

28TH ANNUAL MEETING OF THE EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY

Brugge, September 4, 2002

SYMPOSIUM: Hyperbaric Oxygen in 2002 from Mechanism to Indication

- 19:00 **Introduction** - Peter Germonpré
President of ACHOBEL, Head of the Centre for Hyperbaric Oxygen Therapy of the Military Hospital Brussels
- 19:15 **HBO chambers: technics to suit medicine**
Robert Houman
Safety Director of the Centre for Hyperbaric Oxygen Therapy of the Military Hospital Brussels, secretary of ACHOBEL, member of the CEN Working Party "Normalisation of HBO Chambers"
- 19:30 **Working principles and effects of HBO therapy**
Sven Van Poucke
Anesthesiologist, Head of the Hyperbaric Oxygen Unit of the University Hospital Antwerpen (UZA)
- 20:00 **From mechanism to clinical application: role of HBO in wounds and infections**
Daniel Mathieu
Professor in Resuscitation and Intensive Care, Head of the "Centre Régional d'Oxygénothérapie Hyperbare" (CROHB) of the University of Lille (FR), President of the European Committee for Hyperbaric Medicine (ECHM)
- 20:30 **Does HBO play a cost-effective role in radiation injury treatment ?**
J-CI Lemper
Internal Medicine Specialist, Consultant at the Centre for Hyperbaric Oxygen Therapy of the Military Hospital Brussels
- 21:00 **HBO - a therapy in search of indications ? Role of HBO in sudden deafness and other diseases**
Dirk-Jan Bakker
Surgeon, former Head of the Centre for Hyperbaric Oxygen Therapy of the Academic Medical Center (AMC) of the University of Amsterdam (NL), currently Medical Director of the AMC
- 21:30 **Discussion**
Moderators: Karel Vandeveld, Eric Mortier
Karel Vandeveld: Anesthesiologist, Head of the Hyperbaric Centre of the AZ St.-Jan in Bruges;
Eric Mortier: Anesthesiologist, Professor at the University of Ghent Medical Faculty, Head of the Anesthesiology Department of the University Hospital Ghent
- 22.00 **Reception**, hosted by ACHOBEL and the BVOOG-SBMHS
(Belgian Society for Diving and Hyperbaric Medicine)

28TH ANNUAL MEETING OF THE EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY

Brugge, September 4 - 8, 2002

Thursday, September 5, 2002

Scientific session 1: Diving Medicine

Chairmen: Marroni A., Méliet J.L., van Hulst R.

- 10:00 **Keynote Lecture:** Oxygen transport and oxygenation
Deby-Dupont G., Lamy M. (Liège, Belgium)
- 11:00 O-1 Pretreatment with hyperbaric oxygen may reduce gas bubbles in decompressed prawns (*palaemon elegans*) by eliminating gas nuclei
Arieli Y., Arieli R., Marx A. (Haifa, Israel)
- 11:15 O-2 Intravascular ultrasound contrast agent particles distribution in the cerebral, renal and lower limb arteries - Consequences on diving physiology
Besnard S., Philippot M., Hervé Ph., Porcher M., Arbeille Ph. (Tours, France)
- 11:30 O-3 First results with diving-ergospirometry in the dive-chamber of the German Naval Medicine Institute
Koch A.E., Kramkowski D., Rump A., Bettinghausen E., Rieckert H. (Kiel, Germany)
- 11:45 O-4 A new approach to increase decompression safety in deep compressed air work
Faesecke K.-P. (Hamburg, Germany)
- 12:00 O-5 Long-term effects of saturation diving on pulmonary function - Reduction in FEF 50% and FEF 75% in early period of diving career
Suzuki S., Thorsen E. (Yokosuka, Japan & Bergen, Norway)
- 12:15 O-6 A statistic review of 144 cases of decompression illness treated in the hyperbaric facility of Grosseto
Brauzzi M., Tanasi P. (Grosseto, Italy)
- 12:30 **LUNCH**

Scientific session 2: Diving Medicine

Chairmen: Brubakk A., Van Bogaert H., Ross J.

- 13:30 O-7 Transesophageal echocardiography of divers treated for DCI
Arnell P., Bardin C., Johansson M.C., Örnhagen H. (Göteborg & Stockholm, Sweden)
- 13:45 O-8 What ascent profile for the prevention of decompression sickness? I - Recent research on the Hill / Haldane ascent controversy
Bennett P.B., Marroni A., Balestra C., Cali Corleo R., Germonpré P., Pieri M., Bonuccelli C. (DAN Europe, Malta; Brussels, Belgium; Durham, USA)
- 14:00 O-9 Time related opening of the foramen ovale in divers
N'Guyen A.-F., Germonpré P., Balestra C., Hastir F., Dendale P., Unger Ph., Marroni A. (DAN Europe Research; Brussels, Belgium)
- 14:15 O-10 PFO detection in divers: methodological aspects
Balestra C., Germonpré P., Snoeck T., Marroni A., Cali Corleo R., Farkas B. (DAN Europe Research; Brussels, Belgium)
- 14:30 O-11 What ascent profile for the prevention of decompression sickness? II - A field model comparing Hill and Haldane ascent modalities, with an eye to the development of a bubble-safe decompression algorithm.
DAN Europe DSL Special Project 'Haldane vs Hill'
Marroni A., Bennett P.B., Balestra C., Cali Corleo R., Germonpré P., Pieri M., Bonuccelli C. (DAN Europe; Malta; Brussels, Belgium; Durham, USA)
- 14:45 O-12 Anesthesia in the diver patient before complete desaturation
Eggermont Y., Jacobs D. (Brussels & Charleroi, Belgium)
- 15:00 **COFFEE BREAK**

Scientific session 3: Hyperbaric Oxygen**Chairmen:** *Schmutz J., Vandeveld K., Roque F.*

- 15:30 O-13 Reduction of the healing time in non-ischemic chronic diabetic foot ulcer by hyperbaric oxygenotherapy (HBO) - A prospective randomized study
Bilbault P., Kessler L., Ba Faye A., Zaghdoudi I., Assemi P., Pinget M., Schneider F., Jaeger A. (Strasbourg, France)
- 15:45 O-14 Hyperbaric oxygen in the treatment of non-healing diabetic foot ulcers
Albuquerque e Sousa J.G., Roque A.F., Simao A.G. (Lisbon, Portugal)
- 16:00 O-15 Hyperbaric oxygen therapy in the treatment of diabetic foot lesions - A randomized controlled prospective study
Working Group 'HBO and diabetic foot lesion' of COST B14 action. Mathieu D. (Lille, France)
- 16:15 O-16 Hyperbaric transcutaneous oxygen predicts arteriography results in diabetic foot patients
Cechurova D., Lacigova S., Ruzicka J., Rusavy Z. (Pilsen, Czech Republic)
- 16:30 O-17 Osteoradionecrosis: the root of the problem
Patel K.K., Starr D.G., Laden G. (Humberside, UK)
- 16:45 O-18 Hyperbaric oxygen and radiotherapy - An intermediate report from the COST B14 working group oncology
Sminia P., Schmutz J., Hamilton-Farrell M., Sicko Z., Melamed Y., Jansen E., Luciano D., Carl U., Granström G., Van der Kleij A.J.
- 17:00 O-19 Microbiology of the wounds in patients with clinical gas gangrene: a 7-year retrospective study
Kot J., Sicko Z., Pegiel E. (Gdynia, Poland)
- 17:15 O-20 Femoral head necrosis and hyperbaric oxygen - a MRI study
Study protocol adopted from the COST B14 Working Group "2"
Ditri L., Grigoletto F., Melamed Y., Reis D., Cucci L., Germonpré P., Mesimeris T., Montanari M., Ratzenhofer-Komenda B., Rocco M., Travnik L., Vande Berg B.

Friday, September 6, 2002

Scientific session 4: Hyperbaric Physiology**Chairmen:** *Balestra C., Mortier E., Vanderkleij A.*

- 08:30 **Keynote Lecture:**
Living without oxygen
De Baerdemaeker L. (Gent, Belgium)
- 09:30 O-21 The influence of hyperbaric oxygen (HBO) on primary, platelet-related haemostasis
Van Poucke S., Stockman B., Peelaers K., Van de Heyning P., Beaucourt L. (Antwerp, Belgium)
- 09:45 O-22 Heat acclimation induces protection against CNS oxygen toxicity in the rat: HSP72 may be involved
Arieli Y., Eynan M., Gancz H., Arieli R., Kashi Y. (Haifa, Israel)
- 10:00 O-23 Pathways involving neuronal and endothelial nitric oxide in CNS O2 toxicity
Demchenko I.T., Atochin D.N., Boso A.E., Huang P.L., Piantadosi C.A. (Durham & Boston, USA)
- 10:15 O-24 High pressure modulation of dentate gyrus transfer function of dynamic cortical information
Talpalar A.E., Grossman Y. (Beer-Sheva, Israel)
- 10:30 O-25 Effects of hyperbaric oxygen on reactivity of smooth muscles of isolated blood vessels
Jovanovic T., Brkic P., Mitrovic A. (Belgrade, Yugoslavia)
- 10:45 O-26 Nitrous Oxide and Xenon: therapeutic promises for 'glutamatergic' diseases
Abraini J.H., Davide H.N., Buisson A., Chazalviel L., Berenguer P., Lemaire M. (Caen & Paris, France)
- 11:00 O-27 The effects of HBO treatments on vigiliy of spermatozoids in 'in vitro' circumstances
Mitrovic A. (Belgrade, Yugoslavia)
- 11:15 **COFFEE BREAK AND POSTER VIEWING**

Scientific Session 5: Poster presentation**Chairmen:** *Méliet J.L., Lemper J.C., Ruzicka J.*

12:00 Presentation of posters

- P-1 Result of 918 man-oxygen decompressions in a group of compressed air tunnel workers
Li R.C.T. (Hong Kong)
- P-2 Evidence for a non-hypoxic stimulus on EPO production in healthy humans
Balestra C., Germonpré P., Poortmans J., Schietecatte J., Collard J.-F., Ben-Salem F., Snoeck T., Vann R.D., Marroni A. (DAN Europe; Brussels, Belgium; IDAN)
- P-3 Lymphatic clearance of proteins is enhanced during normobaric oxygen breathing: a lymphoscintigraphy study
Balestra C., Germonpré P., Snoeck T., Ezquer M., Leduc O., Leduc A., Willeput F., Marroni A., Cali Corleo R., Vann R. (DAN Europe, IDAN; Brussels, Belgium)
- P-4 Hyperbaric oxygen in the treatment of sudden deafness (SD) after failure of previous medical treatment
Barthelemy E., Germonpré P., Heiden C., Jansen E., Rocco M. (Working group 1, COST action B14)
- P-5 Postoperative complications after lumbar surgery: is it safe to dive?
Jacobs D., Elbanna S. (Charleroi, Belgium)
- P-6 The use of hyperbaric oxygen to treat faecal incontinence secondary to pudendal neuropathy - a pilot study
Cundall J., Gardiner A., Grout P., Laden G., Duthie G.S. (Cottingham, UK)
- P-7 Decreased pulmonary diffusion capacity of special forces divers during diving with 100% oxygen
van Hulst R.A., Workel E.B.J., Houtkooper A., Blom O.A., Kloek A. (Royal Netherlands Navy)
- P-8 Pulmonary contusion during scuba diving
Van Poucke S., Stockman B., Deraedt D., Beaucourt L. (Antwerp, Belgium)
- P-9 New German training regulations for commercial divers reflect the importance of in-depth medical education
Faesecke K.-P. (Hamburg, Germany)
- P-10 A diving operation on the wreck of Camalti Burnu-1 - Interim Report
Kocaman F., Gunsenin N., Aktas S., Toklu A.S. (Istanbul, Turkey)
- P-11 Psychophysiological and biochemical aspects of hyperbaric oxygenation in toxic encephalopathy
Epifanova N., Lebedeva E., Epifanov Y. (Moscow, Russia)
- P-12 The role of hyperbaric oxygenation in the correction of homeostasis of patients with psycho-organic disorders
Epifanova N., Koukchina A., Epifanov I., Lebedeva E. (Moscow, Russia)
- P-13 Hyperbaric oxygenation (HBO) as a bioenergetical method of immune parameters correction in the patients with acute drugs poisoning
Epifanova N., Romasenco M., Koukchina A., Bulava G. (Moscow, Russia)
- P-14 Effects of hyperbaric oxygen therapy on inflammatory bowel disease in a rat model
Lin T.F., Chang S.F., Lin C.L. (Taipei, Taiwan)
- P-15 Myocardial damage during severe CO poisoning
Rocco M., Marcelli C., Bruno A., Porzi P., Giannetti L., Stazi G. (Rome, Italy)
- P-16 Clostridial sepsis in modern traumatology - electron microscopic analysis
Dekleva N. (Belgrade, Yugoslavia)
- P-17 The changes of staphylococcus aureus resistance and growth under HBO conditions
Vujnovic D., Jovanovic S. (Belgrade, Yugoslavia)
- P-18 Genetic factors in origination of angiopathic changes and effects of HBO therapy
Jovanovic T., Radak D., Dekleva N., Izquierdo G.P., Trajkovic M., Mitrovic A., Brkic P. (Belgrade, Yugoslavia)
- P-19 Adjuvant or 'Therapy of Choice' for the patients with the occlusion of artery femoralis superficialis
Jovanovic T., Radak D., Micevic D., Zoranovic U., Pucar D., Vucurovic D., Lozuk B., Dekleva N., Izquierdo G.P., Trajkovic M. (Belgrade, Yugoslavia)

- P-20 The use of the Oxylator EM-100 in a hyperbaric environment
Van Poucke S., Galicia J., Stockman B., Deraedt D., Beaucourt L. (Antwerp, Belgium)
- P-21 Test of an infusion pump for hyperbaric oxygen therapy
Brauzzi M., Tanasi P. (Grosseto, Italy)
- P-22 Children and diving: physiological aspects
Vandenhoven G., Vanderschueren F., Germonpré P., Balestra C. (Brussels, Belgium)
- 13:00 LUNCH**

Saturday, September 7, 2002

Scientific Session 6: Hyperbaric Oxygen

Chairmen: Desola J., Rocco M., Mathieu D.

- 08:30 O-28 Hyperbaric oxygenation in acute brain insults and neurorehabilitation
Neubauer R.A. (Lauderdale-by-the-Sea, USA)
- 08:45 O-29 Therapeutic effects of hyperbaric oxygenation (HBO) on acute cerebral ischemia in patients after intracranial aneurysms clipping
Levina O.A., Romasenko M.V., Krylov V.V. (Moscow, Russia)
- 09:00 O-30 Bell's palsy (BP) treatment with HBO2
Gosovic G., Gosovic S. (Split, Croatia)
- 09:15 O-31 Is hemodynamic stability during HBO2 therapy a matter of discussion? Assessment of invasive blood pressures in critically ill patients
Ratzenhofer-Komenda B., Offner A., Quehenberger F., Hohensinner I., Gabor S., Renner H., Klemen H., Pessenhofer H., Smolle-Jüttner F.M. (Graz, Austria)
- 09:30 O-32 The efficacy of corticosteroid treatment and hyperbaric oxygen therapy
Sicko Z., Kot J., Narozny W., Stankiewicz C. (Gdynia, Poland)
- 09:45 O-33 Adjuvant hyperbaric oxygen therapy in the treatment of idiopathic sudden sensorineural hearing loss
Desloovere C. (Leuven, Belgium)

10:00 COFFEE BREAK

Scientific Session 7: Nursing & Technical Aspects 1

Chairmen: Van Poucke S., Bennett P., Ruzicka J.

- 10:30 **Keynote Lecture:** Future normalisation and Personnel Education
Pauli H. (Lübeck, Germany)
- 11:30 O-34 A hyperbaric pan-European technician, operator and nurses association: a necessity?
Mannens C., Houman R. (Brussels, Belgium)
- 11:45 O-35 COST Action B 14: editing rules of good practice for hyperbaric medicine
Méliet J.L., Desola J., Gata A.S., Gough-Allen R., Houman R., Kot J., Mortensen C., Mueller P., Sipinen S.
- 12:00 O-36 Ambulance Service and diving accident management in Belgium
Vanderschueren F., Balestra C., Germonpré P., Marroni A. (DAN Europe Benelux; Brussels, Belgium)
- 12:15 O-37 International Congress of Drowning 2002 - Diving Task Force Conclusions
Elliott D., Van Hulst R. (UK & The Netherlands)
- 12:30 LUNCH**

Scientific Session 8: Nursing & Technical Aspects 2**Chairmen:** *Le Péchon J.C., Kot J., Pauli H.*

- 13:30 O-38 COST Action B14: Working group technical aspects: results
Houman R., Desola J., Gough-Allen R., Jansen E., Kot J., Lo Savio F., Mandenoff A., Méliet J.L., Mueller P., Schmutz J., Simao A. (Working Group 'Technical Aspects' - COST B14 Action)
- 13:45 O-39 Expired oxygen measurements during hyperbaric oxygen therapy
Neiryneck Y., Houman R., Germonpré P. (Brussels, Belgium)
- 14:00 O-40 Conditioning of intensive care patients for hyperbaric oxygen therapy
Baekelandt D., Declercq L., Neiryneck Y., Germonpré P. (Brussels, Belgium)
- 14:15 O-41 Installation of a diving-ergospirometric system in the dive chamber of the German Naval Medical Institute hyperbaric chamber facilities
Koch A., Kramkowski D., Rump A., Bettinghausen E., Rieckert H. (Kiel-Kronshagen, Germany)
- 14:30 O-42 Management of fire risk in hospital hyperbaric environments
Houman R. (Brussels, Belgium)
- 14:45 **COFFEE BREAK**

Scientific session 9: Diving Physiology**Chairmen:** *Wendling J., Grossman Y., Brubakk A.*

- 15:30 O-43 Maximum breath hold time during face immersion across gender and water temperatures from 0 to 20°C
White M.D., Power J.T., Bradbury E.E., Pope J.D., Petrie L., Cheung S.S. (St. John's, Canada)
- 15:45 O-44 Children and diving: Medical Aspects – Eight years sports medical follow-up of the first scuba diving club for children in Belgium
Vandenhoven G., Collard F., Schamp E. (Brussels, Belgium)
- 16:00 O-45 Effect of oxygen breathing prior to submarine escape
Gensser M., Blogg S.L., Loveman G.A.M., Seddon F.M., Thacker J.C., White M.G. (Stockholm, Sweden & Alverstoke, UK)
- 16:15 O-46 Heart rate responses during face immersion across gender and water temperatures from 0 to 20°C
White M.D., Pope J.D., Bradbury E.E., Power J.T., Petrie L., Cheung S.S. (St. John's, Canada)
- 16:30 **EUBS ANNUAL GENERAL ASSEMBLY**
- 17:30 **AWARDS & CLOSING CEREMONY**

28TH ANNUAL MEETING OF THE EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY

Brugge, September 8, 2002

Symposium Issues in Diving Medicine and Safety

„De diepten voorbij...” „Au delà des profondeurs...”

A symposium exploring controversial and novel aspects of diving medicine & safety for divers, diving instructors, diving doctors,..

Dr Rob Van Hulst (NI) - Gas embolism: small bubbles - big troubles

Dr Jean-Louis Méliet (F) - Technical Diving: down is easy, up : ?

Ir Jean-Claude Le Péchon (F) - Professional Diving safety standards

Peter Mestdagh (B) - SAR - Heli-lifting of divers

Dr Bernard Stockman (B) - Diving in the Tropics - this is not the 'Oosterschelde' !

Dr Alessandro Marroni (I) - DAN Bubble Research - into space ?

Dr Alf Brubakk (No) - Man in extreme environments

Dr Guy Vandenhoven (B) - Changing aspects of medical fitness to dive

André Charon (B) - The diving accident victim: who is he ?

Dr Peter Benton (UK) - Royal Navy Medical support to the sinking of the Kursk

Avec le support de - Met de steun van:

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ABSTRACTS OF THE 28TH ANNUAL MEETING OF THE EUROPEAN UNDERWATER AND BAROMEDICAL SOCIETY

Brugge, September 4 - 8, 2002

01 PRETREATMENT WITH HYPERBARIC OXYGEN MAY REDUCE GAS BUBBLES IN DECOMPRESSED PRAWNS (*PALAEMON ELEGANS*) BY ELIMINATING GAS NUCLEI

*Arieli Y., Arieli R., Marx A.
Israel Naval Medical Institute, Haifa, Israel.*

Background: It is accepted that gas bubbles grow from pre-existing gas nuclei in tissue. The possibility of eliminating gas nuclei may be of benefit in preventing decompression sickness.

Objective: Our goal in the present study, was to examine the hypothesis that under hyperbaric conditions O₂ may replace the resident gas in the nuclei with oxygen, and due to its metabolic role eliminate the nuclei themselves.

Methods: After pretreatment with oxygen, prawns were 98% saturated with nitrogen before explosive decompression at 30 m/min. Ten transparent prawns were exposed to four experimental profiles in a crossover design: a) Ten minutes compression to 203 kPa with air; b) Ten minutes compression with oxygen; c) Ten minutes compression with oxygen to 203 kPa, followed by 12 min air at 203 kPa, and d) Ten minutes in normobaric oxygen followed by compression to 203 kPa with air. Bubbles were measured under the microscope after explosive decompression.

Results: We found that pretreatment with hyperbaric oxygen (profile "C") significantly reduces the number of bubbles and bubble volume.

Conclusion: We conclude that hyperbaric oxygen eliminates bubble nuclei in the prawn.

02 INTRAVASCULAR ULTRASOUND CONTRAST AGENT PARTICLES DISTRIBUTION IN THE CEREBRAL, RENAL, AND LOWER LIMB ARTERIES - CONSEQUENCES ON DIVING PHYSIOLOGY

*Besnard S., Philippot M., Hervé Ph., Porcher M., Arbeille Ph.
Unité Méd. Physiol Spatiale et Dept. Méd. Nucléaire & Ultrasons, Université de Tours, CHU Trousseau, Tours, France.*

Objective: The objective was to evaluate (a) the degree of enhancement of the Doppler spectrum in different vascular areas (Brain, kidney, legs) and (b) the duration of the contrast effect in these territories.

Method: The renal arteries were investigated both by pulsed and color Doppler imaging, using a Hewlett Packard 5500 Image point echograph. By the same time the patient was instrumented with a transcranial Doppler probe fixed on a bandeau, and a femoral pulsed Doppler probe fixed on the thigh with a harness, in order to monitor in realtime the middle

cerebral and the femoral Doppler spectrum (DMS explorer transcranial Doppler device). The brightness intensity of the spectrum was estimated qualitatively: unchanged, enhanced homogenous, enhanced inhomogenous, saturated. 200 ml of Levovist (air bubbles) were injected at the beginning of the investigation, and again 10 minutes later.

Results: after Levovist injection, oxygen inside bubble dissolves, therefore bubbles (5/6 mm) are only composed by nitrogen. Some seconds after the first injection the cerebral spectrum was markedly enhanced (saturated) with strong flashes over the whole spectrum. The renal and femoral spectrum were significantly reinforced but remained homogenous (maximal frequency envelop unchanged). during the first 10 minutes these pattern did not change nor in amplitude nor in intensity. The second injection increased the intensity of all spectrum but the aspect remained the same as during the first injection: cerebral spectrum saturated, renal and femoral enhanced but homogenous.

Discussion: This simple observation confirms that the contrast agent structure changes according to the distance from the cardiac pump. Close to the heart the contrast agent particles seem to be more or less aggregated which provide the same aspect as groups of air bubbles in the carotid during a cardiopulmonary bypass surgery. The contrast agent particles seem to be more homogeneously distributed into the flow in area far from the heart like the kidney or the legs as the velocity spectrum are enhanced but homogenous. As this phenomenon is reproduced identically at each cardiac cycle during at least the 10 minutes following the first injection we have to consider that the heart by mixing the blood reaggregates the contrast agent particles even these have come back to it from the distal vascular territories homogeneously distributed in the blood. We know venous bubbles was observed after diving. Also, the most little bubbles must pass pulmonary capillaries and circulate within arterial compartment. Measurement are in-progress on divers. As contrast agent, the heart could reaggregate arterial bubbles and create nitrogen embolism which could explain decompression sickness even if decompression-stop was respected and foramen ovalis not functional.

03 FIRST RESULTS WITH DIVING-ERGOSPIROMETRY IN THE DIVE-CHAMBER OF THE GERMAN NAVAL MEDICAL INSTITUTE

*Koch A.E., Kramkowski D., Rump A., Bettinghausen E., Rieckert H.
German Naval Medical Institute, Dept. of Sports Medicine, University of Kiel, Germany.*

Background: Online-ergospirometry during diving down to 50m depth in the dive-chamber (water tank) allows the measurement of physiologic parameters under realistic conditions. The aim of the first pilot study was to find appropriate exercise steps during Diving-Ergospirometry on depth, which are comparable to the established bicycle ergometry under normobaric conditions.

Method: Pilot study for comparison of Diving-Ergospirometry with bicycle-ergospirometry in 8 experienced divers (28±9ys.; 77.7±7.9kg) of the German Armed Forces. Fin-swimming was performed in a suspended-weight system with variable weights in the water-tank and ergospirometric data were collected during exercise using a full-face mask and collection of expiration gas in a Douglas-bag ergospirometry-system. Additionally, before and immediately after all exercises capillary blood was taken for blood-lactate and blood-gas analysis. Ergospirometry during diving was done at 20m depth (0.3MPa) as well as bicycle ergometry under dry conditions at 0.3Mpa ambient pressure and another one under normobaric conditions. The exercise steps in cycling were according to the diving-fitness examination 75-125-175-225-(275) watts, 3 minutes each step.

Results: With respect to heart rate (165±14bpm), minute ventilation (74±30l/min), O₂-uptake (2.52±0.25l/min), and CO₂-elimination (2.66±0.51l/min) 1-kg-steps of lead (8.95 N weight force in water) beginning with 5 kg (counterpart to 75W) suspended weight revealed comparable results in the diving ergospirometry to the mentioned above 50W-bicycle steps. Additionally, like in cycling, increased workload during Diving-Ergospirometry resulted in nearly linear elevations in the measured parameters with $r=0.97-0.99$. The calculated work-efficiency (from O₂-uptake, workload and time) during cycling was 25.8%, whereas the efficiency of fin-swimming was only 9.5%.

Conclusion: In Diving-Ergospirometry, suspended weights of 5-8kg are comparable to 75-225W workload in bicycle-ergometry. The nearly linear relationship between suspended weights and the main ergospirometric parameters allows the calculation of the efficiency of swimming under water, and even with fins, it shows less than the half efficiency of cycling. Together with the possibility of blood-lactate- and blood-gas-analysis Diving-Ergospirometry allows sports-physiological measurements under realistic conditions, the testing of swim-styles with respect to efficiency, different fin-types or nitrogen-effects on motoric coordination.

04 A NEW APPROACH TO INCREASE DECOMPRESSION SAFETY IN DEEP COMPRESSED AIR WORK

Faesecke K.-P.

HyperMedConsult, Hamburg, Germany.

In recent years technological progress has led to ever increasing medical challenges in very deep underwater tunnelling. Modern tunnel boring machines (TBM) are capable of operating in depth close to 100 m. In these regions no work in compressed air is feasible; recent projects in Germany required compressed air work (c.a.w.) up to almost 50m water-pressure. Effective working time there is less than an hour with a minimal decompression requirement of close to or more than two hours.

Background of a new approach to deco-procedures has been primarily the observation that decompressions inside the small personnel-locks of today's TBM almost exclusively lead to bends in the lower extremities, preferably knee, calves and ankles, which is in contrast to earlier observations in caisson work. This is thought to be due to the cramped posture enforced on the men, thereby reducing venous return of nitrogen to the lungs; the small diameter of the lock making it impossible to stretch the whole body regularly.

Since the Elbetunnel project ('97-'00) had yielded a considerable number of DCS cases, in preparing the Weser-crossing ('99-'01) with two parallel road tunnels, built after another, it was planned to compare two methods of decompression:

1. The standard method according to the currently valid German c.a.w. regulations, i.e. O₂-stops at 10 and 5 m of maximal 120 min., according to time spent under pressure;
2. a split decompression with a second sojourn under HBO at 9 m for 30 min after a limited surface interval walking to the recompression chamber topside, plus a short chamber exposure to working depth about 10 min before definitely locking in.

While the first (southern) tunnel required 1319 individual exposures under pressure (range:9 to 49m) applying the existing regulations and leading to 13 cases of DCS, the secondly driven northern tunnel required only 453 interventions under pressure (range: 6 to 44m): almost all of the men accepted the new method right away; of the five who refused in the beginning, one had to be re-compressed for hip and knee bends. From then on it was observed by all the men and no more cases had to be treated.

It is hypothesized that the walk through the tunnel sufficiently activates the circulation of the lower extremities to liberate the captured nitrogen and transport it to the lungs where it is rapidly given off by means of hyperbaric oxygen-breathing. Doppler-probing did not reveal bubbles in the lung circulation, therefore it is postulated that the local amount of nitrogen is well enough to induce pain if not given off, but not sufficient to create circulating bubbles.

Additionally the process of "crushing" bubble nuclei through the initial short "dive" before the actual work-exposure is thought to have contributed to this favourable outcome. The study will be repeated at the "Herrentunnel"- project in Lübeck starting this late summer, applying more sophisticated Doppler technology.

05 LONG TERM EFFECTS OF SATURATION DIVING ON PULMONARY FUNCTION - REDUCTION IN FEF 50% AND FEF 75% IN EARLY PERIOD OF DIVING CAREER

Suzuki S. (1,2), Thorsen E. (2)

(1) Japan Maritime Self-Defense Force Undersea Medical Center, Yokosuka, Japan. (2) Institute of Medicine, University of Bergen, Haukeland Hospital, Bergen, Norway.

Background: It has been reported a tendency of small airway dysfunction after deep saturation dives and long exposure to hyperoxia, in which environmental partial pressure of oxygen was controlled from 40 kPa to 50kPa. It is not clear, however, if the changes will continue for a prolonged time period. To investigate long term effects on pulmonary function in saturation divers, we analyzed data longitudinally.

Materials and Methods: The subjects were 15 healthy, male, active-duty uniformed divers who started first saturation diving at the age of under 25. Thirteen divers were daily smokers and two were non-smokers. Follow up period was 9.6 (SD = 3.8) years. The median depth of the deepest saturation dive was 383 meters (range 300-440) and the time for saturation diving per year was 10.8 days (range 6.9-17.5). Pulmonary function data were taken before each saturation dive as a medical check-up.

Assessment of pulmonary function included static lung volumes, dynamic lung volumes and flows, and transfer factor for carbon monoxide. Correlation between the change of lung functions and diving experience was analyzed.

Results: During the first 5 years of follow up, forced expiratory flow rates at 50% and 75% of forced vital capacity expired (FEF50%, FEF75%) showed remarkable decreases, whereas the other pulmonary functions did not change significantly. The annual reduction in FEF50% was 516 (SD = 128) ml·s⁻¹·yr⁻¹ and for FEF75% 205 (SD = 66) ml·s⁻¹·yr⁻¹. After the first 5 years of follow up, the decreasing rates of FEF50% and FEF75% were slowed down. Through the follow up period, the transfer factor for carbon monoxide and residual volume showed significant increases, while vital capacity had little change.

Conclusions: These observations suggest that young saturation divers have a tendency of small airway impairment in the early period of diving career and the tendency become subsequently small.

06 A STATISTIC REVIEW OF 144 CASES OF DECOMPRESSION ILLNESS TREATED IN THE HYPERBARIC FACILITY OF GROSSETO

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The study consists in a statistic analysis of 144 cases of decompression illness treated in the hyperbaric chamber of Grosseto (Italy) during a period of time of 6 years. These data have been gathered with a standard statistic model which is in current use in the Italian Society of Undersea and Hyperbaric Medicine.

The Authors have divided the number of cases for each year and various data like the age of patients, the depth of the dive at the end of which the accident occurred, the use of computer, the kind of dive (single, repetitive and so on) and the predisposing factors for decompression discovered in their patients.

After this preliminary screening they analyze the therapeutic schedule used, the type of decompression illness and the outcome of the treatments. The helicopter rescue service plays a very important role and, from 1999 July the time from onset of symptoms and recompression treatment has been dramatically shortened (from about 4-5 hours to 35' for a medical evacuation from the isles of Giannutri and Giglio).

The conclusion is that, at the present state of art, the hyperbaric facility of Grosseto, is still ensuring to the diving population a very important health service which is strongly supported from a very effective emergency department.

07 TRANSESOPHAGEAL ECHOCARDIOGRAPHY OF DIVERS TREATED FOR DCI

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Divers treated with recompression after neurological decompression illness (DCI) during a 4 year period were followed up by Trans Esophageal Echocardiography (TEE) in search for patent foramen ovale (PFO). The total number of recompression treated divers during the 4 years was 59 All divers presenting neurological symptoms (n = 36 or 61 %) were selected for ultra sound cardiography. Of these, 5 did not want to participate. A total of 24 male and 4 female divers were examined by standard TEE and agitated Haemaccel. In addition 2 males and one female were examined by TTE (Trans Thoracic Echocardiography). Two ml echocontrast in the form of aerated bovine gelatine solution, (Haemaccel, Aventis Pharma) was injected into the antecubital vein during Valsalva manoeuvre. The patient was instructed to release the strain when the contrast became visible in the right atrium. PFO was defined as three or more bubbles in the left atrium within three beats.

Six PFO were found, which corresponds to 19.4 %. This is in the same range as Fisher et al (1995) found using TEE in a middle aged population, but lower than expected in a young population (Hagen, 1984), and definitely lower than expected in a selected population of divers that have encountered neurological DCI (Bove, 1998).

Possible explanations are 1) Pure statistical variation depending on a low number of individuals or 2) A number of false negative TEE.

Most patients had relatively "mild" symptoms (Numb peripheral extremities and paresthesia) and no patient showed loss of reflex or muscular power. There were no obvious difference in type or severity of symptoms between those who had a PFO and those without.

Conclusions: The prevalence of PFO among divers with neurological DCI was found to be in the lower range of published values, which makes us believe that PFO is not a major factor behind DCI symptoms in recreational divers.

Ref: Bove, AA Undersea Hyperbar Med 1998; 25(3): 175-78
Fisher, D. C., E. A. Fisher, et al.. Chest 1995, 107(6): 1504-9.
Hagen, P et al. Mayo Clinic Proc 1984; 59:17-20

08 WHAT ASCENT PROFILE FOR THE PREVENTION OF DECOMPRESSION SICKNESS?

I - RECENT RESEARCH ON THE HILL / HALDANE ASCENT CONTROVERSY

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Incidence of decompression sickness (DCS) in recreational divers has changed very little over decades in spite of the advent of computers, many different decompression algorithms, etc. It is inferred that this is because critical factors such as rate of ascent, shallow and deep stops, and particularly total time of decompression have not been considered.

Since recreational diving DCS is primarily (65%) neurological in origin, the most likely site is the spinal cord, which has a tissue half time of 12.5 mins.

Examination of tissue tensions indicate that in the deep/short dives, typically made by recreational divers, it is the fast tissue half times of 5, 10, or 20 mins which have the highest gas loadings and are the 'controlling' tissues for the occurrence of supersaturation and DCS. In long/shallow or saturation dives it is the longer 40, 80 min tissue half times responsible for the pain only symptoms.

Our and other author's studies in animals and man support the hypothesis that present ascents of 17 m/min or even 10m/min, with a 3 min safety stop at 6 m, are too short. This gives only 4-6 mins to the surface after a 20 min dive to 30 m, when the spinal cord has a tissue half time of 12.5 mins and is virtually fully saturated. Supersaturation, therefore, will occur and bubbles form.

Such a hypothesis fits more closely with Haldanian theory rather than failed theories of Sir Leonard Hill with linear ascents. The latter is more in keeping with present diving today with direct ascent from a 30 m dive at 18 or 10 m/min to a safety stop at 5-6 m for usually 3 mins, rather than a Haldanian deep stop at 15 m for 5 mins and another at 6 m for 5 mins.

DAN America and DAN Europe are currently investigating the effects of ascent rates of 18 m/min, 10m/min and 3 m/min and stops at 15 m and 6 m (Haldane), or only one stop at 6 m, or no stop at all (Hill), during a series of open water dives to 25 m for 25 min, followed by a repetitive dive to 25 m for 20 min after a surface interval of three hours and 30 minutes.

Preliminary results show that high Doppler scores are related to linear ascents, whereas deep staged ascents produce minimal or no bubbles.

09 TIME RELATED OPENING OF THE FORAMEN OVALE IN DIVERS

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Introduction: Patency of the Foramen Ovale (PFO) has been shown to play a role in the occurrence of certain types of decompression sickness (DCS), by paradoxical embolisation of venous gas emboli ("silent bubbles") after the dive. Anecdotal observations of divers who, after an uneventful diving career of many years, suddenly become extremely susceptible to DCS because of a large PFO, prompted us to investigate if divers may increase the size or prevalence of their PFO with time and or diving experience.

Methods: A group of divers who had been investigated for presence of PFO using a strictly standardized technique of contrast-enhanced Transoesophageal Echocardiography (c-TEE) in the period 1994-1996 (Germonpré et al., 1998) gave their consent for a re-evaluation using the same technique, 6-8 years later. The group consisted of 33 divers of whom 15 had suffered DCS previously, and 16 who never had DCS and who had served as matched controls during the 1994-1996 study. All divers had continued diving, and had not suffered DCS since their first c-TEE. PFO was semiquantified according to degree of paradoxical contrast passage after straining manoeuvre (Grade 0: no bubble passage, Grade I: <20 bubbles, Grade II: > 20 bubbles).

Results: The initial prevalence of PFO in this group of divers was 42.5% (14/33), of whom 5 (36%) had a Grade I and 9 (64%) a Grade II PFO. Mean years of diving between the two c-TEE was 7.28 and mean number of dives was 283 (mean 39 dives/year). The final prevalence of PFO was 51.5% (17/33). Of the 19 divers initially without PFO, 3 divers were found to have a Grade I PFO after a mean of 7.6 years and 556 dives. One diver had a Grade II PFO (7 years, 150 dives). 15 divers were still Grade 0 (mean 7.36 years, 292 dives). Of the 5 divers with an initial Grade I PFO, 4 divers were found to have a Grade II after a mean of 7.75 years and 225 dives. One diver was found to have no PFO anymore (7 years, 100 dives).

Discussion: It has been suggested (cross-sectional analysis of 965 hearts by Hagen et al. 1984) that, with age, the prevalence of PFO decreases, while the mean size would increase. The increase from Grade I to Grade II, as well as the one diver who closed a Grade I PFO, seems to confirm this cross-sectional observation in a prospective way. The 'de novo' opening of 4 PFO's is an important finding, because this may mean that divers would develop an increased susceptibility for DCS with time. More divers are now being re-examined to confirm this observation.

010 PFO DETECTION IN DIVERS - METHODOLOGICAL ASPECTS

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Introduction: Recent publications again raised the urge for a standardization of the Transoesophageal contrast echocardiography; although many agree on the innocuity of the technique in humans^[1], the quantification and the evaluation protocol is not consensual.

Mas et al. 2001 used semiquantitative transoesophageal contrast echocardiography (c-TEE) to determine the size of patency of the Foramen Ovale (PFO) in their patient groups^[2]. They state themselves that there was a substantial degree of disagreement among the three reviewers of the c-TEE video-recordings.

The variability in PFO detection has been studied and showed discrepancies^[1, 3-8] Schuchlenz et al.^[9] have indeed confirmed that the degree of shunting of contrast solution injected in the antecubital vein is by far inferior to that of bubbles injected into the femoral vein; an observation already made by Gin et al. in 1993^[10]; the same conclusions are drawn by Hamann et al. in 1998^[11].

The lack of correlation observed by Schuchlenz is obviously due to the absence of an effective straining manoeuvre, capable of counteract the preferential flow from the Inferior Caval Vein (ICV) towards the fossa ovalis^[12]. It is striking that in not one of all the studies performed, a precise description of the nature and duration of the straining manoeuvre is mentioned, which to our view, represent a serious methodological flaw.

Our Propositions

We have observed that, to achieve adequate contrast mixing in the right atrium, the duration of the straining manoeuvre performed before release is more important than the actual intrathoracic pressure obtained^[13]. Based on this observation, we proposed a standardised straining manoeuvre for c-TEE examinations of PFO^[14].

Protocol

- identify the interatrial septum in long-axis view, possibly focusing on the separation plane between septum primum and secundum^[15]
- perform a first straining manoeuvre in order to exclude false respiratory contrast^[16]
- perform a first contrast study, using the same straining manoeuvre:
 - after a medium to deep inspiration, and with closed glottis, perform an abdominal pressure increase ("push down in the abdomen") while the investigator counts slowly to 10
 - keep the TEE probe immobile, even if the heart seems to shift out of view during this manoeuvre
 - inject contrast medium (in our case, agitated saline 9.5ml + 0.5ml air) through a large-bore catheter in an elbow vein, after 7-8 seconds of straining
 - when the first contrast bubbles appear in the right atrium, instruct the patient to exhale normally
 - observe right-to-left shunting of contrast bubbles within the first three heartbeats after release of the straining manoeuvre: Grade 0 – no passage, Grade I – less than 20 bubbles, Grade II – more than 20 bubbles.

Conclusions

Using this standardised straining manoeuvre, we were furthermore able to demonstrate a high level of correlation between a Grade II PFO and cerebral decompression sickness in sports divers, caused by paradoxical embolisation of nitrogen bubbles arising predominantly from the tissue in the lower extremities and thus transported via the ICV – a mechanism similar to unexplained stroke^[17].

The importance attributed by certain authors to the degree of spontaneous shunting (i.e. without straining manoeuvre) is in view of the post-embryological anatomy and flow characteristics, unjustified. In patients incapable of performing a proper straining manoeuvre, injection of contrast through the femoral vein should be performed.

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011 WHAT ASCENT PROFILE FOR THE PREVENTION OF DECOMPRESSION SICKNESS? II - A FIELD MODEL COMPARING HILL AND HALDANE ASCENT MODALITIES, WITH AN EYE TO THE DEVELOPMENT OF A BUBBLE-SAFE DECOMPRESSION ALGORITHM. DAN EUROPE DSL SPECIAL PROJECT 'HALDANE VS HILL'.

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Circulating venous gas bubbles have been found to be a common occurrence in the otherwise uneventful recreational dives monitored during the DAN Europe's Project SAFE DIVE.

Doppler monitored bubbles have been detected in 37,4% of all the monitored dives. 25,4% of the dives produced Low Bubble Grade recordings only, while 12% produced High Bubble Grades and 2,4% produced Very High Bubble Grades, between grade 3 and 4 according to the Spencer scale.

Repetitive dives showed a different incidence of post dive VGE, with only 15% of the repetitive dives bubble free and HBG and LBG recorded in 67% and 18% of the repetitive dives, respectively.

The DAN Europe SAFE DIVE project showed that post dive High Bubble Grades are directly related to Fast to Medium Half Time Tissues, and Nitrogen Venous Partial Pressure greater than 80% of the allowed M Value for that tissue.

The modification of the ZH-L8 ADT algorithm by the introduction of a *Proportional M-Value Reduction Concept (PMRC)* to the fast and medium HT Tissue compartments, without altering the original speed of ascent to and between any planned stop resulted in a modified ascent slope and in the introduction of extra deep stops during the ascent. This eliminated the occurrence of significant post-dive Doppler detectable Venous Gas Emboli.

The results also showed no apparent relation between "instant" speed (the actual speed of ascent calculated from the depth/time profile of the UWATEC computer) and post-dive Doppler bubble detection. Contradictory results were observed during several test chamber dives with "instant" speeds of up to 24 meters per minute and no bubble signal detection, versus significant high bubble grade signals after dives made according to the standard ZH-L8 ADT algorithm, with "instant" speeds of ascent never faster than 10 meters per minute. These observations suggest that the Delta-P imposed on the leading tissue, irrespective of the "instant" speed of ascent, is the critical factor for precordially detectable bubble production.

This fits with a "Haldanian" approach to decompression computation and a special field study has been started, in cooperation with DAN America, to test this hypothesis.

The study is done with a group of volunteer divers who dive, on 8 different weekends, each one of 8 possible combinations of ascent rate and decompression stops of the same dive to 25 m for 25 min, followed by a repetitive dive to 25 m for 20 min after a 3 hours and 30 minutes surface interval. The ascent rates being of 18, 10 and 3 m/min, with or without 5 min stops at 15 and 6 meters.

The divers serve as their own control for precordially detected Doppler Bubbles and possible symptoms of DCS.

Preliminary results over a group of 12 divers who dove 6 of the 8 profiles show that the highest Doppler scores are observed after the no stop ascents – pure Hill – with a 5 min tissue saturation of 60%.

Medium-high Doppler scores are observed after the dives with a stop at 6 m for 5 minutes, with a 5 min tissue saturation of about 35%.

When the deep stop is introduced (Haldane approach)-, the 5 minutes tissue tension drops to about 25% and the observed doppler score reaches its minimum.

More divers and dives are being currently monitored, including ascent rates of 3 m/min. The results of the current research, which will proceed during the summer 2002, will be reported.

012 ANESTHESIA IN THE DIVER PATIENT BEFORE COMPLETE DESATURATION

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Although the dangers of nitrogen narcosis are well known by divers and hyperbaric physicians, general anaesthesia (or pharmacological narcosis) in the diver patient before complete desaturation had been poorly studied. The aim of our study is to understand the influence of gaseous anaesthetics on microbubbles size during the decompression period, analyse the dangers and propose a safe anaesthesia technique in those patients.

Any diver could need surgical care before complete desaturation, and the anaesthetist must be aware of the dangers of some gaseous volatile anaesthetics. The most studied dangerous gas in case of air embolism is nitrous oxide (N₂O) and its use is controversial in neuroanaesthesia or high risk embolism surgery. As we know that soon after diving our patient is in a physical condition of "asymptomatic" microbubbles air embolism, it is interesting to develop the physical properties of nitrous oxide and to relate it to the Fick gas exchange principles.

N₂O has been used in experimental anaesthesia under hyperbaric conditions of 2 ATA without side effects in normal volunteers. N₂O side effects are well recognised in clinical large air embolism. Its isobaric counterdiffusion is the "key" of the delayed decompression accident after normal diving profile and was confirmed in animal studies. Patent foramen ovale, positive end-expiratory pressure or coughing during extubation can lead to paradoxical air embolism. The safety delay is probably 24 hours or the computer desaturation time. Up to 70 % of laparoscopic operations produce asymptomatic microbubbles (Gas composition CO₂, N₂, CO, Argon, N₂O if used). Video-surgery could be more dangerous in the diver patient as CO₂ diffusion in the microbubble is 28 faster than N₂ washout.

013 REDUCTION OF THE HEALING TIME IN NON-ISCHEMIC CHRONIC DIABETIC FOOT ULCER BY HYPERBARIC OXYGENOTHERAPY (HBO) - PROSPECTIVE RANDOMIZED STUDY

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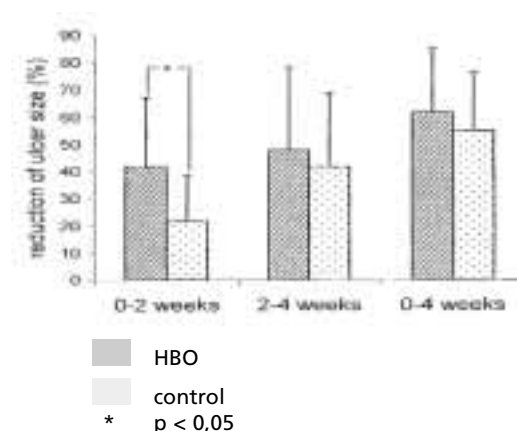
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Background: Diabetes mellitus is one of the most frequent illnesses in the Western world: it affects about 220 million people of which 2.5 % develop a foot ulcer each year, leading to high morbidity and prolonged hospitalization(1). In spite of this incidence, the difficulty in controlling all the parameters (metabolic, vascular, infectious, podologic) involved in the standard therapy explains why there are so few controlled studies available on the actual effect of HBO on diabetic foot healing. Therefore, the purpose of this study was to evaluate, the effect of HBO on the healing time of non-ischemic chronic diabetic foot ulcer in addition to a multidisciplinary management.

Patients and methods: From January 1999 to January 2000, 28 diabetic patients with foot ulcer were included prospectively. All the patients had given their written consent. The ulcers were characterized by the absence of favourable outcome within three months, despite standard care. There were no clinical signs of arteriopathy; the Doppler scan was normal and the transcutaneous oxygen tension (TcPO₂) measured at ambient air on the dorsum of the ill foot was > 30 mmHg. Patients were randomized to undergo HBO. Both groups underwent the same conventional medical and orthopedic treatment. HBO was performed in a multiplace hyperbaric chamber pressurized with air at 2.5 ATA during two sessions of 90 minutes per day, five days a-week for two weeks. The patients breathed O₂ via a facial mask for 25 minutes separated by a 5-min air period, three times a-session. The ulcers were studied by a standardized photograph and analyzed by a computed programme (Monseyes, version 1.1. – 1995).

Description of results:

- 15 patients were included in the HBO group and 13 in the control group. The two groups were compared on the basis of age, sex, type, duration of diabetes and wound surface area.
- HBO was well tolerated: only one patient discontinued the study (barotrauma-otitis).
- TcPO₂ measured around the ulcer was 21.9 ± 12 mmHg in air at baseline with a significant increase to 454.1 ± 128 mmHg in HBO. After the 20th session the results were similar.
- After 2 weeks of treatment, the reduction of wound surface was significantly greater in the HBO group; at the 4th week there was no further significant difference between the groups:



Conclusion: In this study, HBO, in addition to conventional treatment, significantly accelerates the healing of non-ischemic chronic diabetic ulcer. But, this effect is transient according to previous experimental data in the rat (2).

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014 HYPERBARIC OXYGEN IN THE TREATMENT OF NON-HEALING DIABETIC FOOT ULCERS

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Background and objectives: Retrospective analysis of the Portuguese navy hospital experience with hyperbaric oxygen (HBO) in the treatment of healing failure diabetic foot ulcers, with a Wagner grading 2, 3 or 4.

Material and methods: 97 patients were treated, 81,5% (79 patients) male, 18,5% (18 patients) female, mean age 61 years, ranging from 29 to 82 years.

13 patients (13,5%) had Wagner grade 2 ulcers, 32 patients (33%) had Wagner grade 3 ulcers, and 52 patients (53,5%) had Wagner grade 4 ulcers.

All the patients were treated with HBO, in a multiplace chamber, pressurised with air at a stabilised pressure of 2,5 ATA's, with each one of the patients breathing pure oxygen, through a facial mask, in closed circuit.

The length and frequency of treatment sessions were 90 min and five times a week, respectively. The 97 patients underwent 5677 treatments, mean of 58,5 treatments per patient.

Results: The rate of healing and improvement achieved with HBO therapy, was 80,5% (78 patients), with 56,75% of healing rate (55 patients), and 23,75% of clinical improvement rate (23 patients).

The rate of treatment failure was 19,5% (19 patients).

Discussion: In this study, the results of HBO therapy in the groups of patients with lesions Wagner's grade 2, 3 and 4, respectively, had not been significantly different of the global therapeutic results, nor between themselves.

A better selection of patients for HBO therapy, by transcutaneous oxygen tension (TcPO₂) measurements, will be able to contribute for the increasing rate of our good therapeutic results, in the next future.

Summary and conclusions: The results of our study, suggest that HBO therapy may be helpful in non-healing diabetic foot lesions Wagner's grade 2, 3, or 4.

In the current state of our knowledge, these lesions constitute a recommendation of type 2 for HBO therapy.

However, having in consideration the methodological problems of this and other studies published until the present moment, the accomplishment of a prospective, randomised, controlled and multicenter study, is figured necessary, that has as purpose, the definitive validation of the effectiveness of HBO therapy in these lesions, one of which is already ongoing, in the context of Cost B14 Action, which has the participation of our center.

015 HYPERBARIC OXYGEN THERAPY IN THE TREATMENT OF DIABETIC FOOT LESIONS - A RANDOMIZED CONTROLLED PROSPECTIVE STUDY

Working Group «HBO and diabetic foot lesion» of COST B14 action

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Diabetic foot ulceration is a major complication, which affects 4 to 10 p. cent of the diabetic population. Despite prevention and conventional treatment, amputation is a frequent issue and human and economic costs are enormous. Hyperbaric Oxygen has been used as an adjunctive treatment based on both pathophysiological and clinical studies. However, despite an existing positive randomised controlled study by Faglia et al., the place of HBO is still a matter of debate and the ECHM Consensus Conference in London, 1998 concluded that a collaborative international trial was still an urgent need.

Within the frame of the research network COST Action B14, such a study was elaborated.

Protocol:

Objective: To evaluate the efficacy of HBO in the healing of foot ulceration in diabetic patients.

Design: Prospective randomised controlled study.

Patient enrolment: * 2 phases:

- Pre inclusion:

- Type I or II diabetes mellitus, diagnosed more than 2 years earlier
- Foot lesion, Wagner grade 2 - 4, present for more than 12 weeks
- Proper evaluation of revascularisation possibility has been done and no (further) possibility of invasive procedures (angioplasty, bypass...) is present.

- Inclusion: Patient will be definitively enrolled in the study if:

- Foot lesion persists 3 weeks after pre inclusion
- Conventional treatment correctly followed.

Intervention: 3 arms:

- control: No HBO

- 1 HBO: HBO session [2.5 abs atm, 90 min]; 1 / day

- 2 HBO: HBO session [2.5 abs atm, 90 min]; 2 / day.

Evaluation:

Major end point: Failure / success after 6 weeks.

Secondary end points: Major amputation (above ankle); Healing rate; Infection disappearance rate; Time for complete healing; Disability scale; Length of hospitalisation time; Recurrence rate; Eventual adverse effects.

Follow-up: 1 year

Number of patients: 200 patients

This study protocol is actually implemented in 4 countries and pending in 3. Any center able and willing to participate is welcome.

016 HYPERBARIC TRANSCUTANEOUS OXYGEN PREDICTS ARTERIOGRAPHY RESULTS IN DIABETIC FOOT PATIENTS

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Objective: Published papers compare angiographic results of diabetic patients suffering from non healing ulcers with transcutaneous oximetry (TcPO₂) almost in normobaric conditions. Our aim is to compare these diagnostic methods with a special impact on condition at normo- and hyperbaric oxygenation.

Methods: 69 diabetic patients suffering from resistant ulcers (n=76) undergo a digital angiography and TcPO₂ measurement in normal conditions and normo- and hyperbaric oxygenation (PiO₂= 0.1 and 0.2 MPa). Patients structure: age 66 yrs (42-81), time of diabetes 14.3 yrs (1-36), ulcers on diabetic foot 5.4 months (1-36).

Results: Angiography determined the significant arterial patency changes in 80% of ulcers. 82% of ischaemic ulcers (verified by angiography) have had TcPO₂<30 mmHg (sensitivity). Specificity, positive and negative predictive value of this test has been 60, 89 and 47%, relative risk 1,7 and accuracy 78%. The statistical parameters have been shown better under normobaric oxygenation and the best results have been obtained under hyperbaric oxygenation: for the reference value TcPO₂<207 mmHg sensitivity was found out 91%, specificity 77%, positive and negative predictive values 94 and 67%, relative risk 2.8 and accuracy 88%.

Conclusion: TcPO₂ has contributed to the diagnosis of ischaemia. The modification of measurement in the hyperbaric conditions has improved its significance.

017 OSTEORADIONECROSIS: THE ROOT OF THE PROBLEM

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Background. Osteoradionecrosis (ORN) remains one of the late complications following the treatment of Head & Neck malignancy. The incidence has been reported having fallen to 5% (1). There is a strong temporal association between minor surgery and tooth extraction in the irradiated field and ORN. Marx (2) reported the benefits of hyperbaric oxygen in the management of this condition. A recent audit of patients attending a supra-regional hyperbaric facility showed that Head & Neck patients formed 60% of the workload. The principle indication for therapy was the treatment and prevention of ORN (3). This study examines the possible causal factors in those patients who were treated for ORN.

Methods. The records of all patients referred to the North of England Medical & Hyperbaric Service between 1998 and 2002 were reviewed. Patients identified as being treated for ORN were interviewed to obtain information about possible incidents with a temporal relationship to the onset of symptoms of ORN.

Results. Thirty-eight (38) patients from 10 Maxillofacial units were referred by 15 Maxillo-facial Surgeons. Nineteen (50%) were for the management of active ORN. Of these 8 had tooth extraction without pre-operative hyperbaric oxygen.

Treatments in preparation for further surgical interventions accounted for 12 referrals. The remaining 7 patients were for other wound problems.

Discussion. The development of clinical quality standards makes it important to promote awareness of radiation tissue injury and possible responses to injury or minor surgery. The European Consensus Conference (Lisbon 2001) confirmed the use of hyperbaric oxygen in the prevention of ORN. In comparing the almost universal acceptance of antibiotic prophylaxis for endocarditis, it would appear that ORN subsequent to exodontia in an irradiated field needs similar recognition and acceptance of the need for prevention.

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018 HYPERBARIC OXYGEN AND RADIOTHERAPY An intermediate report from the COST B14 Working Group Oncology

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The COST B14 action 'Hyperbaric Oxygen Therapy' started in 1999. The action is managed by appointed experts in HBO from a number of European institutes, and officially representing their countries. After its first year of operation, different working groups were composed, each coordinating a specific subject.

The working group 'Oncology' is concerned with the role of HBO in Oncology, in particular the linkage with radiation oncology.

The main goal of the working group is preparation and actual implementation and follow-up of European clinical randomised studies in the field of HBO and Radiation Oncology, i.e. HBO as radiosensitizer and HBO as therapy for radiation induced normal tissue complications. It is a well-known phenomenon that most tumours are deprived from oxygen and nutrients, and that hypoxic cells are radioresistant. Hyperoxygenation of the tumour by carbogen breathing or HBO treatment has been reported to enhance tumour radiation response. The neo-angiogenic effect of HBO is considered to be the mechanism of action in the use of HBO for treatment of late radiation induced side effects.

The activities of the working group include:

- Elaboration, adoption and approval of protocols
- Implementation and follow-up of protocols
- Advisory board for studies on HBO in Oncology
- Actively providing of information on HBO to radiation oncologists
- Bibliography

The workgroup adopted two protocols on the *radiosensitizing effect of HBO*:

- Re-irradiation of recurrent squamous cell carcinoma of the head and neck after HBO sensitization
- Role of hyperbaric oxygen in enhancing radiosensitivity on glioblastoma multiforme: a clinical study

Other protocols under attention of the WG are focused on *the effectiveness of HBO as therapeutic modality* in previously irradiated patients:

- Osseointegration in irradiated patients. Adjunctive HBO to prevent implant failures
- The role of HBO in the treatment of late irradiation sequelae in the pelvic region

The protocols are presented on the website of the COST B14 action (www.oxyenet.org). At present, they are open for enrolment of patients. Further information can be obtained from the protocol coordinators (see the website) and the working group correspondence address (p.sminia@vumc.nl).

Supported by the European intergovernmental framework COST (European CO-operation in the field of Scientific and Technical research).

019 MICROBIOLOGY OF THE WOUNDS IN PATIENTS WITH CLINICAL GAS GANGRENE: A 7-YEAR RETROSPECTIVE STUDY

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Introduction. Gas gangrene is a devastating, fast spreading local infection and can be life threatening if multiorgan failure develops. Treatment should be aggressive and usually consists of definitive surgical debridement, intensive treatment with antibiotics and hyperbaric oxygen therapy (HBO). The empiric multiple antibiotics should be commenced before the results of microbiologic cultures are obtained and ideally should cover the whole spectrum of bacteria expected in the wound.

The aim. The main purpose of this study was to analyze microbiological results of surgical specimens taken from wounds of patients with gas gangrene treated in the National Center of Hyperbaric Medicine in Gdynia, Poland.

Material and methods. The records of 126 gas gangrene patients consecutively admitted to our ICU between 1995 and 2001 were reviewed retrospectively and results of initial microbiological tests of wounds were compared to those taken after at least 48 hours of treatment. All of patients were treated according to our protocol developed previously, which mainly consists of 1) surgical debridement, 2) intravenous antibiotics (standard of penicillin G, netilmicin, and metronidazole given unless contraindicated), and 3) hyperbaric oxygen therapy.

Results. The mean age of patients was 47 (range 5 to 82 years). There were statistically significant decrease of anaerobic bacteria isolations during treatment as compared to initial evaluation (55,9% vs 17,9%, $p < 0,001$) and significant increase of fungal isolations (4,5% vs 16,1%, $p < 0,001$). The rate of aerobic bacteria isolations remained unchanged (76,6% vs 73,2%, $p = 0,55$). There were no penicillin-resistant *Clostridium* sp strains identified in initial tests, but 37,8% of them were resistant to clindamycin. The protocol implemented in our Center led to significant increase of rate of wounds with negative microbiological examinations (10,8% vs 23,2%, $p < 0,001$). The predicted effectiveness of this protocol defined as lack of resistance of bacteria for at least one of the three antibiotic used (penicillin G, netilmicin, and metronidazole) is approximately 66% as established on the basis of initial examinations.

Conclusions. Penicillin G still remains the primary antibiotic used for empiric therapy of gas gangrene. The protocol leads to definitive decrease of anaerobic infections, however significantly emergence fungal infections.

O20 FEMORAL HEAD NECROSIS AND HYPERBARIC OXYGEN – A MRI STUDY

Study protocol adopted from the COST B14 Working Group "2"

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Background Femoral head necrosis (FNH) is a condition in which the blood supply to the femoral head is compromised. This leads to cell death in the marrow and the bone, and interferes with the activity of osteoblasts and osteoclasts, and loss of the structural integrity of the femoral head. The progression of the disease implies collapse of the femoral head. The treatment of the FNH is an unresolved orthopaedic problem with multiple approaches for its management (1). They include surgical procedures as core decompression, bone grafting, osteotomy, and non-surgical procedures such as electrical stimulation, magnetic fields, high energy shock wave, pharmacological treatment, and hyperbaric oxygen therapy (HBO).

HBO alone or in combination with other orthopaedic interventions, makes oxygen available to cells and enhance osteoblasts and osteoclasts function and the angiogenesis with local bone healing and remodelling.

This study will be limited to the MRI use, because this is the only objective method available for evaluation in the early stages.

Hypothesis under investigation and trial objectives The use of long-term HBO therapy as adjunct to the conventional non-surgical therapy, in stage I and II FHN patients, in comparison to conventional non-surgical therapy alone, is associated with a regression or arrest of the disease and a reduction in the time needed to the recovery of hip functionality.

Primary endpoint The final outcome variable will be the stage of success or failure within the 24-month study period. **Success:** MRI reveals total regression in the radiological signs to normal or no progression to next stage in 24 months. **Failure:** Is defined as radiological progression to femoral head collapse (stage III or worse).

Study Population Patients potentially eligible are consecutive in or outpatients of either sex, 18 to 65 years of age, referring to one of the participating orthopaedic Centres and diagnosed with FHN. The Patients diagnosed with FHN will be graded according to the Steinberg classification: only stage 1 and 2 are eligible. Admission to the trial is by MRI only to be monitored by the MRI director. Due to the nature of the treatments under investigation, this study is an unblinded (open-label) study. To minimize bias, the following strategies will be adopted: a priori criteria will be well defined for qualifying and outcome events; two investigators of whom at least one will be independent from the study organization will perform the assessment of outcome events.

Sample size Based on the meta-analysis by Strauss & Dvorak, where a success rate at 24 months of 81% has been calculated, it is proposed to include a total of 200 hips in the study. These pessimistic view (50% of good result) accounts for different stages, duration and treatment protocols, unnoticed by the authors.

References

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O21 THE INFLUENCE OF HYPERBARIC OXYGEN (HBO) ON PRIMARY, PLATELET-RELATED HAEMOSTASIS

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Objective:

Sudden deafness is an otologic emergency although in most cases, the genesis is still a mystery. Positive results have been found using HBO. Because cochlear hypoxia is one of the hypothetical causes and HBO is related with significant influence on rheologic features, we conducted a prospective study to quantify the impact of HBO on primary, platelet related haemostasis using the relatively new, in vitro test PFA 100.

Materials and methods:

After informed consent, 16 patients (17y - 68y) with sudden deafness (< 10 days after onset) and without clinical or drug related features interfering with hemostasis are enrolled. A standard mixture is administered. Patients served as their own control, are thoroughly observed and informed about the treatment modality. HBO is administered in a multiplace chamber (Hytech, NL). Each patient is compressed to 2.5 ATA followed by 100% oxygen inhalation with a facial mask during 90 minutes. Patients are treated twice daily for 10 sessions or until improvement on audiogram ceases. HBO administration is started before any other drug treatment. Primary platelet related haemostasis is quantified by the platelet function analyser PFA-100 (Dade International Inc., FL). The instrument aspirates a blood sample under constant vacuum from the sample reservoir through a capillary. The high shear stress produced in the analyser leads to plug formation.

Capillary in vitro bleeding time by blood flow through a capillary is measured as closure time (CT) (150 micrometer; aperture cut). The membrane at the end of the capillary is coated with an inductor of platelet aggregation (collagen/ADP or collagen/epinephrine). In this study, platelet function is analysed before and immediately after the first HBO session.

Results:

CT (sec) for collagen/ADP (pre-HBO 87.13 ± 12.40 sec; post-HBO 91.00 ± 19.73 sec) and collagen/epinephrine (pre-HBO 141.88 ± 53.86 sec; post-HBO 156.00 ± 83.36 sec) are assessed before and after the first HBO session. CT pre-HBO and post-HBO showed no significant differences for collagen/ADP (two tailed p 0.38) and collagen/epinephrine (two-tailed p 0.51) PFA analysis using the Paired t Test.

Conclusions:

Although multiple positive effects on rheology have been published using HBO, this study was unable to show a significant influence on the primary platelet related haemostasis quantified by the platelet function analysis.

022 HEAT ACCLIMATION INDUCES PROTECTION AGAINST CNS OXYGEN TOXICITY IN THE RAT: HSP72 MAY BE INVOLVED

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Background: Oxygen toxicity of the central nervous system (CNS-OT) can occur during diving with oxygen-enriched gas mixtures, or during hyperbaric medical treatment. CNS-OT is characterized by convulsions and sudden loss of consciousness, which might be lethal. Long-term heat acclimation is known to provide cross-tolerance to various forms of stress in different organs such as the brain. Objective: The objective of the present study was to examine the hypothesis that heat acclimation may protect against CNS-OT in the rat.

Methods: Male Sprague-Dawley rats were subjected to an ambient temperature of 32°C for four weeks. Rats in the control group were subjected to 24°C. Both groups were exposed to oxygen at 608 kPa at the end of the acclimation period. EEG was recorded continuously until the appearance of the first electrical discharge. CO₂ production was measured simultaneously with the EEG. These parameters were then measured during four weeks of deacclimation. Brain samples were taken from each group at the end of the acclimation period (before compression), after compression-decompression, and after compression-decompression following deacclimation. The level of CNS heat-shock protein-72 (HSP72) was quantified using Western blot.

Results: Latency to CNS-OT was twice as long in the heat-acclimated rats, without any significant changes in CO₂ production. This protection continued for two weeks during deacclimation. We also found a significant increase in the level of HSP72 following heat acclimation, with a subsequent decrease during deacclimation. Conclusions:

We conclude that heat acclimation provides protection against CNS-OT in a way that does not involve changes in metabolism. The acquired protection against CNS-OT is associated with increased levels of HSP72, as the reduction in latency is associated with a decrease in HSP72 levels during the deacclimation period. We suggest that the risk of CNS-OT events may decrease at the end of the summer in subjects inhabiting hot climates.

023 PATHWAYS INVOLVING NEURONAL AND ENDOTHELIAL NITRIC OXIDE IN CNS O₂ TOXICITY

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Background: Evidence is accumulating that nitric oxide (NO) produced by endothelial and neuronal NO-synthases (eNOS or nNOS respectively) is involved in neurotoxic effect of hyperbaric oxygen (HBO₂). We have used mutant mice lacking (-/-) the eNOS or nNOS to examine the specific roles of neuronal or endothelial NO in CNS O₂ toxicity.

Methods: Anesthetized and artificially ventilated C57BL/6 wild type (WT) and eNOS^{-/-} or nNOS^{-/-} mice were exposed to HBO₂ at 5 ATA for 60 min. Regional cerebral blood flow (rCBF) and Po₂ were measured in the striatum, hippocampus and parietal

cortex. NO metabolites (NO_x), as an indicator of brain NO bioavailability, and 3-nitrotyrosine (3-NT), as a marker of peroxynitrite (ONOO⁻) formation, were measured in the striatum by microdialysis and analyzed by chemiluminescence or HPLC-ED. Blood pressure, EEG and body temperature were monitored continuously. Appearance of EEG spikes was used to detect the onset of oxygen toxicity. Blood gases were controlled before and rechecked immediately after HBO₂ exposures.

Results: Steady state rCBF, brain Po₂ and blood pressure were similar in wild type and nNOS^{-/-} mutant mice. During HBO₂ exposures WT mice displayed transient decreases in CBF and NO_x by ~25% over initial 30 min of hyperbaric exposure followed by gradual return to control values. CBF then increased above pre-exposure levels. Brain Po₂ values were ~600 torr during vasoconstriction phase and rose by 2-4 fold during cerebral hyperemia. EEG spikes were observed only after increases in CBF. Extreme hyperoxia decreased CBF in nNOS^{-/-} mice and these responses were more pronounced than in WT animals. nNOS^{-/-} mice also showed less NO production and a greater delay in the onset of EEG discharges compared to wild type mice. Unlike wild type and nNOS^{-/-} mice, HBO₂ in NOS^{-/-} mice did not decrease CBF over the first 30 min and was followed by less hyperemia. Latency of EEG spikes was longer in eNOS^{-/-} mice compared to wild type. 3-NT gradually increased in all type of mice during HBO₂ exposure at 5 ATA but nNOS^{-/-} showed a slower rate of 3-NT accumulation, which is consistent with less ONOO⁻ production.

Conclusion: Mice lacking endothelial or neuronal NOS exhibit different cerebrovascular responses and tolerance to extreme hyperoxia suggesting that eNOS-dependent constitutive NO production plays a key role in the escape from HBO₂-mediated vasoconstriction and the development of hyperemia, which accelerates oxygen seizures. Meanwhile, neuronal NOS appears to be involved in CNS O₂ toxicity primarily by contributing to nitrosative stress, e.g. ONOO⁻ formation.

024 HIGH PRESSURE MODULATION OF DENTATE GYRUS TRANSFER FUNCTION OF DYNAMIC CORTICAL INFORMATION

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Exposure to high ambient pressure induces in animals and humans the high-pressure neurological syndrome (HPNS). At pressures higher than 1.0 MPa, confusion, drowsiness, dizziness, impairment of cognitive performance and sleep disorders occur as well as hyperexcitability signs in the EEG. At higher pressures tremor, myoclonia and seizures are observed. The dentate gyrus is an intermediate station in the information transfer between the neocortex and the hippocampus. This synaptic connection has low-pass filter properties. We studied the effects of high pressure on the cortical medial perforant path (MPP) synapse onto the granule cells of the dentate gyrus, using extracellular recording of field excitatory postsynaptic potentials (fEPSPs). Granule cells excitability was evaluated by their capability to generate population spike (PS) following the fEPSPs and by the generation of antidromic action potentials (AAPs) following stimulation of their axons. Effects on single responses as well as fEPSPs frequency-dependent modulation (FDM) were studied. Cortico-hippocampal brain slices were obtained from anesthetized rats, placed in an

experimental bath, and superfused with physiological Ringer's solution saturated at normobaric pressure with 95% O₂ and 5% CO₂ for a pH of 7.4 at 30° C. Chamber pressurization (5.1 and 10.1 MPa) was attained by compressing helium. High pressure of 10.1 MPa depressed single fEPSP slope (55 %) and amplitude (47 %) while prolonging their decay time and delay. The absolute amplitude of single PSs did not significantly change at high pressure. However, the PS/fEPSP relationship increased significantly due to the reduction in the fEPSPs. Similar pressure reduced AAP's slope by 29 %, increased its duration by 20 %, but did not significantly affect its amplitude and integral. During trains of five stimuli at frequency pressure reduced the depression of the second fEPSP (E₂) at 10-20 ms inter-stimulus intervals (ISI), while facilitated it (5-20 %) at ISIs of 40-120 ms. High pressure also increased the frequency-dependent depression at 25-50 Hz of the rest of the fEPSPs in the train (E₃₋₅). During trains at 25-50 Hz under normobaric conditions the second PS (PS₂) was the largest, and then the amplitude of PS₃₋₅ decayed successively. High pressure did not change this pattern, however it significantly increased the net amplitude of PS₃₋₄. AAPs at these frequencies showed no modulation either under normobaric or high-pressure conditions. Despite the reduction of single f-EPSP, pressure enhanced synaptic efficacy as evident from the increase in the PS/fEPSP relationship. This was particularly evident for PSs generated by high frequency trains that showed net increased firing capabilities. These effects are probably induced by depression of synaptic release affecting also the inhibitory polysynaptic pathways, which normally suppress spike generation. This mechanism plays a major role in effecting HPNS.

025 EFFECTS OF HYPERBARIC OXYGEN ON REACTIVITY OF SMOOTH MUSCLES OF ISOLATED BLOOD VESSELS

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Physiological response on stimulation of vasoactive substances of smooth muscles of blood vessels depends on circulatory level (systemic or pulmonary) and the type of blood vessels (arterial or venous).

Even beside above mentioned the intensity of relaxing or constrictive response on the same stimulus is directly dependant of functional state of endothelial system and oxidative status, in fact pPO₂.

The aim of this work is to show, using the volume of registered responses of isolated preparation a. femoralis and v. saphenae of dogs, the interaction between the response on vasoactive stimulus (acetylcholin, norepinephrin, endothelin, PGI₂ and vasopresin) and pPO₂ on the isolated blood vessel tissue, and medium in which the preparation was incubated. Especially because in estimation of reactivity of blood vessels smooth muscles cells in 'in vivo' and 'in vitro' conditions, specially in clinical experience parameter pPO₂ is, as rule, neglected with periodical taking into account the level of ROS (only with estimation of functional state of endothelial cells).

Reactivity (contractile or dilatatory) is estimated on spirally cut strips of mentioned blood vessels with preserved endothelia. Both preparation of blood vessels were divided in two groups (total of four groups with 10 samples each). One group of arterial and venous preparation were exposed to HBO conditions (3,0 ATA, 90 min, I group arteries and II group venous samples), before placing in the system for isolated organs and registration of contractile possibilities in which was placed the physio-

logical dissolution aerated in standard way (95% O₂ and 5% CO₂ and measured in dissolution of pPO₂ between 6 and 12 mmHg). Samples of group III (arterial) and IV (venous) of experimental group just after the extirpation and adequate procedure of preparation (30 x 3 mm) in spiral, were placed in system for isolated organs, that was containing adequate physiological dissolution previously exposed to the HBO conditions (10 ATA, 90 min) with measured pPO₂ of 42,8 ± 1,2 mm Hg.

Obtained results show important dilatatory effects with the arterial preparation previously exposed to HBO conditions (I group) compared to the preparation group III which were incubated in medium that was previously exposed to the HBO conditions. Responses on relaxing substances were of opposite direction, more significant in group I. Responses of smooth muscles of venous vessels in the both examined cases were almost identical and directioned in the same way, no matter to the previous treatment, of preparation or medium itself, with more obvious spontaneous activity of preparation of group II. Further to the obtained results, it could be concluded that the reactivity of smooth muscles of arterial vessels with preserved endothel are pPO₂ dependant, and specially dependant of the way and conditions of oxygenation. Stronger dilatatory response with the arterial preparation confirms the vasoconstrictive response of arterial vessels on hyperoxy in these conditions, as well as more significant secretion of vasoconstrictive endothelial substances, that is also shown in their response, on vasodilatatory endothelial depending stimulation. Venous musculature response is in concordance with the above said and clearly shows that in experimental conditions must be paid higher attention, same in clinical practice, on the O₂ content in dissolution used as mediums or as dissolution for parenteral use, and all that gives one new dimension and new possibilities of hyperbaric medicine.

026 NITROUS OXIDE AND XENON : THERAPEUTIC PROMISES FOR 'GLUTAMATERGIC' DISEASES

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Neuronal death produced by cerebral ischaemia or stroke is well known to result mainly from excitotoxic processes mediated by the N-methyl-D-aspartate (NMDA) glutamate receptor. As a consequence, NMDA receptor antagonists show potent neuroprotective effect in animal models of cerebral ischaemia, stroke and excitotoxic lesions produced by intracerebral focal injection of NMDA. Unfortunately, these compounds also show adverse side-effects that make their clinical use not possible. Recent advance has demonstrated that the gaseous anaesthetics Nitrous Oxide and Xenon behave as direct NMDA receptor antagonists. In the present study, we investigated the neuroprotective effect of Nitrous Oxide and Xenon in a rat model of cerebral ischaemia induced by middle cerebral artery occlusion (MCAO). MCAO of 1 h 30 duration led to neuronal death and cerebral infarctus in both the striatum and the cortex. Our results show that a post-MCAO treatment of 3-h duration with 75% Nitrous Oxide or 50% Xenon led to a significant and dramatic reduction of the cerebral infarctus volume induced by MCAO. In contrast, a 3-h post-MCAO treatment with 75% Xenon showed no neuroprotective effect and further led to an increase of the striatal infarctus volume induced by MCAO that may indicate a neurotoxic side-effect, as further supported by both calcium studies in neuron cultures and histological studies.

According to the Meyer-Overton rule of a high correlation between hydrophobicity and anaesthetic potency, the anaesthetic potency of Xenon is 1.5 fold that of Nitrous Oxide. In the present study, Nitrous Oxide and Xenon act in respect with the Meyer-Overton rule, since 50% Xenon and 75% Nitrous Oxide show similar neuroprotective effects. In addition, the neurotoxic side-effect produced by 75% Xenon is consistent with the Meyer-Overton rule and previous findings that have demonstrated that 117% Nitrous Oxide produced similar neurotoxic effect, independently of the hyperbaric condition required to reach such a Nitrous Oxide percentage. This study demonstrates that 50% Xenon and 75% Nitrous Oxide show therapeutic promises for the treatment of cerebral ischaemia and stroke, and as recently shown in our laboratory, for the treatment of other brain diseases involving a 'glutamatergic' component.

027 THE EFFECTS OF HBO TREATMENTS ON VIGILITY OF SPERMATOZOIDS IN 'IN VITRO' CIRCUMSTANCES

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Matrimonial infertility in contemporary world presents, even besides the evident progress in medical sciences and higher educational and cultural level of human population, growing problem. Problem, not only for couples and relatively small number of experts and scientists involved in this subject from various sides, but the social problem especially in developed parts of the world.

Having this in mind, most of attention is focused on discovering and solving the problem of female infertility. There are few inspirative projects focused on solving the problem of male infertility, and even those investigations are focused on the anatomic malformations and existing infections.

It can be freely said that both the scientific and clinical experience stays powerless in situation where above mentioned problems does not exist or they are solved, and the problem of infertility persists.

The present situation, as well as the fact that are no scientific investigations connected with the possibility of using the HBO treatments, urged us to investigate the influence of oxygen in hyperbaric conditions on the vigility of spermatozooids.

Samples have been taken from the lab which deals with estimation of functional state of spermatozooids, as the residue after completing all the necessary lab tests. Experiments were done on the samples with proved parameter of spermatozoid volume, spermograms, pH value and fructose status in tolerancy frames and percentage of spermatozooids mobility between 30 and 50 %.

Samples (30 in total) in adequate vessel were exposed to the HBO with 100% oxygen in chamber for fundamental investigations on 2,5 ATA for 90 min in three groups: Group I - only samples of spermatozooids, Group II samples with added 5 ml dissolution used for separation of spermatozooids and Group III samples with 5 ml Tirod dissolution added.

In the period of 30 min after completing the HBO treatment, the evaluation of spermatozooids vigility have been done in regular way. Obtained results showed the positive effect of single HBO treatment on spermatozooids movability in 'in vitro' circumstances as follows: Group I and III vigility was increased for 5 - 8 % and with Group II was increased for 10 - 13 %.

Obtained results clearly shows the positive effect of HBO on spermatozooids vigility and gives the support for continuation of following investigation in this direction, as well as the possibility of positive effect of HBO intervention before the separation of spermatozooids which is used in the courses of insemination or extraternal insemination.

028 HYPERBARIC OXYGENATION IN ACUTE BRAIN INSULTS AND NEURO-REHABILITATION

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Background/Specific Objectives

Compelling worldwide animal and human studies indicate hyperbaric oxygenation will play a major role in neurology, in both the acute insult and long-term neurorehabilitation. Acute effects in anoxic ischemic encephalopathy have been substantiated in France, Mexico City, and Cornell University. Early intervention has proven to reduce morbidity and mortality, as well as in acute traumatic midbrain syndrome. A large study for interventional hyperbaric oxygenation in the first four hours of acute ischemic thrombotic stroke is in progress. Hyperbaric oxygenation is known to reactivate dormant, idling neurons, which may become electrically functional even after a 12-year dormancy. A major role will be forthcoming in long-term neurorehabilitation.

Materials and Methods

The Ocean Hyperbaric Neurologic Center has treated acute and long-term ischemic thrombotic stroke, subacute anoxic encephalopathy, and TBI, including over 500 patients with long-term neurologic deficits. In nearly all cases, a single photon emission computerized tomography (SPECT) scan with L-Scint single-head high-resolution camera was performed as a baseline and at intervals of 40, 80, and 100+ treatments. In the severely traumatized patients, up to several hundred treatments were performed. Vickers monoplace HBO chambers were utilized, pressurized between 1.1 and 1.5 ATA, for one to two hours of treatment a day with four hours in between. Concomitant physical therapy, occupational therapy, speech therapy, acupuncture, and nutritional counseling were recommended.

Description of Results/Discussion

In early acute brain insults, major factors are limitation of the ischemic cascade, reduction of cerebral edema, intracranial pressure, lactate and toxic amine levels. Long-term patients had encouraging results. Cases of acute and long-term thrombotic stroke with SPECT imaging and clinical data will be presented. A long-term TBI patient who progressed from four years of total incapacitation to almost complete recovery will be discussed. A 31-year-old male, 12 years semi-vegetative from AIE, who had a remarkable recovery will also be presented.

Conclusions

The use of HBO in the acute event is extremely rewarding. However, chambers are not available, and knowledge of this procedure is lacking. In late neurorehabilitation, it makes a substantial difference in long-term care and should become a major modality. Ultimately, long-term prognosis depends upon: a) the size and location of the insult; b) the volume of surrounding dormant neurons; c) the organization and reorganization of sensory and motor neurons; and d) decussation at the medullary-cord junction.

029 THERAPEUTIC EFFECTS OF HYPERBARIC OXYGENATION (HBO) ON ACUTE CEREBRAL ISCHEMIA IN PATIENTS AFTER INTRACRANIAL ANEURYSMS CLIPPING

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Objectives: Cerebral ischemia due to vasospasm is the most common and severe complications in the surgical treatment of the intracranial aneurysms. HBO as a method of cerebral protection uses in the treatment after cerebral aneurysms clipping.

Materials and methods: HBO effects were studied on the course of acute cerebral ischemia due to vasospasm after early surgery of ruptured cerebral aneurysms (190 patients). Patients were divided into 2 groups: I - 110 patients receiving HBO seances in the complex therapy of the postoperative period. II - 80 similar patients treating without HBO (control group). The course consisted of 6-15 seances at pressure of 1,2-1,6 ATA. HBO treatment was started at 1-5 days after the aneurysms clipping. Computerised tomography (CT) and brain mapping were used as control methods for of ischemic foci dynamic. Transcranial dopplerography (TCD) was used for evaluation of cerebral blood flow Dynamic study of cardiointervalography with determination of tension index (TI) was used investigated as control method of vegetative nervous system.

Results: A positive dynamic of clinical picture was observed in the majority of patients after HBO seances, that associated with decreasing of infarcts size and perifocal brain edema revealing on CT. As results of (TCD) were demonstrated HBO treatment did not intensify the degree of vasospasm in HBO regimes 1,2-1,6 ATA and normalized the cerebral blood flow in a half of cases.

According to the results of evaluation of EEG changes HBO had positive effect on the brain electric activity. During the HBO treatment decrease of TI was noted. The functional outcome in these patients was more evident in the HBO treated group in comparison with control group. Postoperative complications in HBO treated group were developed more rarely as compared with control group.

Conclusions: There are positive effects on clinical and physiological parameters, when HBO treatment is used as an adjunct to complex therapy of acute cerebral ischemia in early surgay of intracranial aneurysms. Therapeutic effect of HBO in ischemia can be expected in the penumbra area due to cerebral blood flow normalization.

030 BELL'S PALSY (BP) TREATMENT WITH HBO₂

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From physiopathological point of view it is logical to apply HBO in the treatment of BP. Vasoconstrictive, antioedematous effects and better perfusion of HBO have inspired 1984. Racic et al. to apply HBO in the treatment of BP. In spite of high efficiency of this kind of treatment confirmed with double blind controlled study (Racic et al. 1992), this method is not generally adopted. These raisons motivated us to publish our data and experience in the treatment of BP with the HBO.

Material and method: Between the 1995 and 2001, 16 patients have been treated with total or heavy BP (88,8%) and only two (11,2%) with moderate BP. HBO under 2.8 ATA is applied, two times daily during 60 minute periods, seven days a week in the first phases. In the final phases, after marked improvement, the treatment have been performed only one time daily, five days a week. HBO treatment in the 33% of patients have been stopped after a full recovery. For the next 44,4% patients, when the recovery has been almost finished we stopped with HBO treatment 5 to 7 days before a full recovery. For only 22,2% of patient, due to different subjective reasons, the HBO treatments has not been fully realised.

Result and discussion: 14 patients (77,7%) have been cured within 5 to 38 days (average 18,3 days). The 88,8% have been cured within 5 to 58 days (average 21,1 days) and 95% within 5 to 130 days (average 23,7 days). Only one patient has been cured after 131 days with a discrete residua. The average interval for full recovery and percentage of fully recovered patients (95% for average 23,6 days) is similar to the data of controlled study by Racic et al. which cured 95% of patients in the average interval of 22 days. In our study we confirm, as well as Racic et al., that the percentage of cured patients with HBO and specially the average interval for a full recovery is significantly shorter than by others methods of conservative treatments.

031 IS HEMODYNAMIC STABILITY DURING HBO₂ THERAPY A MATTER OF DISCUSSION? ASSESSMENT OF INVASIVE BLOOD PRESSURES IN CRITICALLY ILL PATIENTS

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Specific objective: Blood pressure is reported to remain stable in the course of HBO₂ therapy. The behaviour of radial arterial blood pressure profiles was studied in critically ill patients during the hyperbaric session.

Materials and methods: 9 patients undergoing HBO₂ therapy (2 females, 7 males, mean age: 49 yr, diagnoses: necrotizing fasciitis, impaired wound healing, burn injury) were included in the study. All subjects were mechanically ventilated and had continuous sedation and analgesia, none was dependent on catecholamine support. **Hyperbaric protocol:** 2.2 absolute atmospheres (ata), isopression phase: 50 min. Rate of compression and decompression: 0.15 ata min⁻¹. 3-minute safety stop at 1.3 ata. In one series of measurements, peripheral arterial saturation values (SaO₂), heart rates (HR), systolic (BPs), diastolic (BpD) and mean (BpM) arterial blood pressures were assessed at the following measuring points: before therapy (baseline= 0), during compression at 1.3, 1.6, 1.9, 2.2 ata, during isopression at 1,2,3,4,5 minutes after compression and before decompression, during decompression at 2.2, 1.9, 1.6, 1.3 ata and at 1,2,3,4,5 min of normobaric oxygen (NBO) breathing. Reliability of the device used in the chamber was tested in a simulation model which showed a deviation of + 4 mmHg at 2.2 ata (Propaq Monitor, Protocol Systems, Inc,m Oregon, USA. REF NM-025-8 Monitoring Set, pvb Medizintechnik GmbH,G). **Statistics:** repeated measure ANOVA, 21 series.

Results: Major findings (mean values \pm SEM): *Compression phase:* Decline of systolic blood pressure (BPs 0: 118.9 \pm 8.7 mmHg, BPs(2.2 ata): 111.8 \pm 9.2 mmHg. $P=0.0042$). *Decompression phase:* Increase of HR (HR(2.2 ata): 89.5 \pm 7.1 bpm, HR(1.0 ata):95.4 \pm 7.6 bpm. $P=0.0237$. Increase of BPs,d,m (BPs(2.2ata): 108.3 \pm 5.3 mmHg, BPs(1.0ata):112.2 \pm 5.8 mmHg. $P=0.0021$). *Comparison between baseline and post-treatment values:* Decrease of BPs (BPs0: 118.9 \pm 8.7 mmHg, BPs(NBO5min): 99.2 \pm 5.0 mmHg. $P=0.0150$).

Conclusion: The decrease of BP during and after exposure to HBO₂ is more likely attributable to the hemodynamic condition of the patients (volume status, vascular tone) than to technical features.

The compression phase and the immediate post-treatment period require a close hemodynamic monitoring in critically ill patients.

032 THE EFFICACY OF CORTICOSTEROID TREATMENT AND HYPERBARIC OXYGEN THERAPY

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Introduction. Based on the literature review, experimental research (W. Narozny) and experience with clinical cases, the therapeutic protocol for treatment of patients with sudden sensorineural hearing loss (SSNHL) in Medical University of Gdansk was modified in 1997. The main modification was introducing methylprednisolon pulse therapy, increasing the dose of prednisone and using the hyperbaric oxygen therapy (HBO) for all patients.

The aim. The main purpose of this study was to establish the efficacy of modification of the therapy protocol and to identify the predictive factors to treatment of the SSNHL.

Material and methods. One hundred thirty-three consecutive patients with the SSNHL treated in the Medical University of Gdansk were included in this study. Fifty-two patients (group A) were hospitalized between 1997 and 2000 and prospectively treated by the "new" protocol (modified corticosteroid therapy and HBO). This group was compared to the retrospectively reviewed group of 81 patients (group B) treated between 1980 and 1996 without HBO and with previous protocol for corticosteroid therapy. The multivariate analysis was conducted in order to define the predictive factors to improvement of hearing loss in all frequencies and in predefined ranges of frequencies.

Results. There was no significant difference between both groups in initial hearing loss and in both groups there was statistically significant improvement of hearing loss in all frequencies, however this improvement - measured in both absolute and relative values - was significantly greater in group A than B. The factors most strongly and negatively associated with treatment of the SSNHL in multivariate analysis were: therapeutic delay of more than 10 days from initial symptoms, abnormal results of caloric vestibular stimulation, shape of the hearing loss in initial examination, increased white blood cells, and decreased level of TSH.

Conclusions. Modification of the treatment protocol for patients with the SSNHL with changing of corticosteroid treatment and hyperbaric oxygen therapy has resulted in statistically significant improvement of therapeutic effects. Our observations support the data indicating that the therapeutic delay negatively correlates with final clinical effects of treatment of the SSNHL.

033 ADJUVANT HYPERBARIC OXYGEN THERAPY IN THE TREATMENT OF IDIOPATHIC SUDDEN SENSORINEURAL HEARING LOSS

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Specific objective: The aim of this study was to determine the effectiveness of adjuvant hyperbaric oxygen therapy in the treatment of sudden deafness.

Materials and methods: We compared a group of 250 patients that were treated with hyperbaric oxygen therapy at 1,5 ATA (group 1) with a group of 56 patients that were treated with hyperbaric oxygen therapy at 2,5 ATA (group 2). Both groups of patients were treated before with corticosteroid administration and in some cases with adjuvant hemodilution, but without a successful result (mean hearing gain in the frequency range 500-4000 of less than 10 dB). We also included a historical control group of 85 patients that were unsuccessfully treated with corticosteroids, and that didn't get hyperbaric oxygen therapy, because it wasn't available at the time.

Results: In the first group 14% of the patients had a relevant hearing improvement of more than 10 dB (mean gain over the frequencies 500, 1000, 2000 and 4000 Hz), and 7% even had a hearing gain of more than 20 dB. The mean hearing gain since administration of corticosteroids was 4,8 dB. Eighty six percent showed no improvement at all. In the second group we measured a hearing gain of more than 10 dB in 55% of the patients. An improvement of more than 20 dB was seen in 41%. The mean hearing gain since administration of corticosteroids was 19,7 dB. Again an important part of 45% showed no improvement at all. In the control group we saw a mean hearing gain of 4,9 dB 21 months after administration of corticosteroids.

Conclusions: We state that hyperbaric oxygen therapy at 2,5 ATA is more effective than hyperbaric oxygen therapy at 1,5 ATA for the treatment of idiopathic sudden sensorineural hearing loss. There is also a significant improvement in hearing compared to patients who did not get an adjuvant hyperbaric oxygen therapy.

034 A HYPERBARIC PAN-EUROPEAN TECHNICIAN, OPERATOR AND NURSES ASSOCIATION: A NECESSITY?

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Introduction

In the USA as well as in Australia, a specific Association for hyperbaric paramedical staff exists. The US organization, called "Baromedical Nurses Association", introduces itself as follows: "The BNA provides nurses with a professional organization in order to maintain and promote the status and standards of practice in hyperbaric nursing".

The "Hyperbaric Technicians and Nurses Association" (HTNA) in Australia states as their main objective: "Our purpose is to provide and encourage the exchange of information, standardize practical protocols within technical and nursing communities, educate and inform the recreational diving industry and to encourage hyperbaric research in order to advance the scientific basis of our practice."

In many European hospitals, hyperbaric oxygen therapy (HBO) has found a place and is developing. Unfortunately, this development is not homogeneous and may pose some problems for the hyperbaric paramedical staff concerned.

Taking as an example the USA and Australian nurses' associations, and like already exists in part in Italy, it is high time to harmonise certain aspects of this development – such as educative programs – on a European scale, by creating a common structure.

Methods

In view of this objective, we concretely propose the creation of an International Non-Profit Organisation. The activity panel from this association would be similar to that of the existing Australian HTNA:

- to act as representatives of the members toward all institutions or other associations connected to hyperbaric medicine
- to create reflexion groups relative to all the aspects of various functions in the hyperbaric paramedical area.
- to conduct studies and analysis connected with the hyperbaric paramedical issues
- to facilitate and encourage communication between paramedical staff of all the European hyperbaric centres.
- to study and implement cooperation programmes and exchanges of staff.
- to periodically organise, alone or in collaboration with other associations, technical and scientific symposiums
- to organise and implement educative programs specific to the competencies and functions that are met
- to publish recommendations

Conclusion

We appeal to each category of staff to make the creation of this association possible, and to ensure that it could find a good place, in the interest of everyone who is part of the hyperbaric communities.

035 COST ACTION B 14: EDITING RULES OF GOOD PRACTICE FOR HYPERBARIC MEDICINE

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Due to the lack of safety regulations in the field of hyperbaric medicine in several countries within Europe, the European COST program action B 14 "Hyperbaric oxygen Therapy" built up a working group "Safety" (WGS) in charge of editing rules of safety for hyperbaric medicine which could be accepted and applied by all European countries. Following the work of the working group "Technical Aspects", it holds a double mandate from the COST B 14 Management Committee (MC) : i) to follow the normalisation process of hyperbaric chambers, and ii) to elaborate "rules for good practice" in HBO.

For the first item, the WGS appointed an expert representing the COST B14 MC at the technical board of European Committee for Normalisation, task force 127, which is in charge of drafting a European Standard for medical hyperbaric chambers to be put on the market.

Rules of good practice, which represent most of the work, are elaborated on the basis of existing documents from various European countries and professional associations (British Hyperbaric Association, European Committee for Hyperbaric Medicine, national regulations from Belgium, France, Germany, Italy, etc...).

The topics include the safety of facilities (i.e. standard and emergency operations and maintenance instructions), the safety of the patient (from diagnosis to treatment and management of adverse effects), and the safety of staff and environment, including education and training principles. A large paragraph is devoted to term definitions, after discussions and negotiations inside and outside MCM members, by the mean of *Oxynet.org* discussion lists.

This work is expected to be completed by April 2003, in order to be approved and released by the MCM for the end of action B14 (July 2003).

036 AMBULANCE SERVICE AND DIVING ACCIDENT MANAGEMENT IN BELGIUM

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In Belgium, the Law of 08 July 1964 has installed the public Emergency Medical Service (EMS), making use of a universal telephone call system (900, later 100, recently also 112). This "network" permits easy access to two levels of intervention: ambulance first aid and Emergency Medical Service (called SMUR in the French part of Belgium and MUG in the Dutch speaking part). The aim of this network is to be able to provide (para-)medical (first) aid to the entire population, but also to transport if necessary the patient to a hospital facility, from any place to the nearest accredited hospital.

A set of norms and guidelines have been created for EMS bases, cars and ambulances, for hospitals and personnel. The universal phone number is known by the entire population and thus the system has become a keystone of emergency medical aid in Belgium.

Besides this public EMS system, a large number of private ambulance services exist, who are – at this time – not subject to any formal norms or guidelines (neither for vehicle equipment nor for personnel education). The advantage of these ambulances resides in the fact that they will take on any mission, far or near, whereas the public system is area-restricted.

Divers represent approximately 0.25% of the Belgian population. Diving accidents are rare, and de facto only a negligible part of the EMS interventions. Due to this scarcity, the training and education of ambulance personnel, including the EMS doctors, includes no or only minimal notions of diving pathology. This may seriously compromise the good quality of care for an injured diver, because general EMS guidelines often outright conflict with emergency first aid in case of decompression pathology: "do not let the victim drink", "give a maximum of 6 liters/min of oxygen", "use a standard (FiO₂ 0.4) oxygen mask", "install a standard Glucose 5% IV drip"...

DAN Europe Benelux has set up a DAN Hotline in 1995, using a 24 hour toll-free telephone number and offering telephonic assistance not only to divers but also to EMS personnel. It utilises specific guidelines and procedures and is thus able to combine the advantages of both the public and the private EMS system, while at the same time ensuring an efficient first aid protocol and rapid evacuation of the injured diver.

Parallel to this, DAN strives to have the DAN courses (Oxygen First Aid in Diving Accidents) implemented in the education programmes of EMS personnel, and to sensibilise this personnel to use optimal first aid techniques and equipment.

037 THE WORLD CONGRESS ON DROWNING, 2002

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The World Congress On Drowning (www.drowning.nl) in June 2002 was sponsored by the Maatschappij tot Redding van Drenkelingen that had been established in Amsterdam some 250 years ago to reduce the risks of drowning. The Congress comprised various task forces including one on diving. The scope covered breath-hold, scuba and hose diving by working divers, recreational divers and subsistence fishermen. The objective of this paper is to outline the proceedings of this congress because these will not be published separately. With the permission of the Maatschappij, the sessions of the diving task force have been recorded by members of the Swiss Diving Medical Society for separate publication as a CD.

This summary will introduce the various recommendations relevant to diving health and safety made by informal consensus in the sessions of the 2002 Congress.

038 COST ACTION B14: Working Group Technical Aspects: results

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Working Group "Technical Aspects" – COST B14 Action

Introduction

Besides the initiation and coordination of multicentric clinical studies on the therapeutic effects of hyperbaric oxygen (HBO), one of the designated objectives of the COST Action B14 was to foster the harmonic development of in-hospital hyperbaric chambers, in terms of normalisation.

During the Management Committee Meeting in Copenhagen (March 2000), I proposed the constitution of a Working Group "Technical Aspects" (WGT).

It was decided that the first objective of this group would be the production of a harmonised European Standard on Hyperbaric Medicine, and secondly, the elaboration of a Safety Guideline for Scientific Societies.

Methods

During the Barcelona Meeting (June 2000), it became apparent that only the initiation of a normalisation process with the European Committee for Normalisation (CEN) would apportion a solution to the problem: how to integrate – in normalised terms – the essential requirements of the European Directive 93/42 concerning medical devices ?

In order to prepare the CEN proposition, a methodological approach of the problem, according to the EN 1441 (Risk Analysis of Medical Devices) was performed by the members of the WGT. This project took over a year of collective work; the results were presented at the Management Committee Meeting in Gdynia – Poland (April 2001).

Conclusions

It has become clear that only an open research programme such as the COST Action could give the clinical hyperbaric oxygen therapy community in Europe the opportunities to elaborate a common reflection on the security aspects of their "tool".

Working Group Technical Aspects has demonstrated the urgent need for normalisation in this matter, to initiate a normalisation process and participate in it via a national representation of its members.

039 EXPIRED OXYGEN MEASUREMENTS DURING HYPERBARIC OXYGEN THERAPY

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Introduction

In hyperbaric oxygen therapy, optimal delivery of inspired oxygen is of critical importance to the efficacy of treatment. In high-grade hyperbaric chambers, continuous monitoring of the mask oxygen partial pressure is possible; however, not all HBO centres are capable of such an investment. Personal experience with one patient seemingly unresponsive to HBO, where in fact there was a largely insufficient oxygen delivery due to improper mask fit, unnoticed by the accompanying nurse, led us to make systematic measurements of expired oxygen at different time points during each HBO session.

Methods

Patients breathed oxygen using a demand-type system (Haux Oxymaster System). Expired oxygen pressure was measured by the accompanying nurse two times during each session: once in the beginning and a second time halfway the treatment time. The expiration tubing was connected to a side-flow oxygen monitor (Analox 100HYP), to measure the partial pressure of oxygen. In case of insufficient partial oxygen pressure, the mask fit was verified and corrected.

Two types of masks were routinely used during treatments ("Dräger Combitor Nova RA" and "Laerdal One-Piece Silicone Mask"). The results of the sequential measurements were correlated to the type of mask both as to initial measurement as to consistency of the oxygen administration. Three distinct periods of measurement, each of 28 days duration, were performed. The interval between each period was approximately 1 month, and the start of each period was not announced before to patients nor to the nurses.

Results

During the first 14 days of each period, the number of incorrect mask placements was slightly higher than during the second half of the period (mean over three periods: 4.18 % during first half, 1.03 % during second half). There appeared to be no significant difference as to the type of mask used. In 0.94 % of the second measurements, an improper mask fit was observed. There was no difference between the two mask types. These observations were fairly similar in each of the three periods separately, indicating a decrease of awareness after a one-month interval.

Discussion

Erroneous mask placement is a possible source of insufficient oxygen breathing during HBO therapy. Expired oxygen measurements are capable of detecting and correcting such errors. There appears to be a positive impact of such measurements on the awareness of good mask fit, both by the patients and the accompanying nurse. However, this awareness effect seems to wear off after a period of approximately one month. Mask fit in between these measurements is not known. It is therefore unjustified to state that these sequential measurements can replace a continuous mask oxygen monitoring.

O40 CONDITIONING OF INTENSIVE CARE PATIENTS FOR HYPERBARIC OXYGEN THERAPY

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Introduction

In view of starting a prospective (possibly multicentric) clinical study of the treatment of burn patients with hyperbaric oxygen therapy, a survey was undertaken to identify possible problems and incompatibilities of the treatment of high-care burn patients in the Military Hospital in Brussels.

Methods

An analysis was made of the following items in the treatment of a burn patient:

- the intake and emergency resuscitation, including initial surgical management (fasciotomies)
- the preparation and transport to the hyperbaric department
- the hyperbaric treatment : monitoring, continued resuscitation
- the alternating burn care and hyperbaric treatments

A set of guidelines and checklists was prepared for use by nurses and physicians

Discussion

An essential requirement was that the hyperbaric treatment would in no way compromise the efficacy of the "classical" burn resuscitation and treatment, as applied in our Burn Centre.

It appeared that only minor adaptations in the initial treatment protocol were necessary in order to minimise the delay before the first hyperbaric treatment.

A full respiratory and haemodynamic monitoring appeared essential during transport and hyperbaric treatment. A properly equipped hyperbaric chamber and trained intensive care nurses are a prerequisite for safe treatment.

It appeared that a sound understanding of hyperbaric physics and physiology, as well as experience and practical knowledge were of great importance. Practical checklists and guidelines were considered useful aids in increasing the speed and performance of the treatment protocols.

Conclusions

The intensive care burn patient poses several unique problems when considering an adjunctive treatment with hyperbaric oxygen therapy.

In order to overcome these problems, proper planning and preparation is necessary. An optimisation of the hyperbaric "hardware" as well as the "software" (technical, nursing and medical personnel) is however of the utmost importance.

O41 INSTALLATION OF A DIVING-ERGOSPIROMETRIC SYSTEM IN THE DIVE-CHAMBER OF THE GERMAN NAVAL MEDICAL INSTITUTE HYPERBARIC CHAMBER FACILITIES

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Background: Realization of sports-physiological measurements under diving conditions is difficult, because off-the-shelf ergospirometric devices, stationary or portable, are not pressure-proof.

Method: In the Kiel HYDRA 2000 hyperbaric facilities a fin-swimming-ergometer was installed into our diving chamber with special adaptation of a half-open computerized spirometric system for online-measurement of minute-ventilation, O₂-uptake, CO₂-elimination, respiratory quotient and gas fractions. The fin-swimming ergometer in the diving chamber consists of a stainless steel construction fixed at the chamber ceiling with a pull-back mechanism for the diver and variable weights. In result, the diver is swimming stationary, similar to running on a treadmill. Breathing gas supply is realized via a full-face mask and an umbilicus with slightly elevated pressure inside the mask to keep the ergospirometric system dry. Expiratory gas is collected via a tube-connection into a Douglas-bag, installed together with the Pneumotachograph in the dry part of the chamber outside the Buffalo-wall. The expiratory gas samples are conducted to the computer-ergospirometer outside the hyperbaric environment through a pressure reducer system. The overall nearly 3m tube-length from the face mask to the Douglas-bag causes a measurement-delay for O₂-uptake of round 30 seconds and for CO₂-elimination of nearly 2 minutes. This makes workload steps of at least 3 minutes duration in exercise testing necessary.

Conclusion: Together with a normal bicycle ergometer in the same hyperbaric facility, which is equipped for use with the same gas collection system, this diving-ergospirometric system offers a unique chance for the comparison of physiologic data collected during realistic diving and fin-swimming simulation down to 50m "depth" with the equivalent workload on a typical bicycle ergometer.

O42 MANAGEMENT OF FIRE RISKS IN HOSPITAL HYPERBARIC ENVIRONMENTS

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Introduction

Without a doubt, fire and its consequences represent the greatest danger in hyperbaric environments. Indeed, the increase in pressure and in oxygen partial pressure in ambient air rapidly leads to uncontrollable extension of the fire in a closed environment (without an emergency exit).

Unlike in professional diving circles, the specificity of hospital hyperbaric environments is that patients are received there, i.e., people who have not been trained concerning the specificity of this environment. Furthermore, for many indications, these patients may well be treated in a hyperbaric chamber up to 30 or even 40 times.

Even if, based on adequate initial information, patients then become mindful of the safety regulations during the first days, their attention can be expected to slack over the days...

On the other hand, a large proportion of the work of operators in hyperbaric chambers is composed of repetitive activities, with all the risks entailed by "force of habit". Risks related to human factors are thus in place...

Methods

The study of fire in hyperbaric environments dwells on the problems to be expected, such as flammability criteria, rate of spread, heat, pressure and toxic fumes. Literature reports that some materials which are well-known to be non-combustible will burn very well in a hyperbaric environment.

In line with the problems posed, the Norms and Guidelines Market has been reviewed in order to verify the relevance of the answers found.

Conclusions

In view of the gravity of the consequences of a fire, the author has split his reflections into two parts:

- Preventive measures
 - The implementation of fire suppression systems
- There are two orders of suggested solutions: normalisation of the performance of deluge systems and setting up programmes of continuing education for personnel.

043 MAXIMUM BREATH HOLD TIME DURING FACE IMMERSION ACROSS GENDER AND WATER TEMPERATURES FROM 0 TO 20°C

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It was asked in this study if maximum breath hold time (BHT) with face only immersion varies as a function water temperature and gender. Twelve college (6 male and 6 female) aged subjects (24.9 ± 2.7 yrs, mean \pm SE) of normal physique (BMI = 24.6 ± 2.9) immersed their faces in a stirred water bath, at 0, 5, 10, 15, 20°C, on 5 separate days. Subjects held their breaths, without prior hyperventilation or habituation, to simulate a sudden immersion. At each water temperature and in a separate trial with no face immersion during breath holding in air at 25°C, subjects' values were recorded as the mean of 3 successive BHT trials. For males the longest BHT with face immersion was 76.0 ± 17.6 s (mean \pm SE) at a bath temperature of 20°C and the shortest BHT was 46.6 ± 13.7 s at a bath temperature of 0°C. A similar trend was seen for females who held their breath for 40.0 ± 5.8 s at 20°C and this decreased to 20.3 ± 2.9 s with face immersion in 0°C water. A 2-way ANOVA for Bath Temperature ($F=4.1$, $p=0.01$) and for Gender ($F=9.0$, $p=0.03$) showed at lower bath temperatures BHT was significantly decreased irrespective of gender. As well, at all bath temperatures the female BHT were significantly lower ($0.001 < p < 0.05$) than male breath hold times. In conclusion, irrespective of gender, breath hold times with face immersion in these conditions were decreased at lower bath temperatures and females had lower breath hold time than male during face immersion at all bath temperatures.

044 CHILDREN AND DIVING: MEDICAL ASPECTS – EIGHT YEARS SPORTS MEDICAL FOLLOW-UP OF THE FIRST SCUBA DIVING CLUB FOR CHILDREN IN BELGIUM

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Background:

The interest of children for the underwater world starts growing in the mid-eighties. Trainers, instructors and physicians are confronted with the set-up of structures for the initiation of young divers in optimal conditions aligning children's satisfaction and maximum security. Suggested guidelines for the examination have been reported for adults. Local courses sponsored by national certifying agencies have a minimum age requirement of 12-14 years.

No suggested standards for evaluating prospective pediatric divers with a given age criterion for course participation are available in the mid-eighties.

Aim:

Care, security and prevention in the start of scuba diving initiation of children in Belgium with optimal communication between instructors and sports physician.

Methods:

- 8 Years (1985-1992) prospective follow-up of sports medical evaluations in 234 young subjects (age : 6-13 years) in the first scuba diving club for children (Marmottes et Castors Palmés, Brussels) in Belgium.
- 1-2 Yearly sports medical evaluations including physical examination (with special N.T.E. focus), E.C.G. (rest + cycloergometry) and E.E.G.
- Modified (adults) guidelines for children.
- Weekly swimming pool training.
- 2440 open water dives limited to 5 meters.

Results :

29 Children (12,4 %) are disqualified: 12 children – 5,1 % abnormal E.E.G., 4 children – 1,7 % asthma/bronchial hyperre-activity, 1 child – 0,4 % sickle cell anaemia. 58 Incidents (28,3 % of qualified children) and 5 accidents (2,0 % of qualified children) are reported during 8 years scuba diving initiation in the swimming pool. No incidents, neither accidents occurred during open water dives.

Incidents	Nr. Incidents	% Qualified Children
tuba dysfunction	25	12,2 %
cerumen body	11	5,4 %
otitis externa	8	3,9 %
mycosis (body)	7	3,4 %
otitis media	1	0,5 %
dontalgia	1	0,5 %
epistaxis (diving)	1	0,5 %

Incidents	Nr. Accidents	% Qualified Children
tympanic perforation		
syncope during apnea	4	1,5 %
(excessive hyperventilation)	1	0,5 %

Conclusions:

Periodical sports medical examinations based on modified (adults) guidelines for children and optimal communication between instructors and sports physician result in safe diving initiation with low number and low severity degree of incidents and accidents in children in Belgium. These Belgian data pooled with other international data are used to establish F.E.B.R.A.S./B.E.F.O.S. (Fédération Belge de Recherche et d'Activités Sous-marines / Belgische Federatie voor Onderwater Onderzoek en Sport) and C.M.A.S. (Confédération Mondiale d'Activités Sous-Marines) standards for children and diving.

O45 EFFECT OF OXYGEN BREATHING PRIOR TO SUBMARINE ESCAPE

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Submarine escape from a submarine with raised internal pressure exposes the submariners to a high risk of DCI. Previous experiments showed that the number of circulating bubbles decreased much faster after ascent when a hyperoxic breathing gas was used. However, the hyperoxic gas did not reduce the initial peak amount of bubbles. Also, the incidence of CNS DCI did not decrease. To reduce the initial bubbling, and thereby supposedly decrease the risk of CNS DCS a short period of oxygen breathing before the escape was tested.

Methods: 22 goats in the weight range 35-60 kg were used. Submarine escape profiles from 25 ata were carried out in a computer-controlled hyperbaric facility. The animals were kept at 2 ata in air for 6 h before the escape. Half of the animals were given 15 min oxygen breathing just prior to the escape (O2PB), the others remained on air until the start of the ascent (NPB). During the escapes the animals were breathing a 60/40 O₂/N₂ mixture via a face-mask supplied with gas from the "hood-inflation system". Directly after the escape all animals were returned to air breathing. Pre-cordial Doppler monitoring was carried out every 5 min during the first 30 min, every 15th min between 30 and 120 min, and then every hour for 6 hours or until free of any circulating bubbles. The amount of bubbles was scored using the Kisman-Masurel (KM) scale.

Results: No hyperoxic convulsions were seen in any of the goats despite a maximum inspired PO₂ of 1500 kPa during the ascents. Two animals in the O2PB group, and 1 in the NPB group showed neurological symptoms post ascent. However, post-mortem showed these deaths were caused by barotrauma, not decompression illness. The median peak bubble score was significantly reduced in the goats given oxygen before the escape (KM III+ vs IV-, $p < 0,001$). The time with high bubble scores (KM ≥ 3) was also significantly shorter in the oxygen pre-breathe animals (median time 30 vs 180 min, $p < 0,001$).

Conclusions: A short period of oxygen breathing prior to submarine escape reduced not only the peak score of circulating venous bubbles. It also significantly reduced the time with high bubble counts.

O46 HEART RATE RESPONSES DURING FACE IMMERSION ACROSS GENDER AND WATER TEMPERATURES FROM 0 TO 20°C

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It was asked if the effects of gender and water temperature influence the bradycardia component of the dive response, both with and without breath holding. On 4 separate days, ten college (5 male and 5 female) aged subjects of normal physique (BMI=24.7 \pm 3.1) immersed their faces in a stirred water bath at 5, 10, 15, 20°C. Face immersion during breath-holding was without prior hyperventilation and all subjects were un-habituated to face immersion or breath-holding.

Both of these approaches were taken to help simulate a sudden and unplanned cold water immersion. Subjects' values were recorded as the minimum HR observed during a 30-s period at each water temperature and in a separate trial for breath holding in air at 25°C with no face immersion. Irrespective of bath temperatures or gender, breath holding during face immersion significantly decreased heart rate ($p < 0.001$). The effects of gender and water temperature on heart rate response to face immersion were not significant in these conditions. There was a significant breath hold by gender interaction that was accounted for males have a significantly greater suppression of their heart rate than females with breath holding. The results support that across gender and across the range of bath temperatures investigated, subjects had similar heart rate responses to face immersion. The exceptions were during breath holding when there was a significantly lower heart rate observed relative to non-breath holding, a response that was more so evident for males than females.

P1 RESULT OF 918 MAN-OXYGEN DECOMPRESSIONS IN A GROUP OF COMPRESSED AIR TUNNEL WORKERS

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Objective: To review and analyse the risks and benefits of using French Oxygen Decompression tables in a recent Hong Kong compressed air tunnel construction.

Design & methodology: A retrospective study to all recruited compressed air workers who had exposed to compressed air work with oxygen decompression during the tunnel project.

Main outcome measures: Any sign and symptom related to compressed air work and oxygen decompression were recorded for this study.

Result: There were six cases of ear, one case of tooth barotrauma occurred, and no other dysbarism reported or recorded.

Conclusion: The risks and benefits of oxygen decompression is not easy to evaluate, the application should need a detail consideration. In this small sample size study, the result of using French oxygen decompression tables in compressed air workers in decompression illness prevention are very promising. Observed side effect of oxygen toxicity is mild and transit. High-risk groups candidates include a history of convulsion or epilepsy, air-trapping lung problems and eustachian tube malfunction are excluded from this study group during the initial pre-employment medical examination may explained the promising result. High expertise of supervising teams and stress on the precaution in the application of pure oxygen decompression procedure together with the recognition and practicing of stringent safety measures also contributed to the highly successful rate of decompression illness prevention with oxygen decompression. Provided further fine-tuning of this measures and safety precautions follows the incident of decompression illness and dysbarism will be eliminated.

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P2 EVIDENCE FOR A NON-HYPOXIC STIMULUS ON EPO PRODUCTION IN HEALTHY HUMANS

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Introduction

Erythropoietin (EPO) is a human hormone, synthesised by renal paratubular interstitial cells, that induces red blood cell (RBC) production by activating the red bone marrow progenitor cells. Hypoxia is the main and actually the only recognised trigger for EPO production; it has been well established that reduced oxygen delivery - be it because of anaemia, hypobaric or normobaric hypoxia or reduced renal perfusion - induces a *de novo* synthesis of EPO. Basic EPO concentration ranges from 5 to 25 mU/ml. Human EPO production seems to follow a cyclic circadian rhythm, although this has been debated. We hypothesised that also a non-hypoxic change in oxygen delivery might be able to induce EPO production in healthy humans. After 2 hours of 100% oxygen breathing (1 atmosphere), 27 subjects (9 female, 18 male) underwent repetitive blood sampling for up to 36 hours. Population age ranged from 22-47 years. EPO concentration was measured using a Radio-Immuno-Assay (RIA) test. A group of 16 randomly assigned subjects served as controls, in order to establish a baseline control value.

Results

A non statistically significant circadian variation was found in the control group, ranging from $9,55 \pm 1.25$ mU/ml at noon to $12.11 \pm 3,6$ mU/ml at 22.00 hours. In the normobaric oxygenation group, a significant rise in EPO concentration was observed 10; 22 and still increasing 34 hours after cessation of oxygen breathing (125,7 +/- 30; 152 +/-59; 171,9 +/-66 percent of control value). The concentration curve suggests that EPO production starts around 6 hours after cessation of oxygen breathing.

Discussion

Oxygen breathing for a moderate duration promotes tissular denitrogenation; this leads to increase tissular oxygen levels. After cessation of oxygen breathing, nitrogen partial pressure in all body tissues including the renal tissue, will rise to saturation, causing a concomitant decrease of tissular oxygen tension. This "relative" hypoxia may be able to induce EPO production, without tissue oxygen levels ever dropping below physiologic thresholds.

P3 LYMPHATIC CLEARANCE OF PROTEINS IS ENHANCED DURING NORMOBARIC OXYGEN BREATHING: A LYMPHOSCINTIGRAPHY STUDY

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Introduction: Normobaric oxygen (NBO) is the first aid for decompression sickness (DCS) with beneficial effects that include accelerated elimination of dissolved tissue nitrogen and nitrogen in bubbles. Nitrogen bubbles cause the precipitation of proteins on blood-bubble or tissue-bubble interfaces. We wanted to determine if NBO would accelerate the clearance of interstitial proteins by the lymphatic system.

Methods: Seven healthy air breathing control subjects received an injection into the first interdigital space of 0.2 ml of Tc99-marked human albumin diluted in 2.3 ml of a stable solution of plasma proteins. The injection produced moderate subcutaneous oedema. Subjects underwent lymphoscintigraphy while recumbent. On a separate day, the procedure was repeated, but the subjects breathed NBO for 30 min beginning immediately after protein injection. The isotope activity at the axillary ganglia was recorded to measure the rate of lymphatic protein drainage.

Results: For six of seven NBO subjects, the rate of increase of axillary isotope activity at the start of NBO breathing was more than twice that of the air-breathing subjects. The seventh subject had only a slight increase.

Conclusion: NBO breathing accelerated protein clearance by the lymphatic system in six of seven subjects indicating enhanced lymphatic flow. This also suggested that NBO may have enhanced the resolution of oedema.

P4 HYPERBARIC OXYGEN IN THE TREATMENT OF SUDDEN DEAFNESS (SD) AFTER FAILURE OF PREVIOUS MEDICAL TREATMENT Start up of a multicentric, prospective and randomised study

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Working group 1. COST action B14

SD has an incidence of between 5 and 20/100.000 persons per year and only in approximately 20% of cases, a causal factor can be identified. But whatever the origin may be, the consequence on the inner ear arises from a reduction of the PO₂ in the Corti's organ. Thus the treatment of SD is based on the local enhancement of oxygen supply and generally involves: rhéologic substances, Carbogen inhalation, haemodilution, corticosteroids and hyperbaric oxygen (HBO).

Currently, there is no consensus about none of these treatments. Though it has been employed since numerous years, the place of HBO in this disease needs to be clearly evaluated. So, a multicentric, prospective and randomised study is started on to establish the clinical efficacy of HBO after failure of classical treatments.

Inclusion criteria: SD diagnosed by clinical history and tonal audiometry (at least 30 dB loss in at least 3 frequencies) with a global hearing loss of less than -80 dB and a failure to response (less than 10 dB mean improvement) to a "standard" previous treatment of at least 7 days (involving at least 1mg/Kg of corticosteroids). The delay between onset of SD and initiation of HBO must be less or equal to 4 weeks.

After randomisation, patients will be separated in 2 groups:

- HBO (200 patients): 10 HBO sessions, one per day, 2.5 ATA, 100% O₂ (10-15 minutes compression on air, 70 minutes of oxygen breathing, 10 minutes of decompression on air
- Non HBO (200 patients): no treatment

Duration of the inclusion in the study is of 10 days for each patient (any group). Evaluations will be performed at: day 0 (before start of the trial), day 6 and day 11 (the day after the 10th HBO session or 10th day follow up in the non HBO group).

Data analysis: calculation of a mean hearing loss (MHL): mean of the respective differences between the 3 most affected frequencies and their corresponding contralateral value. Evaluation of the effect of HBO treatment and control group by :

- the mean hearing gain (difference between MHL at day 11 and day 0)
- a hearing recovery score : "excellent" (return to within -10dB or less), "good" (return to within -20dB), "poor" (all other cases)

Expected results: at least a 30% rate of "good" recovery with secondary HBO therapy (Chi square test <0.005).

P5 POSTOPERATIVE COMPLICATIONS AFTER LUMBAR SURGERY: IS IT SAFE TO DIVE?

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Abstract not available.

P6 THE USE OF HYPERBARIC OXYGEN TO TREAT FAECAL INCONTINENCE SECONDARY TO PUDENDAL NEUROPATHY - A PILOT STUDY

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Background: Patients with faecal incontinence secondary to multiple sclerosis have had a non-sustained reversal of incontinence with hyperbaric oxygen therapy (HBO). Idiopathic faecal incontinence secondary to pudendal neuropathy has no adequate treatment.

Method: 12 patients (11 female, age range 40-73) with chronic pudendal neuropathy and faecal incontinence were identified. They received 30 treatments of HBO over 6 weeks. Each treatment was at 2.4 atmospheres breathing pure oxygen for 90 minutes. Pudendal latencies were performed sequentially throughout the treatment and 1 and 6 months after it had finished. Questionnaires were used to assess improvements in symptoms and quality of life (Wexner FIQL)

Results: All patients completed the treatment without major complications.

	Pre	halfway	end	1 month	6 month
PNTML(Msec)	2.34	2.23	2.11	2.10	2.13
Inc. Score (max20, Min0)	12		11	10	9

The improvements in latencies were significant when comparing pre to later, (Wilcoxon 2 Tailed, asymp.sig -pre/halfway, 0.045, pre-end, 0.003, pre-1month 0.007, pre-6 month, 0.027). Using the same test the improvement in incontinence scores was also significant in comparing pre-end (0.05) and pre-1 month (0.017) but not pre-6 month (0.279). Improvements were also seen in all 4 categories of the FIQL.

Conclusions: The cause for this improvement in latencies is unclear at present but may be due to either a direct effect on the nerve or an improvement in blood flow to the nerve through angiogenesis. However these results are good enough to set up further trials.

HBO-Hyperbaric oxygen, VAS- visual analogue system, FIQL-faecal incontinence quality of life

P7 DECREASED PULMONARY DIFFUSION CAPACITY OF SPECIAL FORCES DIVERS DURING DIVING WITH 100% OXYGEN

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Background: Changes in pulmonary function immediately after oxygen dives have been demonstrated with a reduction in diffusion capacity being the most consistent finding. The aim of this study was to determine changes in diffusion capacity during the training program of special forces who regularly dive with 100% oxygen for periods of 3 h at a depth of 5 mt water.

Methods: During training of divers from special forces (n=19) with oxygen breathing apparatus, pulmonary function tests, including single-breath diffusing capacity (DLCO) and transfer coefficient (KCO) were conducted at 1) baseline, 2) after a 'wet' dive with oxygen (180 min/150 kPa; 320 UPTD), 3) 4 h after the wet dive, 4) after a 'dry' oxygen dive in the chamber (180 min/150 kPa; 320 UPTD) and 5) within 4 h after the dry dive.

Pulmonary function tests were performed by experienced clinical respiratory technicians at the Diving Medical Center using Sensor Medics V-max 22 apparatus. Single-breath diffusing capacity and transfer coefficient were measured according to the European Respiratory Society standards and the manufacturer's instruction. DLCO/KCO values were corrected for hemoglobin (Hb) values. Data are presented as mean \pm SD. Statistical significance was established at $P < 0.05$.

Results: At baseline all 19 divers had normal spirometric values for vital capacity (VC), forced expiratory volume (FEV1) and peak expiratory flow (PEF); during all subsequent measurements there were no significant changes in these spirometric values. After the wet oxygen dive, there was a significant decrease in DLCO (10.4%) and in KCO (13.3%), both of which recovered slightly within 4h. In contrast after the dry dives, there was no significant decrease in either DLCO and KCO.

Conclusions: During dive training with 100% oxygen of special forces, there was a significant decreases in both DLCO and KCO after the wet dives; there was a tendency for these values to recover within 4 h. In contrast, the dry oxygen dives in the chamber resulted in an only slight decrease in DLCO and KCO. This latter may be due to differences in workload, ventilation and environmental temperature compared with the wet dive. We conclude that dive training of special forces using 100% oxygen is safe in relation to effects on the diver's pulmonary function. Further studies on pulmonary oxygen toxicity are needed to investigate the role of workload, environmental temperature and ventilation in divers.

P8 PULMONARY CONTUSION DURING SCUBA DIVING

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Objective: We report a severe case of pulmonary contusion in a sportsdiver. Moreover the importance of a hyperbaric facility embedded in a tertiary care referral center staffed with professionals understanding the fundamentals of diving physiology is suggested.

Materials: A 42-years-old male was treated after an uncontrolled emergency ascent following significant respiratory distress at 20msw. While surfacing, the patient became unconscious and started vomiting. After intubation and sedation the patient was transported in a helicopter to our hospital. On admission, a bilateral pneumothorax, pulmonary edema, signs of lung contusion and aspiration were observed radiographically. On clinical examination a right-sided paralysis could be suggested. After initial hemodynamic stabilisation, bilateral thorax suctioning was installed. Recompression therapy (USN 6 Table) was initiated because the diving profile suggested both air embolism (AGE) and decompression illness (DCI). In the hours after recompression, supplementary thorax suctioning and bronchoscopy were necessary because of tension pneumothorax and atelectasis. With high oxygen need (70%) and inotropic support, Swan Ganz values demonstrated cardiac output failure.

Elevated creatine kinases suggested significant peripheral air embolism for which alkalisation of urine was initiated. On day 3, extubation was performed with high oxygen need but without important neurologic sequelae. Radiography showed signs of pneumonia and ARDS for which antibiotics were started. Almost 1 month after initial injury, the patient left the hospital in good condition. The patient was known with hypertension.

Conclusions: This case demonstrates an almost dramatic example of pulmonary barotrauma and peripheral gas embolism in a sports diver with possible coexisting DCI in a patient treated for hypertension during his first dive of the season. Respiratory distress which initiated a panic ascent could be caused by increased preload and afterload effects following submersion, hyperoxia, hypertension, cold and suit compression. Due to intensive hyperbaric medicine, a portion of luck, the patient survived without neurological sequelae. Because of the important lung contusion scuba diving is prohibited in the future.

P9 NEW GERMAN TRAINING REGULATIONS FOR COMMERCIAL DIVERS REFLECT THE IMPORTANCE OF IN-DEPTH MEDICAL EDUCATION

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In contrast to all other countries worldwide, in Germany until recently the training of commercial divers was completely in the responsibility of diving companies, requiring two years of practical diving with no special theoretical education. The increasing diversity of underwater work together with the lifting of national borders raised the necessity for a better understanding of the theoretical foundations of this trade.

In the process of generating new training regulations, it was possible to implement a sufficient amount of medical lectures and practical training. Every apprentice diver is now required, within these two years, to attend courses of all together 320 hours, 60 of which are dedicated to diving medicine. In more detail they contain:

Anatomy and physiology, barotrauma, effects of nitrogen and oxygen under pressure, decompression problems and treatment, drowning, hypothermia, mixed-gas and saturation diving, personal hygiene, compressed air work, environmental factors, diving in tropical waters, emergency procedures and communications, psychological aspects, rules and regulations, etc. This also includes 32 hours of practical training in a semi-clinical setting, like ear inspection, CPR, injection and infusion, wound treatment, neurological examination, transport of injured, chamber operation etc.

The Hyperbaric Training Center, located in Hamburg, is currently the only officially approved institution nationwide, offering all the required courses including

- 80 hours of basic introduction to commercial diving,
- 100 hours of general application of diving gear and technology,
- 80 hours of welding,
- 60 hours of diving medicine (as above).

Additionally the center holds an annual 120-hours-course of advanced medical training for offshore-, nuclear- and tunnel-diving, plus periodical courses for lock-attendants, civil engineer-divers, mixed-gas-diving, and a master-diver training of two years duration; also chamber of physician-certified courses for medical doctors, shaped according to the latest requirements of EDTC.

The center is an incorporated charity with a non-profit board, formed by leading German ex-ponees in diving and compressed air work. It is also supporting medical research projects in these fields; it is sponsor and organizer of the tri-annual "Arthur-Bornstein-Workshop", held in Hamburg. Its homepage "www.hyperbaric-training-center.de" supplies the commercial diving industry in Germany with latest information on technical, practical and legal matters. Try it out!

P10 A DIVING OPERATION ON THE WRECK OF CAMALTI BURNU-1, INTERIM REPORT

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The underwater excavation to the wreck of Camalti Burnu-1 has started in 1998 at the coast of Marmara Island, in Marmara Sea. The wreck has an archeological importance as an example from 13th century. The cargo of the wreck, the last amphoras, ceramic containers have spread over a sandy bottom area at the depth of 20-32 m. Around 2000 SCUBA dives were performed during four diving seasons, each lasted about two months. All dives were performed on air and Bullmann table was used for decompression.

The most common diving related diseases were ear barotrauma, sinus squeeze and external ear infection. There was only one pain only decompression sickness case and the case treated in the chamber on site. The excavation was planned to be finished at the end of 7th diving season.

P11 PSYCHOPHYSIOLOGICAL AND BIOCHEMICAL ASPECTS OF HYPERBARIC OXYGENATION IN TOXIC ENCEPHALOPATHY

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Objectives. Acute poisoning is associated with homeostasis impairments, toxic encephalopathy and often leads to fatal outcomes. Common causes of death are respiratory arrest, toxic encephalopathy and multiple organ failure secondary to acute hypoxia and metabolic disorders. In this connection, the goal of this study was to identify efficiency of HBO in the complex treatment of toxic encephalopathy.

Methods. A comparative study including 339 patients randomized into two groups was undertaken. The 1st group included 263 patients with acute poisonings (63 - opium poisonings, 85 - drugs poisonings, 115 - carbon monoxide poisonings) who received sessions of hyperbaric oxygenation (HBO): 100% oxygen in monoplace chambers under hyperbaric conditions (40 minutes at 1.4-2.0 ATA maximal pressure at each session).

The 2nd group included 76 patients (11 - opium poisonings, 30 - drugs poisonings, 35 - carbon monoxide poisonings) who received a standard pharmacological therapy. We performed the following investigations: study of cerebral blood flow, immune processes, level of serum serotonin and histamine, lipid peroxidation (LP) processes and antioxidant system (AOS), neuropsychological studies, CT, EEG.

Results. Besides hypoxia elimination, HBO facilitates the correction of metabolic processes and the normalization of antioxidant system function, allows to optimize the immune processes. HBO stimulates to increase of serotonin and decreased of histamine level. HBO sessions provided a normalizing effect on LP-AOS system in all the patients. HBO effect on LP-AOS system was mostly significant after the first HBO session and persisted for the whole HBO course. In HBO group the average period of patient's being in coma decreased two times compared to that of the control group.

Conclusions. The obtained data demonstrate the pathogenic role of the impairments in LP and AOS processes in case of toxic encephalopathy and give evidence that HBO of chosen mode produces a normalizing effect on LP-AOS system. HBO treatment allowed to reduce mortality and to prevent the development of persistent neuropsychologic disturbances. The use of HBO-associated detoxicating, antihypoxic and metabolic effects in the complex treatment of acute poisonings allows to improve the outcomes.

P12 THE ROLE OF HYPERBARIC OXYGENATION IN THE CORRECTION OF HOMEOSTASIS OF PATIENTS' WITH PSYCHO-ORGANIC DISORDERS

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Objectives. Disturbances of brain function usually develops after its hypoxic damage. Treatment and prevention of psycho-organic disorders in hypoxic brain damage still remains a great challenge. Poor tolerance to psychotropic agents in these patients should be taken into account.

Methods. A comparative study included 876 patients who sustained acute intoxication with drugs, carbon monoxide (CO), brain injury and strangulation asphyxia. These patients comprised the study group and received HBO sessions: 100 % oxygen in monoplace chambers under hyperbaric conditions (40 minutes at 1.4-2.0 ATA maximal pressure sessions at each session) in combination with pharmacological therapy. The 2nd (control) group included 164 comparable patients who received a standard pharmacological therapy. The HBO therapy course consisted of 10-15 sessions. All patients had neuropsychologic sequelae of hypoxic brain damage. The efficacy of HBO session in patients was assessed on the basis of clinical evaluation, neuropsychological investigations, EEG-topographic study of the brain, computer tomography (CT), the study of cerebral blood flow, immune processes, the level of serum serotonin and histamine, lipid peroxidation (LP) processes and antioxidant system (AOS).

Results. The results showed that HBO had a positive influence on the dynamics of psycho-organic disorders. In the patients of the study group (receiving HBO) the following favourable changes went faster: amnesic disorders were eliminated; the cognitive processes were improved; manifestation of intellectual deficit, affective disturbance, and asthenic symptoms decreased. Neuropsychological investigations confirmed these data.

Besides hypoxia elimination, HBO ensured the correction of metabolic processes and the normalization of antioxidant system function, allowed optimization of the immune processes. HBO stimulated changes in the neuromediator systems: the increase of serotonin and the decreased histamine levels. In HBO group the average duration of manifestation of psycho-organic disorders decreased in two times compared to that of the control group.

Conclusions. HBO treatment allowed to prevent developing persistent neuropsychologic disturbances and decreased the incidence of delayed neuropsychological sequelae. The use of HBO-associated antihypoxic and metabolic effects in the complex treatment of psycho-organic disorders allows to improve the outcomes. Thus, HBO may be used as a method of metabolic brain protection.

P13 HYPERBARIC OXYGENATION (HBO) AS A BIOENERGETICAL METHOD OF IMMUNE PARAMETERS CORRECTION IN THE PATIENTS WITH ACUTE DRUGS POISONING

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Objective: The disturbances of immune parameters are the course of complications and death at the patients with acute drugs poisoning. It seems that HBO is the most physiological bioenergetical method actual to justify expediency of it application in complex treatment of given category of patients.

Methods: A comparative study including 32 patients with acute opium poisoning randomized into two groups was undertaken. The 1st group included 21 patients who received sessions of HBO: 100% oxygen in monoplace chamber under hyperbaric conditions (sessions for 40 min at 0.4-1.0 ATA maximal pressure). The 2nd group included 11 patients received a standard pharmacological therapy. All patients were in coma in admission. We performed the study of immune processes. The blood-test were collected before the beginning of treatment for the 1st (2nd), 3rd-4th, 5th-7th and the 8th-11th day from the beginning of therapy.

Results: After the 3rd-4th session HBO treatment were normalized the level of immunoglobulines. The level of immunoglobuline G were normalized after the 5th-7th session. Also the amount of blood leucocytes normalized in the 1st group and there were leucocytosis in the patients of the 2nd group. After the 1st (2nd) or 3rd-4th session HBO treatment were normalized the parameters of spontaneous activity of fagocytes. The amount of circulating immune complexes was approaching the normal values by the 5th-7th day. In the 2nd group the modification of given parameters was marked more later.

Conclusions: The obtained data testify about the unspecific immunomodelling and immunostimulating HBO effect. And thus HBO is the most physiological bioenergetical method it give evidence for the inclusion it to the complex treatment of patients with acute drugs poisoning.

P14 EFFECTS OF HYPERBARIC OXYGEN THERAPY ON INFLAMMATORY BOWEL DISEASE IN A RAT MODEL

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Background: Inflammatory bowel disease (IBD) is an intractable disease in gastroenterology, and its pathogenesis is still uncertain. With the well known beneficial effect of hyperbaric oxygenation (HBO₂) on wound healing, the aim of this study was to evaluate the efficacy of HBO₂ on the trinitrobenzene sulfonic acid (TNBS)-induced colitis rat model which is used as an animal colitis model similar to human IBD.

Methods: Colitis was induced by intra-rectal administration of a hapten (TNBS). After one week of induction, colitis occurred. HBO₂ (100% O₂, 2.5 ATA, 90 min, once a day, 5 days a week) was initiated in monoplace hyperbaric chamber for 2, 4, 6 weeks of durations respectively. After predetermined duration of HBO₂ treatment, the time-matched HBO₂ treated or untreated rats were sacrificed. The colon tissues and feces were collected to determine colon weight, feces weight, and the macroscopic and microscopic inflammatory indices. Blood sample was collected for WBC counts. Statistical significance was set at level of $p < 0.05$.

Results: Based on macroscopic and histological grading indices, all TNBS-managed rats appeared colitis one week after induction, peaked at 3 weeks and down hilled 5 and 7 weeks afterward. Group of rats colitis treated with 2 weeks of HBO₂ had significant ($p < 0.01$) lower value in wet weight of colon and WBC counts than that of the time-matched untreated colitis group, but only a trend found on the graded macroscopic and microscopic inflammatory scores. However, groups of rat colitis treated with 4- or 6-week HBO₂ did not show any improvement in these inflammatory indices when compared to that of time-match untreated colitis groups. The water content of feces in rats did not show any difference between colitis group and time matched colitis treated with HBO₂ group throughout this study.

Conclusions: Short term of HBO₂ seems modulate acute inflammatory activity of the colitis toward beneficial side during the acute stage of colitis. It may imply HBO₂ might reduce severe complication of IBD in acute stage.

P15 MYOCARDIAL DAMAGE DURING SEVERE CO POISONING

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Introduction: Carbon monoxide (CO) poisoning is a severe and life threatening intoxication due to a CO binding with haemoglobin, myoglobin and mitochondrial respiratory chain. In some patients it can determine a stunned myocardium disease. Aim of our study was to evaluate in 13 CO intoxications the presence of electrocardiographic (ECG), Troponin I, Lactic dehydrogenase (LDH) and creatin kinase (CK) modifications.

Methods: We studied 13 consecutive CO intoxicated patients (age 32.2 \pm 20.3 ys) evaluating the ECG, Troponin I, CK, LDH dosages at the arrival in the hyperbaric facilities. All patients were treated with normobaric oxygen before and after hyperbaric treatment. We gave to every patients a gravity score value (GSV) upon the neurological signs and symptoms recorded (1 less severe 4 more severe)

Results: 6 out of 13 patients had ECG modifications (S-T tract and t wave alterations) while all patients had significant enzymatic modifications (CK and LDH values). In 5 out of 13 patients we observed an important increase of troponin I values (from 1.2 to 19.8 ng/ml). 5 out of 13 patients had a GSV of 4, 7 out of 13 had GSV of 3, 1 out of 13 had GSV of 2.

Conclusions: Troponin I it is a specific and sensible marker of myocardial cellular damage. In our study appear evident that the increase in the Troponin I values occurs in patients with the higher gravity score value with a precise correlation between the neurological gravity and the onset of a stunned myocardium. Early recognition and treatment of this clinical syndrome allows the prevention of myocardial infarction.

P16 CLOSTRIDIAL SEPSIS IN MODERN TRAUMATOLOGY - ELECTRON MICROSCOPIC ANALYSIS

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Introduction

It is difficult to accept the fact that Clostridial infections appear in civilisation with impressive medical achievements. Anyway, the modern pathology is the same as it was in the time of Pasteur and Welch. Clostridium perfringens are still present and each ischemia is potential danger for appearance of alpha exotoxin as it was in the past. The dynamic of the infection and metastatic abscesses is the same as any other septic state.

Material and methods

The observed subjects were 600 patients from 1978 to 2001. The largest numbers of patients were adults aged 40 - 60. Acute anaerobic Clostridial infections affect lower extremities. As a rule the upper extremities were affected by this severe sepsis, because of an extremely short incubation period. The electron-microscopy section observed in function of time showed only scant remains of cellular membranes and fragments of detritus. The preparations were treated by standard methods used in electron microscopy. The oxygen partial pressure was measured with Clarks electrodes, or the transoxide system.

Results

We have four groups. The cases with diabetes mellitus and anaerobic infections was 40%, 9% children in traffic accidents, next group of patients with severe sepsis was bite 7% and last group of 44% is impact, agricultural machines, industrial and traffic accidents. Mortality in the first group was 2%, in second 0,5%, in third 3% and in fourth 1,5%.

Discussion

The common denominators of all pathological states are a deficient oxygen pressure i.e. hypoxia. Electronic microscopy gives the possibility of analysis on subcellular level. Metabolism of clostridium perfringens is characterised by the presence of hydrogen. It is completely inert in the frame of the tissue metabolism and serves only as the suitable area isolation for multiplication of Clostridial flora.

Its growth realises the essential diagnostical sign - crepitation. Frame of electronic microscopy in different steps of sepsis shows the destruction of musculature on characteristic parts of myofibrils. Because of conquesational elements of lesions which leads in ischemia of soft tissue we see first acidosis with presents of lactates, later break in electronic elements of mitochondria, next step is destruction of cellular elements on the end is autolysis and death of the cells.

Conclusion

Subsequent examination of patients who survived anaerobic sepsis indicate that alpha exotoxin mostly attacks the muscles and the damage in muscle cells is beyond repair and there is no biological compensation for it except for the fibrous tissue. The Hyperbaric oxygen can not inactivate existing exotoxin but can inactivate its further secretion, stop the proliferation of anaerobes and revert them to their sporal state and prevent their further aggression.

P17 THE CHANGES OF STAPHYLOCOCCUS AUREUS RESISTANCE AND GROWTH UNDER HBO CONDITIONS

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Introduction: In clinical practice occurring frequently resistant race of *Staphylococcus aureus* can be founded as cause of chronic infections as osteomyelitis or diabetic wound. During HBOT patients with diabetic foot or osteomyelitis noticeable decrease of *S.aureus* resistance become evident and control antibiograms shown again *S. aureus* susceptible to antibiotics.

Material and methods: The desire to see in vitro a behavior of *Staphylococcus* spp. in HBO conditions took away us to name next experiment. Namely, via disk-diffusion method by Kirby-Bauer, we prepared test-tubes with bacterial suspension (4 colonies in 5 ml sterile 0,9% NaCl by McFerland 3, that a number of bacteria measured with haemocitometer was 10^5 /ml base) of three *Staphylococcus* spp.: *S.aureus* resistant on all antibiotics, isolated from smear of diabetic wound (A); *S.aureus* ATCC 33862 (B); *S.albus* ATCC 12228 (C). Then, we used three test-tubes with bacterial suspension of every species and marked: A1, A2, A3, B1, B2, B3, C1, C2, C3. All test-tubes (9) we put in monoplace hyperbaric chamber type Dragger with 100% O₂ on 2 ATA, for 90 min, one exposition per day, totally 10 sessions. After an exposition test-tubes A, B, C we put in refrigerator next 24 hours, test-tubes A2, B2, C2 put into thermostat on 37°C 24 hours and test-tubes A3, B3, C3 used for transplant to blood agar, and after 24 hours for counted bacterial colonies and for antibiograms. Control group consisted of 9 test-tubes with same suspension of *Staphylococcus* spp. as HBO group, with treated in normobaric conditions.

Results: Analysis after 10 expositions to HBO during 10 days, have shown that the number of colonies were decrease slowly day by day, and antibiograms have shown susceptible to antibiotics again.

Conclusion: Reported expositions to HBO decrease *S. aureus* growth and change *S.aureus* resistance for susceptible to antibiotics in vitro too.

P18 GENETIC FACTORS IN ORIGATION OF ANGIOPATHIC CHANGES AND EFFECTS OF HBO THERAPY

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Phenotype similarity is the most significant with the persons who have the highest genetic correspondence. Presented constation is highly confirmed with the twins, specially with the identical, who, besides the phenotype characteristics, behaviour manners of intellectual functions mostly have the same tendency for chronical system disorders. This work presents one of the three registered cases, the special example of changes on blood vessels of twins exposed to the program of HBO therapy.

Twins aged 54 with neglectable phenotype differences were included in the program of HBO therapy because of changes in lower extremities blood vessels as a consequence of diabetes mellitus. Changes were in both patients on the same locations and with minimal differences in the lesions volume. Doppler indexes on magistral blood vessels of tibial area showed identical variations from the normal values as well as the glicemical status before, during and 10 days after completing the HBO treatments (20 HBO treatments, 2,5 ATA, 70 min.). Identical changes in interior environment are also shown through the routined lab analysis. The absence of alterations in the level of lipoprotein status that is mostly genetically determined, and which we expected, initiated us to make the complete chromosome screening which shows identical alterations on the same chromosome couples which brought to the primary illness of diabetes on the leg blood vessels (21. couple).

Identical changes in methabolical status, biochemical parameters as well as practically the identical changes on the blood vessels and identical medicament therapy, made the conditions for identical general and local effects of HBO treatment.

P19 ADJUVANT OR 'THERAPY OF CHOICE' FOR THE PATIENTS WITH THE OCCLUSION OF ARTERY FEMORALIS SUPERFICIALIS

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In conservative therapy of lower extremities insufficient arterial flow, HBO therapy is used as adjuvant therapy to the medicament therapy ordinated by the angiologist.

In the cases where the lower limbs arterial system disorder is of such kind that surgical intervention can not be the solution, such as total occlusion a. femoralis superficialis, and medicament treatment gives modest or no results, these patients are directed on surgical femoral amputation. A great number of patients is included in program of HBO treatment.

The goal of this work is to show the effects of HBO treatments on 64 patients with clinically confirmed above said disorders and clear signs of critical ischemia of extremities. All the patients have passed the same program of HBO treatments (2,5 ATA for 70 min.) which did not exclude the standard medicament therapy.

Before commencing the HBO treatments following data have been taken: the Doppler indexes were measured on patients on magistral blood vessels of both extremities; Claudicational distance (also controlled daily); the scintigraphic method with Tc-99m-tetrafosmin was used for determination of the perfusional reserves, relative perfusion DE and index of perfusion. These results were compared with the results obtained 10 days after HBO treatments.

Along the treatments came the alleviation or disappearance of symptoms of ischemia, and prolongation (40%) and disappearance (60%) of distonia as well as for HBO therapy characteristic variations in Doppler results.

The efficacy of HBO treatments was clearly evident through: the absence or highly important prolongation of claudicational distances without obvious symptoms of ischemia in rest; tendency of equalisation of Doppler indexes on both extremities; equalisation of relative perfusion DE of the affected compared to the health extremity (in rest and after the muscular activity) that is evident in the index of perfusion as well, even besides the clear evidence that the perfusional reserves were diminished (20-50%), for what there is an pathophysiological explanation in unpreparedness of miocytes for strengthened oxidative stress, as well as the evident growth and almost normal results of transcutaneous pPO₂. These results, as well as the fact that in the period of 6 months after the end of HBO treatments (average 17,5 ± 5) only two patients had the above knee amputation, give the clear conclusion that in these cases HBO treatments were not the adjuvant, but the 'therapy of choice' with medicaments as adjuvant therapy.

P20 THE USE OF THE OXYLATOR EM-100 IN A HYPERBARIC ENVIRONMENT

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Objective: The aim of this study was to quantitatively assess the use of the Oxylator® EM-100 in a hyperbaric environment, because, more frequently, ventilated patients are treated with hyperbaric oxygen for various indications.

Materials & Methods: The Oxylator® is a portable, automatic ventilatory apparatus. Its basic function consists of a pressure flow cycling, consequently limiting the respiratory phase to an airway pressure between 25 and 50 cm H₂O. As the pressure has been attained, the automatic cycling changes over to the expiratory phase. The Oxylator® (pressure setting of 50 cm H₂O) was connected to the oxygen source (4.5 bar) in a multiplace, hyperbaric chamber (Hytech, NL) and to a test lung using 2 (inspiratory and expiratory) uni-directional valves to simulate normal airflow direction and a spirometer. The pressure in the chamber was increased from 1 ATA to 2 ATA and 3ATA.

Results: At 1, 2, 3 ATA respectively, we measured respiratory rates; minute volumes and tidal volumes of 19, 14, 11 breaths/minute; 14075, 10650, 8575 ml and 789, 713, 545 ml. The oxygen concentration in the chamber increased progressively above save levels.

Conclusions: This study demonstrates that the respiratory features of the Oxylator® underwent significant changes under hyperbaric conditions. The use of this device can only be accepted using thorough watchfulness and or transcutaneous carbon dioxide measurements. The oxygen concentration in the hyperbaric chamber should be monitored.

P21 TEST OF AN INFUSION PUMP FOR HYPERBARIC OXYGEN THERAPY

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We evaluate an infusion pump for the use inside an hyperbaric multiplace chamber during hyperbaric oxygen treatments. It is well known that inotropes dependent patients become haemodynamically unstable during treatment in the hyperbaric chamber, mainly as a consequence of a failure of infusione devices.

So we have looked for a pump whose mainly characteristic would be the longest possible autonomy, the capability of uncollapse under pressure and to work without problems during pressure changes, also rapid ones.

Materials and methods

We have used for the study the TERUMO syringe pump TE-311 and TE-312, manufactured by TERUMO corporation. We tested their autonomy when powered by battery, the accuracy and reliability of their infusion rate increasing slowly their flows (0.5 to 5 ml./hour). Each test has been repeated 5 times for each volume for each pump. After this preliminary tests, we have performed the same tests under pressure raising it, in different times, from 2 to 2.8 ATA. The fluids used have been saline solution and a colloid gelatine.

Results

The length of the autonomy battery powered has been 3 hours and 42 minutes vs. 3 hours certified by the manufacturer. The accuracy of the flow rate (after 3 hours) has been tested 70 times and the final result has been a change of delivery with a decrease of 0.2 - 0.3 percent from the nominal rate for the flows of 4-5 ml/hour in the final 30' of the test. After these preliminary atmospheric pressure tests we have repeated the same tests in hyperbaric pressures from 2 to 2.8 ATA; at the end of each test we have checked the decompression phase but no change was detected in the performance. We have performed a total of 56 tests. The only change was an increase of 0.5 % in the last 30' when using the higher density solution (gelatine).

So we can conclude that such pumps could be used during HBO with confidence in their accuracy in delivering at the set rate and, of course, for low hyperbaric pressures because it is really possible that a change to a different environmental pressure might become important.

P22 CHILDREN AND DIVING : PHYSIOLOGICAL ASPECTS

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Background:

The growing popularity of recreational scuba diving leads a proportionately large number of pediatric subjects of all ages to physicians for medical examinations to determine qualification for diving courses and active diving.

Aim:

Present medical recommendations for young participants, based on an understanding of basic diving medicine, with increased capability of qualifying physicians for intelligently evaluating and counseling of potential pediatric scuba divers.

Methods:

Review of physiology and most common problems associated with scuba diving in the pediatric age group are based on literature and other available medical data.

Discussion:

The pulmonary maturation is progressing with growth. The number of pulmonary alveoles increases till the age of 8 years. The elastic tissue mainly increases between 7-12 years of age. Pulmonary resistances are higher and passive expiration longer. 30 % of alveoles are less or not ventilated before the age of 7 due to easy closure of small bronchi with the risk of air-trapping and pulmonary barotrauma. The cardiovascular consequences related to diving include modified desaturation of inert gasses in young children due to intracardiac turbulences, permeable foramen ovale and less ventilated alveoles. The risk of decompression sickness at the level of growth cartilage (rich vascularisation, very short period of tissue, ...) is very low. The higher loss of warmth in child compared to adult requests the usage of adapted thermal corporated protection to avoid hypothermia during diving. Hydratation an changing diving suit immediately after diving in a hot environment prevent from hyperthermia. Dependence from visual field and psychological maturity (comprehension, behaviour, anxiety, ...) are also important to evaluate.

Conclusion:

The pulmonary, cardiovascular, otorhinolaryngological, osteomuscular, thermobiological characteristics interfere in the child's possible adaptation to the underwater environment. A child has his own specificity in front of diving and is not a scaled-down model of an adult. Before the age of 7-8 years there are risks of breathlessness, hypoxia or even pulmonary barotrauma due to the pulmonary level of maturation. The medical permission to dive will only be given after the evaluation of those different factors by a team (doctors, parents, instructors) centered around the (sports) doctor in charge of the diving.