalence of morning cough was 16.3 % in previous divers, 11.2 % in present divers and 8.1 % in the references. The prevalence of chronic cough was 20.8, 14.9 and 10.7 %, for phlegm 22.3, 17.5 and 12.4 % and for episodes of wheezing 11.2, 5.0 and 3.0% respectively. For all symptoms there were significant trend differences between groups.

*Discussion/ Conclusion*

The prevalence of pulmonary symptoms was higher in occupational divers than references. The prevalences were highest among previous divers. The findings are consistent with the studies demonstrating reduced airways conductance in divers.

OP-18

## WHY OCCUPATIONAL INSHORE DIVERS END THEIR DIVING CAREER - DATA FROM THE "NORWEGIAN DIVER 2011" PROJECT

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Keywords: Divers, Career, Stopdiving

*Introduction*

For former North Sea divers the mean duration of their diving career was 16.8 years. The aim of the present study was to investigate why occupational divers end their career.

*Methods*

The Norwegian Labor Inspection Authority's Diving Register comprises all occupational inshore divers who have ever held a certificate since 1980. From the 6151 male divers born 1950-90, 89.8% could be identified. A comprehensive questionnaire was mailed, 47.8% were returned. The divers were categorized into former divers (1588), present divers (595) and references that had minor diving experience (480).

*Results*

At present 73.7% of the former divers held a different job, 3.9% were on sick leave, 7.0% received disability pension, 8.1% had old age pension and 3.8% were students, while 6.1% worked with diving logistics. Some had a combination.

Eighty seven percent had listed at least one reason why they had stopped diving: certificate of medical fitness could not be renewed (11.5%), health issues (23.5%), dissatisfied with working conditions (18.0%), dismissed (2.0%), anxiety due to diving(6.4%), got a better job (49.8%) , new education (44.9%).

The former divers were dichotomized into choosing (had got a better job or took education, n=867) or forced to retire (the rest telling why they stopped, n=514). Mean age at retirement in the group who chose to retire was 32.8 years, with a mean number of 1293 dives and 8.1 years as occupational diver. The corresponding figures for the group who were forced to retire were 39.6 years, 2737 dives and 13.2 years. Physical and mental health related quality of life (SF-12) were significantly lower for divers forced to quit.

*Discussion/ Conclusion*

Divers who were forced to end their carrier as divers were older, had more health problems and a lower health related quality of life than those who chose to do so.

## DECOMPRESSION THEORY-CHINESE PRACTICE

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Keywords: Heliox saturation, Safe excess pressure, Decompression schedule

*Introduction*

The choice of decompression mode and the establishment of distance in stop depths will directly affect the safety and efficiency of decompression procedures. In this paper, an appropriate decompression mode concerning deep heliox saturation dive was discussed.

*Methods*

First, the permissible pressure difference between that of the breathing mixtures and the tissue was calculated according to the function of safe excess pressure which was first adopted by our laboratory several years ago, and a nonlinear decompression mode was established. Then, in accordance with Haldane logarithmic gas exchange principle, decompression rates varying with changes in depth were calculated and a practical decompression schedule was thus derived.

*Results*

A series of simulated experimental heliox saturation dives was carried out by the Chinese Navy in 2011. 7 navy divers reached the saturation depths of 65 msw, 250 msw and 480 msw respectively. During the decompression in accordance with the schedule calculated in this paper, no symptoms of decompression sickness occurred to the divers and no bubbles were observed by Doppler ultrasonic bubble detector.

*Discussion*

First, the reliability of the decompression procedure calculated with the safe excess pressure was verified by comparing with the U.S and France decompression procedure. Then, the determination basis of half-saturation time was discussed. In addition, our research also investigated the effect of stop distance on the efficiency of the decompression procedure.

OP-20

# DECOMPRESSION ILLNESS IN RECREATIONAL, PROFESSIONALLY TRAINED AND SHELLFISH DIVERS – RESPONSE TO TREATMENT SUGGESTS MORE THAN ONE DISEASE ENTITY

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Keywords: Decompression illness, Recompression treatment, Professional diving

*Objectives*
This study describes the clinical course and outcome of decompression illness in Scotland from April 1992 to March 2010.

*Methods*
Recreational; professionally trained and shellfish divers were identified. Condition of referral was defined as moderate (pain, skin rash, sensory disturbance or ataxia) or severe (motor weakness, nausea/vertigo or cerebral deficit). Relapse after recompression was defined as symptom recurrence requiring repeat primary treatment. Long term sequelae were defined as persistent ataxia, motor weakness, urinary retention or cerebral function deficit. Outcome was assessed using unadjusted binary logistic regression. For group comparisons the recreational group was used as reference.

*Results*
The study captured 962 recompression treatments. Shellfish divers performed more dives on the day of the incident than sport (p>0.001) or professional (p=0.002) divers. Shellfish diving was a significant risk factor for severe DCI (Mean OR 2.7, 95%CI 1.6-4.7), relapse (Mean OR 2.8, 95%CI 1.4-5.5) and long term sequelae (Mean OR 3.5, 95%CI 1.7-7.1). Professional training was associated with failure of cure on discharge (Mean OR 1.9, 95%CI 1.1-3.2) and long term sequelae . (Mean OR 2.3, 95%CI 1.1-4.7). With the exception of 5 cases a poor outcome was only seen in severe cases regardless of time to treatment. Rapid treatment was related to cure after first recompression for mild but not severe disease (figure 1).

*Conclusions*
The outcome of treatment of DCI is poorer in professional and shellfish divers in Scotland. This is associated with a more severe presentation and a markedly higher rate of relapse in shellfish divers. Severe disease does not respond to recompression in the same manner as mild disease and this suggests the presence of more one disease entity and, accordingly, reconsideration of methods of treatment and the construction of larger data sets. The relationships between disease severity, time to recompression and outcome are important regards the location and availability of recompression chambers.

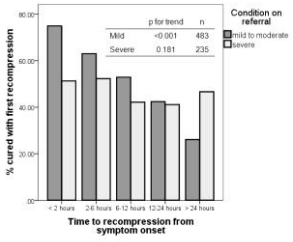


Figure 1 – Relationship between the chances of cure after first recompression treatment and time to recompression treatment.

# TECHNICAL ASPECTS OF ICE DIVING FOR A GROUP OF DIVERS WITH CHRONIC SPINAL CORD INJURY

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Keywords: Ice diving, Spinal cord injury, Overhead environment

*Introduction*

Diving under the ice is a technically demanding and occurs in a limited access environment. It is practiced by public safety divers and by some recreational divers trained for ice diving. Divers with chronic spinal cord injury (SCI) and resulting dysfunctions are classified into a recreational diving group and advised not to dive in cold and overhead environment. This recommendation, however, does not seem to be evidence based. A group of divers with SCI that has been training for years and diving in various circumstances, decided to undertake the ice dive as a normal evolution of their multi-year training.

*Methods*

Diving was planned, monitored and executed in accordance to valid diving standards. A total of eight divers participated, 4 with chronic SCI and 4 healthy able bodied scuba diving instructors. No exercise was performed except slow swimming. Water temperature was 4°C constantly, visibility up to 3m, the sky was clear and air temperature varied between 13 and 19°C. The lake was covered with 15 to 20cm thick ice. Logistic team included backup and safety divers, technical and medical stuff. Only one pair of divers dived at the time. Standard equipment configuration for ice diving was used. Multiple access/exit routes were made into the ice.

*Results*

Dives did not exceed 30 minutes. All divers felt cold. There was no major difference reported by divers with SCI and able bodied controls in spite of exposure to low temperatures. Group of disabled divers was observed for next ten days and they did not report any complications in that period.

*Conclusions*

Ice diving exposes able bodied divers and divers with chronic SCI to extreme cold. However, careful planning and proper logistic support allowed for divers with SCI accompanied by well trained able bodied divers to take part in this activity.

OP-22

## 24 CASES OF NEUROLOGICAL DECOMPRESSION ILLNESS (NDCI) - 14 MONTHS OF A SINGLE CENTER EXPERIENCE

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Keywords: Neurological DCI prognosis lidocaine patterns

*Objective*

To describe the cases of treated NDCI in 14 months in the Subaquatic Medicine Service in Ancud, Chile (SMSHA).

*Methods*

Prospective systematic registry of diving profile and neurological examination made by a neurologist specialized in diving medicine. Revision and analysis of the registries.

*Results*

A review of 24 cases of treated NDCI was made. Thirteen out of these, had affections involving the spinal cord, four affected the brain, and 7 had peripheral nerve disease. Most cases with spinal disease had paraparesia with a sensitive level and in general without compromise of propiocepción. Of these cases, four received lidocaine, and required between 0 and 12 sessions of hyperbaric oxygen therapy (HBO). In this group of patients that did not receive lidocaine, three did not require more sessions and the rest required between 5 and ten sessions. Both groups of patients, treated with lidocaine and untreated, went through initial hyperbaric treatment following a table 6 USN and two extensions at 2.8 ATA. After that, all were treated with sessions of oxygen therapy at 2.3 ATA during 60 minutes. The only patient who suffered from full spinal disease required 25 sessions of HBO. From the cases that had cerebral disease, two of them showed alterations in consciousness. One of them died in spite of hyperbaric treatment and ICU treatment. Two other cases corresponded to lacunar syndromes that were recovered completely with hyperbaric treatment.

*Conclusion*

The presence of a "dissociation" or existence of different patterns of injury in the spinal cord could be explained because of different physiopathologic reasons, that is to say, arterial embolization in cases of spinal disease with respect of the posterior cord, or venous thrombosis in cases of commitment of a complete medullary syndrome, and presence of bubbles in cases of injury of the spinal cord not systemizable. The injury pattern of the complete spinal seems to have worse prognosis.
Lidocaine treatment seems to improve prognosis.

# THE INFLUENCE OF BODY FAT ON BUBBLE FORMATION IN RECREATIONAL DIVERS MEASURED BY DOPPLER MONITORING AFTER DIVING

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Keywords: Adiposity, VO2max, Age, Bubble count, Venous gas embolism

*Introduction/background/objective*

In spite of many studies it is still uncertain whether body fat (BF) is a predisposing factor for venous gas embolism (VGE) and decompression sickness (DCS). BF (range 16-44%) is studied in relation to the bubble grade measured by precordial Doppler monitoring. To prevent bias, the effect of age (range 34-68 years), body mass index (BMI; range 17-34 kg.m-2) and a model estimate of VO2max (maximal O2 uptake; range 24-54 mL.kg-1.min-1) were taken into account.

*Methods*

Bubble grades (Kisman Masurel) were determined in 43 recreational divers after an open sea air dive (20msw/40min). Doppler bubble grade scores were transformed to the logarithm of the number of bubbles/cm2 (logB) and to the logarithm of KISS (Kisman Integrated Severity Score), to allow numerical analysis. Statistical analyses were performed with Pearson's regular and partial correlations, and uni- and multivariate linear regressions.

*Results*

The partial correlations strongly reduced the collinearity between age, VO2max, BMI and BF, allowing for a clear view on the contribution of body fat after correction for confounding factors. For divers in their midlife (and older), the analyses indicate that neither BF nor BMI stimulate bubble formation, since the correlations were highly non-significant. In contrast, age and especially VO2max, appeared to determine bubble development of. For these types of dives and divers it was found that logB = - 1.1 + 0.02age - 0.04VO2max (variance inflation factor only 1.2).

*Summary/conclusions*

We conclude that BF and BMI do not influence VGE. We recommend that in medical examinations more attention is paid to VO2max and age, and that international institutions come to a consensus regarding VO2max criteria. A poor VO2max also restricts the physical reserve (only a pace of 1800 m/h while diving requires 25 mL/min.kg). We recommend a VO2max of 25 mL/min.kg as the minimum value for recreational divers.

OP-24

## PREVALENCE AND GENETIC PREDISPOSITION TO ACUTE RESPIRATORY SYMPTOMS IN BREAT-HOLD DIVERS

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Keywords: Acute respiratory distress syndrome, Breat-old diving, Diving, Emopthisis

*Introduction*

After repetitive deep dives, breath-hold divers are often affected by a syndrome characterized by symptoms such as cough, chest constriction, haemoptysis and rarely, an overt acute pulmonary oedema syndrome, often together with various degrees of dyspnoea (ARS). Aim of this work is an epidemiological investigation to evaluate the prevalence of acute respiratory symptoms (ARS) in Breath-hold divers; we have also investigated for possible inherent risk factor such as genetic predisposition.

*Materials and Method*

A retrospective investigation has been performed using specific questionnaires filled by a selected sample of free divers. A second specific questionnaire was used to identify other possible risk factors that could predispose to ARS. The possible correlation between ARS and individual genetic variability in candidate predisposing genes was also investigated, with a particular focus on EPAS1 and other HIF-related genes.

*Result*

Fifty-six subjects (26.4%) reported previous events of ARS. No statistically significant relationships was noted between the positive or negative reported cases of ARS and biometric data such as height and weight, age, gender, practice of other sports, smoking. No statistically significant relationships was noted between ARS and previous diseases such allergies, asthma, or habitual use of drugs. Important statistically significant relationship was observed between ARS and personal maximum depth limit. Interesting data was observed between ARS and selected genes that could predispose to the condition. Preliminary results seem to suggest interesting associations between expression of evaluated genes and ARS; analysis is, at present, still in progress.

*Conclusion*

Our data show that ARS is a common condition among experienced Breath-hold Divers. Our results allow for better definition of diving methods able to mitigate breath-hold diving pulmonary risk as the identification of possible genetic predisposition to pulmonary oedema, and may improve breath-hold diving safety through better awareness of possible risk factors by the divers themselves.

# VENOUS GAS EMBOLI AFTER COMPRESSED-AIR DIVING: IDENTIFICATION OF PREDICTIVE BIOPHYSIOLOGICAL FACTORS

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*Introduction*

Scuba diving exposes divers to a risk of decompression sickness (DCS) caused by nitrogen bubbles. The presence of venous nitrogen gas emboli (VGE) after a dive is generally accepted to be a measure of the risk for DCS. There appears to be large intra- and inter-individual variability as to the degree of "bubbling" after a similar dive, the exact mechanisms of which are not yet known. In the course of a standardised dive experiment, a systematic search for predictive factors for VGE production was undertaken.

*Methods*

Twenty-four divers, of comparable age, weight, length, BMI, lifestyle and physical condition performed between two and three standard dives, one week apart, in a heated swimming pool (depth 33mfw, bottom time 20minutes). No diving or physical exercise was allowed 48hours before each dive. Before each dive, physiological parameters were measured, including Flow Mediated Dilation, photoplethysmography, impedancemetry, urine density. Venous blood sampling was performed for haematological (haematocrit, white blood cell and platelet count), and biochemical (triglycerides, LDL and HDL-cholesterol) analysis. Post-dive VGE production was measured by transthoracic echocardiography according to a previously described protocol of quantitative bubble counting. Divers were categorised into "bubblers" and "non-bubblers", based on the average number of VGE counted.

*Results*

Sixty-eight dives were analysed; after 40 (59%), VGE were observed. Three divers (12.5%) never showed VGE, and in 8 (33%), VGE were observed after every dive. The 13 remaining divers were "inconstant bubblers". No significant differences were found between "bubble" and "non-bubble" dives for any parameter. There was a significant difference between systematic "bubblers" and "non-bubblers" for Triglycerids ($p=0.049$), HDL ($p=0.014$) and photoplethysmography ($p=0.04$), however, those factors were not found to be predictive in the "inconstant bubblers" group.

*Conclusion*

This systematic and comprehensive evaluation could not identify easy and reliable predictors for VGE production after a standard dive.

OP-26

## EFFECT OF DIVING ON HUMAN CUTANEOUS VASCULAR ENDOTHELIAL FUNCTION

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Keywords: Decompression, Endothelium, Micro-circulation, Laser Doppler flowmetry

*Introduction*

Previous studies have shown bubble-induced vessels damage on large conduit arteries using flow mediated dilation. We aimed to evaluate the effect of endothelium decompression-induced bubble formation on the microcirculation.

*Methods*

Ten divers were assigned to i) one group with a 40-min duration of sea water immersion and finning at atmospheric pressure, ii) one group with a 40-min simulated dive in a dry chamber breathing 100% oxygen at 170 kPa, and iii) one group with an open-sea air dive at 400 kPa for 30 min. Bubble grades were monitored with Doppler according the KISS score. Endothelial microvascular function was tested before and after each protocol by laser Doppler flowmetry (LDF) and iontophoresis. Acetylcholine-induced vasodilation was expressed in percentage of basal perfusion. Endothelial cell activation was quantified by plasma Von Willebrand factor (vWf) and nitric oxide (NO). Inactivation of NO by oxidative stress was assessed by plasma nitrotyrosine.

*Results*

None of the divers developed any signs of DCS. There was no significant change for LDF values in each group (1440.10%+/-504.51 vs 1507.62+/-860.39, p=0.85, after immersion; 1480.31%+/-824.97 vs 1135.53+/-544.92, p=0.27, after hyperbaric oxygen breathing, and 1873.16 +/-2113.24 vs 1479 +/-1644.67, p=0.1, after the open-sea air dive). Furthermore no changes were observed in plasma nitrotyrosine, vWf or NO, excepted after immersion/finning protocol which induced a significant increase of NO (0.028+/-0.027 to 0.11+/-0.08 µg/ml; p=0.023).

*Discussion*

The present results highlighted no change for endothelial function after immersion and finning, hyperbaric oxygen breathing at rest and open sea-air dive in field conditions. This is the first study on the micro-vascular endothelium. These results could show no detectable endothelial micro-vessel damage resulting from decompression-induced bubble formation. They confirm differences between micro-vessel and large conductance arteries. Further studies are needed to evaluate micro-vascular endothelial function in animal model of DCS or in human.

# EFFECT OF OXYGEN-STOP DECOMPRESSION ON BUBBLE FORMATION AND CELL-DERIVED MICRO-PARTICLE RELEASE AFTER AN OPEN-SEA AIR DIVE

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Keywords: Decompression, Bubble-induced platelet activation, Platelet micro-particle

*Introduction*

Endothelial cells and platelet shed micro-particles upon activation and during cell apoptosis. We highlighted a relationship between bubble-induced platelet activation and platelet micro-particle (PMP) release. The aim was to study the effect of oxygen during decompression on PMP and endothelial cell-derived MP (EMP) release after a dive.

*Methods*

Divers were assigned to i) one group (n=10) with an open-sea air dive at 400 kPa (30 msw) for 30 min with a 9 min duration air-stop decompression at 3msw, ii) one group (n=15) with the same dive protocol and oxygen-stop decompression, iii) one control group (n=10) in immersion with a 9 min oxygen breathing at 3msw. Bubble grades were monitored with the KISS score. Blood samples for EMP (CD31) and PMP (Annexine V) were taken 1-h before and after the exposure in each group.

*Results*

KISS bubble score decrease significantly in the oxygen-stop decompression group (4.3 +/- 7.3 vs 32.7 +/- 19.9, $p<0.001$). In the air-stop decompression group, we observed an increase of post-dive PMP values (753 ng/µl +/- 245 vs 381 ng/µl +/- 191, $p=0.003$) but no significant change in the oxygen-stop decompression group (329 ng/µl +/- 215 vs 381 ng/µl +/- 191, $p=0.2$). For the post-dive EMP values, there was no significant change in the air-stop and oxygen-stop decompression groups. In the control group, the results showed a significant decrease for PMP values (993 ng/µl +/- 291 vs 1938 ng/µl +/- 492, $p<0.001$) and EMP values (23 ng/µl +/- 3.6 vs 46 ng/µl +/- 13, $p<0.001$).

*Discussion*

The results in oxygen-stop decompression group highlighted the decrease of decompression-induced bubble formation and the decrease of PMP release. Reducing the pro-coagulant activity in of PMP release, oxygen breath during decompression could reduce bubble-induced platelet activation and prevent the thrombotic event in decompression sickness. Secondary, oxygen breath could have a protective effect on endothelial function reducing endothelial cell activation and inflammatory response.

OP-28

## THE EFFECT OF ICE DIVING ON PERIPHERAL SKIN TEMPERATURE ON DIVERS WITH SPINAL CORD INJURY- A PRELIMINARY REPORT

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Keywords: Ice diving, Spinal cord injury, Peripheral skin temperature

*Objectives*

To monitor the influence of cold water on peripheral skin temperature after ice diving and subjectively estimate the feeling of cold before during and after the submersion in scuba divers with spinal cord injury (SCI).

*Methods*

Eight scuba divers, four with and four without SCI, performed a short single dive under the ice in the wet outfit. The water temperature was 4 °C and average air 19°C. The peripheral skin temperature of the lower extremities was measured prior and after the exposure to ice conditions with two-canal thermometer. The feeling of cold was assessed before and afterwards with the numeric scale from one to ten (one means the lowest and ten the highest score).

*Results*

The measured skin temperature of the big toes were 26.4±3.5°C, 25.5±6.8°C and 19.5±2,0°C, 19.7±3.4°C before and after the dive, for divers with and without SCI, respectively. The average numeric score of coldness before, during and after the dive were 2, 5.5 and 3.5 in the SCI group and 2.25, 4 and 2.5 in the healthy divers. In the two weeks proceeding the dive no urinary or respiratory infection was observed in participants with SCI.

*Conclusion*

The preliminary results suggest that ice diving for people with SCI is not less dangerous regarding hypothermia than in the able ones. The difference in peripheral skin temperature is comparable although it is slightly higher with the SCI as it is the feeling of cold. It is worth to notice that the duration of cold after the dive was longer in the SCI group. However, more questions than answers appeared and the subject requires further investigation.

# TRANSIENT NORMOBARIC HYPEROXIA INHIBITS LEUKEMIA CELL LINE PROLIFERATION SECONDARY TO A CELL CYCLE BLOCKING IN S-PHASE

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This study is part of the Phypode Project, financed by the European Union under a Marie Curie Initial Training Network programme

Keywords: Leukemia, Cell cycle arrest, Normobaric hyperoxia

*Objectives*

The aim of this study was to determine the effect of transient normobaric hyperoxia on the viability, cell growth, morphology and cell cycle distribution of leukemic cell lines and to develop a suitable in vitro model for oxygen sensing mechanisms in cancer cells independent of surrounding tissue.

*Methods*

U937 and JURKAT leukemic cells were cultured in standard medium. The cells were kept in a fully humidified incubator under standard conditions in 21% $O_2$. For 18 hours cells were transferred in a hyperoxic environment (60% $O_2$), while control cells were kept in standard conditions. After hyperoxia, cells recovered under standard conditions. A second treatment of 18h hyperoxia was initiated in 2 experiments after 24 hours of recovery. Samples from the cultures were taken at various times for flow cytometric analysis of apoptosis, using an AnnexinV binding assay and cell cycle distribution using a BrdU Flow Kit.

*Results*

We found a significant decrease in cell growth and number of living cells 24 hours after the end of oxygen treatment with no effect on cell viability. This effect was similar in all cell lines (26-35% reduction of living cells). The decrease in cell growth was maybe not related to apoptosis or necrosis of the affected cells, but a significant increase in the population of cells in S-Phase of the cell cycle was found. A decrease in cell growth was even more obvious 24 hours after the second 18 hours normobaric hyperoxia.

*Conclusion*

The significant decrease in cell growth after normobaric hyperoxia which at that time could not be related to apoptosis or necrosis of the cells, leaves space for further investigation of oxygen sensing mechanisms in the leukemic cell and the protein biochemistry behind it and leads us to investigate the cell cycle blockage in S-phase further.

OP-30

## HYPERBARIC OXYGENATION IN RESTORATION OF THE COGNITIVE FUNCTIONS IN CHILDREN

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Keywords: Cerebral dysfunction, Cognitive functions, Hyperbaric oxygenation

*Introduction*

Premature or delivery with complication, which is followed with the suffering of the infant are the most frequent causes of motor disturbances in children. Main reasons for that is the damage or the inadequate restitution of the small brain functions. In our study we have followed the effects of specific restorative procedure – reeducation of psychomotoricity in children with the diagnosis of cerebral dysfunction.

*Method*

Children from the age of 3 to 5 years old were divided in two groups. The first group (n = 12) was simultaneously with reeducation procedure included in HBO protocol (60 min, pressure 1.7 ATA, twice per day, during 30 days period, in multiple chamber). The second group (n = 12) was only included in reeducation procedure. The following rehabilitation parameters were monitored: gross and fine motor skills, spatial, time and body orientation, body scheme, vocalization, verbalization and sequential thinking, color recognition and lateralization. Our research was approved by the Ethical Committee of the School of Medicine, University of Belgrade.

*Results*

First difference in the degree of the improvement was noticed 7 days after the beginning of HBO treatment. At the end of the treatment significant improvements were noticed in 5 children from the first group, resulting in re-establishing of the functional status at the 90% of the physiological level. It is necessary to conclude that intensive reeducation procedure has improved the parameters in the children from the second group. But statistical analyses of the results have clearly shown that in a significantly strong correlation HBO and reeducation procedures induce the improvement and reduce the dysfunctions.

*Conclusion*

Molecular oxygen implied under the hyperbaric conditions can contribute to the restoration of the cognitive functions in children.

# CHANGES IN MITOCHONDRIAL RESPIRATORY RATE IN LEUKEMIC CELL LINE AFTER TRANSIENT NORMOBARIC HYPEROXIA

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This study is part of the Phypode Project, financed by the European Union under a Marie Curie Initial Training Network programme.

Keywords: Leukemia, JURKAT, Hyperoxia, ROS, Electron transport chain

*Objectives*

This study focused on the metabolism of the leukemic cell line JURKAT exposed to hyperoxia. Measurements were performed at the end of 4h of hyperoxia, after 4h of recovery in normoxia and compared to normoxic controls. Cell metabolism was assessed measuring routine, maximal oxygen consumption and proton leaks.

*Methods*

JURKAT cells were cultured in standard medium. Normoxic cells were kept in a fully humidified incubator under standard condition (air + 5% $CO_2$, 37°C). Hyperoxia was produced increasing oxygen fraction in the incubator to 60%. The routine metabolism, the proton leak and maximal oxygen consumption were measured using different agents modifying mitochondrial activity. The cell metabolism was measured immediately after 4 hours of hyperoxia (T0); 4 hours after return to normal conditions (T4) and compared to controls (C) left in reference conditions.

*Results*

In control JURKAT cells routine metabolism was 48pmol/min/$10^6$ cells, proton leak represented 68% of this value, and maximal oxygen consumption was nearly twice higher (87pmol/min/$10^6$ cells). Routine metabolism was strongly increased by hyperoxia at T0 (to 74 pmol/min/$10^6$ cells) but this effect was not observed anymore at T4. Proton leaks and maximal oxygen consumption state were not significantly modified by hyperoxia.

*Conclusion*

These results clearly show that hyperoxia has a strong effect on JURKAT cell routine metabolism, but apparently without effects on maximal mitochondrial capacity. The increase of routine metabolism could mainly be due to an increase of either cell energetic demand or non-mitochondrial oxygen consumption. Further assessing the impact of hyperoxia on JURKAT cells are needed. They will focus especially on the production of ROS production.

OP-32

## HYPERBARIC OXYGENATION REDUCES NEURONAL DEGENERATION IN THE RAT BRAIN TISSUE AFTER CORTICAL INJURY

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Keywords: Brain injury, Research, Neurodegeneration

*Objectives*

Traumatic brain injuries ought to be looked upon as a process, which consists of primary and secondary insult. It is important to reflect on new approaches in prevention and treatment of the consequences that are following the primary insult. The aim of this study was to investigate whether HBO would prevent neuronal degeneration in the rat brain after cortical injury.

*Methods*

The experiments were conducted on the male Wister rats, 10 weeks old. Animals were organized into following groups (n = 8 per group): Control (C) intact animals, Control + HBO (CHBO) intact animals subjected to HBO treatment, Sham control (S) animals that underwent surgical procedure without damaging the brain tissue, Sham control + HBO (SHBO), Lesion group (L) – the right sensorimotor cortex was removed by suction ablation, Lesion + HBO (LHBO). HBO protocol: pressure applied 2.5 absolute atmospheres (ATA), for 60 minutes, once daily for 10 days. To evaluate the effect of HBO on neurodegeneration we performed double immunofluorescence staining: neurons undergoing degeneration were visualized with Fluoro Jade B, while neuronal specific nuclear protein (NeuN) was used as a marker of neuronal cell body. Our research was approved by the Ethical Committee of the School of Medicine, University of Belgrade.

*Results*

Double immunofluorescence staining revealed that the number of degenerating neurons is much higher in group L compared to group LHBO. At higher magnification in the L group, in the neurons around the site of the lesions formation of apoptotic bodies was observed, suggesting that they have entered the process of apoptosis. In contrast, most of the neurons in LHBO group had healthy body with clearly visible nuclei.

*Conclusions*

Our data indicate that the secondary degeneration of neurons after experimental brain injury was reduced by application of HBO.

# IMPACT OF NORMOBARIC HYPEROXIA ON VASCULAR ENDOTHELIAL GROWTH FACTOR DOWN REGULATION IN LEUKEMIA CELLS

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This study is part of the Phypode Project, financed by the European Union under a Marie Curie Initial Training Network programme.

Keywords: VEGF, NOP, Leukemia, Hyperoxia, Glutathione

*Introduction*

The Vascular Endothelial Growth Factor (VEGF) is increasingly targeted in cancer therapies including in leukemia. In this study, we have compared the impact of normobaric hyperoxia on VEGF regulation among healthy and leukemia T cells considering the possible effect of the normobaric oxygen paradox on the HIF pathway and glutathione (GSH) activity of cancer cells.

*Methods*

We used Jurkat cells from cultures compared to isolated lymphocytes from peripheral blood. They were submitted to 2 hours of 60% oxygen. The VEGF level and the GSH/GSSG ratio were measured 4 and 6 hours after recovery.

*Results*

There was a significant decrease of VEGF 4 and 6 hours after the hyperoxia period in leukemia cells compared to healthy cells (p=0,0003). The GSH/GSSG ratio increased significantly directly after hyperoxia and decreased thereafter in both normal and leukemia cells. The ratio was significantly higher in tumor cells compared to normal T cells.

*Discussion*

The significant VEGF decrease in leukemia cells after the 2 hour hyperoxia period and was concomitant with a maximal GSH activity. The fact that hyperoxia allows a down-regulation of VEGF in leukemia cells without affect healthy cells could justify its be use as an adjuvant treatment in T cell leukemia provided recovery time between two oxygen bouts be defined.

OP-34

## TIME COURSE OF CHANGES IN EXPIRED NITRIC OXIDE AND CARBON MONOXIDE DURING ACUTE NORMOBARIC HYPEROXIC EXPOSURES

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Keywords: Hyperoxia, Lungs, Carbon monoxide, Nitric oxide

*Introduction/background/objectives*

Previous research aimed at determining the effects of acute normobaric hyperoxia on expired nitric oxide ($NO_{exp}$) and expired carbon monoxide ($CO_{exp}$) have reported a $PiO_2$ dose dependent increase in $NO_{exp}$ within 7-10 min (Thorax 52:736-738, 1997), and an increase in $CO_{exp}$ within 5 min of the hyperoxic exposure (J. Clin. Mon. Comp. 20:2:89-94, 2006). However, recent reports describe an $O_2$ dose dependent decrease in $NO_{exp,}$ and $CO_{exp}$ below the limit of detection following prolonged (≥ 1 h) normobaric and hyperbaric oxygen exposures (UHM 38:430, 2011). This project, therefore, reexamined the time course of changes in $NO_{exp}$ and $CO_{exp}$ during the first hour of normobaric hyperoxic exposure.

*Method*

Fifteen males conducted three trials on separate days in which they breathed compressed air, nitrox (60% $O_2$) or 100% $O_2$ for 60 min in a random order via an aviator demand regulator mask while at rest in a laboratory. $NO_{exp}$ at 50 ml/s expired flow rate and $CO_{exp}$ were measured before and after the exposures, as well as during the exposures at 7 and 30 min for $NO_{exp}$ and 11 and 34 min for $CO_{exp}$.

*Results*

$NO_{exp}$ was unaffected by the air and nitrox exposures, but displayed a significant 6.6±11.0% (Mean±SD) decrease after breathing 100% $O_2$ for 60 min. $CO_{exp}$ was unaffected by the air exposure, but increased significantly during the nitrox and oxygen exposures at the 11 and 34 min time points before returning to a value similar to baseline after 60 min of exposure.

*Discussion/conclusion*

In contrast to previous work, an acute exposure to normobaric hyperoxia does not result in an $O_2$ dose dependent increase in $NO_{exp}$, but rather a decrease in $NO_{exp}$ only after breathing 100% oxygen for ≥ 60 minutes. Normobaric hyperoxia at $PiO_2$ ≥ 0.6 ATA induces an early rise in $CO_{exp}$ that returns close to baseline within 60 min of breathing the hyperoxic mixture.

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## SYSTEMIC SCLERODERMA: QUALITY OF LIFE OF THE PATIENTS TREATED WITH HYPERBARIC OXYGENATION

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Keywords: Hyperbaric Oxygenation, Sistemic Scleroderma, Systemic Sclerosis, Qaulity of Life

*Introduction*

HBO administration in the treatment of systemic sclerosis (SSc) improves the condition of internal organs. Positive dynamics reliability is achieved within three years. The purpose of this study was to estimate the effect of HBOT on the quality of life (QL) of such patients using modern methods.

*Methods*

SSc patients (64 women) received standard medical treatment. Of these, 37 patients received HBOT (10 sessions of 30 minutes at 1.3-1.5 ATA of oxygen in monoplace pressure chambers) every 6-12 months. To assess their QL, three standard international questionnaires were used: general (SF-36 including PCS and MCS scales) and special (HAQ and EQ-5D for rheumatoid arthritis). Such an application is possible, because 100% of SSc patients have joint damage.

*Results*

After 3-year observation, significant QL improvement was noted for all patients. QL of HBO-treated patients improved to a greater degree in comparison with non-HB0-treated patients. ΔPCS was 5.9 and 2.3, respectively; ΔMCS 4.4 and 3.4, respectively. ΔHAQ showed satisfactory effect to evaluate the effectiveness in cases with HBO. In patients who did not receive HBO, ΔHAQ showed minimal effect. In both groups EQ-5D demonstrated high efficacy of treatment. The study confirmed that any purposeful regular treatment improved QL of SSc patients. The results showed much more substantial QL improvement in patients who had been treated with complex therapy comprising HBO, in comparison with those who had been treated without HBO. The dynamics of mental status (SF-36, MCS) dominated in the group with the standard treatment. In cases with HBOT, QL improvement was mainly determined by the parameters of the physical status (PCS). We suggest this is resulted from active influence on joint function.

*Conclusion*

The results of the QL study confirmed that the complex treatment with HBO is more efficacious and beneficial for SSc patients, compared to the conventional therapy.

OP-36

## LYMPHEDEMA: THE EFFECTS OF COMBINED HYPERBARIC OXYGEN THERAPY (HBOT), COMPRESSION- DECONGESTION PHYSICAL THERAPY (CDPT) AND VACUSAC THERAPY

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Keywords: Lymphedema, Hyperbaric oxygenation, Vacusac therapy, Compression-decongestion physical therapy.

*Introduction*

Lymphedema is a failure of the lymphatic transport system. The result is the accumulation of lymphatic and edema fluid in specific area of soft tissue. The consequence of this chronic condition is prolonged hypoxia in swelling tissue. The progress of untreated lymphedema, in the function of time, becomes a risk for infections and it restricts extremity motion.

*Methods*

The pilot study was performed on 10 patients taken in random with chronic lymphedema of arms or limbs after a mastectomy or radiation therapy. The patients were treated with combined therapy: HBOT, CDPT and Vacusac therapy. Namely, as it is known, only in HBO condition vulnerable swelling tissue can be completely saturated with oxygen and so it can be protect of an infection. HBOT was used in monoplace chamber with 100% oxygen under pressure of 202.6 kPa during 60 min., one time per day, 10 sessions. CDPT was consisted of special technique of manual massage and lymphatic drainage with applied short elastic bandage. Vacusac therapy with negative pressure of -0.10 bar to -0.30 bar, through rhythmic pulsations, is used to reform lymphatic drainage. The volume of affected limb was measured before and after therapy.

*Results*

The volume of limbs after combined therapy was decreased about 4-8 cm.

*Conclusion*

HBOT in the combination with CDPT and Vacusac therapy gives effective results in repairing damaged tissue and in reducing lymphedema for the period longer than six months and after six months the treatment must be repeated.

## ULCUS CRURIS: THE PLACE OF HBOT AS IMPORTANT COMPONENT IN THE TREATMENT

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Keywords: Ulcus cruris, Hyperbaric oxygenation, Microbiological findings

*Introduction*

Ulcus cruris as a result of chronic vein insufficiency makes 90% of all chronic wounds which are located on low extremities and 14% of patients with chronic vein insufficiency obtain ulcus cruris. The infection associated with tissue hypoxia on account of damaged local circulation make the basis of ulcus cruris. The intention of this paper is to show the place of hyperbaric oxygenation in therapeutical chain during ulcus cruris treatment.

*Methods*

In Special Hospital for Rehabilitation "Gamzigrad" 25 patients with ulcus cruris taken in random were treated with HBOT in the period from 2005 till 2012 year. The patients were 40-60 years old, 70% women and a proportion of wounds was from 2-5 cm to 2/3 surface of lower leg. Same HBOT protocol was used for treatment: in monoplace chamber with 100% oxygen, under pressure of 2,8 ATA, during 60 min., once per day, 10 days. Next parameters were attended: subjective sign- pain and objective (clinical) sign-the change of wound size and quality, microbiological findings.

*Results*

The pain was remarkably decreased, the new granulation cells covered bigger wounds, but the epithelization of smaller wound was expressive. Aerobes lost the power of resistance to the antibiotics.

*Conclusion*

Ulcus cruris is important social problem and there is the necessity, on the basis of this results, to include HBOT in early multidisciplinary treatment of this medical problem.

OP-38

## SIGNIFICANCE OF IMMUNOHISTOCHEMICAL IDENTIFYING OF VASCULAR ENDOTHELIAL FACTOR AND ITS RECEPTOR $R_2$ DURING HYPERBARIC OXYGEN THERAPY IN DIABETIC FOOT TREATMENT

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*Aim*

The aim of our study was to determine the effect of hyperbaric oxygenation (HBO) on angiogenesis in patients with diabetic foot ulcerations measured as expression of vascular endothelial growth factor (VEGF) and its receptor (VEGF $R_2$).

*Methods*

The study population consisted of 90 with diabetic foot ulcerations consecutively referred to Department for Hyperbaric Medicine. The patients were randomized to study group which was treated according to standard protocol (surgical debridement, local wound treatment and antibiotics if needed) and hyperbaric oxygenation, and control group treated according to standard protocol only.

*Results*

Both groups showed significant raise in VEGF expression, but while amplification in HBO group was significant during the whole study period, control group showed amplification of VEGF expression only between the start and $10^{th}$ day. Increase in VEGF R2 expression was also noted in both groups, but while HBO group showed the significant amplification during the whole study period, in control group amplification was significant only between $10^{th}$ and $20^{th}$ day.

*Conclusion*

HBO showed significant effect on amplification of VEGF and VEGF $R_2$ expression in patients with diabetic foot ulcerations, as well as on wound size reduction.

# EFFECTS OF HYPERBARIC OXYGENATION ON PROSTHETIC REHABILITATION OF PATIENTS WITH UNILATERAL LOWER LIMB AMPUTATION

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Keywords: Hyperbaric oxygenation, Prosthetic rehabilitation, Amputation

*Objectives*

Hyperbaric oxygenation (HBO) has been proven to be very effective adjuvant procedure in the multidisciplinary approach to the treatment of gas gangrene, diabetic ulcers, other forms of chronic unhealing wounds and soft tissue necrosis. However, considering the mechanism of action of this method, it is clear that its therapeutic role does not end here. The aim of our study was to investigate the effects of HBO on the prosthetic rehabilitation of patients with unilateral lower limb amputation.

*Methods*

Sixty patients (age 61.6±11.5, male 30, female 30) with unilateral lower limb amputation were randomly divided into two groups (30 patients in each group) : experimental group received HBO treatment (five times a week, for 5 weeks, pressure 2.5 ATA for 90 minutes, in multiple chamber), and control group. Both groups were subjected to the assessment of functional competence of amputated stump, by using LCI test and Narang's score.

*Results*

At the beginning of the study there were no statistically significant difference between the values of LCI and Narang's score among these two groups. After the period of prosthetic rehabilitation in both groups significantly higher LCI scores were registered. Lower Narang's score were also registered in both groups. However 5 weeks later, LCI scores were statistically significantly higher in experimental group compared to the control, and at the same time values of Narang's score were statistically significantly lower in the group of patients that were exposed to HBO.

*Conclusions*

Our results clearly show that in case of a relatively homogeneous group of patients, standard therapy and prosthetic rehabilitation with adjunct of HBO provided better functional capacity of these patients. These findings highlight the increasing validity of this procedure after limb amputation, which should be confirmed by further research in multicenter studies involving a larger number of respondents.

OP-40

## MONITORING CARDIAC OUTPUT DURING HYPERBARIC OXYGEN THERAPY OF HEMODYNAMICALLY UNSTABLE PATIENTS

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Keywords: Hyperoxia, Transesophageal doppler, Sepsis, Shock, Necrotizing fasciitis.

*Background*

Patients suffering from necrotizing fasciitis (NF) are often hemodynamic unstable and require extended monitoring of cardiovascular parameters; yet this is limited during hyperbaric oxygen treatment (HBOT). We aimed to evaluate the use and safety of Transesophageal Doppler (TED) monitoring of cardiac output (CO) under hyperbaric conditions in hemodynamically unstable patients diagnosed with NF and sepsis or septic shock.

*Methods*

Cardiac output was measured prior to, during, and after HBOT with the use of TED (CardioQ®, Deltex Medical Inc., UK) in 7 consecutive included patients diagnosed with NF and sepsis or septic shock. The monitor was placed outside the multiplace hyperbaric chamber and the connection between monitor and probe was established by a pressure-resistant power cable (Deltex Medical Inc., UK). The HBOT followed standard protocol for NF patients and consisted of 90 minutes exposure to 100% oxygen at 2.8 atmospheres absolute. Neither respirator settings, medication, nor fluid therapy were adjusted during the series of CO measurements. The difference between mean CO just prior to HBOT initiation and at maximum treatment duration was accessed using the paired Student's *t*-test.

*Results*

The method was feasible and easy to use under hyperbaric conditions. We experienced no problems with the CO registration or any equipment related safety problems during HBOT. Five patients had an increase in CO from initiation of HBOT to maximum treatment duration. One patient had an almost stationary CO, while one patient experienced a slight decrease in CO. This resulted in a significant increase in mean CO of 1.7 L/min ($P = 0.048$) from HBOT initiation to maximum treatment duration.

*Conclusion*

This is, to the best of our knowledge, the first study to document that TED can provide a minimally-invasive, clinically useful estimate of CO in hemodynamically unstable patients with NF and sepsis or septic shock during HBOT.

# THE INTERNATIONALISATION OF CLINICAL HYPERBARIC FACILITY ACCREDITATION: QUALITY IMPROVEMENT AND RISK MANAGEMENT IN ACTION

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*Introduction/Background/Objectives*

Twelve years ago, no one in the international hyperbaric medicine community was seriously thinking about clinical hyperbaric facility accreditation. Today, there are at least 7 countries/alliances that either have an accreditation process in place or that have one under development. There is a growing recognition amongst the organized worldwide clinical hyperbaric medicine community that such a process of third-party overview and assessment is a positive step to validate quality patient care, patient safety and organizational risk management d for hyperbaric facilities.

*Methods*

Each of these existing or developing programs are based on conducting on-site assessments by a team of experts that evaluate a specific facility against a set of known quality of care and safety standards.

*Results*

For example, in the United States, there are now over 130 facilities that have been accredited by the Undersea & Hyperbaric Medical Society. This program is mandatory for financial reimbursement in the states of Utah, New York, New Hampshire and Vermont. The UHMS program is also one of only five accrediting bodies recognized by the Joint Commission, a leader in international healthcare accreditation, as a Complementary Accrediting Body.

*Discussion/Conclusion*

Clinical hyperbaric facility accreditation is rapidly becoming recognized throughout the international hyperbaric medicine community as the most cost effective means to verify that the quality of care of the hyperbaric patient is at the highest level and that the specific facility meets or exceeds the minimum safety standards and/or matters related to risk management. It is to be considered as a process improvement activity for the entire hyperbaric medicine community.

OP-42

## CHAMBER PERSONNELS' USE OF NITROX DURING HYPERBARIC OXYGEN TREATMENT – A QUALITY STUDY

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Keywords: Hyperbaric treatment, Hyperbaric oxygen, NitrOx, Working safety, Decompression sickness

*Background*

NitrOx is believed to reduce nitrogen gas ($N_2$)-loading in the chamber personnel and to reduce the risk of decompression sickness (DCS). We aimed to evaluate the safety of using NitrOx as breathing gas during attendance in the multiplace hyperbaric chamber.

*Methods*

Data were collected between January and June 2011. Personnel breathed chamber air or NitrOx (50/50). The treatment protocols consisted of 90 minutes of pressurization to either 2.4 or 2.8 atmospheres absolute (ATA). Personnel included five attendants and operators, fourteen doctors, and six nurses. Treatment protocol, $N_2$-loading, and symptoms of DCS were evaluated. $N_2$-loading was quantified by Norwegian Diving Tables. Symptoms were reported at a weekly staff meeting.

*Results*

2227 patient treatments were registered. 398 (73.16%) elective and 146 (26.84%) acute treatment sessions were performed. The attendants were pressurized 514 times (86.53%, mean 1.04 pr. treatment), operators 16 times (2.69%, mean 0.03 pr. treatment), doctors 35 times (5.89%, mean 0.07 pr. treatment), and nurses 29 times (4,88%, mean 0.06 pr. treatment). NitrOx was breathed on 498 occasions (83.84%). In 518 cases (87.21%) the personnel were pressurized to 2.4 ATA and 72 cases (12.12%) to 2.8 ATA. Median $N_2$-loading after first pressurization complied with Letter A (range A-E) and after second pressurization to C (ranges B-F). Only attendants had cases with 3, 4, 5, and 6 pressurizations during a treatment session with a median of D (range B-F), E (range C-G), F (range C-H), and D (range D-F), respectively.

*Conclusion*

This method permits chamber personnel to perform tasks necessary to take adequate care of patients. The highest $N_2$-load was found to be H, equivalent to at least 45 minutes before a safety stop is needed. We conclude that the method is safe, as no symptoms of DCS were registered even though a safety organization was established to catch such observations.

# REVERSE ENGINEERING AS A TOOL FOR THE DEVELOPMENT OF SATURATION INSTRUCTIONS

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*Background*

Recently, a project has been conducted by a large diving Company for the development of new bell saturation excursion procedures.

*Method*

A review was conducted over the Company last 12 years of operations. The vessels using the full excursion distances had recorded several central neurological DCS. The other vessels restricting the excursion distance to 60% of the maximum value, had recorded zero DCS. Review of available data in the industry lead to the same conclusion.

While the industry has accumulated experience, scientists have changed their vision of the decompression process. The recent publications stress the role of micro bubbles as the precursors of circulating bubbles. The lungs are viewed as bubbles filters. Arterial bubbles are considered responsible for DCS. The symptoms are linked to an inflammatory process. These concepts permit exploring new mathematical models.

Using reverse engineering, it was possibly to identify critical mechanisms and describe them by adjusting the coefficients with data fitting. A simple algorithm was designed that permitted computing new saturation excursions.

*Results*

A full set of standard and extended excursions was edited and sent on selected worksites under close monitoring. After two years of operations, the data accumulated demonstrated a net improvement in term of safety and efficiency. The instructions were then approved and have been included in the Company diving manuals.

*Discussion and Conclusion*

It is believed that the time has come for the diving industry to share its experience and rationalize their procedures. It is likely that scientific knowledge accumulated will provide news answers to these old problems. Industry initiatives of this type could help solving the many pending issues such as tables for surface oriented operations, emergency decompression, nitrox, etc.

OP-44

## SUBAQUATIC AND HYPERBARIC MEDICINE CENTER OF THE PORTUGUESE NAVY: EXTENDED MEDICAL CORE TEAM SWITCHING CHALLENGE

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Keywords: Medical Teams, Delaying Factors, Hyperbaric Oxygen Therapy

*Background*

Medical tasks in hyperbaric medicine are wide and need medical knowledge of multiple medical specialties for different care problems in diary practice. In the last decade the Subaquatic and Hyperbaric Centre of the Portuguese Navy increased its clinical team incorporating physicians of different specialities and extending its permanent medical support competences. This study aims to analyse the potential benefit of a wider medical support core team to delaying factors and effectiveness criteria in Hyperbaric Oxygen Therapy (HBO).

*Methods*

Analysis of two cohorts of 150 consecutive patients in the years 2001 (reduced medical core team) and 2011(extended medical core team). The inclusion criteria included the first 150 ambulatory patients treated respectively during the years 2001 and 2011 with the exclusion of all emergency treatments performed during that period. The following variables were analysed: i) mean time between first medical appointment in hyperbaric consultation and onset of treatment; ii) mean duration of HBO treatment in the two groups; iii) global number of sessions performed to obtain therapeutic effect; iv) rate of withdrawn patients during treatment.

*Results*

There were significant reductions ($p<0.05$) of i) and ii) associated with the extended core team medical approach, demonstrating shorter time to HBO onset and “compression” of its total duration. There were no significant differences concerning the number of sessions performed in the two cohorts, meaning an equivalent number of sessions were done, but being delivered in a shorter period of time in the extended core team group. There were no significant differences in the patient withdrawal rate.

*Conclusions/Discussion*

An heterogeneous and wider medical core team of different specialities, sharing clinical skills in an hyperbaric treatment centre – Extended Medical Core Team Paradigm - may minimize defensive attitudes of health professionals in risk validation, spreading the benefits of Hyperbaric Medicine earlier and with less delaying factors during treatment.

# PROGNOSTIC FACTORS OF SPINAL CORD DECOMPRESSION SICKNESS: RETROSPECTIVE ANALYSIS OF 36 CASES

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Keywords: Decompression illness, Recompression treatment

*Introduction*

Aim of the study was to analyze the most important factors which influence the outcome of spinal decompression sickness (DCS). We are convinced that individual and clinical factors have the most significant influence on the final outcome (e.g. the clinical presentation before treatment as expressed by the Boussuges score and the time elapsed between the onset of symptoms and recompression).

*Methods*

In our facility in the period of time between 2010 to 2011, we have treated 36 patients for DCI and 33 had full recovery after 72 hours (91%) ; 16 of 36 had neurological symptoms (44%), in this group 2 had residual symptoms after 72 hours (12,5% of neurological symptoms ), the remaining 14 (87,5% of neurological symptoms) had full recovery. In 27 cases (75%), in which the two ones who had residual symptoms are included, time to recompressions was within 6 hours ($p < 0, 27$), and so it seems to be not relevant to the outcome.

*Results*

Our data show that a Boussuges score < 7 is associated with a good recovery ($p<0.09$). However the result was not statistically significant, and if not a clear evidence, it could at least be considered as an interesting trend. Initial hyperbaric treatment is, in our point of view, very important for the outcome: 19 cases were treated with US Navy TT 6 which is the standard treatment schedule used for the most serious neurological cases, all 16 cases with neurological symptoms were treated with TT 6, full recovery at 72 h. for 14 and 2 with residual symptoms. The remaining 17 cases were treated with US Navy TT5.

*Conclusions*

Clinical symptoms of spinal cord DCS before admission to the hyperbaric center and the initial hyperbaric treatment (Consensus Conference guidelines) in our experience are the major prognostic factors in recovery.

OP-46

## A PROSPECTIVE EVALUATION OF MALE FERTILITY CHANGES IN SATURATION DIVERS

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Keywords: Male fertility, Saturation diving, Oligoasthenoteratozoospermia

*Introduction*

There is a belief amongst divers that saturation diving causes a reduction in male fertility. The authors aimed to study this prospectively in saturation divers.

*Methods*

This study, involving 16 qualified saturation divers, was conducted prospectively over a period of 6 months and evaluated the changes in their semen profiles. All participants completed two saturation dives, lasing an average of 23.5 (SD = 3.1) and 23.3 (SD=3.5) days' duration. Four semen samples were collected from each diver. Sample 1 was submitted 7.75 (SD=2.21) days after the first saturation dive, with sample 2 at 80.2 (SD = 3.3) days from initiation of the dive. Sample 3 was submitted 8.8 (SD=2.6) days after the second dive and sample 4 was collected 80.1 (SD=2.3) days from initiation of the second dive. The divers spent an average of 64.1 (SD=6.3) days with no hyperbaric exposures between the two dives. Samples 1 & 3 represented normobaric spermatogenesis, while samples 2 & 4 represented hyperbaric spermatogenesis.

*Results*

We observed a drop in the sperm count of 29.59 million/ mL (95% CI = 26.8 – 32.4; $p = 5 \times 10^{-20}$); a drop in the average number of sperm with normal morphology of 9.4% (95% CI = 8.1 – 10.6; $p = 9 \times 10^{-16}$); and a drop in the average number of sperm with normal active motility of 36.1% (95% CI = 32.9 – 39.3; $p = 6 \times 10^{-21}$), with all divers typically presenting with oligoasthenoteratozoospermic semen profiles

*Conclusion*

Saturation diving, or other factors associated with saturation diving, has a profound effect on male reproductive function. Future studies should evaluate the effect of helium diving (vs. nitrogen) and measure the temperature in divers' hot water suits

## COGNITIVE SYMPTOMS AND WELDING FUME EXPOSURE

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Keywords: Welding, Diving, inhalation exposure, Neurobehavioural manifestations

*Background*

The prevalence of cognitive symptoms is markedly higher in UK professional divers who have also worked as a welder (28%) than either divers who have not welded (18%) or offshore workers who have worked neither as a diver nor welder (6%).

*Methods*

Three age-matched groups were studied by postal questionnaire: professional divers who had worked as a welder (PDW, n=361); professional welders who had not dived (NDW, n=352); offshore oilfield workers who had not dived or welded (NDNW, n=503). Health related quality of life was assessed by SF12 questionnaire. Cognitive symptomatology was assessed using the Cognitive Failures Questionnaire (CFQ). Welding fume exposure (mg m-3 days) was calculated incorporating welding experience in different environments and welding techniques and use of respiratory protective equipment. Diving exposure was assessed as the number of dives performed plus the number of days saturation diving.

*Results*

Questionnaires were returned by 153 PDW, 108 NDW and 252 NDNW. Ninety divers had welded while diving and, of these, 30 were in-water welders. SF12 scores were the same in all groups and fell within normative values. Mean (95% CI) CFQ scores were higher in PDW (40.3 (37.7 42.9)) than in both NDW (34.6 (31.6-37.7)) and NDNW (32.1 (30.4-33.9)) but no groups fell outside the normative range. Mean (95% CI) NCSS was higher in PDW (16.2 (15.4-16.9)) and NDW (15.7 (14.9-16.4)) than in NDNW (14.6 (14.1-15.1)). Mean fume exposure during hyperbaric welding operations was 2.58 mg m-3. Fume exposure in NDW was three time higher than for PDW. After adjusting for age, alcohol consumption and somatisation there was no signification association of CFQ score with either welding fume exposure (F=0.072, p=0.79, n=152) or diving exposure (F=0.042, p=0.84, n=74).

*Conclusion*

In conclusion, cognitive sympomatology was not related to retrospectively assessed measures of welding fume exposure or diving experience. In addition, the levels of cognitive symptomatology, even in PDW, did not exceed normative values.

OP-48

# ENT PROBLEMS SUFFERED BY SCUBA DIVERS DURING PARTICIPATION IN DIVING ACTIVITIES, A CROSS SECTIONAL STUDY FROM 2009 TO 2011 USING THE DAN EUROPE INSURANCE CLAIMS DATABASE

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Keywords: ENT, Ear Barotrauma, Decompression illness, Epidemiology

*Background*

What types of Acute ENT problems while diving make a diver visit a healthcare facility? We studied incidence of such problems in the DAN member community as probably the biggest diving community diving medical information can be collected from.

*Methods*

*Population studied:* DAN Europe active members from 2009 to 2011.
*Inclusion criteria:* filed insurance claim for diving related ENT problem, defined as any acute medical condition affecting EAR, NOSE, SINUSES &PHARYNX or related functions. ENT problems might be caused by diving or unexpected illness unrelated to diving. Claims were classified into 1-Barotrauma; 2-inner ear DCI (IEDCI); 3-non diving related illness, according to medical reports submitted by treating facilities.
*Areas Studied:* Anthropometric and demographic data, country & time of accident, certification level, area affected, percentage of diving ENT problems vs. total diving problems, previous history.

*Results*

*Cumulative incidence* of diving ENT problems per 10000 members was 21.53 in 2009, 27.60 in 2010, 26.83 in 2011. Diving ENT problems constituted 22.22%, 27.55%, 26.50% of total diving related claims filed in 2009, 2010, 2011 respectively and they increased by 36.53% from 2009 to 2010 and by 20.19% from 2010 to 2011 . Barotraumas constituted 71.04% of all ENT problems and 18.19% of all the diving medical problems in the observed period.

*Conclusion*

Although ENT problems are by far the more frequent medical complaint in recreational diving, and cause significant morbidity, they are too often neglected. More intensive research and educational programs to decrease their incidence and morbidity are advocated. A universal reporting form for diving ENT problems to help research progress in this area is proposed. Furthermore DAN has produced the specific EAR & DIVING educational program to help improve divers' safety and awareness.

# EFFICACY OF VENTILATION AND VENTILATION UTILITIES DURING IN WATER RESUSCITATION

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Keywords: Drowning, Hypoxia, Ventilation, Laryngeal tube, Aspiration

*Introduction*

Drowning is the most common cause of death in diving accidents. The 2010 guidelines of the European Resuscitation Council prompt for in-water-resuscitation (IWR). IWR has been discussed controversially by emergency and diving physicians for decades. The aim of the present study was the assessment of the efficacy of IWR.

*Methods*

Eighteen lifeguards performed a rescue maneuver over a 100 meter distance in open water. All subjects performed the procedure four times in random order: With no ventilation (NV), mouth-to-mouth ventilation (MMV), bag-mask-ventilation (BMV) and laryngeal tube ventilation (LTV). Tidal volumes, ventilation rate and one-minute-volume were recorded using a modified Laerdal Resusci Anne. Furthermore water aspiration and the number of submersion were assessed.

*Results*

NV was the fastest rescue maneuver (advantage ~40 sec). MMV and LTV were evaluated efficient and relatively easy to perform by the lifeguards. While MMV (mean 199 ml) and BMV (mean 481ml) were associated with a large amount of aspirated water, aspiration was significantly lower in LTV (mean 118 ml). Efficacy of ventilation was consistently good in LTV, only initially acceptable due to water aspiration in MMV and continuously poor in BMV.

*Discussion*

A retrospective study of Szpilman et al. reported an improved outcome due to IWR in 46 drowning victims. According Perkins et al. 7-9 ventilation can be performed in a swimming pool efficiently. Based on our recent findings, the efficacy of MMV has to be questioned in open water accidents which raises the question whether IWR is useful at all. If IWR is performed, the use of adequate utilities is urgently recommended.

OP-50

## INFLUENCE OF DECOMPRESSION SICNESS ON THE ENDOTHELIUM DEPENDENT AND INDEPENDENT RELAXATION IN ISOLATED RAT VESSELS

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Keywords: Decompression, Endothelium, Organ bath, Arteries, Rat

*Objectives*

Several studies have demonstrated that endothelium function following a dive without decompression sickness is impaired. Among various endothelium delivered factors only NO has been studied. Link between nitric oxide (NO), bubble formation and decompression sickness (DCS) has been previously made. During the study we tried to determine the effect of DCS on the different pathways of the endothelial dependent vasorelaxation.

*Methods*

A total of 27 male Sprague-Dawley rats were shared in to 4 groups: control- non diving (A), diving without DCS (B), with mild DCS (C), with severe DCS (D). For one hour after surfacing they were observed for symptoms of DCS. Endothelium dependent and independent vasomotion was assessed in vitro by measuring isometric tension in rings of abdominal aorta and mesenteric arteries. Dose responses curves were obtained with phenylephrine (PE) for smooth muscle contraction, acetylcholine (ACh) for endothelium dependent relaxation and sodium nitroprusside (SNP) for endothelial independent relaxation. ACh-induced relaxation was observed in a presence of L-NAME (inhibitor of NOS), Indometacin (COX inhibitor) and L-NAME+ Indometacin (non COX, none NO vasorelaxation).

*Results*

Response to PE was impaired in all diving groups when compared with control one. Contraction in animals with severe DCS was also significantly different from both B ($p=0.0001$) and C ($p=0.04$) groups. There was no difference between B and C groups ($p=0.68$). Dose response curves for ACh and SNP remained unchanged.

*Conclusions*

We did not observe difference in endothelial function after diving and in a presence of severe DCS. The results may indicate smooth muscle injury. Further studies are needed to confirm this hypothesis.

# COMPRESSION EFFECT OF DIVING WET SUIT: A STEP TOWARDS IMMERSION EFFECTS ON WATER BALANCE

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Keywords: Wet diving suit, Immersion, Body compression, Fluid balance, Urine output

*Introduction*

Water immersion alters fluid balance and significantly increases urine flow rate and decreases plasma volume. Hydrostatic pressure is pivotal to the circulatory effects of water immersion. This study aimed at assessing the effects of the WS skin compression on urine output and plasma volume in the air and during scuba diving.

*Methods*

Eight healthy divers (age 35.3 ± 4.8 [SE] yr, weight 72.9 ± 4.8 kg) participated in five 2-hour sessions: sitting in the air in trunks (C-air), sitting in the air in wet suit (WS-air), and three scuba-immersed sessions in wet suit at 1, 6 and 12 m depth. Urine volumes and blood samples were collected. Hemoglobin (Hb), hematocrite (Hte) and plasma sodium concentration were measured. The WS compression effect was assessed (elastic tension of WS material, and interface pressure between skin and WS).

*Results*

Elastic recoil tension of WS material was unchanged by ambient high pressure or by immersion. Mean interface pressures between WS and skin amounted to: 25.8 ±2.8 mm Hg on trunk, and 25.1 ±3.2 mm Hg on lower limb). Weight loss was respectively 2 and 3 times larger on WS-air 430 g) and immersed-WS (710 g) than on C-air (235 g; $p<0.05$). Urine volume accounted for circa 82-85 % of weight loss in either session. Weight loss and urine volume were similar whatever immersion depth. The decrease in plasma volume amounted to 8% of urine volume on C-air, 27% on WS air and 30% on the 3 immersed-WS. Hence, during the four WS sessions, 70 % of urine volume was not embedded in plasma volume shrinkage. Plasma sodium was unchanged after either session.

*Conclusion*

Diving wet suit develops a pressure effect that mimics water immersion (to a lesser extent). During scuba pressures of the diving the suit and water combine to reduce water content of body fluids, unrelated to immersion depth.

OP-52

# PRELIMINARY ANALYSIS OF DAN EUROPE DSL DB AND GRADIENT FACTOR EVALUATIONS PHYPODE PROJECT

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Keywords: Gradient Factor, Compartmental model, Diving, Ascent speed, M-value

*Introduction*

The current large number of dives per year requires in-depth epidemiological analysis. The DAN Europe DSL database (DB) was analysed aiming at comparing its data with tissue saturation values according to Buhlmann ZH16 Model. An analysis of the relationship between ambient pressure and allowed gradient factor (GF) as predicted by Buhlmann ZH16 was completed.

*Materials and Methods*

An original database format (DAN DL7) was developed for statistical analysis. Information about anthropometric data, breathing gas used, equipment malfunctions, medical history was included. Original software was developed for the analysis of GF values.

*Results*

3000 divers (2460 male, 540 female; mean age 37,66) completed 39.944 dives (mean depth 28,03 m +/- 13,75m - mean dive time 46,02 +/- 4,6 min). 91,30% used air, 5,14% nitrox. 0,48% trimix, whilst for 3,08% data are missing. The use or compartmental vs bubble decompression algorithms was equally distributed (50-50 approximately). Preliminary analysis has shown that for each tissue, at any value of the ambient pressure the supersaturation calculated on the basis of the given profile is constantly significantly lower than the maximum allowed supersaturation value as predicted by the Buhlmann ZH16 model. 181 DCS cases were recorded (0.5%), of which only 20% showed a GF > 80%, whilst the majority implied lower supersaturation and GF than expected in a DCS case.

*Conclusion*

Most of the analysed dives lie in the “safe zone” i.e. Divers tend to dive very conservatively. Average ascent speed is lower than recommended by current algorithms. The reliability of current algorithms shows “grey areas” as to ability to predict DCS that need further research and a more physiological approach to decompression. The DAN Europe DSL DB analysis is providing important data to improve safety in recreational diving.

# EFFECTS OF 2H FIN SWIMMING IN 29°C WATER ON WATER BALANCE

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Keywords: Complete immersion, Fin exercising, Warm water, Fluid balance, Urine output

*Introduction*

The aim of the study was to assess the effects of finning during whole body immersion on body fluid balance and plasma volume.

*Methods*

Twelve healthy divers (age 32.6 ± 3.7 [SE] yr, weight 73.7 ± 3.82 kg) performed two 2-hour whole body immersions in a heated pool (Tw = 29 °C). They once rested (*Rest*) and once were continuously finning at a constant speed (*Fin*). They breathed 100% oxygen (scuba rebreather). Urine volumes and blood samples were collected. Hemoglobin (Hb), hematocrite (Hte) and plasma sodium concentration were measured.

*Results*

Heart rate stood at 50 bpm during *Rest* vs 100-120 during *Fin*. Core temperature, mean skin temperature, and inhaled gas temperature remained unchanged during *Rest*, but increased significantly during *Fin*. Respective maximum temperatures reached as follows: 38.5 ± 0.4°C; 36.9 ± 0.8°C and 40.2 ± 0.2°C($p<0.05$). Weight loss was 37% larger during *Fin* (989 g) than *Rest* (720 g; $p<0.05$). Urine volume accounted for 85 % of weight loss in *Rest* session but only for 39% in *Fin* ($p<0.05$). Sweat production amounted thus to circa 46% of weight loss during *Fin*. On *Rest* the plasma volume decrease accounted for 44% of urine volume. Hence 56% of urine volume originated from interstitial and intra-cellular fluids ($p<0.05$). During *Fin* session, the decrease in plasma volume amounted to 85% of urine volume, but feeded the production of both urine and sweat. Plasma sodium was unchanged after either session.

*Conclusion*

In 29°C water and with a rebreathing system, 2h fin swimming causes a larger fluid loss than resting. The heat strain triggers a sweat production that dampens the urine output. Sweat and urine are drawn from plasma volume which is endowed by other body fluids during immersion.

OP-54

## MECHANISMS THAT ALTER BODY FLUID BALANCE DURING IMMERSION

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Keywords: Immersion, Diving, Fluid balance, Plasma volume, Tissue fluid volume

*Introduction*

Body mass decreases during water immersion and diving. Results gathered from serial studies delineate the pathways to fluid content lowering. These results provide also some quantitative models to rearrangement rates of body fluids.

*Methods*

Results of several experimental and field studies with head-out and whole body immersion during 30 min to 6 h were considered. Immersion conditions ranged from cold (10 °C) to thermoneutral (34 °C) and warm. Subjects were fit and trained divers.

*Results*

Body mass decreases as a function of immersion time, and in the absence of heat strain, urine volume accounts for circa 85 % of fluid loss, independent of gender and BMI. The prime mover of these water shifts is water hydrostatic pressure, whose compression effect triggers 4 times higher urine flow rate than on ground (baseline). Immersion depth does not impact this effect during scuba diving. Conspicuous cold strain increased urine volume by 20 % as compared to thermoneutral immersion. Exercising and heat strain reduced urine output, although mass loss (body water) could be markedly increased (sweat) during body heating as compared to thermoneutral immersion. Thus urine output and sweat loss combine to water loss during diving. The decrease in plasma volume is not uniformly linked to mass loss, although urine and sweat flows are directly feed by plasma volume. The decrease in plasma volume amounted to different fractions of total fluid loss, depending on thermal conditions. Interstitial and intracellular fluid volumes were also continuously depleted through the plasma lock. Cold strain caused extravasation that fastened the lowering of plasma volume. Important decreases in plasma volume occur within short (1h) immersion durations.

*Conclusion*

Body's water balance is always negative at the end of immersion as compared to ante-immersion status, independent of gender and BMI. Plasma volume, interstitial, and likely also intracellular fluids are lowered as divers come out of water.

## INTRINSIC AEROBIC CAPACITY AND SUSCEPTIBILITY FOR DECOMPRESSION SICKNESS

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*Background*

Decompression sickness (DCS) is caused by bubbles formed during decompression. In previous experiments, both in animals and man, the effect of a single training session 24 hours before a dive on the prevention/elimination of measurable vascular gas bubbles after decompression have been demonstrated. However, the effect of intrinsic aerobic capacity has not been investigated. An animal model has been developed together with professor Steve L. Britton, University of Michigan, where animals with high and low aerobic capacity has been bred through several generations, enabling research on the effect of intrinsic aerobic capacity. The aim of the present study was to investigate whether intrinsic aerobic capacity would influence on decompression stress and risk for DCS.

*Methods*

A total of 12 rats, 6 high capacity rats (HCR) and 6 low capacity rats (LCR) were used in this study. The rats underwent simulated diving to 500 kPa for 45 min on air. Initial pilot experiments showed that this diving profile killed all the LCR rats, whereas the HCR rats survived. Thus, in the final experiment the decompression stress in LCR rats were reduced by halving the decompression rate to 25 $kPa \cdot min^{-1}$, whereas HCR rats were decompressed at 50 $kPa \cdot min^{-1}$. Vascular gas embolisms were detected by use of transthoracic echo of the heart and the pulmonary artery.

*Results*

Both the LCR and the HCR rats produced vascular gas embolisms after the dive. However, there was no statistical difference between the groups. All rats in the LCR group died within the 60 min observation period after the dive, whereas 50% of the HCR rats survived the observation period.

*Conclusion*

Preliminary results indicate that intrinsic aerobic capacity do not influence production of vascular gas bubbles following decompression, but influences the organisms´ ability to survive strenuous decompression.

OP-56

## COMPARISON OF DECOMPRESSIONS USING ULTRASOUND DOPPLER

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*Background*

Ultrasound detection and monitoring of venous gas emboli (VGE) was used to compare two decompression algorithms, one using deep stops.

*Metods*

Seven military divers took part in this trial. They each carried out two dives in a chamber wet-pot, using a semi-closed mechanical rebreathing set. The depth of each dive was 60 msw and bottom time 15 min. The effective gas mix was 21% $O_2$, 35% He, 44% $N_2$. The decompressions were carried out either according to the Bühlmann ZH16b algorithm (ZH) using a gradient factor of 80/20, or according to the Towanda II algorithm (Tow) calculated with the DCAP table program. The total dive time was 73 and 74 min, respectively. The divers were monitored with regular Doppler ultrasound measurements for a 2 h period post-decompression at rest and after three quick knee-bends in supine position. The VGE scores were assessed using the Kisman Masurel (KM) scale.

*Results*

All dives were uneventful without any symptoms of decompression sickness (DCS) . The median maximum KM score was 3+ for the ZH dives and 1 for the Tow dives. All divers, except one, who scored 0 for both dives, had higher maximum scores after ZH dives than Tow dives ($p < 0.05$, excluding the subject without any VGE).

*Conclusion*

The table calculated using the orthodox neo-Haldanian algorithm produced significantly fewer bubbles than the table with deep stops. Similar trials have been carried out using DCS as end-point, but the total number of dives necessary to be able to differentiate between the tables were in the hundreds (1).

Ref: Gerth WA et al. UHMS 2007.

# INCREASED RELATIVE SIGNAL INTENSITY ON DYNAMIC CONTRAST ENHANCED MAGNETIC RESONANCE IMAGING IN THALAMUS AND FRONTAL CORTEX IN DIVED RATS

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Keywords: Magnetic resonance imaging, Blood-brain barrier, Decompression sickness

*Introduction*

When neurological damage occurs in divers the suspected primary cause are vascular gas bubbles. Entrapment of these bubbles may lead to cellular injury, cerebral oedema and increased permeability of the blood-brain barrier (BBB). Furthermore, studies of North Sea saturation divers have shown that divers report problems with concentration and memory more frequently than controls that can possibly be explained by CNS injuries. In this study, we have investigated effects of simulated diving on the rat brain circulation using MRI.

*Methods*

Rats (n=9) were compressed (200kPa/min) to 600kPa, and decompressed (50kPa/min) after 45 min. Control rats (n=5) were kept at 100 kPa breathing air for a similar time period. Magnetic Resonance Imaging (MRI) was performed on a 7T Bruker Biospec at one hour after decompression and at one week and two weeks after the dive.

*Results*

Region-of-interest based analyses of the dynamic contrast enhanced MRI (DCE-MRI) data showed differences between decompressed and control animals in frontal cortex and thalamus 1 h after dive. In frontal cortex, decompressed animals had higher mean relative signal intensity ($P = 0.023$) and a tendency towards higher time to peak (TTP) and area under the curve (AUC) in frontal cortex than control animals ($P = 0.076$ and $P = 0.068$, respectively). In thalamus, AUC was higher among decompressed animals ($P = 0.033$, Table 3) with a tendency towards higher RSI and TTP ($P = 0.068$ and $P = 0.104$, respectively). For all other areas, there were no significant differences between the two groups.

*Conclusion*

Our study indicates that severe decompression may cause changes in the brain perfusion and integrity of the blood-brain barrier acutely after diving.

# POSTER PRESENTATIONS

## USING OF HYPERBARIC OXYGENATION IN CITY MULTI – FIELD HOSPITAL IN THE FAR NORTH

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*Introduction*

The central city hospital one of the largest hospitals, situated in New Urengoy city. The territory of the Far North. The climate is characterized by long cold and harsh winter storms with strong, cold and frequent snowstorms, low rainfall, the summer is very short (50 days). The number of city population is composed by 118378 people. Hospital accommodation – 755. Among them: surgical – 246, therapeutic – 421, gynecologic – 79, resuscitation – 9. In hospital is providing emergency and planning service to the population on 49 specialties.

*Purpose*

Telling about the application of the method of hyperbaric oxygenation in treatment of patients with various nosology.

*Material and method*

Single - seat barocomplex BLKS – 307 in the complex medical treatment of these diseases.
In traumatology: severe trauma of extremities, osteomyelitis, the positional compression syndrome.
In neurosurgeon: traumatic brain injury, subarachnoid hemorrhage, spinal injury.
In neurology: acute impairment of cerebral circulation, vertebral myelopathy, lateral amyotrophic sclerosis, polyneuropathy of various etiology.
In obstetric: gestational toxicosis, for prophilaxis the asthenia of contraction strength.
In surgical: pancreatitis, gastric ulcer, enteroparesis, diabetic foot, in early postoperative period, getting frostbitten.
In therapeutics: diabetes, coronary artery disease, heart rhythm disorder.
In toxicology: acute carbon monoxide poisoning, alcoholic intoxication.

*Result*

Treatment by HBO gets 40 patients a year. In the course of treatment is appointed 10 – 20 sessions of HBO, duration of 1 - 1.5 hours and the pressure in the period izopressii from 1.5 to 3 ATA, depending on the form and stage of disease. Thanks to the using hyperbaric oxygenation, in common with traditional therapy, managed to reduce the period of being patients in stationary condition an average of 15 – 20 bed-days.
*Conclusions*

The using of hyperbaric oxygenation in difficult living conditions can improve treatment results, quickly restore ability to work, and maintain the health of the population in the north.

PP-02

## CLINICAL EXAMPLE OF SUCCESSFUL APPLICATION HYPERBARIC OXYGENATION TO THE CHILD IN REMOTE PERIOD AFTER CARBON MONOXIDE POISONING

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*Introduction*

Poisoning with carbon monoxide (CO) - the main cause of accidental poisoning worldwide. Carbon monoxide each year to become the cause of hundreds of deaths, both in Russia so and other countries. Long-term effects of the most disturbing and clinicians generate controversy regarding the optimal use of hyperbaric oxygenation (HBO).

*Purpose*

To compare the efficacy of hyperbaric oxygenation in the late period of carbon monoxide poisoning.

*Material and methods*

Sessions were held in the hyperbaric oxygen chamber with child 6 years old with a diagnosis of acute poisoning by combustion products. Burn the respiratory tract of 1 degree. Swelling of the brain. Posthypoxic encephalopathy. Severe left-sided spastic hemi paresis. Motor aphasia. Disruption of the pelvic organs. The child was taken from fire in a critical condition in a deep coma (Glasgow Coma Scale - score 3) with the endotracheal tube on assisted ventilation. Carboxyhemoglobin level at admission - 60%. Hyperbaric oxygen therapy was included in the comprehensive treatment of the child for 15 days from the date of onset, after intensive care with mechanical ventilation in the intensive care unit after stabilization of hemodynamic parameters, full restoration spontaneous breathing. By the indications for HBO use of materials of the European Consensus Conference in 2004. A total of 10 daily sessions of HBO at a pressure within the pressure chamber 2 ATA, total duration of the session 90 minutes

*Results*

After 5 sessions of HBO, the improvement of child's neurological status was marked. Occurred recovery of tendon reflexes, muscle tone, emerged titubation, the control function of the pelvic organs. After 10 sessions, came complete regression all neurological manifestations.

*Conclusions*

CO poisoning remains a serious public health problem. On principle, an important component of treatment remains hyperbaric oxygen. It seems reasonable to extend to young children of the same therapeutic principles used in adults.

## HYPERBARIC OXYGENATION IN THE COMPLEX TREATMENT OF ULCERATIVE COLITIS AND CROHN'S DISEASE

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Keywords: Inflammatory Bowel Diseases, Ulcerative Colitis, Crohn's Disease, Hyperbaric Oxygenation

*Introduction*

Crohn's disease (CD) and ulcerative colitis (UC) are chronic inflammatory bowel diseases (IBD) with severe systemic manifestations that require complex treatment.

*Methods*

The prospective (1980–2011) study using HBO in the complex therapy of 315 IBD patients was conducted. All our patients passed meticulous clinical examination. Our experience of treatment of IBD patients allowed us to develop the standard protocol of the use of HBO in IBD. HBO sessions were administered in monoplace hyperbaric chambers at 1.3–1.7 ATA; the isopressure time was 30–40 min; the HBO course consisted of 10 to 12 sessions.

*Results*

Sustained remission was noted in 49.1% of cases; improvement, in 36.9%. The same parameters in the control group were 21 and 36.9%, respectively. A marked decrease in the severity of dysbiotic shifts from stage 4 through all the intermediate stages up to the restoration of eubiosis in some patients; slowdown of extraintestinal IBD manifestations, reduction in doses and duration of the administration of corticosteroids and nonsteroidal anti-inflammatory drugs; and prevention of the development of operative and postoperative complications were noted. The possibility of administration of prophylactic courses as HBO-monotherapy for sustained remission and social adaptation of patients were revealed. Marked improvement in the clinical course of the inflammatory process against the background of HBO allowed us to discontinue corticosteroids in most cases.

*Conclusion*

The expediency of the inclusion of repeated HBO courses in the complex therapy of IBD and the necessity of the use of individual HBO regimes depending on the IBD stage and the clinical characteristics of patients were proven.

PP-04

## EFFECT OF HYPERBARIC OXYGENATION ON THE QUALITY OF LIFE OF PATIENTS WITH INFLAMMATORY BOWEL DISEASE

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Keywords: Ulcerative Colitis, Crohn's Disease, Hyperbaric Oxygenation, Quality of Life

*Introduction*

The degree of influence of hyperbaric oxygenation (HBO) on the quality of life (QL) can be determined using international questionnaires.

*Methods*

HBO was used in the course of management of 63 IBD cases (36.4%), including 25 patients with ulcerative colitis (UC) and 38 patients with Crohn's disease (CD). To assess disease activity, index of Rachmilewitz (CAI) for patients with UC and CD activity index (W.R.Best) for patients with CD (CDAI) were used. Patients were questioned using the international IBDQ and OAS questionnaires to determine the QL of IBD and postoperative patients, respectively. HBO sessions were administered in monoplace hyperbaric chambers at 1.3–1.7 ATA; the izopressure time was 30–40 min; the HBO course consisted of 10–12 sessions.

*Results*

Patients who received only basic therapy without HBO had lower QL parameter values than HBO-treated patients for 6 and more years ($p$ <0.05). According to the questionnaires (statistically significant sample), an improvement in the patients' condition was noted after the first HBO session in 1.6% of cases; after the third session, in 3.2%; after the fourth session, in 38.1%; after the sixth session, in 57.1%. In 81% of cases, the patients reported that HBO significantly improved their well-being or contributed to sustained remission. Nineteen percent of patients didn't note any improvement. This was observed in those who were on long-term corticosteroid therapy and were given HBO sessions at the late stages of the disease. According to CAI and CDAI after the sixth session stable remission was noted in 50,1% of cases, improvement in 38.5%. Inefficient cases were associated with late inclusion of HBO in complex therapy.

*Conclusion*

HBO can be used in the complex treatment of IBD with good effect. Annual HBO courses contribute to sustained remission in IBD patients and improve their QL.

# A CURRENT OVERVIEW TO THE DANGERS AND MEASURES IN HYPERBARIC CHAMBER

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Keywords: Fire security, Hyperbaric oxygen, Explosion

*Introduction*

Hyperbaric Oxygen Therapy (HBOT) Centers, numbers of which increase progressively in our country and in the world, have become one of the modern treatment methods by many indications applied. Like in all workplaces and treatment centers, fire security is kept in the forefront in these centers, too.

*Methods*

In this study, it was desired to draw attention to the explosion which happened at the HBOT centre in Florida, ABD, on 10th February, 2012. As a result of the explosion, personnel died, an employee was wounded seriously, the horse which was in the treatment at that point and caused the fire, died. The reason of the explosion was found out that the horse was troubled in the chamber, and as a result of this, the spark happened which caused the fire. The horse was being taken to the fourth session and no tranquillizer had been given to the horse because no problem had occurred previously. The employee had been doing this work for two years also.

PICTURE 1

PICTURE 2

PICTURE 3

*Results*

The worst scenario for a HBOT centre is an explosion which happens after a fire. All the personnel who work in hyperbaric units must be careful and educated in respect to this. Some materials which do not burn in normal conditions, can burn because of the high oxygen in the atmosphere. The most basic thing, which must be done to prevent this, is not to insert in the ignition sources, which can occur spark, to the chamber. The greatest danger in front of this is the insensitivity which occurs as a result of repeating same things every day.

*Conclusion*

Hyperbaric oxygen chambers generally can be accepted reliable when they are built in suitable technique conditions, when they are under routine control and entrusted to the educated personnel. Otherwise, a smallest carelessness can cause irreversible results suddenly.

PP-06

## THE CLINICAL EXAMPLE OF SUCCESSFUL APPLICATION OF HYPERBARIC OXYGENATION, IN THE TREATMENT OF PATIENTS WITH SEVERE RESPIRATORY DISTRESS SYNDROME

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*Introduction*

Respiratory distress syndrome (ARDS) - is an acute non-specific lung disease that develops among patients in critical condition, accompanied by persistent violations of the pulmonary circulation and gas exchange, characterized by acute onset, severe hypoxia is not addressed by oxygen therapy, interstitial edema and diffuse infiltration of the lungs. Mortality in the ARDS is 50 - 80%.

*The purpose of hyperbaric oxygenation (HBOT)*

To analyze the effect of HBOT on the course and regression of respiratory failure in ARDS.

*Materials and methods*

Single - seat barokompleks BLKS - 307. Patient aged 55, was diagnosed with stab wounds of the chest right, penetrating into the pleural cavity. Gemopnevmotoraks. Thoracoabdominal wound with injury of the right lobe of the liver. Intraabdominal bleeding. Hemorrhagic shock of 3 degrees. ARDS syndrome in this patient was diagnosed on a scale of severity lung injury LIS (Lung Injury Score). The degree lesion of lung was higher than 2.5, which corresponded to heavy lung disease. HBO was included in the comprehensive treatment of the patient for 15 days from the beginning of disease, after intensive care and mechanical ventilation according to the protocol ARDS in the resuscitation department, for the stabilization of hemodynamic parameters, improved X-ray picture of the lungs, the appearance of spontaneous breathing through a tracheotomy tube. A total of five daily sessions of HBOT at a pressure into the pressure chamber 2 ATA, the total duration of the session 60 - 90 minutes.

*Results*

After the fifth session of HBOT positive dynamics of X-ray pictures (full recovery pneumatization) of the lungs and the disease were observed.

*Conclusions*

The result of ARDS treatment with HBOT is better than without HBOT, faster regression of respiratory failure occurs.

## CHRONIC WOUNDS IN CALCIPHYLAXIS TREATED WITH HYPERBARIC OXYGEN: A CASE SERIE REPORT AND A BRIEF REVIEW OF LITERATURE

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Keywords: Calciphylaxis, Hyperbaric oxygen, Calcifik uremic arteriolopathy, Dialysis, Renal failure,

*Introduction*

Calciphylaxis also called calcific uremic arteriolopathy, presents itself with itchy, necrotic and ulcerated skin defects, in combination with severe pain. It is a rare but serious complication of end-stage renal failure. Hyperbaric oxygen (HBO) therapy has been used to enhance wound healing, but its effect the treatment of calciphylaxis is unclear. The aim of this particular research is to improve this knowledge with a case series of patients treated in our medical center and a literature review about HBO therapy on Calciphylaxis.

*Methods*

All patients treated in between 1996 and 2011 in the AMC hyperbaric department had been retrospectively reviewed. Demographic, clinical and biochemistry characteristics were abstracted from their medical records and presented in a descriptive overview.

*Results*

All 15 patients (60.4 ± 10.6 years, 1:2 male/female ratio) experienced renal disease. Frequent co morbidities were hypertension, diabetes mellitus type 2 and obesity. Six patients experienced biopsy-proven calciphylaxis. Thirteen patients required dialysis as well as seven patients had undergone a kidney transplantation, two of them actually twice. Patients had a mean of 4.6 wounds (SD ± 2.5; range 2-10) with a total 15.8 cm in diameter (± 8.2 cm; range 7-39 cm). In 10 patients the effect of $HBO_2$ therapy was documented and had complete resolution of the wounds. Calcium and phosphate levels were increased in most patients of this study.

*Conclusıon*

Our data HBO in the treatment of patients with calciphylaxis and support a role for wounds. The actual complexity of this disease requires the multidisciplinary strategy, in which HBO therapy may perform an important role as adjuvant therapy for healing wounds.

PP-08

## THE EFECT OF HYPERBARIC OXYGENATION ON NEURONAL PLASTICITY AFTER EXPERIMENTAL CORTICAL INJURY IN RATS

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Keywords: Brain injury, Research, Regeneration, GAP43, Synaptophysin

*Objective*

The fact that hyperbaric oxygenation (HBO) as a therapeutic procedure has the synergistic effect with other treatments in promotion of neo-angiogenesis and tissue regeneration, strongly suggests that combining standard therapeutic procedures with HBO, after traumatic brain injury could yield better results than either alone. Our aim was to investigate whether HBO can enhance neuronal plasticity in rats after unilateral suction ablation of the right sensorimotor cortex.

*Methods*

Experimental paradigm implies the following groups (n = 8 per group): Control animals (C), Control + HBO (CHBO), Sham controls (S), Sham control + HBO (SHBO), Lesion group (L), right sensorimotor cortex was removed by suction, Lesion + HBO (LHBO). HBO protocol: pressure applied 2.5 atmospheres absolute, for 60 minutes, once a day for 10 consecutive days. Expression profiles of growth-associated protein 43 (GAP43), microtubules associate protein 2 (MAP2) and synaptophysin (SYP) were detected using immunohistochemistry. Our research was approved by the Ethical Committee of the School of Medicine, University of Belgrade.

*Results*

10 days of HBO markedly increased GAP43 immunostaining in the perilesioned cortex, principally in the subcortical white matter where long, strongly labeled fibers can be seen at the left side of the lesion cavity. HBO treatment induced over-expression of MAP2 as well in the cortex bordering the lesion site and more distantly strong staining was concentrated in a particular part of neuronal cell. Immunopositive SYP staining of axons in the subcortical white matter and in the entire injured cortex was markedly increased after HBO.

*Conclusions*

Based on these results HBO can intensify neuroplastic responses by promoting of the axonal sprouting and the formation of new functional synaptic circuits and contributes to the recovery of rats. These experimental data are clearly showing that molecular oxygen under hyperbaric condition can contribute to the neuronal plasticity.

# THE COMBINED USE OF HBOT AND OTHER WOUND CARE INSTRUMENTS IN CHRONIC WOUNDS WITH DIFFERENT ETHIOLOGIES: A CASE SERIES OF 41 PATIENTS

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Keywords: HBOT, Chronic wound, Wound care products, Wound infection

*Introductıon*

Wounds that don't heal in 4-6 weeks are named as chronic wounds. It is difficult to treat a chronic wound, especially if it is infected. In recent years treatment approaches to chronic wounds are renewed due to understanding the importance of micro-environment, of cellular insufficiencies and wound infections.

*Methods*

In this study combined use of different therapies in chronic wound management are presented upon 41 cases. All wounds were infected. 39 cases were hospitalized and/or followed in our clinic, two in Orthopedy and Traumatology Department. 23 cases were also evaluated by the Chronic Wound Council of Istanbul Faculty of Medicine which gatheres in our department every week.

*Results*

There were 13 female and 28 male patients. The mean age was 55,5. 23 cases were DF ulcers, 3 diabetic nonhealing wounds, 5 nondiabetic nonhealing wounds, 5 soft tissue radiation necrosis, and the rest were venous ulcer, extravasation, Buerger disease, chronic ostemyelitis and PVD cases. Antimicrobial treatments were programmed according to deep tissue cultures. All patients received HBOT at 2.4 ATA. The average number of HBO sessions was 54. Surgical or enzimatic debridements, negative pressure wound dressing, maggot therapy, and application of thrombocyte enriched plasma were other treatment instruments used. Selection of wound dressings such as hydrogel, collogen, alginate or anti-bacterial coverings were done as needed. Different treatment modalities and wound care products were used together or alternatively. 16 patients completely healed. Improvement was obtained in 25 patients with a 70% or more decrease in wound size. Average healing time of 16 cases was 15 weeks.

*Conclusıon*

Chronic wound treatment, especially if it is an infected diabetic wound, needs a dynamic, multidisciplinary and coordinated approach. Treatment instruments should be chosen according to the needs of the wound in different stages of healing.

PP-10

## CICATRISATION IN THE POST-AMPUTATION DIABETIC FOOT WOUND, WITH A HUGE TISSUE LOSS, TREATED WITH SMALL NUMBER OF REPEATED HBOT: CASE REPORT

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Keywords: Diabetic foot, Cicatrisation wound, HBOT

*Background*

Diabetic polyneuropathy and microangiopathy might cause diabetic foot syndrome. As a consequence, trivial injuries which are unrecognized by the patient might develop into ulcers. More than 90% of foot ulcers occur in the forefoot. Most commonly affected are the great toe and the head of first and fifth metatarsal bones. There is some chance for regeneration only in the early stages of this process. Once when the point of no return is reached, further progression can only be slowed, and the risk of amputation becomes high. Inadequate cicatrisation in post-amputation period is usually the problem, as the area of the skin defect is huge, while functional abnormalities of the microcirculation and the polymicrobial nature of these wounds represent another problem. As the cicatrisation is time dependent and biologically limited process, HBO is an effective additional therapeutic option.

*Methods*

We used repeated small series HBOT in the monoplace hyperbaric chamber ( BLKS 303 MK ALKORP) with the dose at 2,0 ATA 100 % $O_2$, for 60 min, five times a week, with ongoing wound nursing and dressing.

*Case report*

A 63 year old male has been diabetic (type II) for more then 10 years and without any medication. He was admitted to the HBOT facility after amputation of his fifth toe and massive plantar skin necrectomy. He received first 10 sessions of HBO and then, additional small series of 5 sessions, every three weeks. Patient had only 35 treatments of HBOT during 5 months. Wound was cleaned before each HBO session, left uncovered during HBOT in the chamber and redressed after the session. The patient also started with oral antidiabetic medication. During three weeks period, without HBOT, the wound was redressed every second day. Cicatrisation process was completed after 5 months.

*Conclusion*

Plantar skin defect loss is very complex issue for reconstructive surgery and often demands repetitive reconstructive procedures. Small number of repeated HBOT series, with proper wound nursing, can be efficient successful in achieving complete healing and cicatrisation of the wound, without need for reconstructive surgery.

# HYPERBARIC OXYGEN THERAPHY AND CHELATION; AN EFFECTIVE COMBINATION FOR TREATMENT OF NEUROINFLAMATION IN CHILDREN WITH AUTISM : CASE REPORT

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Keywords: HBOT, Chelation, SPECT, Neuroinflamation, Autism

*Introductıon*

A.S. is a 7 years old boy diagnosed with autism. Mother was 29 years old at birth. Delivery was vaginal and full term with no problem. He was a good baby, a good sleeper and a good eater. He didn't crawl. He preferred round spinning toys. He had good eye contact and language comprehension. Family had seen the first signs at 2 ½ years old. He was not speaking !

Family history showed biochemical aftermath secondary to gastrointestinal inflamation at all family members.

*Methods*

During consultation we looked to brain anatomy with Magnetic Resonance scan (MR) and brain function with perfusion SPECT scan (SPECT). He had abnormal SPECT revealing focal areas of decreased perfusion. By contrast he had normal MR findings. As a cause for neuroinflamation, A.S. had very elevated levels of lead in urine provocated with DMSA 30mg/kg.

As a result of both studies, we conclude that the areas with decreased perfusion were all neuroinflammatory areas (idling neurons) secondary to toxic overload. We planed to do "chelation + HBOT combination" for treatment.

*Results*

In 26 months; after totally 90 sessions of HBOT at 1.5 ATA with 100% oxygen for 60 minutes and using a special chelation protocol at the same time, he showed significiant improvement on speach, judgement, learning, fine motor and gross motor functions. He was calm and happy. Beter sleeping, beter behaviour and more interest with environment were other changes.

Lead levels were decreased from 45micg/g creatinin to 14 micg/g creatinin in DMSA provocated urine and control brain perfusion SPECT showed increased perfusion at the inflammatory areas, compairing with previous scan.

*Conclusıon*

In this case, a combined treatment with chelation and HBOT showed a great success to decrease the symptoms secondary to neuroinflamation in children with autism.

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## CLINICAL AND MICROSCOPIC EFFECTS OF HYPERBARIC OXYGEN IN DIABETIC FOOT ULCERS

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Keywords: Research, Diabetic foot, Wound Healing

*Introduction/Background/Objectives*

Wound healing involves several mechanisms, including extracellular matrix synthesis, angiogenesis, epithelisation, scar remodeling; the majority depend on oxygen content. In diabetic environment, healing is modified resulting in decreased microvascularization of the inferior limbs and lower levels of vascular endothelial growth factor A. This wide variety of processes is associated to oxygen withdrawal. Thus, hyperbaric oxygen therapy (HBO) is used in hypoxic diabetic foot ulcers (DFU). The authors aim to compare DFU healing process of patients treated with HBO and not.

*Methods*

We are conducting a prospective cohort study including patients with active DFU that, after 8 weeks of standard therapy (including angioplasty and/or revascularization surgery if needed) had no significant wound evolution and comparing those treated with HBO with untreated ones (patients that refuse the treatment or have contra-indication). Clinical endpoints (at 3, 6, 9 and 12 months) include: primary – percentage of wound epithelisation; secondary – amputation(s), time till complete healing, infections, hospital admissions, ulcer recurrence.

*Results*

Data on the first patients treated and not treated with HBO that entered the study will be presented including available clinical endpoints and differences between the groups. Regarding primary clinical endpoint, treated patients (9) had wound area reductions between 29,27% and, approximately, 100% at 3 months and 68,18 to 100% at 6 months. The 4 patients not treated had a worse evolution with 3 major amputations (1 died 2 weeks after the procedure) and 1 transmetatarsal amputation posteriorly complicated by a plantar abscess (died 3 months later from lung cancer). Immunohistochemistry data regarding ulcer bed at 0 and 4 weeks will be shown.

*Discussion/Conclusion*

The authors present the data to reinforce the potential efficacy and benefit of this therapy when added to current standard treatment.

# HYPERBARIC OXYGEN THERAPY FOR NONARTERITIC ANTERIOR ISCHEMIC OPTIC NEUROPATHY: A CASE REPORT

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Keywords: Nonarteritic optic neuropathy (NAION), Quadrantanopsia, Hyperbaric oxygen therapy

*Introduction*

Nonarteritic optic neuropathy (NAION) is a condition characterized by a painless, sudden and usually unilateral loss of vision. It results from damage to the optic nerve from insufficient blood supply. Major risk factors are age (less than 50 y.o.), cardiovascular risk factors (hypertension, diabetes, high cholesterol levels), a significant drop on blood pressure during the night and a small cup-to-disk ratio (optic discs just large enough to harbor the optic nerve axons). The only known therapeutical approaches to NAION have been systemic corticosteroid therapy and less-effective optic nerve sheath decompression or neuroprotective agents. A theoretical basis for the use of hyperbaric oxygen therapy (HBOT) is the oxygenation of the optic nerve from choroidal branches of the Circle of Haller and Zinn.

*Methods*

We present a case of a 48 years old male patient, with no known cardiovascular risk factors, which was diagnosed with NAION on the right eye (OD) 13 days before. His best-corrected visual acuity (BCVA) was 1/10 on the OD and 10/10 on the left eye (OS). His right optic nerve had a very mild oedema but was hyperfluorescence on fluoresceinangiography. He had a right inferior quadrantanopsia documented on Goldmann kinetic perimetry.

*Results*

The patient underwent 20 sessions of HBOT (2,5 atm for 90 minutes each). At session 14 his BCVA OD was 9/10. The kinetic perimetry performed at that time was normal.

*Discussion / conclusion*

HBOT, by increasing the coroidal oxygenation may provide an alternative oxygen source to an ischemic optic nerve in NAION, hence, improving visual acuity and visual field as documented in this case. Further controlled studies are needed to demonstrate conclusively this outcome.

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## HYPERBARIC OXYGEN THERAPY IN ACUTE AND CHRONIC SUDDEN DEAFNESS

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Keywords: Sudden deafness, HBOT, “Acute”, “Chronic”

*Objectives*

The etiology and pathogenesis of sudden deafness, still remains unclear in great deal. It is generally considered to be vascular nature. The aim of this study was to evaluate if is it useful to use HBOT in chronic phase of sudden deafness and what are the difference between recovery results in patients treated in acute and chronic phase.

*Methods*

Between April 2011 and April 2012, a total number of 29 patients with sudden deafness were treated in CHM, Belgrade, 13 of them in acute phase (within 4 weeks of symptom onset – “Acute”) and 16 in chronic phase (1-4 months after onset – “Chronic”). Treatment protocol implied - 100% O2 at 2.2 ATA for 70 minutes, five times weekly. All patients were treated by ENT specialists from several institutions and had received same therapeutic regimen including corticosteroids, intratympanic instillation of dexamethasone and vitamin therapy. Tonal audiometry was performed before and after HBOT. The improvement level of hearing gain in dB was defined as “significantly” (hearing gain >30 dB), “moderately” (hearing gain<30 dB but>10 dB) and “no change” (hearing gain<10 dB).

*Results*

After 15 HBOT sessions the following results were found. “Acute” patients: 30.77 % showed significant improvement (almost complete recovery), 46.15% showed recovery and in 23.08% there were no changes. “Chronic” patients: 12.50% showed significant improvement, 43.75% moderate improvement and in 43.75% there were no changes. Hearing gain was significantly higher in “acute” in comparison to “chronic” patients( p=0.035, chi-square test).

*Conclusions*

The results are indicating that patients suffering from sudden deafness can benefit from HBOT. However, considerable improvement can be expected in “Acute” patients. But the possibility of significant improvement in some of the “Chronic” patients appears to justify the delayed use of HBOT in selected “Chronic” cases.

## POLYNEUROPATHY AS A CHALLENGE IN HYPERBARIC MEDICINE

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Keywords: HBOT, Diabetic polyneuropathy, Quality of life

*Objectives*

Polyneuropathies are a large and heterogeneous group of diseases which are the result of damage of peripheral neurons with different etiology. Among all acquired neuropathies the most frequent one is the diabetic polyneuropathy which is present in 40-60% of all diabetic patients and greatly reduces the quality of life and increases patient's handicap.

The objective of our study was the assessment of subjective decrease of polyneuropathic problems in patients treated with HBOT, as well as the difference of the therapy success between diabetic and other peripheral neuropathies.

*Methods*

In one year period (2011), 140 patients with the confirmed polyneuropathy by EMNG, were treated in our clinic. 85% had diabetic etiology and 15% did not (alcoholic polyneuropathy and polyneuropathy in systemic disease). The HBOT protocol 2,2 ATA by 70 minutes, 5 times a week, 20 treatments in all. We analysed the polyneuropathic problems with changes in sensitivity, such as numbness, tingles, cramps and claudical problems.

*Results*

83,57% of patients had subjective improvements, and in 16,43% the results were the same as before. 85,71% of patients with the diabetic polyneuropathy stated improvement and 14,29% stated no changes. In other polyneuropathies in 71,43% of patients the problems decreased, and in 28,57% there was no therapeutic effect.

*Conclusions*

HBOT in patients with polyneuropathy is still a big challenge for the evidence based medicine. Our guided procedure led to positive therapeutic effect in large number of patients. The group of patients with the diabetic polyneuropathy had a better response compared to other polyneuropathies, which points to the fact that diabetes is a microvascular illness. It is our opinion that if introduced on time HBOT can improve the quality of life and reduce handicap.

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## EFFECT OF HYPERBARIC OXYGEN THERAPY ON PULMONARY FUNCTION IN PATIENTS WITH CHRONIC SYSTEMIC VASCULITIS AND DIABETES MELLITUS

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Keywords: Pulmonary function, Vasculitis, Diabetes mellitus

*Introduction*

HBO therapy has no advantage over normobaric oxygen therapy, which is widely used in treatment of pulmonary insufficiency. The basic problem with HBO therapy in patients with pulmonary disorders is the fear of pulmonary pathology deterioration, which is caused by pulmonary toxicity caused by oxygen. Pulmonary toxicity is not a problem in patients with healthy lungs who receive HBO therapy under the pressure of 3 atm for a 90-minute period, once or twice a day. Further research and studies are required to define a beneficial effect on asthma and bronchitis. A big problem is the fact that most of those treatments are administered under the 1.5 atm pressure.

*Material and Methods*

The prospective study encompasses 70 patients classified into two groups – diabetics and patients suffering from vasculitis. The groups contain 50 and 20 patients respectively. In addition, both groups are composed of the basic and control group with an equal distribution – 25 patients receiving HBO therapy and the equal number of those not receiving HBO therapy (the control group).

*Results*

The average age is 62.6429 years (with deviation of 12,33 years). In this simple the average number of smoking years (that is excluding those patients who do not smoke) about 36,3. There is statistically significant difference for the value FEV1 and FEF_75 for patients with diabetes mellitus, while for patients with HSV is not statistically significant difference in FEV1.

*Discussion*

Morphological investigations of diabetics have shown the presence of microangiopathy in alveolar arteriole and capillaries. Damage to microcirculation of alveolar and capillary membrane is one of the earliest morphopathological indicators of diabetes; it causes plasmorrhagia and exudation, concentration of macrophage, sclerosis of alveolar walls and development of centrolobular emphysema. This further leads to insufficiency of pulmonary function, decrease of arterial blood oxygenation and, as one of the factors, decompensate diabetes.

*Conclusions*

Patients who can undergo the HBO therapy for some other indications should be subjected to detailed lung examinations accompanied by additional tests and control of the pulmonary function. We must bear in mind that pneumothorax and pulmonary lesions are contraindication for the HBO therapy.

# THE EFFECTS OF HYPERBARIC OXYGENATION (HBO) UPON THE PATIENTS IN THE STATE OF VIGIL COMA

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Keywords: Vigil coma, Hyperbaric oxygenation, Consciousness, Brain

*Objectives*

Comatose condition is most recreantly a consequence of severe head trauma, but unfortunately it can also arise after cardiac arrest. Lethality rate in comatose patients is very high, however not all patient who arouse from coma are regaining their functional and intellectual capabilities. Some of them are lingering in state of "vigil" coma, awaken but without capability to communicate with others. The aim of this study was to evaluate the effects of hyperbaric oxygenation (HBO) upon patients with vigil coma.

*Methods*

During three years period, four patients with vigil coma (age from 18 to 35 years, 3 male, 1 female, in coma from 18 to 26 month, Glasgow scale 3-5) were referred to the Center for hyperbaric medicine. Causes of the state were: cardiac arrest, electric shock, car accident and fall from the height. During one year period they underwent 3x30 HBO exposures (100% molecular oxygen at 2 absolute atmospheres (ATA) for 90 minutes).

*Results*

General conditions were improved in all of the four patients. Bedsores that were present in two of them were healed. A healthier form of circa dial rhythm was achieved. During the third series of HBO sessions two patients have regain consciousness with limited sensory motor performances. After third series of HBO sessions NMRI and PET scan have showed greater than before brain activity in all four patients. Intensive rehabilitation restorative treatment was applied along side with continuous HBO exposures and noticeable improvements were observed.

*Conclusions*

The results presented in this study are suggesting that by increasing oxygen supply to the endangered regions of the brain HBO can intensify neuroplastic responses, produces convenient environment for neuronal recovery and improve brain performances in patients with vigil coma.

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## THE EFFECTIVES OF HYPERBARIC OXYGENATION IN DIABETES MELLITUS TYPE II HETEROGENIC PATIENTS

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Keywords: Diabetes mellitus type II, Hyperbaric oxygenation, Data collection/analysis

*Objectives*

Most proposed risk factors for the development of diabetes mellitus tip II are considered to be: unhealthy life stile, obesity, “red” and “white” muscle fiber ratio, poor communication between the cells and genetic factors. The aim of this study was to evaluate whether chromosomal heterogeneity can be useful mean for predicting the clinical outcome of hyperbaric oxygen therapy in patients with diabetes mellitus type II.

*Methods*

During two year period, genetic screening was performed in thirty patients with diabetes mellitus type II (age 52 ± 7 years, 18 male, 12 female). They were referred to the Center for hyperbaric medicine in an effort to reduce the neuropathy and angiopathy. They were given 100% molecular oxygen at 2.5 absolute atmospheres (ATA) for 90 minutes, five times a week.

*Results*

Chromosomal heterogeneity was found in twenty one patients. Restitution of the functional ability was significantly poorer in patients with chromosomal heterogeneity. The first signs of improvement (elongation of claudication distance) were observed after 17 to 20 HBO sessions, while among the patients without heterogeneity claudication distance was eliminated after 9 to 12 sessions.

*Conclusions*

If we apply genetic screening may help to evaluate the appropriate hyperbaric treatment protocol, and can contribute to estimation of the clinical prognosis among the patients with diabetes mellitus type II.

# AUTISM AND OTHER DEVELOPMENTAL DISORDERS AS CHALLENGE TO HYPERBARIC MEDICINE

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Keywords**:** Autism, Developmental disorders, Hyperbaric oxygenation, Consciousness

*Objectives*

Autism is a developmental disorder of the brain whose symptoms are recorded early in childhood. Upon exhaustion of all so far known and recognized diagnostic and therapeutical procedures, these patients refer to hyperbaric medicine centers considering the molecular oxygen under hyperbaric conditions as “catching at a straw”.

*Methods*

During one year period, in the Center for hyperbaric medicine, after detailed examination of every child, medical history obtained from parents and inspection of supporting documents, 36 children aged from 2.5 to 9 years were included in HBO program. Out of these, 11 children (27%) had autism as the only diagnosed condition, and the rest of 25 (73%) had also a series of other developmental disorders. The effects of applied HBO procedures were monitored on daily basis during the course of HBO treatment and upon completion of 30 HBO exposures.

*Results*

Introduction into normal circadian rhythm, sleep-wake pattern, change in behavior in terms of reducing the degree of hyperactivity with significant expression of positive emotions, as well as considerable improvement of general health condition are the first rapid and encouraging positive effects. They reflect in mild regression in week 6 upon the completion of HBO treatment. At the beginning of a new session, they re-established with a tendency to create a good realistic basis for as good as possible integration of these children and their re-involvement, by implementation of special precautionary measures, in regular pre-school and school activities.

*Conclusions*

For achieving these effects an intensive simultaneous multidisciplinary restoration-rehabilitation work with special participation and motivation of parents is also required. This is where the extent of parent’s motivation during and after completed HBO treatment is crucial for accomplishing HBO effects, whose role and further investigation in this field is still of extraordinary significance.

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## HBO HYGIENE PROCEDURES: HOW TO PREVENT NOSOCOMIAL INFECTIONS

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*Introduction*

Hospital acquired nosocomial infections with multi-resistant micro-organisms is a growing problem. During hyperbaric work in our intensive care multiplace hyperbaric chamber the attending doctor and nurse follow hospital dress codes and procedures. There is also a vast array of cables, pressure lines, breathing circuits, keyboards and computer screens with dead so called “inanimate” surfaces where bacteria and fungi can hibernate. With increased number of critically ill patients treated in our hyperbaric chamber we wanted to study whether we have a problem with nosocomial pathogens persisting on inanimate surfaces (cf. Kramer A. et al BMC Inf Dis 2006).The aim of this work was to identify such inanimate surfaces and find preventive disinfection routines for hyperbaric use. After each HBO treatment session cleaning& disinfection is done according to normal standard procedures. Additionally we do regular scheduled preventive disinfection on weekly basis to avoid contamination due to the long survival time of bacteria and fungi on inanimate surfaces. The disinfectant used is Desisoft®, (PHMG, and PolyHexaMethhylGuanidinHydrochloride); a water-soluble, non-flammable disinfectant with long-term 7-day activity and no harm to acrylic windows.

*Methods*

Surface hygiene has been monitored in 6-12 months intervals in cooperation with the hospital hygiene section. Swab cultures for bacteria and fungi have been taken from the outlet of the built-in breathing circuit, the condense water tray of the air conditioning system, the in-chamber telephone keyboard and the keyboard & touch screens of computers and hands-on surfaces like handles, arm rest, patient transportation modules.

*Results*

We have found “acceptable” levels of microbes on the non-sterile areas tested and no cultures of pathogenic microorganisms despite repeat culturing at a number of inanimate surfaces.

*Conclusion*

Our preventive multidisciplinary hygiene program has raised the awareness of good hygiene routines. We stress the importance of regular scheduled disinfection of inanimate surfaces to prevent nosocomial infections.

## WAS FREDERIC CHOPIN ABLE TO LIVE LONGER?

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Keywords: HBO, Frédéric Chopin, Nikola Tesla

*Objectives*

At the last EUBS Conference, we have heard a respectable lecture of Dr Jordi Desola that the main problem in the short life of the famous composer Frederic Chopin was a lack of oxygen with excess $CO_2$ and mainly CO, incurred as a result of severe living conditions. All that was 50 years before Nikola Tesla`s discovery of alternating current which still heats our homes. Our aim was to scientifically verify that claim.

*Methods*

During winter months we allocated anamnestically ten male patients, age of 35-55, w/o previous smoking experience - who were involved in HBO therapy because of angiopathy of lower extremities, resulted from diabetes mellitus. They heat their homes with open fire, wood and coal. In the course of five days, theirs saturation % of hemoglobin (Hb), as well transcutaneous oximetry during the HBO treatment was monitored.

*Results*

Day before the start of HBO treatment in the experimental group Hb saturation was 96.5% (3/10), 97% (5/10), 97.5% (2/10), while in the control group was 99% (5/5). On the fourth day of HBO treatment, in experimental group Hb oxygen saturation was registered at value 98%. Transcutaneous oximetry in experimental group showed significantly low values of $P_PO_2$ before the HBO treatment, as well as a slower increase in incidence in the course and the final value at the end of HBO treatment. Such a relationship is maintained with a slight increase in the experimental group in just five days time to reach maximum values of % Hb oxygen saturation, which fully correspond to physiological conditions HBO.

*Conclusions*

These results clearly suggest that the arguments of Dr Desola were absolutely correct. The life of Chopin would be significantly longer, and the world immeasurably richer in a living conditions with electricity heating excluding hemoglobin disorder.

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## EVALUATION OF EFFECTS OF HYPERBARIC OXYGENATION IN TYPE 2 DIABETES PATIENTS BY THE MEANS OF TRANSCUTANEOUS OXIMETRY ($Tcp0_2$)

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Keywords: Hyperbaric oxygenation, Transcutaneous oximetry, Diabetic wounds

*Introduction*

We made a hypothesis that there is no leading therapy in non-surgical treatment of wounds in patients with diabetes type 2 and that HBOT is an important part of a combined treatment modality.

*Aim of the study*

The aim of the study was to try to quantify effects of hyperbaric oxygenation (HBO) by the means of $Tcp0_2$ in patients with type 2 diabetes and to point out HBO as a possible treatment modality.

*Material and methods*

We have enrolled 30 patients with foot ulcers and leg pain for tcpO2 measuring. All patients underwent three measuring; upon arrival, 30 minutes after the first HBO session and after the tenth session. All patients were treated in monoplace hyperbaric chambers at 2,4 ATA during 60 minutes. Microcirculation was measured at the foot and lower leg with $TcpO_2$ (PeriFlux 5000) in 30 patients (26 men and 4 women). We have used Sheffield's criteria (20 mmHg) as a threshold for the study. Lowest values for the study were 26 for the lower leg and 19 for the foot. All measurements were performed by same doctor and nurse.

*Results*

In 25 patients (83,34%) we measured an increase of basal values of partial pressure of oxygen in average of 30% for lower leg and 21% for the foot after 10 sessions of HBO. After four months there was no leg pain in 25 patients, but in 5 (16,66%) beside the leg pain there was a deterioration of local finding and they were sent for surgical treatment (three lower leg amputations and two foot amputations)

*Conclusion*

Treatment of diabetic wounds requires engagement of different treatment modalities and hyperbaric oxygenation can be applied as a useful treatment modality for diabetic wounds. TcpO2 can be used to choose patients for HBO, but also to evaluate the effect of HBO and should be used in wound healing centers.

# EXCEPTIONAL DIVING EXPOSURE, REPETITIVE DIVE AND THE DIVE COMPUTER (CASE STUDY)

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Keywords: Decompression illness, Dehydration, Hemoconcentration, Hematocrit

*Introduction*

Exceptional diving exposure represents dive profile that exceeds usual recommended limits, and contraindicates any SCUBA dive during next 12-18 hours.

*Method*

Case study of a 60-year old diver with decompression illness after two successive dives to depths of 68.2 m and 50.8 m. Breathing mixture during both dives and ascents to 20 m was compressed air. Bottom times were 12 and 19 minutes, and total diving times were 1 hour 5 minutes, and 55 minutes respectively. In both dives prophylactic decompression has been done breathing nitrox 49, and 100% oxygen above depths (shallower) of 20 and 9 meters respectively. With surface interval of 3 hours 45 minutes, it was a case of repetitive dive after exceptional exposure, highly un-recommended as a hazardous and unsafe practice.

*Results*

Besides clinical symptoms developed at the end of the last dive, and subsequently evolved in serious neurological impairment including cerebral, vestibular, spinal, musculoskeletal, and skin manifestations of decompression sickness, hypothermia, and hypotension,, laboratory results revealed intense hemoconcentration with hematocrit of 0.66 and red blood cells count of $7.18\times10^{12}$/L, confusing parameters of coagulation with shortened prothrombin time of 0.42, elevated INR index of 1.6, low blood platelets count of $126\times10^{9}$/L, and elevated D-dimers level of 4.97 mg/L, low sodium level of 131 mmol/L, and mild hyperglycemia of 10.3 mmol/L, which persisted more than 60 hours after surfacing, despite copious intravenous hydration.

*Discussion/conclusion*

Although many of standard safety procedures were neglected in these particular dives, the most disturbing fact is that state-of-the-art dive computer allowed such diving practice without any warning. Another similar, but poorly documented previous case of a diver who developed symptoms of decompression sickness with almost the same laboratory results, after SCUBA diving in extreme dive profile, indicate possible existence of a specific pattern of fluid shifting, with metabolic and hormonal changes, as a consequence of exceptional exposure to depth during SCUBA dive, which need to be meticulously investigated in future cases.

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## PREDICTORS OF MYOCARDIAL INJURY FOLLOWING IMMERSION PULMONARY OEDEMA IN SCUBA DIVERS: A REVIEW OF 48 CASES

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*Introduction*

Immersion pulmonary oedema (IPE) during scuba diving is increasingly observed for 10 years but the prevalence, risk factors and individual predispositions contributing to the development of this incident are still unknown. It has been recently reported that IPE tended to recur with a potentially fatal outcome, particularly in older divers. We hypothesize that the detection of cardiac abnormalities suggesting myocardial injury on laboratory investigations, ECG or transthoracic echocardiography at initial admission are at greater risk of acute heart failure that may explain some fatalities associated with IPE.

*Methods*

We collected information on scuba divers treated in 2 French hyperbaric facilities from January 2007 to March 2012 with a clinical and chest computed tomography evidence of IPE. Anthropometric data, diving and medical history, risk factors for cardiovascular diseases, diving procedure, breathing gas, context of exertion or anxiety, and water temperature were analyzed as potential variables predictive of IPE with cardiac involvement.

*Results*

Forty-eight consecutive patients (36 men, mean age (SD) 45 ± 13 years) were included (n = 39, Toulon; n = 9, Brest), representing 10% of all diving-related injuries treated during the period in question. We found that 16 (33%) patients initially presented elevated serum troponin levels associated with ventricular hypokinesis on echocardiography or ST-segment alterations on ECG. None of them complained of chest pain and all improved within 48 hours. Statistical analysis revealed that among all variables examined, only advanced age (P = 0.008, Mann-Whitney test), increased body mass index (P = 0.013, Mann-Whitney test) and combination of 2 risk factors including hypertension, smoking, dyslipidemia or diabetes (P = 0.012, Fisher exact test) were predictors of transient cardiac dysfunction following IPE.

*Conclusion*

Our study supports the notion that known individual risk factors of cardiovascular diseases are associated with IPE potentially leading to myocardial injury. The hypoxic or catecholaminergic nature of this condition remains to be established.

## LABORATORY VALIDATION OF DIVING COMPUTERS

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Keywords: Diving computer, Validation, Pressure sensor simulator

*Introduction / background / objectives*

Diving computer validation is a currently widely discussed topic. The diving computer workshop in Gdansk 2011 highlighted, that currently there are no standardized procedures or normative that address validation of a diving computer. EN13319 is typically applied during the EC certification of a diving computer, however this standard only addresses accuracy of pressure sensor and the clock, decompression calculation is explicitly excluded.

*Methods*

One major aim in design verification and validation is to develop test procedures that can be carried out in laboratory and this without requiring software changes in the original code of the diving computer. The approach followed in this part is based on laboratory testing of diving computers with a) simulated pressure values and b) in simulated dives in a wet test chamber.

*Results*

A pressure sensor simulator was developed using the I2C sensor protocol of Intersema – one of the major manufacturers of pressure sensors for diving computers. Pressures up to 30 bar can be simulated. A chamber pressure control unit was manufactured that uses the same commands as the simulator. A GUI was developed under National Instruments Labwindows in order to generate dive profiles and log dive data. The chamber is designed for a maximum operational pressure of 10 bar.

*Conclusion*

The current setup allows testing of a diving computer with the pressure sensor simulator by simply changing the I2C address in the firmware. No further changes are necessary. After passing this test, a diving computer can be tested using the same profile in a test chamber. Verification and validation files are automatically generated.

*Acknowledgment*

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## HEAD UP DISPLAY FOR FULL FACE MASKS

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Keywords: Diving computer, Head up display, Near eye display, Full face mask, AGA mask

*Introduction / background / objectives*

Professional and commercial divers prefer full face masks for a variety of reasons: Full protection of the face can be achieved and oral underwater communication is possible. Such divers often have to dive in very bad conditions including silt out – low or 0 visibility, where reading of a conventional diving computer is impossible. Previously we have already presented a first approach for a display for a diving mask (Koss B, Sieber A.IEEE Journal of Display Technology, Vol 7, Issue 4, pp 193-199, 2011).

*Methods*

Our first prototype head up displays were secondary and identical displays connected via a cable to a primary wrist worn diving computer. Different from that, the current device (patent pending) is a fully featured diving computer mounted directly in front of the visor of a full face mask. It can be easily adjusted to the diver's eye, as the support consists of several ball joints.

*Results*

One prototype was manufactured and tested on AGA style masks as well as OCEAN Reefs Neptune mask. The diving computer includes TRIMIX decompression calculation, multi gas support, a tilt compensated compass, tank pressure readout and a 96x64 pixel micro OLED RGB screen. The device can be connected and charged via USB and is recognized as pen drive mass storage medium.

*Conclusion*

This novel prototype provides a hands free diving computer solution for FFMs: Important diving data are always in the field of view of the diver, even in conditions like zero visibility, which is especially interesting for professional and commercial divers, who often have to dive in extreme conditions.

## LACUNAR SYNDROME AS AN INTRODUCING FORM OF BRAIN DECOMPRESSION ILLNESS

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Keywords: Lacunar Syndrome, Neurological decompression illness, Neuroimagenology, Diving medicine.

*Introduction*

Most of the cases described of neurological decompression illness (DCI) are caused by injuries in the spinal cord, and a very few cases reported by brain DCI. In a previous report I introduced a group of cases of neurological decompression illness, 50 % of brain DCI corresponded to lacunar syndromes, but with no images to prove their existence. The present communication corresponds to a lacunar syndrome case, confirmed by means of radiology as a way of introducing the neurological DCI.

*Methods*

Case analysis.

*Results*

SCM, 54 years old, without previous neurological decompression illness. He performed a 30 meters diving in cold water during an hour, and making a hard physical work, fixing of cages of salmon nets ,with omission of decompression. Comes up out of the water and right after that, he gets subtly transitory blindness, gets dizzy and also suffers from left side hemiparesis. Recompression in the sea with air was made as treatment twice. The treatment with hyperbaric oxygen therapy is started with a table 6 USN after 72 hours the symptoms appeared, and days after, 3 treatments with a table of 9 USN. After the treatment, the patient presented left side hemiparesis fighting moderate resistance, and showing sign of Babinski to the left. Head CT study spotted hypodense image in subcortical region of right hemisphere.

*Conclusions*

The case introduced, presents the symptomatology of a typical lacunar syndrome in a diver, in absence of major cardiovascular risk factors, so a diagnosis of neurological decompression illness is made. Transitory blindness the patient suffered could have been caused by nitrogen emboli in ophthalmic arteries, because of the big amount of bubbles present in divers from the area showed previously in autopsies and echocardiograph studies. The head CT highlights subcortical hypodensity (lacunar stroke) and doesn't show any sign of leucoaraiosis, so it is less likely to common etiology and supports diagnosis of disbaric origin.

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## NEUROLOGICAL DECOMPRESSION ILLNESS: BRAIN AND SPINAL CORD RESONANCE IMAGENOLOGY FINDINGS

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*Introduction*

Decompression Illness (DCI) is caused by the liberation in the blood and the tissues of inert gas bubbles during fast rising to the surface after diving. Neurological problems are the most serious expression of the DCI.

*Aim*

Introduce our experience in diagnosis by images of neurological DCI.

*Methods and materials*

Retrospective study between 09/2009 and 09/2010, with neurological DCI patients studied by means of Magnetic Resonance Imagenology (MRI) 1.5T.

*Results*

During that period, three masculine 40 year old patients were evaluated, all of them divers who suffered from disbaric accidents and treated in specialized centers with hyperbaric oxygen therapy. Two of the cases presented spinal cord DCI, with **tetraplegia** and **paraparesia**, respectively, besides sensitive and **esphinterian** alterations, developed progressive recovery of motor deficit but persisted with neuropathic pain. Spinal Cord MRI after 6 months, demonstrated hiperintense extended injuries of lateral cords in the first case and isolated focused lateral cords injuries in the second case. The other case presented neurological DCI, with conscious compromise, hemiparesia and cutaneous affection; all symptoms are reduced partially. After a month, neurological MRI showed **hiperintense** cord and subcortical **bifrontoparietal** injuries of **secuelar** aspect.

*Conclusions*

Neurological DCI shows typical characteristics in the MRI, in relation with its physiopathology. In Spinal Cord DCI, we observe injuries of white substance of the motor via at spinal cord level, in coincidence with literature reports. Those images do not belong to clinic syndrome, rather in injuries level nor in cordial compromise. In brain DCI cortical and subcortical injuries are observed. Clinical diagnosis is supported by MRI showing spinal cord and neurological injuries in different stages of the disease.

# HEART RATE VARIABILITY DURING A STANDARD DIVE: POSSIBLE INFLUENCE OF INSPIRED OXYGEN LEVEL?

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This study is part of the Phypode Project, financed by the European Union under a Marie Curie Initial Training Network Program

*Introduction*

One single field study on autonomic nervous system (ANS) activity during self-contained underwater breathing apparatus (SCUBA) diving highlighted, as during hyperbaric exposure, that diving induced a rise in vagal activity and a decrease in cardiac sympathetic activity. Unfortunately these results are subject to caution because of the small sample and the variability of the depth-time profile.
In the course of a standardised dive experiment, we tried to confirm these ANS modifications and to understand the role of oxygen (if any) in these mechanisms.

*Methods*

Thirty divers, of comparable age, weight, length, lifestyle and physical condition performed a standard dive to 33msweither in open circuit with compressed air (OC=24) or closed circuit with a fixed set point at 1.4 (CCR=6). Divers were equipped with a Polar® belt in order to record the RR intervals. These were analysed using time-domain, frequency-domain, Poincare plot and fractal analysis.

*Results*

Mean RR, root mean square of successive differences of interval (rMSSD), high frequency of spectral analysis and standard deviation 1 of Poincare Plot increased ($p<0.01$) during the dive. Low frequency/high frequency ratio decreased during the dive ($p<0.01$) but increased after the dive ($p<0.05$). This decrease was more pronounced while in closed circuit suggesting a role of oxygen exposure.
While remaining within physiological limits, we observed an increase in fractal dimension (FrD) mainly during the descent. This increase was more marked for CCR divers ($p=0.034$).

*Conclusion*

These results confirm a rise in parasympathetic activity and a decrease in cardiac sympathetic activity during SCUBA diving and suggest that oxygen exposure could have a part in it.

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## COMPARISON BETWEEN AN ACTIVE AND PASSIVE SEXUAL INTERCOURSE WORKLOAD: "EFFORT AFTER DIVING?"

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This study is part of the Phypode Project, financed by the European Union under a Marie Curie Initial Training Network programme

Keywords: Metabolic cost, Sexual intercourse, Effort after diving, DCS risk

*Objectives*

Following a question from divers, whom wanted to know if sexual intercourse after diving can be at risk as an effort, we analysed the level of effort for an active sexual intercourse (ASI) and a passive one (PSI) compared to the same $VO_2$ and watts reached on a cycloergometer.

*Methods*

Nine young (mean age 22.6+/-0.94 years) healthy, Caucasians, heterosexual individuals (5 boys and 4 girls) volunteered for the study. Using a VO2000 - Medgraphics® and a Polar® belt, we recorded the $VO_2$, $VCO_2$, ventilation rate, respiratory quotient, heart rate, RR intervals, etc. In order to guaranty the privacy of the participants, data were recorded on a PC with a telemetry system. The partners had to perform several measurements during one week. The results obtained during the sexual intercourse were then compared to a calibrated effort on a cycloergometer. The comparison of the level of $VO_2$ consumption at the climax of sexual intercourse to the same $VO_2$ consumption reached during the ergometric effort, allowed us to determine the workload in watts.

*Results*

We note that sexual intercourse leads to a general increase of workload depending on the type of activity (passive or active). The oxygen consumption increased to 29.5 l/min/kg for an ASI and 17.3 l/min/kg for a PSI. Ventilation ranges from 33.5 to 44 l/min. Changes in cardio respiratory parameters during an ASI and a PSI have shown that the effort is not as important as sometimes supposed. The increase in workload and ventilation is relatively mild. An ASI corresponds to a mean workload of 139 Watts and a PSI to 81 Watts mean workload.

*Conclusion*

Our results have shown that to perform a sexual intercourse increased the workload in a relatively mild way and would not be considered as heavy physical activity after diving. To be on the safe side we recommend not to "rock the boat" to heavily. This study may also find its interest in rehabilitation programs for patients with cardiopulmonary risk or heart transplant patients.

## IN VITRO CONSTRUCTION OF COMPRESSION AND DECOMPRESSION MODEL SYSTEM

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Keywords: Diving, In vitro real time monitoring, Activity of arterial endothelial cell, Bubble formation, Decompression sickness

*Background*

Mechanism of intravascular bubble formation and its effect on the activities of arterial endothelial cells during diving is the focus of recent studies on decompression sickness. *In vitro* compression and decompression model system is being constructed to achieve *in vitro* real time monitoring of cell activity by fluorescent microscopy and confocal microscopy during decompression on endothelial cell or mesenteric artery.

*Methods*

A small chamber with sapphire windows on both sides and located on the stage of an inverted microscope was built to allow compression and decompression of isolated cell or organ. Hydrostatic pressure, gas partial pressures, temperature and perfusion speed inside the chamber were monitored and controlled in order to reproduce diving conditions *in vitro*.

*Results*

Activity of endothelial cell or mesenteric artery during diving simulation was real time monitored through the chamber. Moreover, hydrostatic pressure control ranges from 100 to 1000 kPa during compression and decompression. Speed controls of compression and decompression range from 20 to 2000 kPa/min. Temperature of perfusion flow was controlled between 37 and 38 ℃. Carbon dioxide of air saturation was constant at 35 mmHg. Real time oxygen partial pressure in the system was optically measured. Perfusion speed could be controlled from 0.05 to 10 ml/min.

*Conclusion*

The system can support physiologically viable organs and cells with observable scape for real time monitoring of cellular activity during diving. The system allows regulating of hydrostatic pressure, speed of compression, decompression, temperature, gas saturation (oxygen measured *via* oxygen partial pressure) and perfusion speed. It also permits to maintain carbon dioxide partial pressure constant during the dive. This compression and decompression simulation model for *in vitro* diving will be a valuable tool for investigations in the field of decompression sickness.

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## DECOMPRESSION SICKNESS IN CAISSON WORKERS IN A TUNNEL PROJECT IN AMSTERDAM

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Keywords: Decompression sickness, Caisson work, Hyperbaric medicine

*Background*

In 2003 a major caisson project has started in Amsterdam to build a new underground railway line. In 2011 one of the underground stations was partly constructed under increased atmospheric pressure (1.8 – 2.2 ATA). For this part of the project 312 workers have been certified 'Fit to dive'. In a period of 4.5 months 8500 dives (max 6 hrs dive time) were made. The hyperbaric department of the AMC delivers the medical backup system in close cooperation with the Diving Medical Center.

*Methods*

The patients were admitted and examined on the emergency department by an emergency physician and neurologist and a CT-scan was made of the affected area and the lungs. Anamnesis was taken with information regarding their diving history. If the diagnosis of decompression sickness was confirmed the patients were treated in the hyperbaric facility of the AMC.

*Results*

Five patients had symptoms of decompression sickness and were treated in the hyperbaric chamber. Four patients had pain in their upper joints, one also in the hip joint. Two of them also had a rash and spots on the skin. The CT-scan showed a small gas bubble in a joint in two patients. These four patients were treated with the US Navy treatment table 6. One patient with only skin symptoms was treated with the HBO treatment table (2.5 ATA, 1.5 hr $O_2$). All patients were symptom free after the hyperbaric treatment. Four workers were permitted for caisson work after 4 weeks. In one patient a bleb was found in the right lung top.

*Conclusion*

The incidence of 0.06% is normal compared to the literature for divers (0.03 – 0.09%). Numbers for caisson workers are not available. The treatment given was sufficient for the signs and symptoms of the patients. The coincidental finding of the bleb in the lung of one caisson worker resulted in a prohibition of compressed air work and diving.

# A CROSS-SECTIONAL STUDY DESCRIBING ALL DIVERS SEEN AT A PRIVATE MEDICAL PRACTICE IN DUBAI, UAE

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Keywords: Diving medicine, Private practice, Scope of practice

*Introduction*

SCUBA diving is getting more popular as a sport and occupation and with its increased popularity many doctors are faced with the requirement to perform routine diving medical examinations and attend to diving related injuries. This cross-sectional study describes all divers seen at the private medical practice in Dubai, United Arab Emirates.

*Methods*

All consultations in the practice are electronically captured and IT personnel extracted all consultations containing the words “diving” OR “dive” or “diver” or “scuba” over a one-year period for analysis

*Results*

There were 209 patient visits related to diving medicine. The largest percentage of patients (54%) was seen for a routine diving medical examination and no underlying disease was detected. Of the patients who presented with underlying illness, the greatest number of persons presented with ENT conditions (36% of all consultations). Persons declared as unfit to dive (n=18) were more likely to be at the extremes of age (younger that 20 or older than 50) (OR=3.1; 95%CI=1.1–9.2; p=0.037), more likely to present with respiratory system (OR=9.1; 95%CI=3.2–25.7; p<0.000) or cardiovascular (OR=4.7; 95%CI=1.3–16.7; p=0.029) concerns, but less likely to present with a problem related to the ENT system (OR=0.2; 95%CI=0.06–0.8; p=0.012), more likely to be a student on a diving course than someone who has already qualified as a diver (OR=10; 95%CI=2.8–35.8; p<0.000). Decompression sickness made up only 2% of all consultations and the other pathologies combined made up 8% of all consultations.

*Conclusions*

Any doctor involved in diving medicine should have a thorough knowledge for fitness to dive examinations, diving fitness criteria (with specific reference to the ENT, pulmonary and cardiovascular systems), as well as diving related ENT pathology. Although ENT pathology is seen most commonly, it rarely is a cause for declaring a person permanently unfit to dive.

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## A SURVEY OF ANTIMALARIAL MEDICATION USE AND ITS EFFECTS IN RECREATIONAL SCUBA DIVERS

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Keywords: Malaria prophylaxis, Side effects, Recreational diving, Scuba

*Introduction*

Malaria is prevalent in many popular diving areas and a growing number of scuba divers are at risk of contracting malaria. Medication side-effects could be problematic in divers. The risk of side-effects versus contracting malaria should be assessed in prospective travellers. Divers are known for risk-taking behaviour, including non-compliance with prophylaxis. This study aimed to describe the practices and experiences of recreational divers.

*Methods*

An online survey was used (August to September 2011) after contacting dive operators in thirteen endemic countries. Potential participants were requested via email to complete the survey.

*Results*

283 questionnaires were analysed. 58% didn't use any prophylaxis during their last malaria area visit and 8.5% previously suffered malaria. Americans were more likely to take prophylaxis (OR=1.86; 95%CI=1.05-3.3; p=0.03). Current prophylaxis was not associated with a history of malaria (OR=1.26; 95%CI=0.77-2.04; $Chi^2$=0.372); likewise, there was no association between the prophylaxis use and experiencing constitutional symptoms (OR=1.6; 95%CI=0.98-2.85; p=0.059) or an adverse diving incident or accident (OR=0.995; 95%CI=0.45-2.19; p=0.99); Doxycycline was associated with gastrointestinal symptoms (OR=2.72; 95%CI=1.20-6.18; p=0.014) and Mefloquine with an experience of psychological symptoms during the diving holiday (OR=3.26; 95%CI=1.34-7.90; p=0.006). Malarone was not associated with side-effects. Reasons for not taking malaria prophylaxis included: not knowing it was a risk area (9%); not willing to take medication (11%); considering the malaria risk small (19%); thinking it complicates the diagnosis (8%); being advised by a health care worker that it was not necessary (9%); previously experiencing side-effects (5%) and "other" reasons (25%).

*Conclusion*

Assessing malaria risk and prescribing prophylaxis should be part of diving physician training. Side effects are common, but don't seem to be associated with diving incidents or accidents. Qualitative studies would be helpful to elucidate specific factors associated with non-compliance. Prospective studies should look at side-effect rates in divers.

## OXIDATIVE STRESS IN BREATH-HOLD DIVERS AFTER SUCCESSIVE DIVES

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This study is part of the Phypode Project, financed by the European Union under a Marie Curie Initial Training Network programme

Keywords: Free radicals, Nitric oxide, Peroxinitrites, Thiols, Apnea

*Objective*

The aim of the study was to analyse the plasmatic oxidative stress variations after a series of successive breath-hold dives at 20 meters depth adding up to 20 minutes.

*Methods*

Thirteen breath-hold divers (29 +/- 4,6 years, 176,5 +/- 4,4 cm, 73,9 +/- 4,6 kg) were asked to perform a series of dives to 20 m adding up to 20 minutes in open sea (Isola d'Elba – Italy). Nitric oxide (NO), peroxinitrites ($ONOO^-$) and thiols (SH) were measured before and after the dive.

*Results*

Breath-hold divers were asked to perform a minimum of 5 dives. The average was 9 ± 2 dives with average immersion time of 20,9 ± 0,2 minutes. Circulating NO significantly increases after a series of breath-hold dives (169,1 ± 58,26 % of pre-dive values; $p < 0,001$). $ONOO^-$ doubled after the successive breath-hold dives (207,2 ± 78,31 % of pre-dive values; $p = 0,0012$). Thiols significantly reduced. (69,88 ± 19,23 % of pre-dive values ; $p<0,001$).

*Discussion*

During breath-hold diving, an increased circulating NO is observed along with an increase in $ONOO^-$ and a reduction of SH. NO can be produced by physical effort caused by breath-hold diving. Physical exercise, the transient hyperoxia followed by hypoxia and accumulation in $CO_2$ increase the level of anion superoxide ($O_2^{\cdot-}$). It facilitates interaction of $O_2^{\cdot-}$ with NO to form $ONOO^-$, opposed to a production of SH. Oxidative stress is thus present in breath-hold diving.

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## REDUCTION OF VENOUS GAS EMBOLI LOAD AFTER BREATHING NORMOBARIC OXYGEN

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Keywords: Oxygen, DCS, normobaric, VGE

*Background*

The following five case studies were drawn from a large number of experimental and routine dives. Any venous gas emboli (VGE) evolving post-decompression were monitored with audio Doppler ultrasound in order to assess decompression sickness (DCS) risk. In a number of cases, the VGE load was so great for a prolonged period post-dive that the subjects were administered normobaric oxygen, with the intention to aid 'wash-out' of supersaturated inert gas from the tissue and so reduce VGE production.

*Methods*

Over a period from 2009 to 2012, a wide range of dives, both wet and chamber, routine or experimental, were made. Some used air for decompression, while others used nitrox or trimix. Post-decompression, monitoring of VGE was carried out, using the Kisman Masurel (KM) grading system. If a subject's score remained high (circa KM 3+ or above) across the observation period (up to 2 h) and showed no sign of decreasing, then the decision was made to administer normobaric oxygen over 30 minute periods until the VGE load decreased.

*Results*

Five cases in which normobaric oxygen was administered are reported. Of these, one described some very mild shoulder pain that disappeared on breathing $O_2$, while another complained of itching and then shoulder pain and was subsequently treated for DCS.

*Discussion*

In all cases (bar the one treated for DCS) breathing normobaric oxygen reduced the peak KM grade. The dive profiles and breathing gases from which these case studies are taken are varied and may account for the reason why 30 min $O_2$ administration was enough to reduce the VGE load in some subjects, while in others, 60 min of $O_2$ was necessary.

## DESTRUCTION OF A PROPTOSIS, A POSSIBLE CAUSE OF PULMONARY BAROTRAUMA

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*Background*

This case report illustrates a possible pathogenetic mechanism of barotrauma. “Emphysema Like Changes” (ELCs) have been documented in central lung regions, in spontaneous pneumothorax (SP) patients, who have never smoked. A central location of the ELC may suggest weakness and potential rupture of proximal airways as a cause of SP.

*Case report*

A male non-smoking metal worker with SP 1986, contracted debilitating dyspnoea in 2003, which deteriorated until 2007. All examinations, including chest-X-rays, were negative. High Resolution Computerized Tomography (HRCT) of the lungs in 2007 was also considered negative. A 3D image of the airways was reconstructed from both the horizontal and vertical series of 2D sections of a HRCT in 2007. This demonstrated previously undetected peribronchial air, located mainly along the presegmental airways on the right side. After digital subtraction of the air an approximately 1.5 mm x 2.0 mm hole was detected on the dorso-cranial side of the right main bronchus, near the origin of the right, upper 3rd generation of airways. The perforation could be identified at the re-examination of the 2007 HRCTs.. In 2009, a new HRCT with a 3D airway reconstruction was performed, confirming the previous results, but showed a decreased size of the perforation. The patient’s health continued to improve. In 2010 control HRCT examinations showed healing of the perforation. A retrospective study of a HRCT from 2002 demonstrated a 2 mm in diameter hemispherical protruberance (namned *proptosis*) contiguous with the intrabronchial space at the site of the perforation. It may be interpreted as an indicator of a local weakness of the bronchial wall.

*Conclusion*

A 3D HRCT reconstruction should be considered to detect bronchial anomalies, including wall-perforation, when unexplained dyspnoea or other chest symptoms call for extended investigation especially in SP patients, and in people exposed to changing ambient pressures.

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# DECOMPRESSION MODELLING: A PROJECTION PROCEDURE FOR DISSOLVED PHASE TRACKING SIMULATIONS

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Keywords: Dissolved phase tracking, Decompression modelling, Scuba diving, Bülhmann algorithm

*Introduction/ Background/ Objectives*

The goal of the current work is to develop a decompression model which would give quantitative bubble loads post-dive. As a first step to develop a simulation platform, a decompression procedure using dissolved phase tracking (Bülhmann) was implemented in MatLab. The objective was to see whether a projection procedure could choose the best ascent scenario from the set of all possible ascents that would not violate the Bülhmann prerequisites.

*Methods*

Two constraints were given to exclude impractical decompression stops. The shallowest stop allowed and the minimum distance between subsequent stops were both set to 3m. A mathematical relationship between the number of scenarios to test and the calculated compulsory first decompression stop was found.

*Results*

In addition to being in practice much easier to implement since it is easier for a diver to limit the number of stops required, the projection procedure was also found to save a few minutes of decompression time on the profiles tested, compared to the traditional Bülhmann implementation.

*Discussion/ Conclusion*

A better implementation in terms of saving decompression time and simplifying the decompression procedure practically by reducing the number of stops was found possible through the use of the projections method, calculating all possible ascent scenarios and choosing the fastest one. The number of scenarios to test was shown to be dependent on the first decompression stop and therefore could be used to maximise speed of implementation on a dive computer. Obviously, the next step is to incorporate explicit bubble dynamics after in-vitro experiments to predict bubble load post-dive, as well as bubble counting procedures post dive for the validation of the physical model physiologically.

# ACUTE MEDULLARY SYNDROME PROVEN BY MRI AFTER STRENUOUS EXERCICES UNDERWATER, TREATED SUCCESSFULLY BY HBOT PROVE BY REPEATED MRI

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Keywords: Acute medullary syndrome, Stroke, Barotrauma, Hyperbaric oxygen treatment

*Introduction*

Formation of gas bubbles is a major feature in the pathophysiology of diving sickness although other factors and mechanisms may play an important role. We report a clinical case of a diving accident in the context of heavy exercise, in spite of a well done ascending protocol.

*Clinical case*

We report an acute medullary syndrome in a previously healthy 45-year-old man, after diving 25 m deep transporting heavy materials (maximal depth 25 m, bottom time 30 minute, rate of ascend lower than 18 m / minute, performed 5 minutes stop at 3 m during ascend). The patient complained of incapacity to walk and lost sensibility in both legs soon after reaching surface. In the emergency room he presented a paraparesis with plegia of the right leg, a level of sensibility at D8, and urinary incontinence. A medullary MRI depicted an acute ischemic intramedulary lesion at D5-D7. The patient was treated with hyperbaric oxygen chamber sessions (started with table 6 extended followed by routine sessions) and physiotherapy with significant functional recovery. A control medullary MRI showed no lesions.

*Discussion/conclusion*

Despite a good protocol and no previous vascular risk factors, the reported patient developed a spinal stroke. Strenuous exercises underwater were the only identified risk factor for a diving accident. We discuss the role of an increased demand for oxygen when doing strenuous exercise while diving, and the possible development of ischemia in susceptible individuals with lower tolerance to hypoxia. It is important to report clinical cases of stroke in diving accidents. The identification of contributive risk factors to diving sickness other than decompression may help to understand and characterize the pathophysiology of ischemic lesions underwater, in particular, stroke.

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## BODY COOLING IN COLD WATER IMPROVES DYNAMIC FUNCTIONAL NASAL PARAMETERS

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Diving is associated with a number of hazards, and one of them is a barotrauma of the middle ear or the sinusoids due to blocking of the nose and problems with pressure equalization. Little is known, if diving in cold water might increase the risk of nose blocking by swelling of the musosae.
We exposed 28 male volunteers (22.6±3.5ys, BMI 24.2±3.6) in a basin to 18°C water temperature in head-out immersion until subjective end of well-being. Rectal temperature was measured before and after exposure, and acoustic rhinomanometry as well as rhinoresistometry were used for measurement of functional nasal flow parameters.

*Results*

Mean exposure time in the basin until end of well-being was 35.5±13 min., and rectal temperature dropped from 36.9±0.4 °C to 36.1±0.9 °C directly after leaving the basin and further to 35.9±0.6 °C in the late measurement 30 min after leaving the basin. Rhinoresistometry revealed that nasal diameter correlated significantly negative with rectal temperature (p=0.007), and nasal resistance decreased significantly concordant to rectal temperature (p=0.023), too.

*Conclusion*

Mild core cooling due to cold water immersion is accompanied by an improvement in some dynamic functional nasal parameters. Thus, diving in cold water seems not to increase the risk of nose blocking.

Mit freundlichem Gruß

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## EXHALED NITROUS OXIDE AND LUNG FUNCTION AFTER PROVOCATION WITH COLD DRY AIR IN HEALTHY AND ASTHMATIC SUBJECTS

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Keywords: Asthma, Nitrous oxide FeNO, Exercise-induced bronchoconstriction, Full-face-mask FFM, Mouthpiece regulator

*Introduction*

With the growing number of recreational SCUBA divers, an increasing number of asthmatic subjects perform SCUBA dives as well. Cold and dry air is known to trigger bronchoconstriction and airway inflammation. Nasal breathing via full-face-masks (FFM) provides warmer and more humid air and might attenuate respiratory effects

*Methods*

Six asthmatic and nine non-asthmatic subjects breathed air via a full-face-mask or a mouthpiece-regulator in random order. Each provocation consisted of breathing air for one hour on five consecutive days. Before and after each provocation, assessment of exhaled nitrous oxide and spirometry were performed.

*Results*

The provocation pattern used in the present study did not result in a significant increase in exhaled nitric oxide or a decline in expiratory flows and volumes in asthmatic and non-asthmatic subjects. Furthermore, there was no significant difference between full-face-masks and mouthpiece regulators.

*Conclusions*

In the present study, the use of full-face-masks did not result in beneficial respiratory effects.

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## EFFECTS OF COLD WATER SCUBA DIVES WITH FULL-FACE-MASK OR DIVING MASK AND MOUTHPIECE REGULATOR ON BODY TEMPERATURE, HEART RATE AND LUNG FUNCTION

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Keywords: Heat loss, Hypothermia, Bradycardia, Spirometry, Winter dive

*Background*

The use of full-face-masks (FFM) is becoming more common even in recreational diving, especially for cold water dives. FFM prevent the diver's face from cold and enable nasal breathing. The aim of the study was to evaluate the effect of FFM on heat loss, heart rate and lung function.

*Methods*

21 divers performed two cold water dives – one with a full-face-mask and the other with a conventional diving mask. Spirometry was performed 45 and 15 min before and 10, 20 and 30 min after each dive. Oral, tympanic and various skin temperature measurements were measured before and after each dive. Diving depth, ambient temperature and heart rate were measured continuously during the dives. Each diver evaluated his well being and cold sensation during each dive on a visual analog scale.

*Results*

Significant declines of static and dynamic pulmonary function parameters, heart rate and oral, tympanic and skin temperature occurred after both dives with FFM and dives with conventional diving mask. After FFM dives oral and tympanic temperatures decreased significantly less than after diving mask dives. While well-being and cold-sensation were significantly improved with FFM dives compared to conventional mask dives, no differences were obtained between exposures for heart rate or lung function.

*Discussion*

During cold water dives the use of FFM appears to prevent divers from hypothermia more efficiently than diving masks. Furthermore FFMs reduce the cold sensation and enhance the well-being of the divers. Even though protecting the face from cold water and heat loss, FFMs do not reduce cardiac and respiratory effects of cold-water SCUBA dives.

# AFTER IMMERSION PULMONARY OEDEMA OF COMMERCIAL DIVERS: IS MORE THAN PULMONARY HRCT NEEDED IN THE FTD EXAMINATION?

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Keywords: Diving, Immersion pulmonary oedema, FDT

*Introduction*

Immersion pulmonary oedema (IPE) can affect previously healthy divers and is characterized by coughing, dyspnoea, hemoptysis, and hypoxemia. The condition is probably induced by heavy work, cold temperature, negative transrespiratory pressure, and oral fluid loading before diving and caused by increased pulmonary vascular pressure leading to pulmonary capillary leak and transudative oedema. The incidence of IPE is difficult to assess as many cases probably go unreported or misdiagnosed. Most divers with IPE recover after treatment with normobaric oxygen or beta2-agonist therapy, but fatalities have been reported. Recompression therapy is not indicated. Post event evaluation of individuals with IPE often includes high-resolution, thin-section CT scanning of the lungs (HRCT), measurement of the CO diffusion capacity of the lungs and serial pulmonary function tests.

*Methods*

*Incident report:*
A previously healthy commercial diver experienced shortness of breath and coughing of frothy sputum during and after a cold water work-dive to 8 m. Medical examination post-dive was normal except for low oxygenation of the arterial blood. The X-ray examination of the lungs was normal.

*FTD examination:*
The FDT examination performed 2 weeks later included HRCT of the lungs, TEE, work load test and functional tests of the lungs including CO/VA. All tests were normal and even better than average. The diver was judged to be healthy and fit to dive and was allowed to return to work.

*Discussion*

Tests of divers who have recovered from IPE show that they have an exaggerated vasoconstrictive response to cold. This indicates that some divers are more likely to develop IPE than others. At present, however, the recommended evaluation after IPE does not include any test that would show this exaggerated response to cold.

What should we recommend? That any diver that develops IPE is ‘not fit to dive’? That an in-water test that could provoke IPE is included in the FDT examination?

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