

Second Tricontinental Conference on Diving and Hyperbaric Medicine

Durban, South Africa, September 23-29, 2018

TRICON2018

44th Annual Meeting of the European Underwater and Baromedical Society (EUBS)
47th Annual Scientific Meeting of the South Pacific Underwater Medical Society (SPUMS)
Conference of the Southern African Underwater and Hyperbaric Medical Association (SAUHMA)

Abstract & Conference Book

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M Bennett
P Germonpré

Congress Secretariat:
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SCIENTIFIC PROGRAMME OVERVIEW

	Sunday 23 sep 2018	Monday 24 sep 2018	Tuesday 25 sep 2018	Wednesday 26 sep 2018	Thursday 27 sep 2018	Friday 28 sep 2018	Saturday 29 sep 2018			
8:30							EUBS & SAUHMA Annual General Meeting			
8:50	Workshops in Diving and Hyperbaric Medicine Practical aspects of diving	SPUMS Executive Committee Meeting	Invited Speaker Adel TAHER	Workshops in Diving and Hyperbaric Medicine Practical aspects of diving	Keynote Address Chris EDGE	Workshops in Diving and Hyperbaric Medicine Practical aspects of diving	Keynote Address Michael LANG			
9:10					Scientific Session 2 Diving safety		Scientific Session 4 Diving injuries		Scientific Session 6 Fitness and Toxicity	
9:30										
9:50										
10:10										
10:30										
10:50										
11:10										
11:30			SPUMS Annual General Meeting		Invited Speaker Charles VAN WIJK			Special Address Ran ARIELI		
11:50										
12:10										
12:30										
12:50										
13:10										
13:30			LUNCH		LUNCH					
13:45		Opening Ceremony								
14:00		Keynote Address Michael H. BENNETT	Invited Speaker Ron LINDEN		Keynote Address Simon MITCHELL					
14:20	EUBS ExCom Meeting									
14:40										
15:00		Scientific Session 1 Clinical Hyperbaric Oxygen	Scientific Session 3 Toxicities and Complications		Scientific Session 5 Equipment and Safety					
15:20										
15:40										
16:00										
16:20										
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17:00										
17:20										
17:40										
18:00										
18:20										
18:40		Welcome Reception			SAUHMA ExCo meeting					
19:00						Conference Dinner				
19:20				Social Event						
19:40										
20:00				Invited Speaker Matt DICKEN						
20:20										
20:40										
21:00										
21:20										
21:40										
22:00										

INVITED SPEAKERS & KEYNOTE LECTURERS

Invited Speaker: Dr Adel Taher



Adel Mohamed Taher was born April 12th, 1956 in Cairo, Egypt. Adel studied Medical at Al Azhar and Cairo University and graduated in 1982, Dr. med., M.B., B.Ch. He is a PADI OWSI, MSDT, 1982. Spent three years in the Medical Core in the Armed Forces and worked as an anaesthiologist. Specialized in Diving Medicine in Germany (Schiffs-Med.-Inst., German Navy) and the USA (Duke University, FG Hall Laboratory, N.C.). He built the first Hyperbaric Medical Center in Egypt in Sharm el Sheikh, in 1993. He acts as a Consultant in Diving & Hyperbaric Medicine for the GTÜM and the Austrian Society for Underwater and Hyperbaric Medicine (ÖGUHM/ASUHM). He is currently the Director of the Hyperbaric Medical Center, Sharm el-Sheikh, and the CEO, Hyperbaric Medical Center & Sea Rescue, Dahab, South Sinai, Egypt. He is the Medical Director of Divers Alert Network – Egypt.

He is CEO, Sharm Medical Group (Sinai Clinic/Hospital), Sharm el-Sheikh, South Sinai, Egypt, DAN-Oxygen Instructor Trainer Evaluator, Member of (GTÜM), Honorary Member, ASUHM/ ÖGUHM, Corresponding Member, European Diving Technology Committee (EDTC), Expert Member, European Committee for Hyperbaric Medicine (ECHM), Ex-Member of the Board and current member, EUBS. He organized and presided over the 2007 EUBS 33rd Scientific Annual Meeting in Sharm el Sheikh.

Invited Speaker: Dr Charles van Wijk



Charles is a clinical psychologist, working at the Institute for Maritime Medicine in Simon's Town, South Africa. There he is responsible for coordinating clinical psychology services to the South African Navy, as well as for statutory occupation (mental) health monitoring.

His current interests focus on the development and implementation of mental health screening and intervention in extreme environments, as well as on the development of psychological resilience.

Recent research publications dealt with personality and diving, mental health, and coping in isolated, confined, and extreme environments. His presentation will address perspectives on the assessment of psychological competency to dive.

Invited Speaker: Dr Matt Dicken



Matt is currently the senior scientist at the KZN Sharks Board, based in Durban, KZN. He is also a Director of Bayworld Centre for Research and Education (BCRE) and a Research Associate at the Nelson Mandela Metropolitan University (NMMU) and the Port Elizabeth Museum. As a senior scientist specialising in shark and fisheries research he currently leads several major projects including a beach and bather shark safety program for the Nelson Mandela Metropolitan Municipality. During his doctoral and post-doc work, he has investigated the behavior and movement patterns of white sharks within Algoa Bay, the behavior and movement patterns of tiger sharks within the Aliwal Shoal, and the population dynamics of raggedtooth sharks in South Africa. His research developed one of the world's first open population models for a recreational shark

species. He is an excellent educator, to young children as to senior diving doctors

Keynote Lecturer: Professor Michael Bennett



Professor Bennett is the Academic Head of the Department of Anaesthesia, a Senior Staff Specialist in diving and hyperbaric medicine at Prince of Wales Hospital and Conjoint Professor in the faculty of Medicine, University of New South Wales in Sydney, Australia. He graduated from the University of New South Wales in 1979 and spent his early post-graduate training at the Prince Henry/Prince of Wales Hospitals before undertaking training in Anaesthesia in the UK. He returned to Sydney in 1990 as a retrieval specialist on the Lifesaver Helicopter and here developed an interest in both diving and hyperbaric medicine. He also has a strong interest in clinical epidemiology and is an experienced clinician and researcher. In 2002 he was the recipient of the Behnke Award for outstanding scientific achievement

from the Undersea and Hyperbaric Medical Society. Since 2004 he has been highly involved in the teaching of Evidence-based Medicine within the Medical faculty at UNSW and in 2005 was appointed co-director of the Quality Medical Practice Program there. He is the author of over 130 peer-reviewed publications including 15 Cochrane reviews of the evidence in Diving and Hyperbaric Medicine. Prof. Bennett was the convenor of the Australia and New Zealand Hyperbaric Medicine Group Introductory Course in Diving and Hyperbaric Medicine from its inception in 1999 to 2014. He is an executive member of the Australia and New Zealand College of Anaesthetists (ANZCA) special interest group in diving and hyperbaric medicine, chief examiner for the ANZCA Certificate in diving and hyperbaric medicine and Chair of the ANZCA Scholar Role Subcommittee. He is a past Vice-President of the UHMS and currently the Past President of SPUMS.

Keynote Lecturer: Dr Ron Linden



Dr. Linden is the Medical Director of the Judy Dan Research & Treatment Centre and CEO of Ontario Wound Care Inc, a federally registered charity that raises funds to provide wound care and hyperbaric treatments.

Dr Linden is committed to promoting HBO research and ensuring reporting of research is both accurate and ethical. He believes that one of the greatest issues facing the UHMS and HBO internationally, is the dissemination of false and misleading publications and failure to confront, expose and hold accountable researchers, institutions and journals for misleading the medical profession and public

Keynote Lecturer: Dr Chris Edge



Chris graduated from Cambridge University, UK with a double first in Natural Sciences in 1974, then carried out research in semiclassical scattering theory at Cambridge and Manchester Universities for a PhD. He worked with Prof F. Sanger at the MRC, Addenbrookes in 1980 on sequencing of the human mitochondrial genome. He was trained in medicine at Cambridge University and the Middlesex Hospital, London, graduating in 1984. He carried out research in glycobiology at Oxford University (1987-1994) and was medical tutor at Pembroke College, Oxford (1990-1993), then became clinical research manager in the Early Clinical Research Group at Pfizer Ltd., Sandwich followed by research at Qinetiq, Farnborough in aviation and diving medicine. He trained as an anaesthetist in Reading, Oxford, and London and now works as a consultant anaesthetist at the Royal Berkshire Hospital, Reading specialising in anaesthesia for robotic-assisted uro-oncological surgery. Whilst training, he became involved with research as an Honorary Senior Lecturer at Imperial College, London with Prof N. Franks into how anaesthetics (particularly propofol) act at the molecular level and whether xenon can mitigate the effects of blunt trauma on the brain (with Dr R. Dickinson). He started diving in 1974 at Cambridge and has dived all over the world. He has been a member of about twenty diving expeditions (mainly archaeological) in the Mediterranean; the last with Prof. G. Bass (Texas A&M University). He ran the Diabetes and Diving project since its inception in the UK in 1992 and has been a member of the UK Sport Diving Medical Committee (now the UK Diving Medical Committee) since 1987 and an Approved Medical Examiner of Divers for the UK Health and Safety Executive since 1991. He is an author on more than 70 medical and scientific papers and co-author with Dr Phil. Bryson of a (controversial) chapter on diving with diabetes in the 4th edition of Diving & Subaquatic Medicine.

Keynote Lecturer: Dr Ran Arieli



Dr. Arieli completed his PhD study in Tel Aviv University 1978. 1978 – 1981 post doctorate in Buffalo, New York. 1981 – 1986 teaching respiration physiology in the Technion School of Medicine, Haifa and conducting research in respiration physiology. 1986 – 2010 Head of the Research Unit in the Israel Naval Medical Institute. 2010 until today volunteer researcher at the Israel Naval Medical Institute and Western Galilee Medical Center. The research interests of Dr. Arieli are Respiration physiology, Diving physiology (decompression, oxygen toxicity and thermal protection) and Integrative physiology and he have published 116 papers. Ran is married to Yael and have 7 children and 12 grandchildren.

Keynote Lecturer: Professor Simon J. Mitchell



Simon is a physician and scientist with specialist training in diving medicine and anaesthesiology. He is widely published with over 130 papers or book chapters. He co-authored the 5th edition of "Diving and Subaquatic Medicine" and has 2 chapters on decompression illness in the most recent edition of Bennett and Elliott. He has twice been Vice President of the Undersea and Hyperbaric Medicine Society (USA) and in 2010 received the society's Behnke Award for contributions to the science of diving and hyperbaric medicine. In the past Simon was a naval diving medical officer and medical director of the Wesley Centre for Hyperbaric Medicine in Brisbane. He now works as a consultant anaesthetist at Auckland City Hospital, and Professor in Anaesthesiology at the University of Auckland. He provides on-call cover for diving and hyperbaric emergencies at the North Shore Hospital Hyperbaric Unit in Auckland. Simon is the incoming editor of Diving and Hyperbaric Medicine, and takes on this role in January 2019.

Simon's diving career has included more than 6000 dives spanning sport, scientific, commercial, and military diving. He was a lead member of teams that were the first to dive and identify 3 deep wrecks of high historical significance in Australia and New Zealand. At the time of one of these dives (2002) the 180m depth represented the deepest wreck dive ever undertaken. He was elected to Fellowship of the Explorers' Club of New York in 2006, and was the DAN Rolex Diver of the Year in 2015.

Keynote Lecturer: Dr Michael A. Lang



Michael is a marine biologist, environmental physiologist, author, and international lecturer. He is Co-Director of the UC San Diego Center of Excellence in Diving and holds a research faculty appointment in the Department of Emergency Medicine. He is a Senior Research Fellow at The Ocean Foundation and served as director for nonprofit organizations, including AAUS, DAN, UHMS and AUAS, and as expert consultant to the National Science Foundation, U.S. Coast Guard, U.S. Geological Survey, The Nature Conservancy, and Conservation International. Former Marine Collector/Curator at San Diego State University, Director of the Smithsonian Marine Science Network, Smithsonian Scientific Diving Officer, and National Science Foundation Polar Diving Safety Officer, Lang holds a B.Sc. in Zoology from San Diego State University, and a PhD in Environmental Physiology from the Norwegian University of Science and Technology in Trondheim. He is fluent in five languages, has published over 50 scientific papers and popular articles and presented over 350 seminars/papers on current marine science and diving medicine topics. Honors include DAN/Rolux Diver of the Year, U.S. Antarctica Service Medal, NAUI Outstanding Instructor Award, Smithsonian Special Act Award, UHMS Excellence in Diving Medicine Award, AAUS Conrad Limbaugh Scientific Diving Leadership Award, DEMA Reaching Out Award, and the AUAS NOGI Award for Science

SCIENTIFIC PROGRAMME

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Sunday, September 23, 2018

08:30 - 17:00	Diving Medicine Practical Workshop (separate registration)			
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Monday, September 24, 2018

11:00 – 12:30				
SPUMS Annual General Meeting				
12:30 – 13:30				
Registration		<i>Location: Londocor Desk, Central Foyer</i>		
13:30 – 14:00				
TRICON2018 - Opening Ceremony				
14:00 – 18:00				
Scientific Session 1: Clinical Hyperbaric Oxygen				
<i>Keynote Address</i>				
	M.H. Bennett	Clinical Research in Hyperbaric Medicine - where to next?	H-01	12
Session 1 Chair: WAJ. Meintjes, K. Hasmilller				
	R. Brouwer	Meta-Analysis On The Effect Of Hyperbaric Oxygen As Adjunctive Therapy To Improve The Postoperative Outcome In Colorectal Resections	H-02	13
	A. Hadanny	Hyperbaric Oxygen Therapy Effects post Stroke Cognitive Functions – Retrospective Analysis	H-03	14
	K. Eltobgy	Hyperbaric Oxygen Therapy Induces Clinical Improvement in Patients with Chronic Ischemic Stroke: a Randomized Controlled Study	H-04	15
	P. Longobardi	Use of Real-World Data to Enhance Clinical Trials and Support Regulatory Decision-making for HBOT in Wound Care	H-05	16
Coffee Break				
	D. Breetveld	Patient-reported Effects of Hyperbaric Oxygen Therapy for Head and Neck Late Radiation-induced Tissue Toxicity	H-06	17
	O. Hyldegaard	Hyperbaric Oxygen Therapy for Necrotizing Soft Tissue Infections – Experiences from the Prospective, Observational INFECT Study	H-07	18
	G. Frey	Intracranial Abscesses – a Forgotten Indication for HBOT?	H-08	19
	A. Hadanny	Traumatic Brain Injury Patient Selection for Hyperbaric Oxygen Therapy using Baseline Functional Brain Imaging	H-09	20
	R. Kruize	Hyperbaric Oxygen Therapy and Hyaluronic Acid Filler Induced Dermal Ischemia	H-10	21
18:30 – 20:30				
Welcome Reception		<i>Location: Ocean Breeze Pool Deck & Bar</i>		

Tuesday, September 25, 2018				
08:30 – 13:00	Scientific Session 2: Diving Safety			
	<i>Invited Speaker</i>			
	A. Taher	Politics of Diving in the Red Sea	D-01	22
	Session 2 Chair: C. Balestra, D. Wilkinson			
	G. Vandenhoven	Variation of Lung, Vascular and Cognitive Functions during and after Recreational Diving with Regular Compressed Air Compared to Oxygen Enriched Air (Nitrox 32)	D-02	23
	L. Davids	A Retrospective Review of the Utility of Chest X-Rays in Diving and Submarine Medical Examinations	D-03	24
	S. Mitchell	Does Hypoxia Training Improve Cognitive Performance during Subsequent Hypoxia?	D-04	25
	G. Vandenhoven	Impact of a Four Weeks Pranayama Respiratory Yoga Training on the Pulmonary Function of Starting Freedivers	D-05	26
	A. Winsor	Collecting Bubbles – A Method of Collecting Expired Gas from Scuba Divers for Analysis of Energy Expenditure	D-06	27
	Coffee Break			
	<i>Invited Speaker</i>			
	C. van Wijk	Perspectives on Assessing Psychological Competency to Dive	D-07	28
	G. Vandenhoven	Effects of Water Temperature and Type of Diving Suit on Body Temperature as well as Cognitive and Pulmonary Parameters during Scuba Diving with Compressed Air.	D-08	29
	D. Smart	Outside the Comfort Zone – Medical Support of the Antarctic Diving Program 2014-15	D-09	30
	F. Z. Kiboub	Effects of a Commercial Saturation Dive on Hemoglobin and Erythropoietin Levels	D-10	31
	J-P. Imbert	Site Evaluation of Deep Divers' Safety and Performance	D-11	32
	Lunch Break			
13:00 – 14:00	Poster Session 1: Diving Medicine Posters			
	Poster Jury: M. Sayer, MH. Bennett, C. Balestra			
14:00 – 18:00	Scientific Session 3: Toxicities and Complications			
	<i>Keynote Address</i>			
	R. Linden	Serious Problems with the Toronto Hyperbaric Oxygen (HBO) for Diabetic Foot Ulcer (DFU) Study: 'How the Truth Was Amputated'	H-11	33
	Session 3 Chair: O. Hyldegaard, M. Marshall			
	A. Jovanovic	Ovarian Aging and HBO - CANCELLED		
	F. Guerreiro	Evaluation of the Clinical Impact and Functional Pulmonary Effects of Hyperbaric Oxygen Therapy	H-13	35
	M. Bennett	Reduction in Oxygen-Induced Myopia when Wearing a Mask Versus a Hood – A Randomised Controlled Trial	H-14	36
	A. Hadanny	Hyperbaric Oxygen Effects on Pulmonary Function	H-15	37
	Coffee Break			
	F. Tillmans	Effect of the Antioxidant Quercetin on ROS-Induced DNA-Fragmentation in Human Lymphocytes	H-16	38

	E. Ozer	Pneumothorax Developed during Hyperbaric Therapy in an Intubated Patient with Carbon Monoxide Poisoning	H-17	39
	P. Bothma	Proposed Pragmatic Study of Clinicians' Management of Iatrogenic Cerebral Gas Embolism	H-18	40
	Y. Arieli	Hyperbaric Oxygen Causes Transient Alterations in Cognitive Function in Mice	H-19	41
	N. Lansdorp	Hyperbaric Oxygen Therapy for the Treatment of Perianal Fistulas in Crohn's Disease (HOT-TOPIC): Study Protocol of a Prospective Interventional Cohort Study with 1-year Follow-Up	H-20	42
18:00 – 18:30	Discussion			

Wednesday, September 26, 2018

08:30 – 17:00	Diving Medicine Practical Workshop (separate registration)			
19:00 – 22:00	Social Event			
	Visit to uShaka Marine Aquarium & Dinner			
	<i>Busses depart from Elangeni Hotel Reception from 17:45 on</i>			
	Invited Lecture			
	M. Dicken	Sharks and how to make good use of your sensory organs.		

Thursday, September 27, 2018

08:30 – 13:00	Scientific Session 4: Diving Injuries			
	Keynote Address			
	C. Edge	Diving with Diabetes (The United Kingdom Database of Divers Diving with Diabetes Mellitus)	D-12	43
	Session 4 Chair: SJ. Mitchell, J-E. Blatteau			
	P. Longobardi	Functional Gene Polymorphisms in Divers with Previous DCS	D-13	44
	T. Vandongen	Medication and Fitness to Dive: What is the Evidence?	D-14	45
	P. Longobardi	Measurements of Equalization Effort and New Strategies to Reduce it	D-15	46
	I. Millar	A Case Cluster of Cognitive Impairments following Deep Saturation Diving	D-16	47
	J. Siewiera	Successful Treatment of Severe High-Altitude Decompression Sickness in a Jet Pilot using Hyperbaric Oxygen Therapy and Extra Corporeal Oxygenation	D-17	48
	Coffee Break			
	Special Address			
	R. Arieli	Vascular and Extravascular Nanobubbles: Constructing a Comprehensive Physiology of Decompression	D-18	49
	B. Mirasoglu	Inner Ear Decompression Sickness or Sinus Mucocele: Case Report	D-19	50
	S. Ferguson	The Effect of Sudden Drop in Partial Pressure of Oxygen on Heart Function During Ascent	D-20	51
	A. Bliznyuk	NMDAR Involvement in HBO toxicity	D-21	52

	S. Ferguson	The Effect of Oxygen and Nitrogen on Nitrogen Narcosis Severity	D-22	53
	Lunch Break			
13:00 – 14:00	Poster Session 2: Hyperbaric Medicine Posters			
	Poster Jury: M. Sayer, MH. Bennett, C. Balestra			
14:00 – 18:00	Scientific Session 5: Equipment and Safety			
	Keynote Address			
	SJ. Mitchell	Diving and Hyperbaric Medicine Journal into the Future	H-21	54
	Session 5 Chair: MH. Bennett, R. Pignel			
	S-Y. Teoh	Staged Procedure to Assess Repeated Hyperbaric Exposures and Glass Ampoule Safety (SPAREGAS)	H-22	55
	A. Toklu	The Evaluation of the Sound Levels inside 36 Hyperbaric Chambers during Hyperbaric Oxygen Treatment in Turkey	H-23	56
	P. Germonpre	Two Case Reports: Malfunction of Siaretron Iper1000 Ventilator during a Hyperbaric Treatment Session	H-24	57
	E. Ozer	Measurable Reliability of Glucometer Devices in Hyperbaric Condition	H-25	58
	Coffee Break			
	M-A. Gagnan	Severe Hand Frostbite Treated by Hyperbaric Oxygen Therapy; the International Frostbite Registry (IFR)	H-26	59
	D. Smart	The Grattan Report – Australia: When Bureaucrats Decide what Appropriate Care is for Patients	H-27	61
	C. Balestra	Effect of Normobaric Oxygen on Lymphoedema	H-28	62
	I. Millar	Testing of The Medtronic 5392 External Pacemaker Device and VBM Electronic Endotracheal Cuff Controller for Hyperbaric Medical Use	H-29	63
	K. Strauss	How to Speak 'Contemporary Orthopod' - A Marriage of Disciplines between Orthopaedic Surgery and Hyperbaric Medicine	H-30	64
18:00 – 18:30	Discussion			

Friday, September 28, 2018

08:30 – 17:00	Diving Medicine Practical Workshop (separate registration)		
20:00 – 23:00	Conference Dinner	Location: Great Ilanga	

Saturday, September 29, 2018

08:30 – 09:30	EUBS General Assembly			
	SAUHMA General Assembly			
09:30 – 12:30	Scientific Session 6: Fitness and Toxicity			
	Keynote Address			
	M. Lang	Recreational and Technical Freediving: Advances in Safety and Performance	D-23	66
	Session 6 Chair: M. Sayer, C. Meehan			
	I. Barkovic	Do We Need to Warn against Diving with Beta Blockers ?	D-24	67

	D. Fothergill	Impulse Oscillometry and Spirometry Indices of Pulmonary Function in a Diver with Severe Symptoms of Pulmonary Oxygen Toxicity	D-25	68
	P. Germonpre	Fitness to Dive after Spontaneous Pneumothorax: Challenging the Guidelines	D-26	69
	P. Denoble	Intra-Individual Variability of Post-Dive Venous Gas Bubbles Occurrence: An Invitation for Multi-Centric Collaborative Study	D-27	70
	S.B. Ardestani	Endothelial Function and Cardiovascular Stressmarkers in ApoE Knockout Rats after a Single Simulated Heliox Dive	D-28	71
	X. Vrijdag	Measuring Gas Narcosis Objectively: Two New Methods	D-29	72
12:30 – 13:00	Closing Ceremony			

Scientific Posters @ TRICON2018

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Diving Medicine Posters

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P. Louge	The Use of Hyperoxic Additional Long Tables in Scuba Divers with Neurological Decompression Sickness: The Experience of the Geneva University Hospital Hyperbaric Centre	PD02	74
E. Thorsen	Diving in the Fish Farming Industry in Western Norway	PD03	75
J-E. Blatteau	Facial Paresis Associated with Pneumocephalus Caused by Scuba Diving	PD04	76
U. Lindblom	A Case Report: Cerebral Arterial Gas Embolism during Underwater Escape Training with Compressed Air at a Depth of One Metre or Less	PD05	77
C. van Wijk	Personality and Adaptation: Associations in a Sample of Experienced Navy Divers	PD06	78
C. van Wijk	Associations of Personality and Underwater Behaviour among Sports Divers: a Pilot Study	PD07	79
O. Castagna	Immersion Pulmonary Oedema in a Healthy Diver not Exposed to Cold or Strenuous Exercise	PD08	80
P. Louge	An Unusual Case of Sinus Barotrauma: A Case Report of Orbital Surgical Emphysema with Agenesis of Frontal Sinus Bone	PD09	81
G. Smerdon	Factors Affecting Cardiovascular Health in Certified Scuba Divers: An Online Survey	PD10	83
A. Toklu	Double Case Report Following Free Ascent of Two Sea Harvesting Divers.	PD11	84
C. Sadler	Hypoxia is not Reliably Prevented by Setting a 60 Second Apnea Limit during Exercise: The Failure of the "One Minute Rule" for Free Diving	PD12	85
J. Martin	Diving, Risk, and Cannabis: Examining a Sample of Professional Divers' Vocabularies of Motive for Cannabis Use	PD13	86

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R. Pignel	A Nitrogen Dosimeter: How to Reduce the Risk of Decompression Sickness in Hyperbaric Attendants	PH02	88
M. Pellegrini	Oxygen Partial Pressures under Hyperbaric Conditions in A Child with Congenital Heart Disease Presenting with Right to Left Shunts	PH03	89
M. Pellegrini	Usefulness of Hyperbaric Treatment to Heal a Critical Wound in Pediatric Heart Disease	PH04	90

A. Chandrinou	EBAss Safety Manager Course Evaluation. Identification of the Requirements for Properly Accreditation Staff	PH06	91
K. Witheridge	Hyperbaric Oxygen for Idiopathic Sudden Sensorineural Hearing Loss and Tinnitus – A Cochrane Review Update	PH07	92
D. Cavalheiro	HBO for Mixed Arterial and Venous Retinal Occlusion – A Case Report	PH08	93
E. Koca	Sudden Sensorineural Hearing Loss after Spinal Anaesthesia: Case Report	PH09	94

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CLINICAL RESEARCH IN HYPERBARIC MEDICINE – WHERE TO NEXT?

M H Bennett

Prince of Wales Hospital Clinical School, University of NSW and Det. Of Diving and Hyperbaric Medicine, Prince of Wales Hospital, Sydney

Introduction

The practice of hyperbaric medicine is a relatively recent addition to clinical practice. As an adolescent field in the 1960s, practitioners began to experiment with a heady mixture of oxygen and pressure in order to achieve the rush that can only be experienced with healing the sick. Enthusiasm was almost unlimited and proof of effect often consisted of a few case reports and a lot of conjecture. This presentation will explore the current state of hyperbaric research and a plan for the future.

The state of play

More mature branches of medicine have never really accepted this unusual area of practice and we have all struggled hard to convince the sceptics that hyperbaric oxygen therapy (HBOT) really does have a place in modern medicine. Hard work, good science and relevant clinical research mean we have made a great deal of progress in the late 20th Century.

But there were grave problems. Comprehensive, physician-based hyperbaric facilities offering 24/7 coverage are getting harder to find, while in the USA, stand-alone wound-care facilities multiply rapidly. Remuneration-driven admission and treatment protocols are replacing the approach where teaching and research are valuable activities that complemented patient care.

A plan for the future

This presentation will discuss the means by which we can execute large-scale, well-designed clinical research specifically designed to change clinical practice. The principal means are the development of effective regional and global registries to drive outcome-based results in the ‘real world’ on the one hand, and the simultaneous development of effective regional and global Clinical Trials Networks to plan, co-ordinate and successfully complete high-quality clinical research on the other.

Both these efforts are now in place with three major regional registries in planning, including co-operative attempts to synchronise the data collected in each. Along with the development of a global CTN – The “Diving and Hyperbaric Medicine Global Clinical Trials Network” (DAHMMNet).

Keywords

Clinical research, Outcome Registry

H-02 META-ANALYSIS ON THE EFFECT OF HYPERBARIC OXYGEN AS ADJUNCTIVE THERAPY TO IMPROVE THE POSTOPERATIVE OUTCOME IN COLORECTAL RESECTIONS

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Background

Colorectal cancer is the third most common form of cancer and colorectal surgery is the treatment of choice in local disease. Anastomotic leakage following colorectal surgery is a major complication with high incidence and mortality. Adjuvant hyperbaric oxygen therapy (HBOT) is associated with reduction of anastomotic leakage. A systematic review and meta-analysis was conducted regarding HBOT as an adjunctive therapy to colorectal surgery.

Methods

Systematic review (1900-2017) using PubMed, Cochrane, EMBASE, Web of Science and EMCARE. All original published studies on the effect of HBOT as an adjunctive therapy for colorectal surgery with the formation of an anastomosis were considered.

Results

Thirteen animal trials performing colorectal resections in rats were included for qualitative synthesis. Primary outcomes involved hydroxyproline levels and bursting pressure. A meta-analysis was performed for both normal and ischemic anastomoses and showed that postoperative HBOT improves the bursting pressure and hydroxyproline levels, significantly in both normal ($P \leq 0.001$ and $P = 0.02$) and ischemic anastomoses ($P \leq 0.001$ and $P = 0.04$).

Conclusions

Postoperative HBOT has shown potential to reduce the risk of anastomotic leakage following colorectal surgery. This effect is only observed in rat model and further research should focus on a larger systematic animal study to confirm this effect.

Keywords

Anastomotic leakage, Colorectal cancer, Colorectal surgery, Hyperbaric oxygen therapy, Animal studies

H-03 HYPERBARIC OXYGEN THERAPY EFFECTS POST STROKE COGNITIVE FUNCTIONS – RETROSPECTIVE ANALYSIS

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Background

Previous studies have shown that hyperbaric oxygen therapy (HBOT) can induce neuroplasticity and improve cognitive function of post stroke patients in the chronic stage. However, previous studies considered stroke as one entity despite heterogeneity in clinical and anatomical presentation.

The aim of this study was to evaluate the effects of HBOT on cognitive function in different types and locations of stroke.

Methods

A retrospective analysis was conducted on patients who were treated with HBOT for 60 daily sessions for all types of chronic stroke (>3 months since the event) between 2008-2018. Patients with pre and post computerized cognitive function assessments (Neurotrax) were included.

Results

162 patients (75.3% males) with a mean age of 60.75 ± 12.91 were included. Seventy seven (47.53%) had cortical stroke, 87 (53.7%) were located in the left hemisphere and 121 suffered ischemic stroke (74.6%).

HBOT induced a significant increase in all cognitive function domains ($p < 0.05$). There were no significant differences in the mean relative increase post HBOT in all of the cognitive domains of cortical strokes compared to basal ganglia strokes ($p > 0.05$), and right hemisphere strokes compared to left hemisphere strokes ($p > 0.05$).

Hemorrhagic strokes had a significantly higher improvement post HBOT with regard to information processing speed compared to ischemic strokes (7.61 ± 14.47 vs. 1.66 ± 10.1 , $p = 0.04$). In all other domains, there were no significant differences between stroke types ($p > 0.05$).

In all cognitive domains, the baseline cognitive function was a significant predictor of a clinical improvement (> 0.5 SD) ($p < 0.05$), while stroke type, location and side were not significant predictors.

Conclusion

HBOT can induce a significant improvement in cognitive function even at the late chronic stage. The selection of post stroke patients for HBOT, should be based on functional analysis and baseline cognitive function rather than the stroke type or location.

Keywords

Hyperbaric oxygen therapy, Stroke, Cognitive function, Retrospective analysis

H-04 HYPERBARIC OXYGEN THERAPY INDUCES CLINICAL IMPROVEMENT IN PATIENTS WITH CHRONIC ISCHEMIC STROKE: A RANDOMIZED CONTROLLED STUDY

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Introduction

Stroke, also known as a cerebrovascular accident, is a common and serious neurological disease and the fourth leading cause of death in the USA. Hyperbaric oxygen therapy (HBOT) is one of the promising modalities in treatment and rehabilitation of cerebrovascular stroke.

This study assesses HBOT as an adjuvant in the rehabilitation of ischemic cerebrovascular stroke.

Methods

We report a prospective, randomized, controlled, trial on 80 patients assigned to either conventional therapy (pharmacotherapy and physiotherapy) plus HBOT at 1.5 ATA, for 60 minutes daily for eight weeks (40 sessions) or to a control group receiving only the conventional therapy. Neurological function was evaluated by modified Ashworth scale and modified Rankin scale at baseline and at four and eight weeks after inclusion.

Results

There was a statistically significant improvement in spasticity (mean change in Ashworth score from baseline to 4th week of the study group (1.14 ± 0.70) compared to that of the control (0.43 ± 0.63) ($p < 0.001$) and from baseline to 8th week of the study group (1.58 ± 0.61) compared to that of the control (0.67 ± 0.66) ($p < 0.001$).

There was a statistically significant improvement in disability and dependence in daily life activity using modified Rankin scale shown by the difference in the mean change of the modified Rankin score from baseline to 4th week of the study group (0.92 ± 0.27) compared to that of the control (0.53 ± 0.51) ($p < 0.001$) and from baseline to 8th week of the study group (1.30 ± 0.54) compared to that of the control (0.63 ± 0.61) ($p < 0.001$).

Anatomical distribution of infarct (right versus left and anterior circulation versus posterior circulation) didn't affect the benefit from HBOT.

Conclusions

HBOT can induce significant neurological improvement in post-stroke patients. The neurological improvement in the chronic stage demonstrate that neuroplasticity can be activated by HBOT even long after acute brain insult.

Keywords

Hyperbaric oxygen therapy, Ischemic stroke, Hemiplegia

H-05 USE OF REAL-WORLD DATA TO ENHANCE CLINICAL TRIALS AND SUPPORT REGULATORY DECISION-MAKING FOR HBOT IN WOUND CARE

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Introduction

Real World Data (RWD) can expand the evidence for the effectiveness of HBOT and provide support for the regulatory decision-making process. Randomized Controlled Trials (RCTs) exclude half the total population of patients with chronic wounds, resulting in a limited understanding of HBOT effectiveness in the real-world clinical setting of wound care.¹ Real-world patient care does not occur under ideal conditions and are much more likely to suffer an amputation. Sadly, HBOT trials are often not performed on worthwhile patients. Some Diabetic Foot Ulcer (DFU) trials on HBOT efficacy (i.e. Fedorko et al.) provide a powerful argument for RWD.

Methods

A prospective clinical trial on 100 patients with hard-to-heal wounds treated with a multi-specialist approach including HBOT. On half group, there was relax on some constraints of a normal RCT. In the comparison group, standard care was administered strictly following the guidelines.

Results

RW patients had more than two comorbidity compared to the comparison group, the initial wound area was, on average, three times higher and the WIfI classification and the Wound Bed Score (WBS) was worse ($p < 0.05$). In the RW patients, HBOT was prescribed in case of failure after an average of 60 days of standard care.

Conclusion

Daily clinical practice (Real World Data) shows that patients with non-healing ulcers are more complex than those included in Randomized Controlled Trials (RCTs). The former have more comorbidities; delayed HBOT; more ulcers with larger size; golden standards are not applied (such as complete discharge in the neuropathic DFU; adequate compression therapy in the Venous Leg Ulcers). To demonstrate the effectiveness and value for money of HBOT in wound care, RWD studies of high quality, as well as the Randomized Controlled Trials (RCTs), need to be published.

Keywords

Guidelines, Hyperbaric oxygen therapy, RCTs, Real-World Data, Wounds

Reference

Fife, C.E., Eckert, K.A. (2017), Harnessing electronic healthcare data for wound care research: Standards for reporting observational registry data obtained directly from electronic health records. *Wound Rep Reg*, 25: 192-209. doi:10.1111/wrr.12523

H-06 PATIENT REPORTED EFFECTS OF HYPERBARIC OXYGEN THERAPY FOR HEAD AND NECK LATE RADIATION-INDUCED TISSUE TOXICITY

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Background

The purpose of this study is to investigate the effects of hyperbaric oxygen therapy (HBOT) in patients suffering from late radiation-induced tissue toxicity (LRITT). This study focuses on patients treated for head and neck LRITT and treatment of HBOT for osteoradionecrosis (both prophylactic and therapeutic).

Methods

The data of 23 patients, treated with HBOT for LRITT, was gathered by using a validated European Organization for Research and Treatment of Cancer (EORTC) QLQ-C30 in combination with specific head and neck questionnaires (QLQ-H&N35). The HBOT consisted an average of 40 sessions. In total 80 minutes of 100% oxygen was administered to patients under increased pressure of 2.4 atmospheres absolute (ATA) during a 110 minutes hyperbaric oxygen session.

Results

The treated patients completed and returned the questionnaires before HBOT and after finishing the treatment. The following suffered from severe pain in the orofacial area before treatment: oral pain 39%, jaw pain 39% and pharynx pain 26%. 57% of the patients reported difficulty swallowing solid foods and 52% experienced xerostomia. After finishing the HBOT, the severe pain complaints were 17%, 22% and 4% respectively. 39% of the patients reported difficulties swallowing solid foods and 39% experienced xerostomia.

Conclusions

The results of the study indicate that substantial improvement occurred in patients with LRITT after finishing the HBOT. The analysis of the QLQ-H&N35 questionnaires reveals an appearance of improvement in multiple domains, varying from pain reduction in the orofacial area to improved swallowing and xerostomia. In conclusion, HBOT has positive effects in patients suffering from LRITT in head and neck.

Keywords

Hyperbaric oxygen treatment, Late radiation-induced tissue toxicity

H-07 HYPERBARIC OXYGEN THERAPY FOR NECROTIZING SOFT TISSUE INFECTIONS – EXPERIENCES FROM THE PROSPECTIVE, OBSERVATIONAL INFECT STUDY

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Background

Hyperbaric oxygen therapy (HBOT) is recommended as an adjunctive therapy in the treatment of life threatening necrotizing soft tissue infections (NSTI) such as necrotizing fasciitis or gas gangrene[1]. Large, prospective studies on the effects of HBOT on these infections are lacking. From February 2013 to June 2017 a group of 5 Scandinavian Hospital centres in Denmark, Norway and Sweden, treating NSTI patients using HBOT as adjuvant therapy, enrolled patients into the INFECT study. As of today, this is the largest prospective, multicenter study of NSTI patients including the use of adjuvant HBOT.

Methods

The INFECT study was a clinical, prospective, observational study in patients above 18 years of age with the surgically confirmed diagnose of NSTI. Patient characteristics of underlying comorbidities, use of steroids/immunosuppressing medicine, objective findings at admission, microbiology, antibiotic treatment, surgery, supportive care, HBOT, immunoglobulin treatment and outcomes were recorded.

Results

A total of 409 patients were included during the enrolment period. Of these 80% received HBOT. Overall 30 and 90-day mortality of the entire cohort was 14% and 18%, respectively. Patient characteristics, management of HBOT with respect to protocols used, timing and frequency were recorded and will be presented.

Conclusion

NSTI is a life-threatening condition resulting in septic shock and multi organ failure requiring timely and aggressive surgery, intensive care support and broad spectrum antibiotic therapy. The use of adjuvant HBOT with respect to timing, dosage and frequency vary.

Keywords

Sepsis, Tissue necrosis, Shock, Antibiotics, Intensive care, Prospective observational study

Reference

Mathieu D, Marroni A and Kot J. Tenth European Consensus Conference on Hyperbaric Medicine: recommendations for accepted and non-accepted clinical indications and practice of hyperbaric oxygen treatment. Diving Hyperb Med 2017,47(1):33-37.

H-08 INTRACRANIAL ABCESSSES – A FORGOTTEN INDICATION FOR HBOT?

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Background

Based upon considerations similar to the rationale for the use of HBOT in gas gangrene and necrotizing soft tissue infections, the treatment of intracranial abscess with adjunctive HBO was approved by the Undersea and Hyperbaric Medical Society (UHMS) in 1999, followed by the European Committee for Hyperbaric Medicine (ECHM) in 2004 in Lille.

The first review of the bacteriologic and pathophysiologic rationale for HBOT for intracranial abscesses was published in the *Journal of Hyperbaric Medicine* in 1989. Data from animal series remain scarce, and the number of case series and case reports has only been increasing slowly over the years.

Inasmuch as the clinical course, diagnosis, and treatment of subdural and epidural empyema has similarities with intracranial abscess, these are all included along with intra-cerebral abscesses under the blanket term “intracranial abscess”.

Methods

Prospective randomized trials examining HBOT for intracranial abscess in humans are not expected. Case series from seven hyperbaric centers are available internationally, involving 230 patients. The comparison between adjuvant HBOT and standard management in patients is therefore possible.

Results

Mortality in 230 patients treated with additional HBOT is markedly lower than patients treated with conventional therapy alone (4.3% and 19.2 % respectively). In survivors following HBOT, long term sequelae such as moderate or severe lifelong disability could be significantly reduced or even completely avoided.

Conclusions

In patients with intra-cranial abscess, adjuvant HBOT should be considered early in the course under the following conditions: proven or suspected anaerobic or mixed pathogens; multiple abscesses in one or both hemispheres; abscesses in a deep or dominant location; compromised host; surgery contraindicated or high risk; deterioration or no response to standard surgical care.

Keywords

Intra-cranial abscesses, Hyperbaric oxygen therapy, Case series analysis

Reference

Lampl L, Frey G, Fischer D, Staps E. Hyperbaric Oxygen in Intracranial Abscess. In: E. Kindwall, H. Whelan (eds.): *Hyperbaric Medicine Practice* (4th ed.), 2017. Best Publishing, North Palm Beach (FL), USA

H-09 TRAUMATIC BRAIN INJURY PATIENT SELECTION FOR HYPERBARIC OXYGEN THERAPY USING BASELINE FUNCTION

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Background

Previous studies have shown that hyperbaric oxygen therapy (HBOT) can induce neuroplasticity and improve cognitive function of patients suffering from post-concussion (PCS) due to traumatic brain injury (TBI). However, there is insufficient data in regards to selection of patients and prediction of the therapy outcome.

The aim of this study was to evaluate the baseline functional brain imaging using SPECT as a possible predictor for the cognitive outcome following HBOT in PCS patients.

Methods

A retrospective analysis was conducted of 242 patients suffering from chronic neurocognitive damage due to TBI, treated by HBOT from 2008-2017. The final analysis included 114 patients who had both pre- and post-HBOT computerized cognitive evaluations and pre-HBOT SPECT.

Significant clinical improvement was defined as an increase in 0.5 SD from baseline score of each cognitive domain.

Results

114 patients (54.4% males) with mean age 42.95 ± 14.6 were included. The mean time from injury to HBOT was 31 ± 4.1 months. Significant clinical improvement was calculated post HBOT in 22%, 38.6%, 28.9%, 26.3% and 31.6% of the patients in the global, memory, executive function, information processing speed, visual spatial cognitive domains, respectively.

By applying support vector machine model on pre-HBOT SPECT, clinical significant improvements in memory, executive function and attention can be predicted with accuracies of 75.2%, 73.5%, 65.5% and AUC of 0.72, 0.70 and 0.62, respectively. Each domain was predicted using different array of Broadmann areas which were found most predictive.

Conclusion

HBOT induced clinical significant cognitive improvements in 22-38.6% of the patients suffering from chronic deficits in TBI. Patients' selection for HBOT may be improved using the baseline functional imaging.

Keywords

Traumatic brain injury, Hyperbaric oxygen therapy, Patient selection

H-10 HYPERBARIC OXYGEN THERAPY AND HYALURONIC ACID FILLER INDUCED DERMAL ISCHEMIA

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Background

Vascular compromise is a rare but severe complication which can occur after injection with hyaluronic acid filler. Several options are available to treat this complication, with varying outcomes. Little is known about treatment with hyperbaric oxygen therapy. This case highlights the clinical significance of hyperbaric oxygen therapy to treat dermal ischemia.

Case report

A 43-year-old male received injections with hyaluronic acid filler in the chin and nasolabial folds. Immediately after injection, perfusion was reduced in the right half of the face. For four days, the patient was injected multiple times with hyaluronidase in a cosmetic clinic. Hyaluronidase is an enzyme which catalyzes the degradation of hyaluronic acid to reverse the effects of the fillers. The patient was also treated with amoxicillin/clavulanic acid, fusidic acid, valaciclovir, carbasalate calcium and several analgesics. Six days after the initial treatment, the patient was sent to the Academic Medical Center for hyperbaric oxygen therapy. The patient was treated with ten sessions of oxygen at 2.4 atmospheres absolute pressure for 90 minutes. The first two days the patient received this treatment twice daily, the following six days, once a day.

After finishing the hyperbaric oxygen therapy, the wounds recovered completely without scarring.

Conclusions

Vascular compromise caused by dermal fillers is a major concern. This case illustrates the potential benefits of hyperbaric oxygen therapy to treat wounds caused by vascular occlusion in cosmetic interventions. However, more information about the use of hyperbaric oxygen therapy in similar cases is needed.

Keywords

Hyperbaric oxygen therapy, Hyaluronic acid filler, Dermal ischemia, Case report

D-01 INVITED SPEAKER

POLITICS OF DIVING IN THE RED SEA

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Introduction

The political situation of a diving region has a profound influence on diving industry regulation, diving safety, tourism levels, and the ecology of the marine and shore regions. Therefore, politicians should take into consideration historical, biological and tourism development experiences.

Although the Red Sea extends for thousands of miles and many countries have it as their natural border, ancient Egypt had an unwritten claim over it and considered it all 'Egyptian'. This implied a certain respect for the marine environment, commanded by the Pharaohs and Queens.

The Suez Canal, opened in 1869, liberated the world's marine trade and at the same time profoundly changed Egypt's history, owing to trade and other wars to control this important passage. Only in 1979, after the peace treaty between Israel and Egypt, diving tourism started in the Sinai with the creation of Ras Mohamed National Marine Park in 1983. Hurghada started few years earlier with the first charter flight landing in 1970.

Diving in the Sinai

The first SCUBA diving regulations were actually drawn up by concerned divers and dive centers. The necessity for creating a recompression facility in Sharm el Sheikh became evident when it appeared that even seriously ill Egyptian divers could not be transported to Eilat for treatment, because of the Camp David Peace Treaty!

Despite a boom in the numbers of divers in the period 1994-2000, the Minister of Tourism established the 'Chamber of Diving and Water Sports' (CDWS) only in the year 2007. It represents all Diving Center, Safari Boat and Water Sport owners. It applies stringent standards of excellence to all its members and introduced an obligatory ISO auditing for all diving centers and related activities.

In December 2010, a number of shark attacks on snorkelers caused a dramatic setback to the tourism industry, with 60% cancellations. The Egyptian revolution started end of January 2011 and major political unrest continued well into 2013. In October 2015, the explosion of a Russian Airbus shortly after take-off from Sharm el Sheikh, caused most European countries to almost completely stop flying tourists to the area. Only recently, flights are starting again to come in. On a positive note: in the meantime, reefs and corals have very much recovered owing to the decreased environmental pressure by sports divers.

Challenges

Industrial development projects and politics threaten both the stability of the region and the ecosystem: the planned 32km long causeway/bridge between the Kingdom of Saudi Arabia and Egypt; compromise of the free access to the Red Sea for Israel; the ongoing war in the Yemen, not only a tremendous human catastrophe but also a major threat of oil spill pollution and destruction of marine fauna and flora, and the plans to develop a huge Red Sea Mega tourism complex on the east shore, stretching on the north-western coast of Saudi Arabia, including 52 islands and extending into the Gulf of Aqaba.

D-02 VARIATION OF LUNG, VASCULAR AND COGNITIVE FUNCTIONS DURING AND AFTER RECREATIONAL DIVING WITH REGULAR COMPRESSED AIR COMPARED TO OXYGEN ENRICHED AIR (NITROX 32)

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Introduction

Nitrox diving could harm lung, vascular or cognitive function in divers. This study compares air versus nitrox breathing with respect to these functions.

Methods

Recreational divers made two dives with a one week interval (one breathing air and one Nitrox 32) to 30msw for 30 minutes in water at 6-8°C. Biometry, spirometry, carotid nitrogen bubbles, vascular endothelial function (FMD – Flow Mediated Dilation), cognitive state (PEBL© Math processing Task & Perceptual Vigilance and CFFF - Critical Flicker Fusion Frequency) and hydration (urine specific gravity) were measured before (T0), during (T1), immediately after diving (T2) and 2 h after diving (T3). At T1, only Math Proc and PVT tests were done.

Results

We recruited eight males, aged 42.6 ± 17.8 years, 178 ± 3 cm height and 25.9 ± 5 kg/cm² body mass index, They had performed on average $1,443 \pm 865$ (air + Nitrox) dives over 20.1 ± 7.9 years diving without incident.

There was a statistically significant decrease in FVC after both air and Nitrox dives (T0 to T1: $p < 0.05$, T0 to T2: $p < 0.05$) and FEV1 after air dives (T0 to T1: $p < 0.05$, T0 to T2: $p < 0.05$). No changes in respiratory measures were found, except a significant decrease for DEM75 2 hours after the Nitrox dives. Non-significant improvement in CCCF and decrease in cognitive function was observed during all dives, with a significantly faster return to normal values while using nitrox ($p < 0.05$). There were fewer carotid nitrogen bubbles after Nitrox diving. Nitrox diving caused a significant reduction of FMD after diving with a return to baseline values at two hours.

Conclusion

Although statistically significant, reductions in lung function after diving were small and within normal parameters. A decrease of DEM75 at two hours after Nitrox diving was the only significant difference between Nitrox and air diving.

Keywords

Nitrox diving, Pulmonary function, Endothelial function, Cognitive state

Reference

Zenske A, Wataru K, Koch A et al. Is Nitrox Dangerous for Recreational Diving ? 24th EUBS Annual Scientific Conference, O-23, Geneva 2016.

D-03 A RETROSPECTIVE REVIEW OF THE UTILITY OF CHEST X-RAYS IN DIVING AND SUBMARINE MEDICAL EXAMINATIONS

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²Institute for Maritime Medicine, South African Military Health Services

Introduction / Background

There is controversy regarding the use of routine Chest X-rays (CXR) as part of the fitness-for-work evaluation of divers and submariners. In the United Kingdom, the HSE does not require any CXR unless a clinical indication exists, while prevalent tuberculosis (TB) areas (e.g. South Africa) annual CXR is mandatory. The utility of CXR should be evaluated. In SA, excellent records are available for military divers and submariners. This information was used to evaluate the utility of CXR in this population.

Methods

CXR performed on military divers and submariners from 1987 to April 2018 were reviewed to determine the incidence of abnormalities and to describe the pathology found.

Results

894 individuals (47% divers, 51% submariners and 2% both) contributed 5,281.41 person-years of service (range 1 to 28.43 years). 3,562 fitness-for-work evaluations were performed, including 2,777 CXRs, (reports available for 2772). Abnormalities were reported for 58 (6.49%) participants and in 72 (2.6%) of CXRs. One was a possible case of active TB.

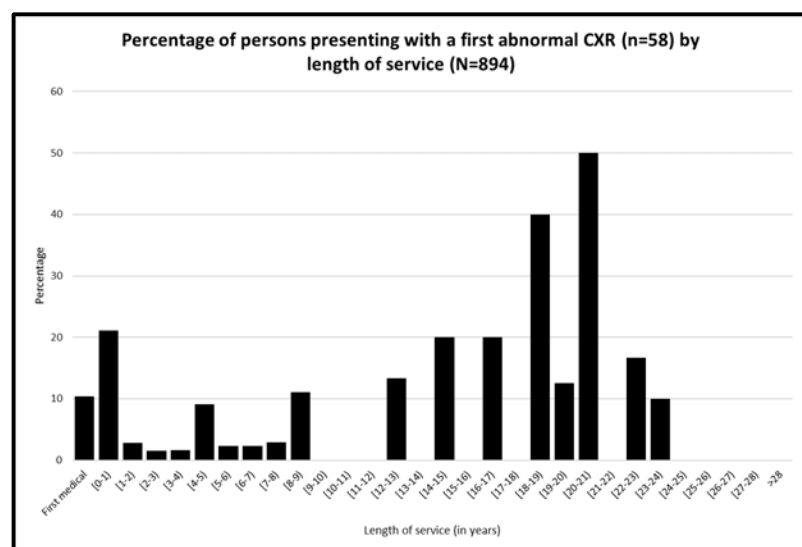
Of the 58 individuals with abnormal CXRs, 31 received no radiological follow-up. Of the 27 receiving follow-up radiology, 19 were normal. Radiological findings caused nine (15.5%) being declared unfit (of which six were temporary) and 45 were declared fit (one was fit with restrictions). Three were declared unfit for other medical reasons.

Discussion / Conclusions

Almost one in every 15 participants had an abnormal CXR, most commonly at baseline. However, 32.8% of these were found to be normal on subsequent examinations (including cases of infection). Based on this study, we recommend that high-prevalence countries receive a routine CXR evaluation at baseline and that this be repeated every five years thereafter, and possibly more frequently after more than 15 years of service (see graph). Additional CXRs may be required upon clinical indication.

Keywords

Chest X-ray; Fitness-to-dive; Screening tests; Pulmonary



D-04 DOES HYPOXIA TRAINING IMPROVE COGNITIVE PERFORMANCE DURING SUBSEQUENT HYPOXIA?

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Introduction

Hypoxia training experiences are often provided for aircrew in the belief they enhance capacity for self-rescue from future exposure. Some suggest similar training for rebreather divers. Enhanced self-rescue could be due to improved symptom recognition or improved ability to cognate clearly, or both. We investigated the effect of an hypoxic experience on actual and perceived cognitive function at subsequent hypoxia.

Methods

Twenty-five subjects underwent two hypoxic experiences one month apart (trials 1 and 2). Monitoring included pulse oximetry and cerebral near infrared spectroscopy (NIRS). Subjects breathed 5% oxygen whilst performing a playing card recognition test. The primary outcome was the time taken to make three consecutive errors in card recognition (time of useful consciousness – TUC). Secondary outcomes were the total number of errors made and the accuracy of recollection of errors. We also recorded heart rate and oxygen saturation to evaluate whether hypoxic training is advisable for non-medically supervised, unscreened technical divers.

Results

Mean TUC was 166 s (sd 37) and 169 s (sd 35) in trials 1 and 2 respectively ($t_{24} = 0.38$, $p = 0.70$). On average, subjects made 8.9 (2.4 SD) and 7.8 (2.0 SD) errors in trials 1 and 2 respectively ($t_{24} = 1.79$, $p = 0.087$). Subjects exhibited poor recall of the number of errors they made whilst hypoxic, with participants, on average, failing to recall 6 (sd 3) errors made in trial 1 and 6 (sd 2) in trial 2 ($t_{24} = 0.12$, $p = 0.91$). Mean peak heart rate was 128 and mean nadir oxygen saturation was 52%.

Conclusions

Hypoxia did not improve cognitive performance or insight into cognitive performance during a second exposure one month later. It is therefore unlikely a cognitive acclimation process contributes to any improved ability to self-rescue during a subsequent hypoxic experience. Hypoxia caused a significant tachycardia whilst oxygen carriage was profoundly reduced. We do not believe this is an appropriate training strategy for unscreened, non-medically supervised technical divers.

Keywords

Hypoxia, Training, Rebreather diving

D-05 IMPACT OF A FOUR WEEKS PRANAYAMA RESPIRATORY YOGA TRAINING ON THE PULMONARY FUNCTION OF STARTING FREEDIVERS

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Introduction

Breath hold diving is a discipline where performance depends on a high level of physical capacity, such as the ability to relax the body, store a large volume of oxygen and tolerate high CO₂ levels. To improve these capacities, freedivers use techniques which soften and reinforce the thoracic musculature. One technique is Pranayama, a respiratory branch of Yoga. The purpose of this study is to investigate the impact of Pranayama on pulmonary function in freedivers.

Methods

This study is a clinical trial involving the participation of 14 volunteers who are beginners in freediving. The divers were split into two groups: a control group (CG) and a Pranayama group (PG) who committed to practice respiratory exercises over four weeks. The subjects were measured before starting the program (T0) and at the end of the program (T1) on anthropometric parameters, thoracic and abdominal circumference as well as respiratory parameters derived from spirometry tests, according to the American Thoracic Society/European Respiratory Society (ATS/ERS). The divers also completed two questionnaires to determine their anxiety level and participated in performance tests. The respiratory data intergroups (unpaired tests) and intra-groups (paired test) were analysed using z-scores.

Results

The intragroup measurements at T0 and T1 demonstrated that the PG freedivers showed significant enhancements in forced vital capacity (FVC) (p=0.04), maximal voluntary ventilation (MVV) (p=0.04) and thoracic mobility (p=0.03) as reduction of Tiffeneau index (FEV1/FVC ratio) (p=0.02).

Conclusion:

The addition of Pranayama respiratory Yoga training for the practice of freediving results in an increased respiratory function and thoracic mobility.

Pranayama can also have a positive impact on representative variables of softness and power of pulmonary revalidation for weak populations such as geriatric, (ex-)smokers or people with neurological diseases.

Keywords

Breathhold diving, Pranayama yoga, Pulmonary function tests, Thoracic mobility

Reference

Schagatay E. Human Breath-hold diving ability and its underlying physiology. *Human Evolution* 2014,29(1-3):125-140

D-06 COLLECTING BUBBLES – A METHOD OF COLLECTING EXPIRED GAS FROM SCUBA DIVERS FOR ANALYSIS OF ENERGY EXPENDITURE

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Introduction

There is an increasing use of SCUBA equipment by people with disability. For a future study of energy expenditure of people with disability undertaking supervised activity in a shallow pool using SCUBA equipment, a method of collecting expired gas for indirect calorimetry is required. Equipment and methods for collecting expired gas from SCUBA divers for analysis have been previously described. However they are complex and expensive systems or they limit the diver's activity or depth.¹ I describe a simple and inexpensive method of collecting expired gas from SCUBA divers that can be used at variable depth and that causes little interference with activity.

Methods

The available literature was reviewed. Various prototypes were tried and tested by the author. Once a method had been developed it was tried with a small number of subjects in a pool using both a half mask with standard SCUBA second stage regulator and a full-face SCUBA mask incorporating a second stage regulator. The subjects included people with disability.

Results

The equipment for collection of exhaled gas will be described. The method of analysis of exhaled gas will be described. The intention is to use the equipment to compare energy expenditure at rest and with activity. The collected exhaled gas samples will be analysed following collection in Douglas bags. Initial analysis of collected samples available at the time of the conference will be presented.

Conclusions

The discussion will cover the topics of exercise in people with disability and the difficulties with measuring energy expenditure in people with disability. The advantages of the method developed and potential applications beyond the proposed study will be outlined.

Keywords

SCUBA diving, Energy expenditure, Indirect calorimetry, Disability

Reference

Almeling M, Shega L, Witten F, Lirk P, Wulf K. Validity of cycle test in air compared to underwater cycling. *Undersea Hyperb Med* 2006;33(1): 45-53

PERSPECTIVES ON ASSESSING PSYCHOLOGICAL COMPETENCY-TO-DIVE

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Introduction

Diving, as a safety-critical activity, may require specific decisions regarding a person's competency to dive. In the context of psychological or mental health, such decisions are often complex, as there are very few absolute contra-indicators. For example, psychological performance and mental health lies on a continuum, and it is therefore difficult to identify specific cut-off points to guide clinical decision making. Thus, psychological competency-to-dive is mostly decided on a case by case basis.

In its most basic form, a diver's competency-to-dive is dependent on appropriate cognitive, emotional, and behavioural self-regulation, underpinned by intact neuropsychological functioning. The presentation deals with this definition, and its practical implications, in detail.

The presentation will provide a brief overview of the reasons why psychological opinions are requested (in South Africa), including questions around the presentation of psychopathology, questions around a diver's neuropsychological functioning, questions around motivation to dive, and questions around aptitude/ability.

Assessing psychological competency to dive

When considering a diver's psychological competency to dive, a range of factors need to be considered. In this event six "clinical profiles" (i.e. diagnostic; treatment; symptom; substance use; context-based dysregulation; neuropsychological) are compiled and then evaluated against the demands and conditions of the diving being pursued. These profiles can be thought of as 'lenses' with which to bring relevant aspects into clearer focus, and are discussed in detail in the presentation.

Application / case study

The presentation will conclude by briefly considering the condition of Adult Attention-deficit/Hyperactivity Disorder as a 'case study' to demonstrate the application of the six lenses, and explain how evaluating these six profiles against the demands of the environment could inform clinical decision making.

Keywords

Psychology, Fitness to dive evaluation, Mental health, Safety

D-08 EFFECTS OF WATER TEMPERATURE AND TYPE OF DIVING SUIT ON BODY TEMPERATURE AS WELL AS COGNITIVE AND PULMONARY PARAMETERS DURING SCUBA DIVING WITH COMPRESSED AIR.

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Introduction

Water temperature and type of diving suit can influence body temperature as well as cognitive and pulmonary parameters during scuba diving with compressed air.

Methods

We included 24 dives with 17 subjects divided into four groups: wet suit (GH), semi dry suit (GSE), dry suit (GS) and pool without suit (GP). The dives were made in sea (water 7°C, depth 20 m) or in swimming pool (water 28°C, depth 4 m) during 30 min in the air.

We measured the following parameters before (T0) and after (T2) diving: Perceptual Vigilance Task (PVT), fractional exhaled nitric oxide (FeNO), spirometry, skin and central temperature, cold perception, bioimpedance, urinary specific gravity (GUS). During each dive we also measured (T1): PVT, skin and core temperature.

Results

Skin temperature decreased between T0 and T2 in all groups (GH $p < 0.001$; GSE $p < 0.05$; GS $p < 0.01$; GP $p < 0.001$). The core temperature decreased between T0 and T2 for GSE and GS ($p < 0.05$). Cold perception increased for GH and GSE compared to GS and GP ($p < 0.0001$). PVT increased to T1 for GSE, GS and GP ($p < 0.05$). FEV1 and DEM 25 decreased for GP ($p < 0.05$) and DEM 25-75 for GSE ($p < 0.05$). Airway inflammation status, bioimpedance and urinary specific gravity did not change ($p > 0.05$).

Conclusion

Scuba diving with compressed air decreased skin temperature in all subjects, more so with colder water and less waterproof suits. Core temperature dropped slightly during cold water dives with all suits, while remaining within safety standards and without risk of hypothermia. Cold perception decreased in line with skin temperature decrease only in less waterproof suits. Cognitive function does not appear to be affected by water temperature or by type of suit used. Pulmonary function was maintained within normal limits and without any increase in airway inflammation. All divers remained within safe limits during these dives.

Keywords

Scuba diving, Thermal protection, Body temperature, Pulmonary function tests, FeNO, Cold perception

Reference

Pendergast DR, Lundgren CE. The underwater environment: cardiopulmonary, thermal, and energetic demands. *J Appl Physiol* (1985) 2009; 106: 276-283

D-09 OUTSIDE THE COMFORT ZONE – MEDICAL SUPPORT OF THE ANTARCTIC DIVING PROGRAM 2014-15

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Introduction

Antarctica is one of the most isolated places on earth. To successfully undertake a diving program in this environment places all systems and personnel out of their comfort zone.

Description

In November 2014, the author spent four weeks at Casey Base assisting the diving program to support the Antarctic Free Ocean Carbon Enrichment (Ant - FOCE) experiment. The role included working as a medical specialist to support the dive team, independent review of dive procedures, emergency procedures and hyperbaric chamber set-up, and a review of the AAD Dive Medicine Support facilitated by the Polar Medicine Unit and Station Doctors.

The Ant-FOCE project involved assembling the scientific equipment to connect surface to ocean water and bottom under permanent ice, monitoring and collection of samples, then disassembly and removal of equipment. Backing this dive program were emergency procedures and the setting up of a hyperbaric facility on base (from scratch in kit form). Temperatures were as low as minus 15°C and wind chill from up to 25k winds. The water temperature was a balmy minus 1.8°C.

Issues for diving included cold surface and water temperatures, access through ice, overhead environment, wind chill for surface attendants and divers, remoteness, electrical safety and the need to be self-sufficient for emergencies, including multiple safety redundancies. In addition the scientific program had limited time for completion, leading to a desire to work seven days per week and fatigue.

The recompression chamber was 40 minutes from the dive site. Dive preparation took much longer than for temperate or tropical diving. Divers wore dry suits for thermal protection, but a limiting factor was manual dexterity of the hands. The program used conservative DCIEM dive tables, with maximum 60 minute time limits. The program commenced 24 November 2014 and was completed 4th March 2015. Ten divers completed 250 dives (212 hours) up to 22m deep under ice with no serious incidents. This paper provides an overview and personal reflections of providing diving medical support outside the comfort zone.

Keywords

Antarctica, Extreme environments, Ice Diving, Medical support

D-10 EFFECTS OF A COMMERCIAL SATURATION DIVE ON HEMOGLOBIN AND ERYTHROPOIETIN LEVELS

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Introduction

Professional saturation diving involves living and working in high pressure while breathing gas mixtures at elevated oxygen partial pressure (ppO₂) for extended periods. In previous experimental saturation dives¹, reduced erythrocyte oxygen transport capacity involving hemoglobin (Hb) and erythropoietin (EPO) has been reported after a deep dry saturation dive and breathing hyperbaric oxygen.

Methods

Hb and EPO levels were measured in 13 commercial saturation divers prior to diving, immediately post-dive, and 24 h post-dive. The ppO₂ was 40 kPa inside the saturation chambers during storage, between 50–80 kPa during the bell excursions, and 50 kPa during decompression until 15msw. The chamber oxygen content was kept at 21% from 15 msw to surface.

Results

The Hb and Hct levels were slightly reduced relative to pre-dive values immediately after saturation diving, and 24 h later. There was no change in EPO immediately after diving, but a marked increase (88%, $P < 0.0001$) was observed 24 h later. With the exception of one diver, all the values were within normal ranges.

Conclusions

This is the first time such measurements were conducted in real operational saturation dives, involving divers working in the North Sea. The changes in Hb and EPO mirror the effects of moving from hyperbaric hyperoxia to normobaric normoxia called relative hypoxia. During these conditions, up-regulation of EPO triggers erythrocyte production which compensates the lack in oxygen transfer capacity. This phenomenon is known as the normobaric oxygen paradox and demonstrates a successful acclimatization to the environmental conditions. The fast increase of EPO 24 h after surfacing suggests that the diving procedure did not present lasting changes to the divers' hematological status, even after long exposure to hyperoxic hyperbaric conditions.

Keywords

Hyperoxia, Hypoxia, Hematology, Normobaric oxygen paradox, Saturation diving

Reference

¹ Hofso D, Ulvik RJ, Segadal K, Hope A, and Thorsen E. Changes in erythropoietin and haemoglobin concentrations in response to saturation diving. *Eur J Appl Physiol* 2005;95:191-196.

D-11 SITE EVALUATION OF DEEP DIVERS' SAFETY AND PERFORMANCE

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Introduction

During the past 25 years, there have been continuous diving operations in 200-260msw around the world. The background to these operations are research studies in the 70's, technical developments in Norway in the 80's, and field validation in Brazil in the 90's. If the Brazilian deep diving regulations are regarded as a reference, their scientific basis is now 40 years old. Currently, the industry operates through Management of Changes to improve procedures and needs tools for monitoring divers' performance. We specified, designed and implemented a physiological monitoring onboard a TechnipFMC DSV, during standard (North Sea) and deep (224 msw) contracts.

Methods

Hazard identification and risk assessment for working deep divers cover HPNS but also thermal balance, work of breathing, fatigue, decompression stress, pulmonary oxygen toxicity, oxygen acclimatization, diet, hydration and sleep. Assessing these issues is performed with tests, questionnaires and monitoring devices organized around a computer. Scientifically, the system refers to a series of measurements (weight, cardiac frequency) and psychomotor tests (reaction time, Flicker, hand grip). Operationally, the system is used before, during and after saturation. Technically, the system operates inside the chambers with adapted human interfaces. Legally, the system complies with the European data protection regulations.

Results

The system has evolved significantly to overcome several difficulties: disparate computer installations, use of batteries in hyperbaric environment, endurance of electronics and maintenance of confidentiality inside a chamber.

The lessons learnt include the importance of briefing divers to gain acceptance, training divers to obtain consistent data, simplifying interfaces, selecting pertinent tests and minimizing interference with operations.

Conclusions

This project is the first large scale on-site monitoring of working saturation divers. It fits into the "plan/monitor/review/improve" loop of Diving Safety Management Systems that support modern diving development. It offers a basis for new physiological studies compatible with operational conditions. It provides the longitudinal data for diving long term health effects assessment.

Keywords

Saturation diving, Deep diving, Diver monitoring, HPNS, Long-term health effects

H-11 KEYNOTE ADDRESS

SERIOUS PROBLEMS WITH THE TORONTO HYPERBARIC OXYGEN (HBO) FOR DIABETIC FOOT ULCER (DFU) STUDY: 'HOW THE TRUTH WAS AMPUTATED'

Ron Linden, Kenneth M. LeDez

Judy Dan Research & Treatment Centre, Toronto, Canada

Introduction

The Ontario-government funded study¹ purported to show no benefit of HBO for DFU.

Methods

Detailed review of the Fedorko paper¹, clinicaltrials.gov, REB-approved protocol, health-ministry documents, clinical outcomes, papers the authors claimed supported their methods, correspondence with REB, authors and Journal was undertaken.

Results

The REB-approved primary outcome method (surgeon examination) was ignored, for most patients - only photo assessment used, a serious violation. One small (control) toe was amputated, contrary to claimed 50%, (half major) amputations. Authors withheld one-year results contradicting 12-weeks findings and fact that 80% of unhealed sham group crossed over to HBO. Unpublished 1-year clinical assessments and per protocol analysis demonstrated approximately 78% healing and only 10% amputation if at least 30 HBO treatments received. No publication validates digital photos instead of surgeon assessment to determine amputation need. On the contrary, Fedorko¹ demonstrated no relationship between actual amputation and photo-assessment of their unvalidated criteria.

Multiple ethical and protocol violations were uncovered: no transcutaneous oximetry; exclusion criteria violated; study data sequestered from coinvestigator review; forged signature on REB application; refusal by journal to consider ethical and scientific flaws or critical letters, and retaliation against coinvestigator 'whistleblower'.

Discussion

Londahl demonstrated 12 weeks is too early to detect significant differences between control and HBO groups. Numerous patients reported¹ as amputated at 12 weeks were ambulatory on healed limbs at 1-year, highlighting ethical and scientific shortcomings. Despite lack of retraction or University recognition of serious problems, government proposals to eliminate HBO for DFU were withdrawn. Research integrity is paramount for protecting patients. The complete failure of Journal, University and ethics authorities to take action is profoundly disturbing. This study¹ must not be used to guide clinical or healthcare funding decisions, as it is false, misleading, lacks validity and violated research and publication ethics and public trust. It is essential to challenge faulty research.

Keywords

Hyperbaric oxygen therapy, Diabetic foot ulcer, Research integrity

Reference

¹ Fedorko L, Bowen JM, Jones W, Oreopoulos G, Goeree R, Hopkins RB, O'Reilly DJ. Hyperbaric oxygen therapy does not reduce indications for amputation in patients with diabetes with nonhealing ulcers of the lower limb: a prospective, double-blind, randomized controlled clinical trial. *Diabetes Care* 2016.

H-12 OVARIAN AGEING AND HBO

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CANCELLED

H-13 EVALUATION OF THE CLINICAL IMPACT AND FUNCTIONAL PULMONARY EFFECTS OF HYPERBARIC OXYGEN THERAPY

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Introduction

Previous studies reported changes in pulmonary function tests in patients receiving Hyperbaric Oxygen Therapy (HBOT). This study aimed to analyse the respiratory clinical impact and quantify both any short-term and cumulative effects of our standard HBOT protocol on pulmonary function.

Methods

We undertook a prospective observational study of patients treated between December 2012 and June 2016. Patients with lung disease, clinical respiratory findings previous irradiation to the head, neck or thorax, or abnormal chest x-ray were excluded. Patients completed daily HBOT sessions, stopping on week-ends. Patients answered a symptoms questionnaire and performed serial lung function tests during the treatment course (before and after 1st, 10th and 20th sessions). We tested forced vital capacity (FVC), forced expiratory volume in one second (FEV1), forced expiratory flow at different levels of pulmonary volume (FEF 25-75%), peak-flow (PEF), residual volume (RV) and single-breath carbon-monoxide diffusing capacity (DLCO).

We compared different time periods with a paired sample analysis.

Results

We evaluated 59 patients (21 females), aged 53 years (28 - 76 years). Another 18 patients were excluded during treatment. Four patients reported nonspecific thoracic complaints. FEV1, FEF and PEF declined both in short-term evaluation (before and immediately after HBOT sessions) and in different treatment phase evaluations (before 1st, 10th and 20th session), in some cases significantly so. DLCO also declined during the course of treatment but not statistically significantly so.

Discussion

Intermittent exposure to HBOT had a short term effect on pulmonary function, causing mainly a decrease in FEV1 and FEF's. As patients were evaluated approximately 20 hours after the previous HBOT session we can't be sure about the role of cumulative effects. No relevant clinical impact was found among patients evaluated.

Keywords

Pulmonary function, Hyperbaric oxygen therapy, Oxygen toxicity, Short-term oxygen exposure, Cumulative oxygen exposure

H-14 REDUCTION IN OXYGEN-INDUCED MYOPIA WHEN WEARING A MASK VERSUS A HOOD – A RANDOMISED CONTROLLED TRIAL

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Introduction

Hyperbaric oxygen therapy (HBOT) is generally safe but adverse effects may occur. The most commonly reported adverse effect following HBOT is the development of a temporary myopic shift, and this can have a considerable impact on quality of life. This shift is most likely due to changes in the crystalline structure of the lens.

HBOT can be administered via a hood, an oronasal mask or delivered while breathing an oxygen atmosphere. We hypothesise a significant contributor to myopic shift is the absorption of oxygen directly from the atmosphere into the anterior chamber of the eye. This trial aims to quantify refractive changes in the eye after a standard HBOT protocol using either a hood or an oronasal mask.

Methods

We randomised patients scheduled for 20-30 sessions of HBOT at 2.4 ATA for 90 minutes daily to use either a hood or mask. The primary outcome measure was a change in visual acuity (VA) quantified using manual refraction at the completion of 20 and 30 treatments, with follow-up at four and 12 weeks where possible.

Results

We enrolled 120 patients (63 hood and 57 mask). Using all eyes, the mean refractory change after 30 treatments was -1.21 with a hood and -0.56 with a mask (0.65 [95% CI 0.43 to 0.87], $P = 0.0001$). Four weeks after completion of treatment these changes were -0.56 and -0.14 dioptres (0.42 [0.21 to 0.64], $P = 0.0001$).

At 30 treatments, 69% of eyes in the hood group had a refractory change of more than one dioptre, while in the mask group this number was 27.8% (Risk ratio 2.2 [95% CI 1.6 to 3.1] $P = 0.0001$).

Conclusion

The use of an oronasal mask to deliver HBOT results in less refractory change and possibly more rapid recovery of VA than the use of a hood. This study did not examine the efficacy of treatment.

Keywords

Hyperbaric oxygen therapy, Side effects, Hyperoxic myopia, Randomised prospective study

H-15 HYPERBARIC OXYGEN THERAPY EFFECTS ON PULMONARY FUNCTION

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Background

Oxygen toxicity is considered one of the potential side effects of Hyperbaric Oxygen Therapy (HBOT). Previous small studies showed mild reduction in pulmonary functions reflecting reduction in small airways conductance due to after repetitive HBOT sessions. There is no updated data with well performed pulmonary tests regarding the pulmonary effects of currently used HBOT protocols. The aim of this study was to evaluate the effects of 60 HBOT daily sessions on pulmonary functions in patients treated for different indications.

Methods

Prospective analysis included patients scheduled for 60 HBOT daily sessions between 2016-2018 who signed an informed consent.

Pulmonary function was measured at baseline (prior to oxygen exposure) and after completion of 60 daily sessions, 5 days per week, each session was 90min of 100% oxygen at 2 ATA with 5min air breaks every 20 min. Pulmonary functions measured included forced vital capacity (FVC), forced expiratory volume in one second (FEV1), peak expiratory flow rate (PEF) and mean forced mid-expiratory flow rate (FEF25–75%). The best/highest readings obtained from at least three satisfactory forced expiratory maneuvers were used.

Results

Eighty-eight patients were included. Of them 62% were male, the mean age was 60.36 ± 15.4 years, 30.7% were previous smokers and 5.7% had a chronic pulmonary disease.

Compared to baseline values, at the completion of 60 HBOT sessions, there were no significant changes in FEV1 ($p=0.163$), FEV1/FVC ratio ($p=0.953$) and FEF25-75% ($p=0.423$). There was a significant increase by 0.1 ± 0.38 liters ($p=0.014$) of the. PEF was also increased significantly by 0.5 liters ($p=0.001$).

Conclusion

The current used HBOT protocol is safe without any negative effects on pulmonary function.

Keywords

Hyperbaric oxygen therapy, Side effects, Pulmonary function

H-16 EFFECT OF THE ANTIOXIDANT QUERCETIN ON ROS-INDUCED DNA-FRAGMENTATION IN HUMAN LYMPHOCYTES

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Background

We have previously shown that hyperbaric oxygen (HBO) exposure induces dose-dependent DNA double strand breakage in human peripheral blood mononucleocytes (PBMCs) *in vivo* and *in vitro*. Antioxidants are of vital importance in the protection against ROS-mediated cell damage. The antioxidant quercetin, which is particularly present in onions, is already well-investigated and known to provide protection against cellular oxidative damage.

Methods

In this study, we investigated the protective effect of a human water-soluble metabolite of Quercetin, Quercetin-3-glucuronide (Q3G), against oxidative DNA-damage in human lymphocytes *in-vitro*, using a hyperbaric oxygen stress model (400 kPa / 3 h O₂) for generating ROS (reactive oxygen species) endogenously. After pre-incubation with different concentrations of Q3G and HBO treatment the ROS-mediated DNA-damages were quantified by application of single cell gel electrophoresis (alkaline comet assay).

Results

The results indicate that all applied concentrations of Q3G (1, 10, 50 and 100 µM) reduced the extent of ROS-mediated DNA-damage in comparison to the untreated control (0 µM) in a dose-dependent manner. The total amount of DNA double strand breaks was influenced by the duration of incubation (30 min and 120 min). The most relevant reduction of damaged nuclei (-13%) was found after a 30 min incubation with 1 µM Q3G, which equals a very high physiological plasma concentration.

Conclusions

Our results show that Q3G pretreatment has a protective effect on human lymphocytes against ROS endogenously generated by hyperbaric oxygen treatment. How these findings are to be potentially applied in oxygen-exposed human subjects remains to be investigated in further experiments.

Keywords

Reactive oxygen species, Antioxidants, Hyperbaric hyperoxia, Genotoxicity

H-17 PNEUMOTHORAX DEVELOPED DURING HYPERBARIC THERAPY IN AN INTUBATED PATIENT WITH CARBON MONOXIDE POISONING

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Background

Pneumothorax (PTX) in patients who receive Hyperbaric Oxygen Treatment (HBOT) is a rare but serious complication. PTX may arise in a variety of conditions. In some there can be air trapping (such as chronic obstructive pulmonary disease or asthma), in others the visceral pleura is scarred (such as spontaneous pneumothorax and previous thoracic surgery), and in others there can be tearing of internal lung architecture (eg in interstitial lung diseases).

We report an unusual case where the risks are high. A 75 year old man had a pneumothorax while receiving HBOT for carbon monoxide poisoning.

Case Report

The patient was referred to our ER department for chronic carbon monoxide poisoning when the COHb value could not be measured in the health facility. He had been exposed to stove smoke for two days. Blood values on arrival in our ER were COHb 8.3% (Normal range 0.5-1.5), lactate 4.9mmol/L (NR 0.5-1.6) and pH 7.12 and he had blurred consciousness. During hyperbaric oxygen therapy planning, the patient was anaesthetised, intubated and mechanically ventilated. A Chest X-ray performed before transfer showed bilateral pneumonic infiltration.

He was transferred to the pressure chamber and received HBOT for 60 minutes at 2.4 ATA. After decompression, auscultation of the right chest revealed reduced lung sounds. Tension PTX was detected by chest CT. He was successfully resuscitated by immediate thoracic drainage of the right basal lung. On the following day HBOT continued but after second session, multiple organ failure has developed and required monitoring in the intensive care unit. HBOT could not be continued due to his instability. After a month-long admission, the patient died following a cardiac arrest.

Conclusion

We present a case in which a HBOT was the presumed cause of a barotraumatic pneumothorax. This was successfully treated but the patient died due to comorbidities.

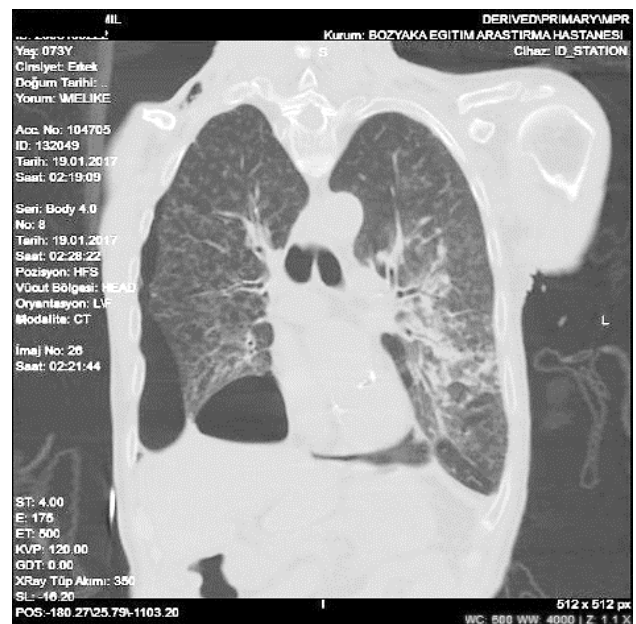
Keywords

Hyperbaric oxygen therapy, Complications, Pneumothorax

Reference

Kot J, Michałkiewicz M, Sićko Z.
Pneumothorax during hyperbaric oxygenation.
Anestezjol Intens Ter 2008;40(1):35-8

Figure 1: after first HBO session, right-sided pneumothorax



H-18 PROPOSED PRAGMATIC STUDY OF CLINICIANS' MANAGEMENT OF IATROGENIC CEREBRAL GAS EMBOLISM

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Introduction

Iatrogenic Cerebral Gas Embolism (CGE) occurs when gas enters the cerebral vascular system (called CAGE when arterial and CVGE when retrograde embolus into the venous system).

Iatrogenic CGE presents with stroke-like symptoms and signs and may occur with any invasive procedure including removal of a central venous or arterial line, during cardiac surgery and peripheral vascular line manipulation.

In the UK a disproportionately small number of cases are referred compared with France or Australia. This may mean many cases have been treated with modalities not widely reported, e.g. lignocaine infusion or hypothermia.¹ It is more likely physicians adopt an expectant approach rather than referral and transfer for Hyperbaric Oxygen therapy (HBOT).

The aim of this presentation is to gauge further international support.

Methods

We propose a pragmatic observational study of the diagnosis and management of CGE. No interventions are planned. Two broad management approaches are anticipated:

A- Neuroprotective measures, organ support including oxygen and cooling or lignocaine infusion.

B - Neuroprotection and organ support with referral for urgent HBOT.

We propose data collection at one week, four weeks and 26 weeks after the event. Data collected will include full or partial neurological recovery using the Glasgow Outcome Scale, and quality of life assessment.

Results

We have indications of support from other a number of organizations including the UK Critical Care Research Forum, the Research and Audit Forum of Anaesthetic Trainees (RAFT), Stroke UK, the Society for Cardiothoracic Surgery and several hyperbaric units in Europe.

Conclusions

Hyperbaric clinicians have no doubt about the benefit of HBOT for CGE. In many parts of the world there is skepticism arising from difficulties accessing HBOT in a timely manner and ignorance of the existing evidence. There has never been a prospective comparative designed to compare outcomes of patients who received HBO compared to those who do not.

Keywords

Cerebral air or gas embolism, Iatrogenic, Treatment options, Study design

Reference

Inoue S, Takizawa H, Yamamoto Y, Tangoku A. Therapeutic hypothermia for severe cerebral air embolism complicating pleural lavage for empyema. *Interact Cardiovasc Thorac Surg.* 2013;17(1):199-201

H-19 HYPERBARIC OXYGEN CAUSES TRANSIENT ALTERATIONS IN COGNITIVE FUNCTION IN MICE.

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Introduction

Exposure to hyperbaric oxygen (HBO) is routine in hyperbaric medicine and when diving with closed-circuit apparatus. However, despite the well-known hazard of CNS oxygen toxicity (CNS-OT) associated with breathing pure oxygen, the effect of continuous inhalation of hyperbaric oxygen on cognitive function is poorly understood.

Methods

In the present study, we examined whether different dosages of hyperbaric oxygen, at 3 atmospheres absolute (ATA) for 45 min (sub-toxic) and at 5 ATA until the appearance of convulsions, might cause impairment of behavioral and cognitive abilities. We assessed cognitive status by means of three behavioral tests: Y-maze, novel object recognition (NOR), and the elevated plus maze (EPM). Mice were examined immediately after exposure to HBO, as well as 7 and 30 days post-exposure.

Results

We found significant impairment of performance on the Y-maze test in the 5 ATA group immediately after exposure to HBO. One week post-exposure, we found significant prolongation of the time taken to complete the EPM test in both groups. A similar trend was observed for the NOR test, but this did not reach statistical significance. Differences between the experimental groups 30 days post-exposure were insignificant for all three tests.

Conclusion

We conclude that exposure to hyperbaric oxygen results in transient impairment of performance on behavioral tests in a mouse model within the first week post HBO exposure. Further investigation is required to establish the mechanism and location of the insult, and to determine whether the observed changes on the EPM and Y-maze tests represent permanent injury or transient damage with slow resolution.

Keywords

Oxygen toxicity; Cognitive impairment; Animal (mouse) study

H-20 HYPERBARIC OXYGEN THERAPY FOR THE TREATMENT OF PERIANAL FISTULAS IN CROHN'S DISEASE (HOT-TOPIC): STUDY PROTOCOL OF A PROSPECTIVE INTERVENTIONAL COHORT STUDY WITH 1-YEAR FOLLOW-UP.

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Introduction / Background

Perianal fistulising Crohn's disease (pCD) has a significant impact on patients' health and quality of life. Current treatment options have a relatively low success-rate and high recurrence risk. Positive effects of hyperbaric oxygen (HBO) therapy have been indicated in animal studies as well as in small case-series. The aim of this study is to further investigate the feasibility and therapeutic effect of HBO in pCD.

Methods

This is a non-randomised, controlled, pilot study. A total of 20 patients with pCD that have been refractory to standard-therapy (both medical and surgical) will be included. Patients with a seton and stable treatment regimen will be included. Patients with anal strictures, rectovaginal fistulas, stoma or deep ulceration of the rectum will be excluded. Patients that are eligible but refuse HBO will be asked to serve as controls. Patients in the HBO group will be treated with 40 sessions of HBO therapy, with the seton being removed after 30 sessions. Co-primary endpoints are changes in the perianal disease activity index and MRI-scores. Secondary outcomes are fistula drainage assessment, laboratory findings and patient-reported outcomes. Assessment will be done at baseline, 16 weeks, 34 weeks and 60 weeks after finishing HBO.

Results

At the time of submission of the abstract, 6 patients are included in the trial (3 in the HBO group and 3 in the control group).

Discussion / Conclusions

The aim of this study is to investigate the feasibility and therapeutic effect of HBO on pCD. The 1-year follow-up should provide information on the effect durability. A comparison between patients treated with HBO and patients that continue to receive standard care will be made. The risk of bias will be limited by using clearly defined in- and exclusion criteria, baseline characteristics and consecutive recruitment of patients through an outpatient fistula clinic.

Keywords

Hyperbaric oxygen therapy, Inflammatory bowel disease, Crohn's disease, Perianal fistula, Pilot study

THE UNITED KINGDOM DATABASE OF DIVERS DIVING WITH DIABETES MELLITUS

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Introduction

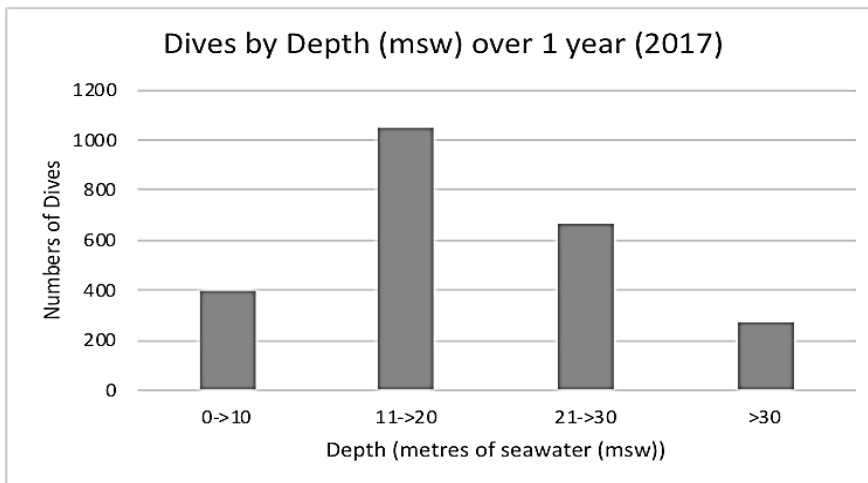
Since 1991 the United Kingdom Diving Medical Committee (UKDMC) has maintained a database of UK divers who are diving with diabetes mellitus (DM). Initially the database comprised mainly divers with type 1 DM but over the last 20 years in the UK the incidence of type 2 DM has increased dramatically, and this is reflected in the population of the database. Since 2003 when data were last reported from this database, 523 divers have reported on their diving to the database and have performed a total of 2387 dives in the last year alone (2017) including dives to more than 30 msw and dives requiring compulsory decompression stops. These dives have taken place in both cold water and warm water conditions.

Methods

All divers and potential divers who have either type I or type II diabetes mellitus should register with the database. There is however, no compulsion for them to register and currently about 100 divers register with the database each year. For the divers to be allowed to dive they must not have any long-term medical conditions resulting from diabetes (macro- or microvascular disease, proliferative retinopathy, cardiac disease, or renal disease) and they must show that their long-term control of their diabetes is reasonable ($HbA_{1c} \leq 9.0\%$). All applications to dive are scrutinized and those divers who do not show good long-term control are informed that they must improve their diabetic control before being allowed to dive.

Results

The last 15 years of data analyzed from the database has shown an increase in the number of divers diving with type II diabetes mellitus. None of the divers has reported any problems when diving that were attributable to their diabetic condition. Numbers of dives in 2017 (the last complete year that data are available by depth range (metres of seawater- msw)) are shown below:



Five (two with type I DM) of these divers have demonstrated very good control of their diabetic condition in and out of the water and have been allowed to become commercial SCUBA instructors.

Discussion

It is reasonable to conclude from the lack of problems over 15 years whilst diving with diabetes mellitus that it is safe to dive with either type I or type II diabetes mellitus provided certain conditions are imposed on the divers. In future it may be possible to relax these restrictions.

Keywords

Diabetes mellitus, Diving safety

D-13 FUNCTIONAL GENE POLYMORPHISMS IN DIVERS WITH PREVIOUS DCS

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Introduction

Decompression sickness (DCS), involves endothelial damage. The aim is the correlation between DCS genetic polymorphism.

Methods

Functional polymorphisms in genes encoding enzymes involved in the synthesis of endothelial nitric oxide - ACE (Angiotensin converting enzyme) and NOS3 (Nitric oxide synthase 3), as well as prothrombotic risk factors – MTHFR, FII, FV – were studied using 5 nuclease assay. Genotyping of NOS3 c.-786T>C, NOS3 c.894G>T, ACE 287bp ins/del in exon 16, MTHFR c.677C>T, MTHFR c.1298A>C, F2 c.20210G>A, and F5 c.1691G>A were performed using TaqMan probes and real-time PCR thermocycler (ABI 7300 Applied Biosystems).

52 divers were evaluated: 26 with a history of DCS and 26 without DCS or any history of cardiovascular or thrombophilic events (control group). In order to evaluate the association between DCS and single functional polymorphisms, the Fisher's Exact Test at one tail has been used. When testing the hypothesis of significant association, p-value was <0.05, one tail for all analysis. Statistical computations were made using SPSS version 21.0 for Windows (SPSS, Inc.,Chicago, Illinois).

Results

50% of divers without DCS history have none or one polymorphism in the genes analyzed. 69% of the divers with a history of DCS have two or more polymorphisms (15% have 4-6 polymorphisms compared to 7.7% of divers without DCS). Table 1 shows the distribution of the polymorphisms in the genes detected.

number of functional polymorphisms in genes altered	DCI (26 divers)	No DCI (26 divers)
none	3	5
1	5	8
2	7	4
3	7	7
4	1	1
5	3	-
6	-	1

Conclusion

In this preliminary study, DCS did not appear related to any significant genetic predisposition. There is a suggestion divers with a history of DCS may have more polymorphisms in altered genes. A larger sample is required to confirm this trend. At the moment, we believe the genetic assay used is valid. We suggest that in order to predict a genetic predisposition to DCS, the evaluation of several polymorphisms in genes will be required, rather evaluating just one or a few.

Keywords

Decompression sickness, Genetic polymorphism, Nitric oxide, Thrombophilia

D-14 MEDICATION AND FITNESS TO DIVE: WHAT IS THE EVIDENCE?

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Introduction

SCUBA diving is increasingly popular. Physiological changes are induced by immersion, swimming and using special dive-equipment. Divers must be fit to dive. Many protocols have been written for work under hyperbaric circumstances or diving, however robust evidence is limited. The requirement to use medication can impact upon the capacity to adapt to hyperbaric conditions. The aim of this systematic review is to assess the interaction of hyperbaric conditions and medication to assist decision making regarding fitness to dive.

Methods

This systematic review included both human and animal studies. Retrieved studies were subdivided in the topics (1) medication and hyperbaric interaction and (2) decompression sickness (DCS) prevention. We excluded studies unrelated to diving with compressed air, and those concerning oxygen toxicity, hyperbaric oxygenation or oxygen therapy were excluded.

Results

44 studies matched inclusion criteria. Animal studies suggest diazepam and valproate give limited protection against the onset of neurologic symptoms. Lithium has a protective effect against nitrogen-narcosis and losartan has potentially protective effects against DCS. Human studies showed no beneficial or dangerous pressure related interaction. Considering DCS prevention, pseudo-ephedrine and vitamins C and E provided limited beneficial effects but no significant decline in the prevalence of DCS.

Discussion

Animal studies suggest psycho-pharmaceuticals can limit the onset of neurologic symptoms whereas cardiovascular protective drugs could add a potential protective effect against DCS. No evidence was available to suggest significant risks due to changes in pharmacologic actions in the human body. Normobaric limitations in fitness to dive should be the cornerstone in diving medical assessment, most medication is not a contra indication. For decision-making in prescribing medicine for recreational and occupational divers and to enhance safety by increasing our understanding of pharmacology in hyperbaric conditions, future research should focus on human control studies.

Keywords

Diving, Hyperbaric, Medication, Fitness to dive, Systematic review

Reference

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D-15 MEASUREMENTS OF EQUALIZATION EFFORT AND NEW STRATEGIES TO REDUCE IT

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Introduction

Equalization is a key manoeuver for both free-divers and scuba-divers. There are many methods available to both help people to understand and to improve the techniques. All have low repeatability. This paper introduces the EQ-Tool, which can measure in real time the pressure inside the upper aerial cavities. This tool allows the user to control both the soft palate and glottis pressure used to equalize and thereby reduce the required pressure to a minimum in order to protect the ear from over-pressure.

Methods

Using the *EQ-Tool*, connected to a mobile phone, we examined a control group by video otoscopy and the *EQ-Tool* to measure equalization pressures and evaluate the equalization skills. After a period of 20 days using a dedicated Eustachian gymnastic together with the *EQ-Tool*, the group was examined again and the results compared.

Results

All members of the group dramatically reduced the pressure needed to equalize and improved their control on the equalization techniques.

Conclusion

The collected data shown how the EQ-Tool, use together with a specific Eustachian gymnastic program, can enhance equalization skill and reduce pressure stress on the middle ear.

Keywords

Equalization, Eustachian tube, Eustachian gymnastics



Figure 1 Athlete during an equalization session

D-16 A CASE CLUSTER OF COGNITIVE IMPAIRMENTS FOLLOWING DEEP SATURATION DIVING

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Background

Divers who are pressurized in excess of around 150-180 MSW usually experience the phenomenon known as High Pressure Neurological Syndrome (HPNS). Although HPNS can be unpleasant and disabling, the symptoms usually moderate within a period of hours to a day or two, enabling performance of underwater work. To date, there has been a general consensus that HPNS does not cause long term sequelae. In mid 2017, a group of 15 commercial divers were exposed to HPNS during a saturation diving operation in tropical waters at depths between 235 – 275MSW. A number of the divers subsequently reported persistent neurocognitive sequelae and the exposed divers were therefore referred to a single centre for evaluation.

Methods

Referred divers underwent clinical assessment by an experienced diving physician, high resolution brain MRI and detailed neuropsychological testing. Blood was collected for assay of late biomarkers of brain injury.

Results

Two divers declined assessment, reporting that their post dive health was normal. 13 divers attended for assessment at 5 to 7 months post dive. All but one reported having experienced HPNS and all reported that it took longer than usual to recover from the dive. Over half the divers reported persisting symptoms including headaches, balance problem and cognitive impairments. Neuropsychological testing indicated mild deficits in domains consistent with symptomatology and 8 of the divers had their fitness to dive certification withdrawn based upon impairments thought to create unacceptable risk in the diving environment. Research analysis of MRI and Biomarkers is pending.

Conclusions

A number of features of deep saturation diving other than HPNS can be hypothesized as pre-disposing or contributing to neurological injury, perhaps only when multiple synergistic factors are present. This incident suggests that HPNS can be followed by late sequelae, at least in certain circumstances.

Keywords

Saturation diving, Sequelae, High Pressure Neurological Syndrome

D-17 SUCCESSFUL TREATMENT OF SEVERE HIGH-ALTITUDE DECOMPRESSION SICKNESS IN A JET PILOT USING HYPERBARIC OXYGEN THERAPY AND EXTRA CORPOREAL OXYGENATION

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Introduction

The clinical characteristics and consequences of high-altitude decompression sickness are distinct from those associated with diving. This paper is a case study of a life-threatening form of High Altitude Decompression Syndrome (HADCS) in a 51-years old jet pilot. This study does not refer to military circumstances of DCS development.

Case report

The patient was admitted to the Military Institute of Medicine approximately 6 hours after landing in a dynamically deteriorating condition with progressing dyspnoea and oedema. He reported increasing limb paresthesia, fluctuating consciousness and right-sided paresis. His haematocrit was 66%, haemoglobin concentration 22.7g/dl, lactate 4.7mmol/l, potassium 6.0 mmol/l and he showed progressive symptoms of acute kidney injury (AKI). No gas bubbles were seen on cardiac ultrasound and head CT.

Prior to definitive treatment, the National Centre for Hyperbaric Medicine was contacted for advice, given their greater experience in this area. The consultation led to a confirmation of HADSC as the likely diagnosis and the institution of hyperbaric oxygenation in the intensive therapy mode.

A therapeutic recompression utilizing the US Navy Treatment Table 6 was performed, followed by sedation, mechanical ventilation and significant doses of catecholamines in the Intensive Care Unit. Continuous veno-venous haemodialysis (CVVHD) and renal replacement therapy was instituted. In the face of disturbances in oxygenation, during the second day of treatment the patient was commenced on veno-venous extracorporeal oxygenation (ECMO) and transferred to the ICU of the Cardiosurgery Clinic. Over the next six days his condition slowly improved, and he became polyuric with a reduction in peripheral pulmonary oedema. After satisfactory mechanical ventilation, extracorporeal oxygenation was discontinued. On the 19th day he was discharged in very good general condition, fully alert and with no neurological deficits on physical examination.

Conclusion

This extremely unwell patient suffered a near fatal episode of HADCS and in addition to hyperbaric treatment, required extreme resuscitative measures, including ECMO, over the acute period. A glucose-labelled PET-CT was arranged for follow-up.

Keywords

Case report, Altitude decompression sickness, Treatment

VASCULAR AND EXTRAVASCULAR NANOBUBBLES: CONSTRUCTING A COMPREHENSIVE PHYSIOLOGY OF DECOMPRESSION

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Introduction / Background

Decompression illness (DCI) occurs following a reduction in ambient pressure. Decompression bubbles can expand and develop only from pre-existing gas micronuclei. The different hypotheses hitherto proposed regarding the nucleation and stabilisation of gas micronuclei have never been validated. It is known that nanobubbles form spontaneously when a smooth hydrophobic surface is submerged in water containing dissolved gas

Discussion

These nanobubbles may be the long sought-after gas micronuclei underlying decompression bubbles and DCI. We exposed hydrophobic and hydrophilic silicon wafers underwater to hyperbaric pressure. After decompression, bubbles appeared on the hydrophobic but not the hydrophilic wafers. In a further series of experiments, we placed large ovine blood vessels in a cooled high pressure chamber at 1000 kPa for about 20 h. Bubbles evolved at definite spots in all types of blood vessel. These bubble-producing spots stained positive for lipids, and were henceforth termed "active hydrophobic spots" (AHS). The lung surfactant dipalmitoylphosphatidylcholine was found both in the plasma of the sheep and at the AHS. Bubbles detached from the blood vessel in pulsatile flow after reaching a mean diameter of ~1.0 mm. Bubble expansion was bi-phasic – a slow initiation phase which peaked 45 min after decompression, followed by fast diffusion-controlled growth.

Conclusions

Many features of decompression from diving correlate with this finding of AHS on the blood vessels. (1) Variability between bubble and non-bubble. (2) An age-related effect and adaptation. (3) The increased risk of DCI on a second dive. (4) Symptoms of neurologic decompression sickness. (5) Preconditioning before a dive. (6) A bi-phasic mechanism of bubble expansion. (7) Increased bubble formation with depth. (8) Endothelial injury. (9) The presence of endothelial microparticles. We also suggest that bubbles expand in the distal arteries, and that extravascular hydrophobic surfaces may be the source of joint pain, spinal cord injury, cutis marmorata and osteonecrosis.

Keywords

Decompression illness, Gas micronuclei, Hydrophobic surface, Arterial bubbles

D-19 INNER EAR DECOMPRESSION SICKNESS OR SINUS MUCOCELE: CASE REPORT

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Introduction

The diagnosis of decompression sickness (DCS) relies primarily on dive history and physical examination. However, symptoms and clinical findings may be misleading as they are not specific to diving diseases. We present a patient who was treated as DCS but later diagnosed as having a sinus mucocele.

Case report

A 59-year-old male patient was referred to a local emergency department with diplopia, nausea, vomiting, tinnitus and bilateral hearing loss after diving. He had undertaken two dives to 25 metres, each with 40 minutes bottom time and prolonged decompression stops. Intravenous rehydration and normobaric oxygen therapy were started. The patient had a history of Type 2 diabetes and hypertension. One year previously he had been treated for neurological DCS after which minimal hearing loss had persisted. When he was admitted to our department he had diplopia, bilateral horizontal nystagmus, an unsteady gait, ataxia and left sided dysdiadokokinesia. HBO therapy was started immediately. Echocardiography and thorax CT scanning were performed for “unexpected” DCI, but did not reveal any pathology. Nystagmus and ataxia persisted after HBO treatment. Electronystagmography showed weakness in caloric test and bilateral vestibular hypofunction. A sphenoid sinus lesion which eroded the temporal bone was seen in cranial MRI. With CT it was shown to be in the mid brain cavity adjacent to the optical nerve and cavernous sinus. He was diagnosed with a sphenoid sinus mucocele and this was surgically removed. After surgery he recovered completely.

Discussion/Conclusion

Mucocele is a cystic mass that is filled with mucus. Sphenoid mucocele, a very rare form, may expand and compress optic nerve and cavernous sinus which carries cranial nerves 3, 4 and 6. Therefore it may cause visual disturbances that would present as nystagmus and gait problems. These symptoms may easily be confused with DCS when they occur after diving.

Keywords

Decompression sickness, Case report, Misdiagnosis, Sinus mucocele

D-20 THE EFFECT OF SUDDEN DROP IN PARTIAL PRESSURE OF OXYGEN ON HEART FUNCTION DURING ASCENT

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Introduction

Cardiovascular disease is second only to drowning as a leading cause of diving deaths. Linking these two, scuba diving immersion pulmonary edema (SDIPE) may be caused by increased cardiac workload and also a common cause of drowning. Scarcity of 12 lead ECG recordings during dives leaves many questions unanswered regarding cardiac function during ascent. We hypothesized that decreased O₂ partial pressure (PpO₂) initiates cardiac arrhythmia on ascent. We examined heart rate variability (HRV), rhythm and circulating markers of cardiac damage in the blood in response to submersion, increased pressure and reduction in the partial pressure of oxygen during the ascent.

Methods

Twenty-three subjects completed two dives to 5 ATA; one typical ascent and one with PpO₂ clamped at 1.0 ATA. Twelve lead ECGs were acquired by holter recorder and analyzed for rhythm (CalECG, AMPS LLC) and heart rate variability (HRV) (HeartScope, AMPS LLC). Cardiac troponin and B-Type Natriuretic Peptide (BNP) was assessed pre and post dives using an iStat handheld device (APOC).

Results

The QTc during ascent and surface swim of the control dive was longer than during submersion pre-dive, and clamping oxygen eliminated this QT elongation. T-peak-to-T-end was prolonged at depth (5 ATA), but unaffected by clamping O₂. The ST segment was unaffected. Heart rate increased during all phases of both conditions compared to rest. HRV showed equivalent increases in HF and a decrease in LF between the two conditions. BNP production was significantly higher in the clamped O₂ dive.

Conclusions

Increase in BNP when O₂ remains high suggests vasoconstriction from high PpO₂ combined with increased preload leads to ventricular stretch from increased volume. Elongation of the T-peak to T-end increases the chance of ventricular tachyarrhythmia. These findings should be explored for contribution to SDIPE. Drop in PpO₂ during ascent contributed to prolongation in the QTc, which in those with undiagnosed channelopathies could contribute to SCD.

Keywords

Heart rate variability, Scuba diving immersion pulmonary edema, BNP, Cardiovascular function

Reference

2017 DAN Annual Diving Report

D-21 NMDAR INVOLVEMENT IN HBO TOXICITY

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Introduction

Combat divers who are using closed-circuit breathing apparatus expose themselves to the risk of developing central nervous system oxygen toxicity (CNS-OT). A previous study¹ demonstrated that treatment with MgSO₄ significantly prolongs latency to electroencephalographic (EEG) manifestations of CNS-OT in rats. They propose the mechanism is via blockade of the N-methyl-D-aspartate-receptor (NMDAR). The objective of this study was to investigate the influence of HBO conditions on NMDAR biophysical properties, more specific to check the hypothesis that voltage-dependent Mg²⁺ inhibition decrease under HBO conditions.

Methods

GluN1-1a was co-expressed with GluN2A in *Xenopus laevis* oocytes. Ionic currents were measured in Ba²⁺ solution with no added [Mg²⁺] or [Ca²⁺], constantly bubbled with 100% O₂. We used a two-electrode voltage clamp and measured the response to bath application of the co-agonists glutamate (100 μM) and glycine (10 μM). Mg²⁺ (as MgCl₂ salt) was added to the solutions in increasing concentrations up to the level of at least 75% NMDAR response blockade at control 1ATA and O₂ pressure of 5.5ATA.

Results

An increase in current response under HBO conditions was observed (33.76 ± 6.53 %, n=11, p< 0.001). Addition of Mg²⁺ to the solution decreased the currents under control and HBO conditions. However, averaged IC₅₀ at control (0.39±0.06mM, n=11) and HBO (0.40±0.05mM, n=11) showed no statistically significant change (Fig 1).

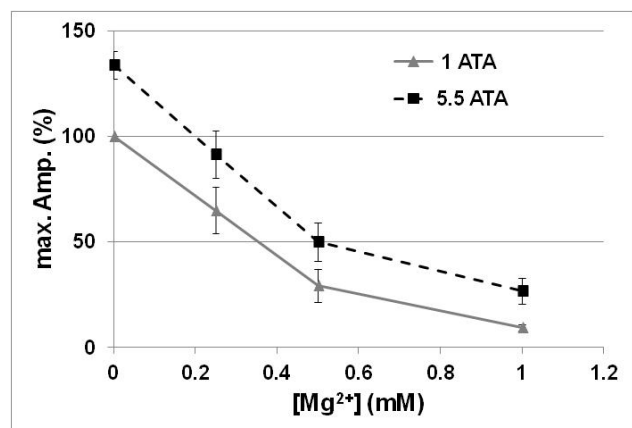


Figure 1. Current amplitudes of the GluN1-1+GluN2A subtype at different [Mg²⁺]₀ concentration, normalized (%) to the 1ATA, [Mg²⁺]₀=0.

Discussion

The results indicate HBO at 5.5 ATA increases the NMDAR currents response; this could be one of the major generators in EEG hyperexcitation during HBO exposure. Although there was no statistically significant change in averaged IC₅₀, higher [Mg²⁺]₀ concentration was needed in order to reduce the current to the control value (Fig 1). This finding is a possible explanation for success of MgSO₄ treatment in significantly prolongation of the latency to EEG manifestations of CNS-OT in rats. It is suggested that Mg SO₄ pretreatment may be used to prevent HBO toxicity in divers.

Keywords

NMDAR, Central nervous system, Oxygen toxicity, MgSO₄

Reference

¹ Katz A, Kerem D, Sherman D. Magnesium sulfate suppresses electroencephalographic manifestations of CNS oxygen toxicity, Undersea Biomed Res 1990;17(1): 45-9.

D-22 THE EFFECT OF OXYGEN AND NITROGEN ON NITROGEN NARCOSIS SEVERITY

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Background

Nitrogen Narcosis (NN) is a cognitive impairment similar to alcohol intoxication that occurs when gases are breathed at a pressure greater than three atmospheres (ATA). The exact mechanism of NN is unknown, and the exact role of N₂ and O₂ in regard to NN severity is still unclear. We hypothesize that the partial pressure of O₂ will have a greater impact on NN than N₂.

Methods

Participants (N=27) completed cognitive tasks while breathing air at ambient pressure for familiarization, at 45 m and 57 m, and a normoxic gas mixture at 45 m. The partial pressure of each gas is shown in table 1. Cognitive tasks included Digit Span forward and back, simple math, and Trail Making A and B. To compare the two conditions, we performed a fixed effect ANOVA on least square means.

Results

Participants had significantly more correct responses with a simple digit math task in the 45 m air condition than in the 57 m air condition. Participants performed a task subtracting 7 from 100 significantly faster in the familiarization condition than in the 45 m air condition. The Trail Making B task came up significant in the ANOVA; however, it was not significant in a Tukey post-hoc test. Our other tasks did not reach significance, and this may be due to a lack of power.

Conclusions

Our hypothesis was not fully supported, as we show that N₂ may have a greater effect on NN than O₂, or together they may have a large additive affect. It may be that NN leads to working memory impairment by decreasing the amount of attentional resources, leading to difficulty performing arithmetic.

Keywords

Nitrogen narcosis, Cognitive function, Oxygen

Table 1

	45m air	57m air	45m normoxic
Depth	45m	57m	45m
Gas composition	21% O ₂ 78% N ₂	21% O ₂ 78% N ₂	3.8% O ₂ 96.2% N ₂
Total Absolute Atmospheres (ATA)	5.5 ATA	6.7 ATA	5.5 ATA
P_p O₂ (ATA)	1.2 ATA	1.4 ATA	0.2 ATA
P_p N₂ (ATA)	4.3 ATA	5.3 ATA	5.3 ATA
Oxygen level	hyperoxic	hyperoxic	normoxic

DIVING AND HYPERBARIC MEDICINE JOURNAL INTO THE FUTURE

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Introduction

2018 is a watershed year for Diving and Hyperbaric Medicine (DHM), the journal of the European Underwater and Baromedical Society (EUBS) and the South Pacific Underwater Medicine Society (SPUMS). Three important factors are shaping the future.

Discussion

First, the journal has transitioned from a print publication to an electronic journal. A high-quality pdf is available to members through society websites. Of major significance is the journal's acceptance for listing on Pubmed Central. This means full text and pdf copies of all papers published from the first edition 2017 will be immediately available on MEDLINE (the one-year embargo still applies). The transition has not been unanimously popular, but I confidently predict all members will come to fully understand the superior utility of this modern approach.

Second, DHM has maintained its impact factor of 1.2 for the second year running. This is a great number for a niche field journal and a notable achievement in the absence of readily available papers on-line. The presence of DHM on Pubmed Central is likely to positively influence the journal's impact in the future.

Third, the end of 2018 sees the retirement of Mike Davis as Editor and leadership passing to me. It is impossible to overstate the role Mike has played in the journal's evolution – both the two points above and many others in previous years (such as the original Medline listing). The last two years have required an immense amount of high quality extra work by Mike and our Editorial Assistant Nicky Telles; all whilst keeping the normal journal activity ticking over smoothly. Both deserve the immense gratitude of all members of both societies.

The future

In this presentation I will describe my vision for the journal's future, and discuss the challenges ahead. SPUMS and EUBS are scientific societies, and DHM is undoubtedly the most conspicuous component of their societal footprints in the wider world. Members of both societies should be immensely proud they publish the top-ranked publication in the field and be determined to maintain the journal's growth. The journal depends on our members prioritizing publication of their work in our own journal, and on continuing to provide their invaluable support in a high-quality peer review process.

Keywords

Diving medicine, Hyperbaric medicine, Research, Publication, Journal

H-22 STAGED PROCEDURE TO ASSESS REPEATED HYPERBARIC EXPOSURES AND GLASS AMPOULE SAFETY (SPAREGAS)

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Background

It has been our institution's policy to not place glass medication ampoules inside our hyperbaric chamber for fear of rupture. There is only a small and conflicting amount of data as to whether the ampoules are safe for use under hyperbaric conditions.

Methods

We performed a repetitive, rapidly staged compression and decompression of multiple different glass medication ampoules inside the medical lock of a medical hyperbaric chamber. Medication ampoules of varying sizes – 1 ml to 10 ml – of medication that may be required in a hyperbaric emergency were assessed. The ampoules were rapidly compressed 100 times to pressures of 140 kPa, 180 kPa, 300 kPa, 400 kPa and 500 kPa. They were then dropped from a height of 30 cm while compressed at 500 kPa and then half the ampoules were opened while pressurized at 500 kPa.

Results

No ampoules were broken during compression or decompression. No ampoules broke when dropped from 30 cm onto the chamber floor. All ampoules opened at a pressure of 500 kPa functioned normally. No lids/ampoules shattered upon opening.

Conclusions

This study suggests that glass medication ampoules appear to be safe for use inside a medical hyperbaric chamber at routine treatment pressures.

Keywords

Medications, Glass ampoules, Risk assessment

H-23 THE EVALUATION OF THE SOUND LEVELS INSIDE 36 HYPERBARIC CHAMBERS DURING HYPERBARIC OXYGEN TREATMENT IN TURKEY

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Background

In this study, we aimed to measure and evaluate the sound levels in hyperbaric chambers during hyperbaric oxygen (HBO) treatment sessions, to check if there is a high risk of adverse health effects. The sound level inside the chamber is critical for patients who receive HBO for the treatment of sudden sensory neural hearing loss, since these patients might be more sensitive for acoustic trauma.

Methods

A sound meter, Bruel & Kjaer decibel meter, which can be calibrated to measure sound levels in hyperbaric conditions, was used to measure sound levels in hyperbaric chambers in Turkey during HBO treatment sessions. Measurements were done during compression, oxygen periods and decompression phases. The decibel meter was calibrated during compression and decompression, since sound levels change with changes in environmental pressure. Measurements were done in 25 seconds intervals and the calibration value after each measurement was recorded. The results were evaluated to check if the sound levels exceeded the allowed limits.

Results

Thirty six HBO centers in Turkey were included. At least eight measurements were performed for each pressure chamber and the highest measured level of sound was 102.6 dB. The majority of sound levels measured were within safe limits.

Conclusions

In hyperbaric chambers sources of noise are multiple and should be measured during different phases of HBO therapy. Noise levels should be checked to confirm they are within safe limits. The noise level in the chamber is especially important for patients receiving HBO for the treatment of sudden hearing loss.

Keywords

Hyperbaric oxygen therapy, Sound levels

Reference

Chalmers A, Mitchell C, Rosenthal M, Elliott D. An exploration of patients' memories and experiences of hyperbaric oxygen therapy in a multiplace chamber. J Clin Nurs 2007 Aug;16(8):1454-9.

H-24 TWO CASE REPORTS: MALFUNCTION OF SIARETRON IPER1000 VENTILATOR DURING A HYPERBARIC TREATMENT SESSION

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Introduction / Background

Only a few ventilators have been designed or adapted for use in the hyperbaric environment and have received CE marking. The Siaretron IPER1000 has been in use in our hyperbaric department since 2010. This ventilator automatically compensates the delivered tidal volume according to ambient pressure and is capable of delivering various modes of ventilation. We describe two recent life-threatening malfunctions that required immediate intervention.

Case reports

Case 1. Following 60 minutes of normal operation, a change was made to tidal volume and the ventilator cycled rapidly with triggering of the high-pressure alarm and a failure to ventilate the patient. Manual ventilation was instituted and the treatment was interrupted. Restarting the ventilator at pressure did not resolve the problem. At 1 ATA, the ventilator worked normally on a test lung.

The ventilator was returned to the company for (scheduled) six-monthly maintenance. No fault was detected by the company. Although operator error was suggested, we are confident this was not the case.

Case 2. Five months later, using the same device. After the first 20 min oxygen period at 2.8 ATA during a USNTT6, we attempted to decrease the FiO₂ in small steps, as previously described.¹ We were unable to do so because at each attempt the ventilator displayed the same problem as for case one. Reverting to an FiO₂ of 0.99 restored effective ventilation. The treatment was shortened due to the inability to provide air breaks at 2.8 ATA. During the 1.9 ATA period, the ventilator behaved normally again. Subsequently the error was reproduced in further treatments.

On examination, the manufacturer reported a valve seating problem with the proportional air and O₂ valves which may have caused the valve to stick and trigger increased flow. Sudden opening of the valve causes the overpressure alarm.

Discussion / Conclusions

These cases illustrate the need for constant vigilance as to the proper functioning of all introduced medical devices and ensuring a proper backup strategy.

Keywords

Hyperbaric intensive care, Incident report, Technical

Reference

Bothma PA, Brodbeck A, Bapat U. Malfunction of the Siaretron 100 Iper hyperbaric ventilator. *Diving Hyperb Med* 2009;39:45-7

H-25 MEASURABLE RELIABILITY OF GLUCOMETER DEVICES IN HYPERBARIC CONDITIONS

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Introduction

This study was planned to investigate the safety of the use of pressure-sensitive glucometer devices for the evaluation of hypoglycaemia symptoms, which are a frequent occurrence during the treatment of diabetic wounds. Certification of medical devices for use under pressure in the hyperbaric chamber is required for both safety and reliability of use during treatment. There is no glucometer device that has been tested for suitability to operate in the pressure chamber. However, it has been reported that lithium batteries used in these devices does not affect the safety of treatment.

Methods

After we received approval from our ethics committee, blood samples were taken into pathology bottles containing sodium fluoride to prevent glycolysis (BD vacutainer®) while breathing air at 1 ATA outside the chamber and in the hyperbaric chamber at pressure. Blood glucose measurements were taken simultaneously with three different glucometer under the same conditions: Yasee (Glucoleader®) which uses glucose oxidase, Freestyle (Abbott®) and Accu-check (Roche®) which use glucose dehydrogenase.

Results

Sixty-one patients were included in the study. The lowest measured blood sugar level was 38mg/dL (2.1 mmol/L), and the maximum 445mg/dL (24.7 mmol/L). When analyzing the difference between the pressure chamber and room air, it was significantly lower with AccuCheck (p 0.009).

Discussion

We did not detect any difference in the pressure chamber measurements during hyperbaric oxygen therapy in devices using the glucose oxidase enzyme.

Keywords

Hyperbaric oxygen therapy, Glucometer, Blood glucose value, Validation

Reference:

Tsouras T. Test results for the evaluation of a glucometer for use under hyperbaric conditions: Technical report. Undersea Hyperb Med. 2017 Jan-Feb;44(1):27-32.

H-26A SEVERE HAND FROSTBITE TREATED BY HYPERBARIC OXYGEN THERAPY

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Introduction

Frostbite is a specific, infrequent pathology. When extensive and without proper treatment, it can result in serious amputations. Medical care has often been deduced from empiric considerations. Hyperbaric Oxygen Therapy (HPOT), when administered soon enough could provide real added value, significantly improving severe frostbite prognosis.

We describe a case for which HBOT seemed to provide added value compared to usual treatments.

Case Report

A 36 year old man was climbing at an altitude of over 6000m on the Lenine Peak (Kirghizstan), when he fell in a crevasse, losing his left glove. The temperature was -30°C and the cold exposure was approximately 2 hours. He was rescued by local responders and went to the local hospital. The hand was slowly rewarmed and he was diagnosed as suffering severe stage three frostbite. No efficient treatment for frostbite was available locally and he was repatriated by the REGA on day three.

The amputation risk was high (close to 80%). The patient came directly from the airport for medical care. Despite the late presentation (over 48h after rewarming) he received the SOS GELURE treatment protocol: iloprost infusion for seven days and HBOT twice a day for three weeks (90min per session) and daily dressing until complete recovery. The rate of healing was impressive and he did not require amputation, despite the initial prognosis.

At the first follow up at six months, no early arthrosis has been found. Two years later he can climb again and plays volleyball without pain. He still does not have any arthrosis. The only side effect left is pain to cold exposure.

Discussion

Studies have shown that iloprost infusion given late (over 48h) isn't very effective. His recovery in this case was impressive. Three years further follow up is required to check for late frostbites side effects, especially arthrosis.

Keywords

Frostbite, Hyperbaric oxygen therapy, Prognostic classification

H-26B THE INTERNATIONAL FROSTBITE REGISTRY (IFR) PRESENTATION

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Introduction

Frostbite is a specific, infrequent pathology. When extensive and without proper treatment, it can result in serious amputations. Medical care has often been deduced from empiric considerations.

The number of cases compiled is still largely insufficient to validate new hypotheses and therapy. Therefore it is difficult to provide evidence-based recommendations for treatment. For these reasons, we decided to create an international registry.

Methods

An online registry is a modern way to collect cases from different geographical origins. It should allow working on larger retrospective and prospective series and sharing knowledge amongst different centers.

We have set up the first International Frostbite Registry whose goal is to gather relevant data about frostbite from multiple centers around the world. Thus large-scale studies about this pathology should result in new discoveries about treatment efficiency.

This registry reflects different ways of approaching this pathology and compiles all necessary information for a detailed analysis.

This work has been done within the framework of collaboration amongst the hyperbaric medicine center and the division of Medical Information Sciences at University Hospitals of Geneva. This programme was made possible thanks to the support of the Swiss foundation and Geneva city (SOS GELURE INTERREG programme)

Conclusion

The IFR has been put online on a secure network and can be accessed at www.sos-gelures.org. It needs more centers to participate and register new cases of frostbites.

Keywords

Frostbite, Patient registry, Hyperbaric oxygen therapy

Reference

Foufi V, Gaudet-Blavignac C, Chevrier R, Lovis C. De-Identification of Medical Narrative Data. *Stud. Health Technol. Inform.* 2017;244:23–7

H-27 THE GRATTAN REPORT – AUSTRALIA: WHEN BUREAUCRATS DECIDE WHAT APPROPRIATE CARE IS FOR PATIENTS.

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Background

The Grattan Institute (GI) released a series of publications, culminating in a Medical Journal of Australia (MJA) paper. GI authors determined clinical conditions for which they identified “do-not-do” treatments. Do-not-do treatments included Hyperbaric Oxygen Treatment (HBOT) - 79% of GI report total numbers - including HBOT for soft-tissue radiation injury and non-diabetic wounds. The report claimed: “More than 4500 people a year get hyperbaric oxygen therapy when they don’t need it,” (in Australia). From independent national clinical data, hyperbaric clinicians were aware only 1276 (total) patients received HBOT same year. Claims by GI appeared outrageously inflated.

We aimed to evaluate the Grattan Institute report and associated publication. Determine the validity of their assertions regarding HBOT in Australia.

Methods

Critical analysis of the GI Study was undertaken and compared with other publicly available Australian Government and independent data sources. Consistency, accuracy and reproducibility of data definitions and terminology were appraised and GI authors’ methodology was reviewed. Reference sources were examined for relevance and temporal eligibility.

Results

GI methodology had fundamental flaws and misrepresented data. Patient treatments were confused with total patient numbers, HBOT treated clinical conditions were misclassified as inappropriate (compared to GI quoted references); the primary GI dataset was seriously compromised compared to other data sets. There was lack of appropriate clinical input, and inconsistent methodology/terminology across the series of papers. Methodological errors produced >70-fold (7000 percent) over-estimate of Australian patients alleged as inappropriately treated with HBOT. The above serious inaccuracies were further compounded by a refusal to allow detailed critical response in the MJA.

Discussion

The GI report demonstrates misuse of metadata to attempt to influence clinical practice. Inappropriately access of metadata without knowledgeable clinician input led to erroneous conclusions, which is dangerous if used to guide health funding. Clinicians must be proactive and provide learned oversight to establishing and analysing data sets.

Keywords

Critical appraisal, Data, Evidence, Health economics, Hyperbaric oxygen therapy

Reference

Duckett SJ, Breadon P, Romanes D. Identifying and acting on inappropriate care. Med J Aust 2015; 203:183,e.1-6

H-28 EFFECT OF NORMOBARIC OXYGEN ON LYMPHOEDEMA

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Introduction

We have previously reported our experience in increasing lymph nodes activity (Protein Capture) during normobaric oxygen breathing. These data were from normative subjects by means of lymphoscintigraphy and Tc99 marked plasmatic protein subcutaneously injected in the First dorsal interosseous space and measured with a gamma camera in the axillary area (Balestra *et al.*, 2004). This new experiment is on patients with lymphoedema after mastectomy compared to normatives with non-invasive methods.

Methods

15 subjects participated at this randomized controlled study. We analyzed blood flow variations in the upper limb microcirculation by means of a Laser Speckle Contrast Imaging system (LSCI). The measurements were performed in recumbent position, while breathing 100% Oxygen (Demand Valve mask) and after Manual Lymphatic Drainage (Leduc Method). The LSCI system was aimed on the region of interest, mainly the forearm.

Results

We recruited 8 individuals to the lymphoedema group (age range 50-81, mean 67±11,5, and compared these to 7 healthy volunteers. Cutaneous perfusion in patients with lymphoedema increased significantly ($p<0,03$) (204%) during and after breathing 100% FiO₂ but also after manual lymph drainage ($p<0,04$) (157%). The difference in blood flow between oxygen breathing and manual lymphatic drainage was not statistically significant. Cutaneous blood flow decreased significantly in the control group ($p<0,04$) (68%), compared to baseline values.

Conclusion

Significant changes are observed in blood microperfusion of the forearm in lymphedematous patients, the increased blood flow in the pathological group and the decreased blood flow in healthy subjects may be due to a 'Robin Hood' effect, a constriction in oxygen rich areas allowing increased perfusion in oxygen poor areas (edemas). Further research is needed to determine the potential benefit of combining normobaric oxygen breathing together with manual lymphatic drainage.

Keywords

Normobaric oxygen, Lymphoedema, Manual lymph drainage, Laser Speckle Contrast Imaging (LSCI), Microcirculation

Reference:

Balestra C, Germonpre P, Snoeck T, Ezquer M, Leduc O, Leduc A, Willeput F, Marroni A, Cali Corleo R & Vann R. (2004). Normobaric oxygen can enhance protein capture by the lymphatic system in healthy humans. *Undersea Hyperb Med* 31, 59-62

H-29A TESTING OF THE MEDTRONIC 5392 EXTERNAL PACEMAKER DEVICE FOR HYPERBARIC MEDICAL USE

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Introduction / Background

Patients requiring hyperbaric oxygen therapy for arterial gas embolism can sometimes be dependent upon cardiac pacing with a temporary external cardiac pacing device. The Alfred Hyperbaric Service has previously used the Medtronic 5388 device for this purpose, with nitrogen purging via enclosure in a plastic bag. This model is no longer supported by the manufacturer and a potential replacement was therefore identified and tested.

Methods

The Medtronic 5392 Dual Chamber Temporary External Pacemaker was assessed according to our previously published risk assessment process for devices to be used in our multiplace hyperbaric chamber. The device's patient leads were connected via an electrical penetrator to a pacemaker performance testing unit external to the hyperbaric chamber. Testing was performed at chamber pressures up to 200kPa (3ATA).

Results

The device is powered by a replaceable 9 volt alkaline battery, and internal inspection did not identify any components or failure modes of concern. The device performed within manufacturer's specifications during all tested pressure and pressure change conditions.

Discussion / Conclusions

The Medtronic 5392 device was approved for clinical use in The Alfred Health hyperbaric chamber in unmodified form, without purging and at pressurization rates up to 180kPa/min, pressures up to 200kPa and oxygen concentrations up to 23.5%. Medical Lock pressure change rates exceed the maximum tested rates and passage via the medical lock is therefore contraindicated.

Keywords

External pacemaker; Hyperbaric equipment testing

Reference

Smale A, Tsouras T. Evaluation of the Carefusion Alaris PC infusion pump for hyperbaric oxygen therapy conditions. *Undersea Hyperb Med.* 2017; 44(1):17-25.

H-29B TESTING OF THE VBM ELECTRONIC ENDOTRACHEAL CUFF CONTROLLER FOR HYPERBARIC MEDICAL USE

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Introduction / Background

The provision of hyperbaric oxygen to intubated patients requires management of the compressible air volume within the endotracheal tube cuff. This is most commonly done by replacing the air in the cuff with fluid. The Alfred Hyperbaric Service has instead previously successfully used a VBM HBO Cuff Controller designed by the manufacturer for hyperbaric medical use. This model is no longer supported and a potential replacement was therefore identified and tested.

Methods

We tested the standard (non hyperbaric) VBM model 55-13-500 electronic cuff controller, following our previously published risk assessment approach at chamber pressures up to 200kPa (3ATA). Consequent upon our previous experience with cuff controllers, we chose to only use the manufacturer recommended thick wall, low compliance, medium-small bore connecting tube sets to avoid the potential for propagation of pulsations in pressure leading to excessive alarming.

Results

The device's rechargeable internal battery is of the user replaceable rectangular 9 volt form and this was replaced with a 1300 mAH capacity Nickel Metal Hydride battery to extend the duration of operation without external power. The device performed within manufacturers specifications during all tested pressure and pressure change conditions, with cuff pressure and volume maintained within clinically acceptable limits during chamber pressure changes.

Discussion / Conclusions

The VBM 55-13-500 cuff controller was approved for clinical use in The Alfred Health hyperbaric chamber, without external power connected, unmodified apart from use of a high capacity replacement battery, with pressurization rates up to 180kPa/min and at pressures up to 200kPa and oxygen concentrations up to 23.5%. In use to date it has proved fully functional and problem free apart from intermittent and self terminating "beeping" generated by the cuff leakage alarm function during pressurisations.

Keywords

Endotracheal tube; Hyperbaric intensive care, Hyperbaric equipment testing

Reference

Smale A, Tsouras T. Evaluation of the Carefusion Alaris PC infusion pump for hyperbaric oxygen therapy conditions. *Undersea Hyperb Med.* 2017; 44(1):17-25.

H-30 HOW TO SPEAK ‘CONTEMPORARY ORTHOPOD’ - A MARRIAGE OF DISCIPLINES BETWEEN ORTHOPAEDIC SURGERY AND HYPERBARIC MEDICINE

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Introduction / Background

Modern Orthopaedic research devotes much attention to the concept of ‘Mechano-Biology’. The term describes the relationship between human mechanics (the science of human movement), and the biological environment associated with those particular mechanics. Understanding this allows Orthopods to manipulate the mechanics in favour of the biology specific to the pathology of interest.

This talk will focus on two goals:

1. To review Orthopaedic pathology which may benefit from HBOT (i.e. Orthopaedic Indications)
2. To establish a common-ground between our disciplines and improve communication (i.e. quality of referrals and feedback).

Methods

Review of orthopaedic pathophysiology of conditions which may benefit from HBOT. Review of orthopaedic literature in support of HBOT.

(Specifically: Osteonecrosis, Fractures, Infections, Non-unions)

Results

Best Evidence Based Medicine relating to orthopaedic pathology which may benefit from HBOT. Critical evaluation of Classification systems currently in use - ‘Are we speaking the same language?’

Discussion / Conclusions

The pathophysiological principles that are not in dispute, should serve as a guide as to what constitutes ‘a reasonable referral for HBOT.’ Understanding these principles will establish a common ground upon which the merits of each case could be argued for and against. This scarce and precious resource must be protected and applied where indicated by the governing scientific principles, and the custodians of these units should be empowered with the tools to deny inappropriate referrals. In essence, the gap between the Orthopaedic interpretation of the problem and the Hyperbaric Unit’s interpretation of the same, must be closed down so that we may deliver a better service to our patients. We can only hope to achieve this, if ‘we are speaking the same language.’

Keywords

Orthopaedic indications, Hyperbaric oxygen therapy, Osteonecrosis, Non-union

RECREATIONAL AND TECHNICAL FREEDIVING: ADVANCES IN SAFETY AND PERFORMANCE

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Introduction

The increase and diffusion of freediving knowledge to the broader diving medical community is timely and important in this growing segment of the U.S. diving population.

Methods

A 2017 UC San Diego interdisciplinary review of recreational and technical freediving experience highlights findings and status from clinical medical evidence, incident case studies, extreme freediving exposures, freediving safety training programs, experimental oxygen pre-breathing, and comparative marine mammal physiology to put human performances into perspective.

Results

This experience-based examination of practical/operational parameters of freediving athletes and evidence-based evaluation of scientific and medical issues provided the basis for experimental research designs of future breathhold diving studies. The challenges of duration and depth lead to a re-examination of the proposed 60-second breathhold limit.

Conclusions

To mitigate the constraints of physiological parameters (hypoxia, ventilatory control, diving response, arrhythmias, and glossopharyngeal insufflation) a set of training protocols were reported that increase hypoxemic tolerance, facilitate recovery and reduce decompression stress.

Keywords

Breathhold diving, Safety, Training, Clinical medical evidence, Report

D-24 DO WE NEED TO WARN AGAINST DIVING ON BETA BLOCKERS?

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Introduction

Beta blockers are a commonly prescribed class of drugs for blood pressure control, coronary artery disease, etc. Many scuba divers use beta blockers. Beta blockers can lower heart rate which can lead to poor adaptation to effort, reduce cardiac contractility and increase peripheral vasoconstriction. Scuba divers pulmonary edema (SDPE) is usually described as an uncommon disorder although the actual incidence is unknown. During scuba-diving there is an increase in pulmonary blood "pooling", systemic and pulmonary arterial pressure and resistance, physical effort, stress and blood viscosity. If we combine the effects of immersion with those of beta blockers we might expect some potentially problematic interaction.

Methods

We retrospectively reviewed all SDPE cases in our Centre during a one month period (June 2018.) retrospectively.

Results

Three experienced scuba divers (all with 250 or more logged dives) were treated for SDPE in our Centre. The mean age was 56 and there were two males and one female. The diagnosis was made based on symptoms, clinical findings, blood gas analysis and radiological findings (plain X-ray, CT scans). In all three cases symptoms (dyspnea) started on the bottom about 15 minutes after immersion and maximal depths were around 18 meters. Two of the three used beta blockers and in both cases these were started recently (it was the first dive while taking beta-blockers in one case). Two patients recovered within 24 hours and the third was resuscitated out of the hospital and admitted to the Intensive Care Unit. Follow-up investigations ruled out any cardiopulmonary disease.

Conclusions

SDPE is not very well understood and has many different contributing factors such as age, cold, physical stress, negative pressure ventilation etc. Beta blockers are noted to be a potential contributing factor in many cases, but there is not enough evidence and research to prove it.

Keywords

Diving, Beta blockers, Scuba diving pulmonary edema, Case series

D-25 IMPULSE OSCILLOMETERY AND SPIROMETRY INDICES OF PULMONARY FUNCTION IN A DIVER WITH SEVERE SYMPTOMS OF PULMONARY OXYGEN TOXICITY

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Introduction

Guidance on acceptable oxygen exposures for diving have traditionally relied upon the concept of the Unit Pulmonary Toxic Dose that bases tolerance to a given oxygen exposure upon the estimated decrease in forced vital capacity. With the introduction of commercial impulse oscillometry (IOS) systems it may now be possible to detect changes in pulmonary function at an earlier stage in the oxygen toxicity process than is possible with traditional spirometry measures of pulmonary function. The objective of this study is to contrast IOS measures of pulmonary function with traditional spirometry in a case study of a diver who experienced severe symptoms of pulmonary oxygen toxicity (PO₂tox) following a prolonged hyperbaric oxygen chamber dive.

Methods

The subject was a healthy male US Navy diver (height: 1.70 m, weight: 68.2 kg, age: 21 years) who consented to participate in a larger study investigating individual susceptibility to PO₂tox (Fothergill 2017). He completed two dry hyperbaric chamber dives separated by 1 week: Dive 1 (control), 390 min breathing 30.6% O₂ balance N₂ at 2 ATA; Dive 2 (high O₂), 304 minutes breathing 100% O₂ at 2 ATA. Basic spirometry, diffusion capacity for carbon monoxide (D_LCO), and IOS parameters were measured before and immediately after each dive.

Results

The subject aborted the high O₂ dive after 304 min on oxygen rather than the intended 390 min due to severe PO₂tox symptoms, including persistent cough and difficulty performing a full inspiration. The relative changes in pulmonary function following the control and high O₂ dives are shown below.

IOS Variable	Values are % change from pre-dive	
	Nitrox control dive	High O ₂ dive
Total airway resistance (R5)	+10	+125
Proximal airway resistance (R20)	+0.3	+38
Peripheral capacitive reactance (X5)	-29	-65
Lung resonance frequency	+54	+176
Reactance area (AX)	+113	+1369
Spirometry		
Forced Vital Capacity (FVC)	-4.7	-4.4
Force Expired Volume in 1 s (FEV1)	-5.6	-10.3
Forced Expiratory Flow at 25-75% of the pulmonary volume	-8.1	-21.1
Peak Expiratory Flow (PEF)	-3.6	-17.8
Inspiratory Capacity (IC)	+0.3	-6.4
Diffusion capacity for carbon monoxide (D _L CO)	+6.2	+15.6
D _L CO adjusted for Hb levels (D _L COadj)	+8.2	+14.4

Discussion

In this case study, symptoms of PO₂tox coincided with large increases in pulmonary impedance that resulted from order of magnitude increases in airway resistance and lung reactance area (AX) compared to the control dive, that are not well reflected by spirometry, particularly FVC and D_LCO measures of lung function.

Keywords

Hyperoxia, Pulmonary function, Oxygen toxicity

Reference

Fothergill, D. M. (2017) Validation of an Exhaled Nitric Oxide (NO) Based Model of Hyperbaric Oxidative Stress and Pulmonary Oxygen Toxicity Susceptibility. NSMRL IRB protocol 2017.0002. Naval Submarine Medical Research Laboratory, Groton, CT.

D-26 FITNESS TO DIVE AFTER SPONTANEOUS PNEUMOTHORAX: CHALLENGING THE GUIDELINES

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Introduction

Spontaneous pneumothorax is considered an absolute and definitive contra-indication for SCUBA diving because of high recurrence rates both ipsi- and contra-laterally, and the potentially dramatic consequences of suffering a pneumothorax while at depth. In the current Fitness to Dive Guidelines¹ this contra-indication is confirmed, unless divers are treated with bilateral surgical pleurectomy and have a normal post-operative evaluation (CT scan, lung function tests).

In view of recent surgical progress and follow-up data, these guidelines may no longer be optimal.

Methods

We present four cases of divers who underwent a surgical procedure for spontaneous pneumothorax. Three returned successfully to an intensive diving career, with variable post-operative follow up periods and no recurrence to date. The fourth, a healthy young male with only occasional diving activity, suffered a spontaneous ipsilateral complete pneumothorax six years after surgical pleurectomy. A small bullous abnormality was found in the apical lobe on high-resolution CT scan (HRCT) and he was again surgically treated, this time with Video-Assisted Thoracoscopic (VATS) apical bullectomy, pleural abrasion and talcum powder pleurodesis. There was anatomical and histopathological evidence of a complete regeneration of parietal and visceral pleura, even though the pleural stripping during the initial intervention was as complete as surgically possible.

Results

In recent years, video-assisted thoracoscopic pleurodesis has become the standard of (surgical) care for spontaneous and recurrent pneumothorax. While it proved to be very difficult to extract exact recurrence rates for the various surgical and chemical procedures from the published literature, VATS pleural abrasion completed by talcum powder chemical pleurodesis seems to offer the highest degree of protection against recurrence.

Discussion

The current guidelines for fitness to dive after spontaneous pneumothorax may need to be revised taking into account recent technical techniques and follow-up data.

Keywords

Fitness to dive, Spontaneous Pneumothorax, Surgical Pleurodesis, Pleurectomy

Reference

British Thoracic Society Fitness to Dive Group. British Thoracic Society guidelines on respiratory aspects of fitness for diving. *Thorax* 2003;58(1):3-13.

D-27 INTRA-INDIVIDUAL VARIABILITY OF POST-DIVE VENOUS GAS BUBBLES OCCURRENCE: AN INVITATION FOR MULTI-CENTRIC COLLABORATIVE STUDY

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Background

It is commonly thought that some divers are more prone to develop post-dive venous gas bubbles (VGE) than others. However, studies addressing intra-individual variability are rare. This pilot study aimed to assess whether a distinction between bubbleers and non-bubbleers exists.

Methods

Echocardiography monitoring of post-dive VGE was conducted in volunteers after daily pool dives to 25 mfw for 25 minutes. VGE monitoring was conducted at 15, 35, 55, 75, 95, 115 and 135 min post dive. Recordings were saved for later analysis. The initial VGE assessment for each timepoint was binarily classed as “present” or “absent”. A conditional nested model design with likelihood ratio test was used to determine the likelihood of VGE presence after diving being independent of VGE outcome after previous dive(s).

Results

30 divers made a total of 89 dives. Five showed no VGE on any dive, 20 did so after all three dives, three were inconsistent and two did not complete the study. Final post-dive VGE status was found dependent on previous post-dive VGE status ($p < 0.001$).

Conclusions

In this pilot study of three consecutive diving days, individual VGE outcome appears associated with previous post-dive VGE status. However, with only three repetitions of the same dive profile, we were not able to establish with confidence the probability of outcomes after future dives. We also found the decay of post-dive VGE grade was faster following consecutive dives, possibly indicating acclimatization. To advance this research and cover the range of recreational dive profiles while controlling for acclimatization, we invite researchers with capabilities for this kind of study to join us in a multi-centric study.

Future work will include validating bubble counts at each timepoint for time-series analysis, exploring the effect of longer surface interval between dives, and the influence of physiological variables.

Keywords

Venous gas emboli, Post-dive bubbles, Variability, Study design

D-28 ENDOTHELIAL FUNCTION AND CARDIOVASCULAR STRESSMARKERS IN APOE KNOCKOUT RATS AFTER A SINGLE SIMULATED HELIOX DIVE

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Introduction

Compressed gas breathing during diving augments the inspired partial pressure of oxygen, causing the oxygen concentration in the blood to increase above normal (hyperoxia). Hyperoxia, in combination with gas bubbles that develop during the decompression (ascent) phase, may cause oxidative stress leading to endothelial dysfunction. The number of aging divers is rising and aging itself is associated with a gradual impairment of endothelial function. These alterations play a central role in the pathogenesis of atherosclerosis and coronary artery disease. While diving and aging are independent modulators of cardiovascular function, little is known about their combined effect. Thus, the central question is: does diving expose an already impaired cardiovascular system to further endothelial damage?

Methods

ApoE homozygous knockouts (KO) rats prone to develop atherosclerosis due to a defect in lipoprotein metabolism were used as a model for atherosclerosis. 10 ApoE rats (male and female) were exposed to 500 kPa heliox gas (80% helium/ 20% oxygen) for 1 hr in a pressure chamber to simulate diving. 10 ApoE rats served as a control group. Endothelial function was examined in-vitro by isometric myography of the pulmonary and mesenteric artery. Oxidative stress biomarkers were measured in plasma (collected from the heart ventricle) and lung tissue via TBARS assay. Relative expression of total and phosphorylated endothelial NO synthase was quantified by Western blot and normalized to loading control, alpha-actin.

Results

A single dive causes endothelial dysfunction in pulmonary arteries of ApoE KO rats.

Conclusion

The endothelial dysfunction seems to be associated with reduced relative contribution of all three major endothelium-dependent relaxing pathways (NO, cyclooxygenase product(s) and endothelium-dependent hyperpolarizing factor). These responses were more pronounced in male than female rats.

Keywords

Endothelial dysfunction, Atherosclerosis, Cardiovascular function, Saturation diving, Animal study

D-29 MEASURING GAS NARCOSIS OBJECTIVELY: TWO NEW METHODS

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Introduction

Divers may be subject to narcotic effects caused by hyperbaric gases (particularly nitrogen). The principal hazard of gas narcosis is the induction of euphoria, overconfidence and loss of judgment. This may cause the diver to become less alert, take extra risks, and start a chain of events culminating in a serious diving accident. No early warning signal is available. Therefore, an objective method for detecting narcosis could improve diver safety and prove useful in related research. Critical flicker fusion frequency (CFFF) has been used for measuring narcosis but requires cessation of other activity. Pupil dilation has been observed during alcohol intoxication, but has never been studied in gas narcosis.

Methods

Sixteen divers were compressed to 6 ATA in a hyperbaric chamber while breathing air. All participants undertook the CFFF test (manual and automatic modes) and underwent pupillometry (in which change in pupil size was recorded) two times: immediately prior to compression (baseline) and 5 minutes after arrival at 6 ATA (depth). The primary outcome was comparison of performance in CFFF and change in pupil size between baseline and depth recordings and comparison between both CFFF methods.

Results

There was no significant difference between baseline and depth for the manual (mean pre-post difference 0.14%, 95% CI -3.26 to 3.54) and automatic (2.25%, 95% CI -1.27 to 5.76) CFFF methods. The CFFF methods were in agreement with each other ($p=0.30$). There was no significant difference between baseline and depth in pupillometry (mean pre-post difference -1.40%, 95% CI -4.34 to 1.62).

Discussion

Neither measurement method showed a difference from surface compared to the narcotic environment. Previous research with CFFF showed significant performance decrements during air breathing at 4 ATA. Therefore, further research is needed to evaluate any differences between the CFFF measurement methods used in previous studies and the present research. Pupillometry has too much variation to be suitable for detecting gas narcosis.

Keywords

Inert gas narcosis, Critical flicker fusion frequency, Pupillometry

PD-01 RELIABILITY OF VGE DETECTION IN SUBCLAVIAN AREA FOR DECOMPRESSION STRESS ASSESSMENT FOLLOWING SCUBA DIVING

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Introduction

Ultrasonic detection of venous gas emboli (VGE) in the precordial (PRE) region is commonly used in evaluation of decompression stress. While subclavian (SC) VGE detection can also be used to augment and improve the evaluation, no study has compared rigorously VGE grades from both sites as decompression stress indicators.

Methods

This retrospective study examined 1016 man-dives breathing air extracted from the Defence Research and Development Canada dataset. Data for each man-dive included dive parameters (depth, bottom time, total ascent time), PRE and SC VGE grades (Kisman-Masurel) and post-dive decompression sickness (DCS) status. Correlation between SC and PRE grades was analyzed and the association of the probability of DCS (pDCS) with dive parameters and high bubble grades (HBG – III- to IV) was modeled by logistic regression for SC and PRE separately for DCS risk ratio comparisons.

Results

PRE and SC VGE grades were substantially correlated ($R=0.66$) and were not statistically different ($p=.61$). For both sites, pDCS increased with increasing VGE grade. When adjusted for dive parameters, the DCS risk was significantly associated with HBG for both PRE ($p=.03$) and SC ($p<.001$) but the DCS risk ratio for SC HBG (RR=6.0, 95% CI [2.7–12.3]) was significantly higher than for PRE HBG (RR=2.6, 95% CI [1.1–6.0]).

Conclusions

The association of bubble grades with DCS occurrence is stronger for SC than PRE when exposure severity is taken into account. The usefulness of SC VGE in decompression stress evaluation has been underestimated in the past.

Keywords

Decompression sickness risk, Bubbles, Doppler detection, Regression analysis

PD-02 THE USE OF HYPEROXIC ADDITIONAL LONG TABLES IN SCUBA DIVERS WITH NEUROLOGICAL DECOMPRESSION SICKNESS: THE EXPERIENCE OF THE GENEVA UNIVERSITY HOSPITAL HYPERBARIC CENTRE

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Introduction

The hyperbaric treatment of decompression sickness (DCS) usually consists of an initial standard table (2.8 ATA for 300’ or 4 ATA for 420’) followed by one or two additional HBO sessions per day with HBO at 2.5 ATA for 90 min. Some hyperbaric centres use deeper or extended tables for these additional treatments.

Method

We retrospectively analysed data and outcome on all cases of Neurological DCS who were admitted to our centre from 2010 to 2016. From 2010 to 2013 eleven patients were treated with standard tables while from 2013 to 2016 eighteen patients were treated by hyperoxic additional long tables (2.5 ATA 150’ two sessions per day or 2.8 ATA 300’ one session per day until complete recovery or no further clinical improvement).

Results

Results are summarized in Table 1. Statistical analysis suggests there is no significant difference between the two groups, particularly in regard to outcome.

Conclusion

Use of additional hyperoxic tables does not seem to bring any particular benefit to patients. Despite some limitation in this study (relatively short studied groups) we decided not to continue additional long tables.

Table 1: Analysis of demographics, medical history, diving parameters and clinical data

Variables	Standard	HyperO2	
Age (years)	45.0 +/- 11.8	43.7 +/- 12.5	p = 0.834
Male/Female	9/2	23/0	p = 0.123
Diving certification ^a (low-average/high)	5/8	12/11	p = 0.501
Median depth (msw)	46 [18-60]	47 [20-142]	p = 0.081
Mean Total dive time (min)	40 +/- 25	49 +/- 49	p = 0.479
Violation of decompression	0	0	
Breathing gas (Air/Trimix)	12/1	20/3	p = 1
Successive Dive	10/3	18/5	p = 1
Initial Table (Cx18/Cx30)	7/5	7/16	p = 0.089
OHB Table	7 +/- 8	8 +/- 9	p = 0.779
Boussuges Scale	9.2 +/- 5	7.4 +/- 6	p = 0.396
Outcome Cure/Deficit	10/3	14/9	p = 0.468

^a Low and average levels for diving certification consisted of divers with a certificate to dive to at least 40 meters, while high level comprised divers allowing deep air dives up to 60 meters and beyond for trimix mixture (helium and nitrogen as diluent gases). Statistical test: Welch Two Sample t-test or Fisher test respectively

Keywords

Decompression sickness treatment, Hyperbaric treatment table, Retrospective study

PD-03 DIVING IN THE FISH FARMING INDUSTRY IN WESTERN NORWAY

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Introductio

Diving is necessary for inspection and maintenance of fish cages housing up to 1000 tons of salmon. The cages can have diameters up to 50 m and have depths down to 40 m with an additional cone shaped section of 20 m for collection of debris. The size and shape of these cages poses a challenge with respect to dive profiles. The dive tables approved by the Norwegian Labour Inspection Authority (NLIA) at the time of the study were not providing the most effective working time along the vertical cages. A proposed revision of the approved dive tables allowing a 3-level or a 5-level dive profile, treating each level as a repeated dive, is under debate.

Method

We conducted a field study within three diving companies and registered all diving activity over a 6 week period. Depth and time were registered with a personal pressure sensor (Sensus Ultra, ReefNet Inc., Ontario, Canada). Data were transferred for analysis after the working period..

Results

23 divers performed 1143 dives between 4 and 48 m with air as breathing gas, the majority being between 18 and 36 m. Only 40 % of the dives were within the standard Norwegian Diving and Treatment Tables (NDTT) which were recommended by NLIA at that time. Multilevel profiles were calculated by assuming repeated dives according to NDTT with 3 and 5 levels with a maximum depth of 39 m. 59% of the dives were within a 3-level profile and 99 % within a 5-level profile. According to NDTT only three repeated dives are allowed each day. Nonetheless, repeated multilevel dives were common, and 2 or 3 dives each day were done 248 (3-level profile) and 38 times (5-level profile) respectively.

Discussion

NLIA has now approved 3-level dives for use in occupational diving. This is within the limits for repeated dives according to NDTT. A considerable number of the dives in our study were outside these recommendations.

Keywords

Commercial fish farm diving, Risk analysis, Dive table selection

PD-04 FACIAL PARESIS ASSOCIATED WITH PNEUMOCEPHALUS CAUSED BY SCUBA DIVING

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Introduction / Background

Middle ear barotrauma is one of the common complications of SCUBA diving, usually presenting as acute otalgia, hearing loss, and bleeding. Facial palsy is rare.

Case report

We report a case of a 39-year-old diver who suffered bilateral middle ear barotrauma with transient facial palsy after SCUBA diving. He had difficulty equalizing pressures in middle ear with the Valsalva maneuver during diving, and suffered right facial palsy and bilateral otalgia after diving. Clinical examination shortly after the resolution of pain showed remarkable bulging of the tympanic membranes but no facial palsy or other neurological findings. Brain computed tomography (CT) revealed free air in the left subdural space above the tegmen tympani near the temporal bone, bone mastoids hyperpneumatization and right mastoiditis. In this case, the apparent exposure of the facial nerve in the tympanic cavity was not observed on a CT scan.

Discussion / Conclusions

Extreme hyperpneumatization is accompanied by very marked thinning of the bony walls and may lead to rupture of the bone from minimal trauma. Intracranial air (pneumocephalus) in this case could be caused by trapped air in the middle ear forced into the subdural space through the thin bony wall of tegmen tympani during a Valsalva manoeuvre. Although a pneumocephalus may produce symptoms of compression related to its position, facial paresis was no longer present although pneumocephalus was still present on CT scan.

In this case, the bony canal of the facial nerve did not undergo spontaneous dehiscence in the middle ear cavity (tympanic segment). Hyperpneumatization may develop by slightly positive intermittent or sustained pressure towards the mastoid air cells (Valsalva maneuver or abrupt changes in pressure). Thus, we considered that the etiology of this case was neuropraxia of facial nerve in its mastoid segment caused by over pressure in the temporal bone.

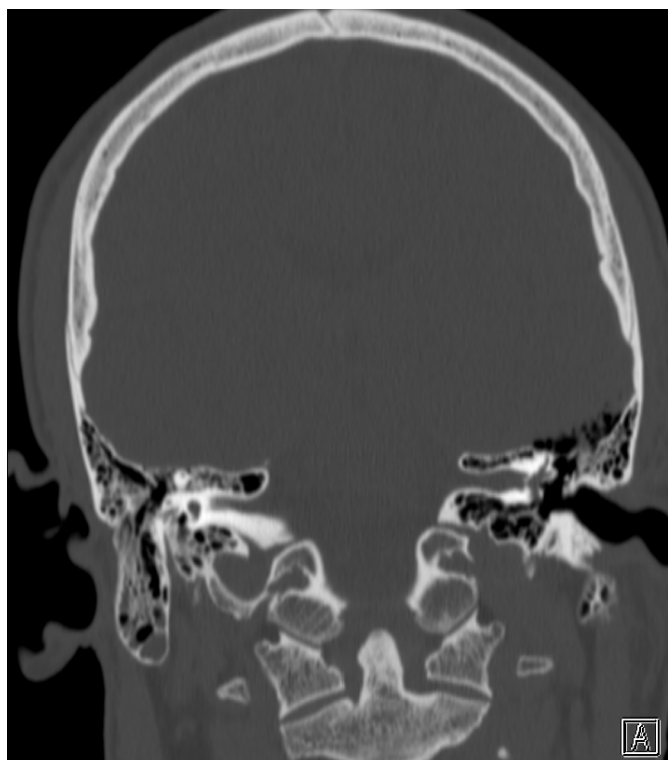
Keywords

Facial Paresis, Pneumocephalus, Middle ear barotrauma, Case report

Reference

Hyams AF, Toynton SC, Jaramillo M, Stone LR, Bryson PJ. Facial baroparesis secondary to middle-ear over-pressure: a rare complication of scuba diving. *J Laryngol Otol.* 2004 Sep;118(9):721-3.

Figure 2: Coronal CT scan: Pneumocephalus above left tegmen tympani with bone mastoids hyperpneumatization.



PD-05 CASE REPORT: CEREBRAL ARTERIAL GAS EMBOLISM DURING UNDERWATER ESCAPE TRAINING WITH COMPRESSED AIR AT A DEPTH OF ONE METRE OR LESS

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Introduction / Background

Under water escape training has been performed by helicopter crews for many years, using systems with compressed air. In some countries this has also been introduced for crews in armoured personnel carriers (APC).

Methods

This is a case report of a soldier, part of an APC crew, who suffered cerebral arterial gas embolism during underwater escape training with compressed air at a depth of 1 meter or less.

Results

The soldier was evacuated from the water with an altered level of consciousness, slurred speech, and a sensory deficit of the right side of the body. The soldier was treated with hyperbaric oxygen using a treatment table 6, starting 11 hours after the accident, and made an almost complete recovery.

Discussion / Conclusions

This is a rare type of accident. It has been described only once before.

Keywords

Compressed air, Under water escape training, Arterial gas embolism, Case report

PD-06 PERSONALITY AND ADAPTATION: ASSOCIATIONS IN A SAMPLE OF EXPERIENCED NAVY DIVERS

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Introduction

Established associations between personality profiles and adaptive coping suggests that personality markers may be able to predict psychological adaptation, possibly also among Navy divers.

The present study set out to investigate whether a psychometric measure of personality could differentiate between good and poor psychological adaptation among a sample of experienced Navy divers. If meaningful associations could be identified, it may eventually allow for the use of psychometric results to guide clinical decisions and interventions.

Methods

Clearance diving qualified Navy divers, with a minimum of three years operational experience, were each allocated to a good adaptation (N=133) or poor (N=15) adaptation group based on data from self-report coping, mental health measures, and work performance indicators. Personality profiles – using the Big Five Inventory (BFI-44) – was available for each diver. Comparative statistics and a ROC analysis were conducted.

Results

Good adaptors displayed a profile characterised by higher scores for Agreeableness and Conscientiousness and lower scores for Neuroticism. Poor adaptors displayed an undifferentiated profile. Significant and large differences were found between the personality profiles of good and poor adaptors, and the personality factors could significantly predict poor adaptation.

Discussion

The strong associations (and large effect sizes) between personality factors and adaptation among Navy divers suggest that the BFI-44 may be useful to identify (and per implication predict) poor adaptation among Navy divers. When administering the BFI-44 prior to entry into the diving field, it may help inform the level of risk for poor adaptation later in a career. When administered early in a diver's career, it may inform the planning of interventions to enhance psychological resilience.

Keywords

Personality, Psychological adaptation, Navy divers, Psychometric measure

PD-07 ASSOCIATIONS OF PERSONALITY AND UNDERWATER BEHAVIOUR AMONG SPORT DIVERS: A PILOT STUDY

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Introduction

Personality profiles are often associated with specific behaviour patterns, and reports suggest that personality is also associated with the underwater behaviour of sport divers in specific contexts.

This study explored whether personality factors – in a sample of sport divers diving off Cape Town, South Africa – could be associated with their self-reported underwater behaviour. This referred in particular to a) safety behaviour, b) buoyancy control, and c) no contact (of reefs/wrecks) behaviour.

Methods

A total of 74 qualified sport divers, of different ages, diving qualifications, and experience, completed an anonymous, self-report survey consisting of a 14-item diving behaviour checklist and a short personality scale (BFI-44). Correlational statistics were used to explore associations between personality factors and diving behaviours.

Results

Heterogeneous personality profiles were reported, while diving behaviour profiles were highly homogenous. Moderate correlations were found between two personality factors and behaviour: higher scores on factors Agreeableness ($r = 0.3$ to 0.4 , $p < .05$) and Conscientiousness ($r = 0.3$ to 0.5 , $p < .01$) were associated with a range of ecologically responsible diving behaviours.

Discussion

This pilot study used a small sample, and the results need to be interpreted with caution. The absence of stronger correlations were surprising (given previous reports), and a number of reasons may have contributed to this:

- 1) Apart from the small size, the sample was highly diverse in terms of personality, while their reported behaviour was consistently similar;
- 2) Divers are susceptible to the effects of social evaluation, and completion of the diving behaviour checklist may have been influenced by peer norms of acceptable behaviour, rather than their actual experiences (leading to the homogenous behavioural profile).

Finally, the data did not support the idea of a circumscribed 'personality profile' for sport divers in general.

Keywords

Personality, Diving behaviour, Sport divers, Safety

PD-08 IMMERSION PULMONARY OEDEMA IN A HEALTHY DIVER NOT EXPOSED TO COLD OR STRENUOUS EXERCISE

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Introduction

In healthy divers, the occurrence of immersion pulmonary oedema (IPE) is commonly caused by contributory factors including strenuous exercise, cold water and negative-pressure breathing.

Case report

Contrary to this established paradigm, we report the case of a 26-year-old, well-trained combat swimmer who succumbed to acute IPE during static immersion in temperate (21°C) water while using a front-mounted counterlung rebreather. The incident occurred during repeated depth-controlled ascent practice at the French military diving school.

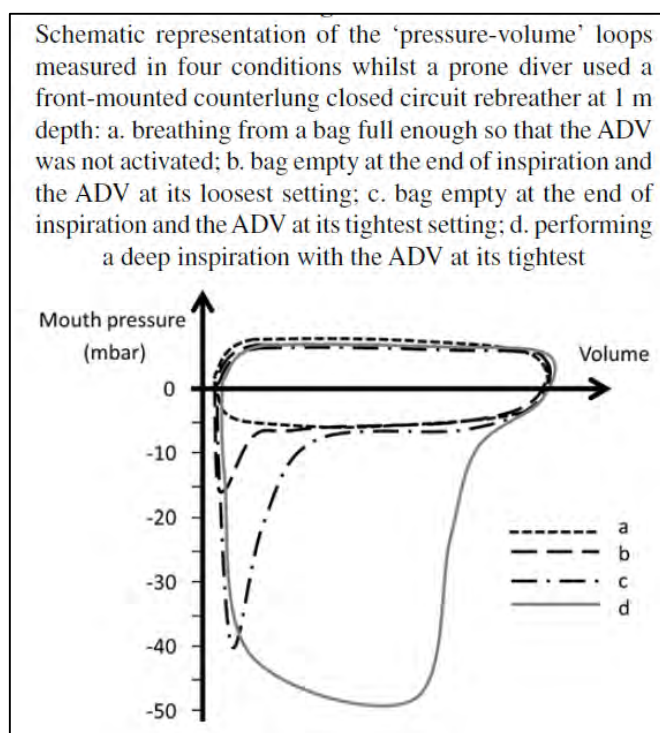
Discussion

It was discovered that the diver had attempted to stop any gas leakage into the system by over-tightening the automatic diluent valve (ADV) (25th notch of 27) during the dive, thus causing a high resistance to inspiratory flow. The ventilatory constraints imposed by this ADV setting were assessed as a 3.2 J·l⁻¹ inspiratory work of breathing (WOB) and -5 kPa (-50 mbar) transpulmonary pressure.

This report confirms the key role of negative pressure breathing in the development of interstitial pulmonary oedema. Such a breathing pattern can cause a lowering of thoracic, airway and interstitial lung pressure, leading to high capillary pressure during each inspiration. Repetition of the diving drills resulted in an accumulation of interstitial lung water extravasation, causing pathological decompensation and proven symptoms.

Keywords

Closed circuit rebreathers, Pulmonary function, Negative pressure breathing, Case reports



PD-09 AN UNUSUAL CASE OF SINUS BAROTRAUMA: A CASE REPORT OF ORBITAL SURGICAL EMPHYSEMA WITH AGENESIS OF FRONTAL SINUS BONE

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Introduction

Sinus barotrauma is a well-recognised diving injury. We report an unusual case where the presentation and underlying cause were atypical.

Case Report

A 25-year-old male scuba divers presented with orbital oedema (Fig 1) immediately after dive under instruction. He was a student professional diver without any relevant medical history. This was the second training dive of the course, consisting of two return trips to the surface (a controlled lift speed exercise at 15 msw (45 fsw) maximum depth. The divers did not describe any equalizing problem or pain. Orbital palpation shows the existence of a “crunching” sensation consistent with orbital subcutaneous emphysema.

Cranial CT scan confirmed the orbital subcutaneous emphysema (Fig 2A) and showed an agenesis of the left frontal sinus bone (Fig 2B Arrow).

The treatment consisted of simple surveillance with emphysema disappearing in eight days.

This diver was declared unfit for scuba diving.

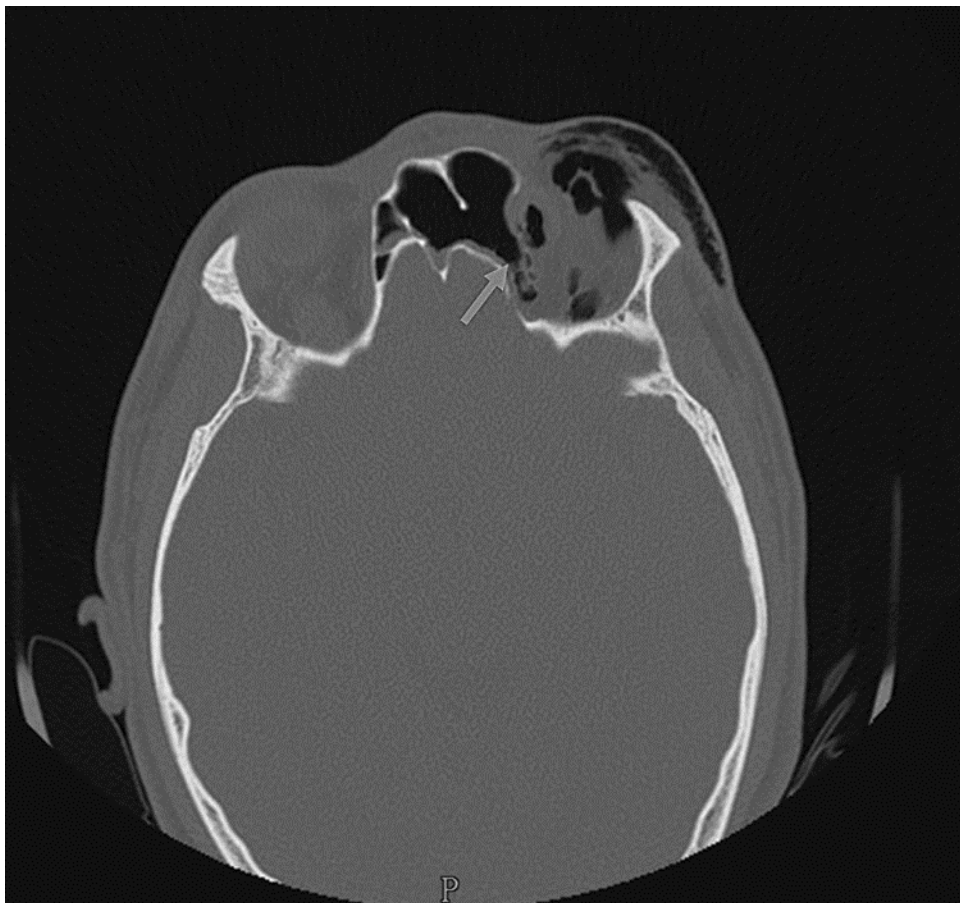
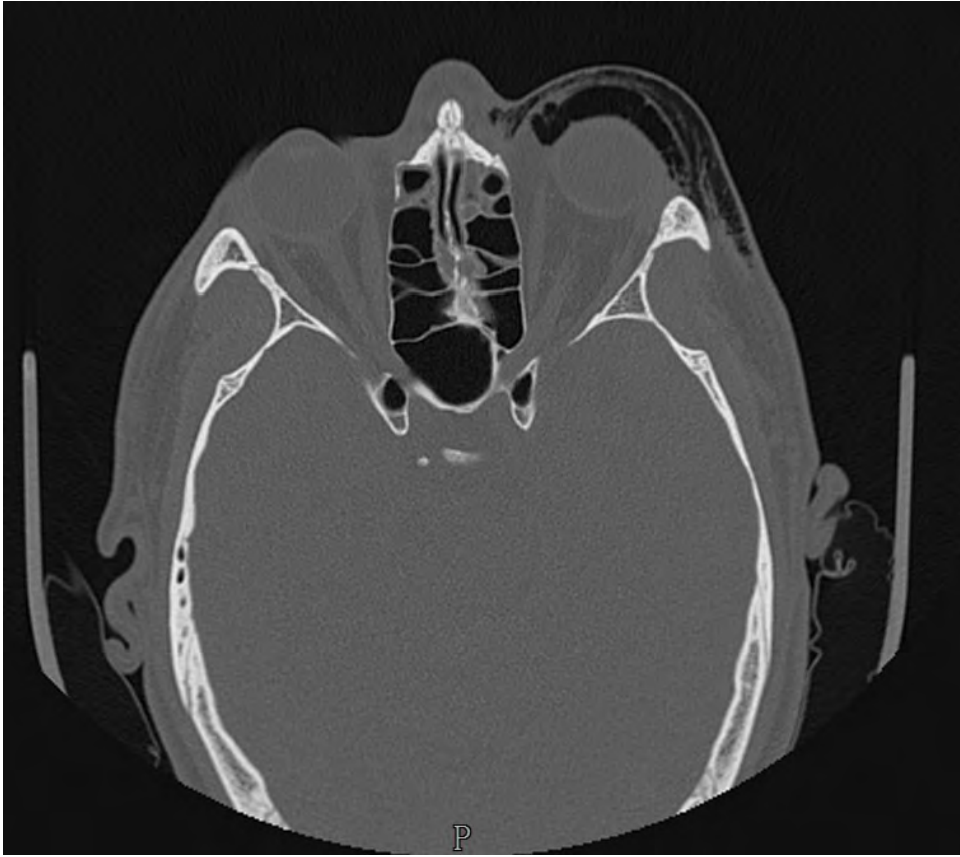
Discussion

Sinus barotrauma may occur as a result of changes in ambient pressure where there is failure to equalize that pressure within the air-filled sinus. Estimates of prevalence range from 26 to 34 % in divers. Acute sinus barotrauma involves a single sinus, with the frontal sinus most commonly affected (68-100%) due to an obstructed frontal ostium. Some cases have been reported of sinus barotrauma with orbital surgical emphysema following Valsalva manoeuvre following recent asymptomatic fractures to the lamina papyracea. In our case, the barotrauma appears during ascent without Valsalva manoeuvres and is secondary to the pressure increase in the frontal sinus on ascent with subsequent rupture of the sinus mucosa weakened by the absence of a bony wall.

Fig 1:



Fig 2: CT (A) visualization of an orbital emphysema (B) the arrow highlights the presence of an agenesis of the wall of the left frontal sinus



PD-10 FACTORS AFFECTING CARDIOVASCULAR HEALTH IN CERTIFIED SCUBA DIVERS: AN ONLINE SURVEY

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Introduction

Scuba divers develop health problems similar to the non-diving population. However, some continue to dive with cardiac issues, failing to seek specialized diving advice. Despite cardiovascular disease (CVD) being responsible for a quarter of diving fatalities (Lippmann et al., 2016), few studies to-date have investigated possible contributing factors. We aimed to evaluate the wellbeing & health factors of scuba divers and identify possible contributors to their CVD risk.

Methods

Preliminary data were collected via an anonymous (on-going) online survey distributed via social media, the DDRC Healthcare website and Plymouth Marjon University website. Information regarding demographics, diving specifics, general health, physical activity and the QRISK2 score for cardiovascular risk was collected via 40 questions. The study received ethical approval (EP034/2017).

Results

In total 553 certified scuba divers have completed the survey, of which 3 were disqualified for inconsistency. Participants (36.4% female; 36.4% >50 years of age, BMI mean 26.2 {range; 17.2-53.8} kg/m²) reported a median total number of dives of 350 (range 4-15,000) per person. Twenty percent of participants scored above 10% on the QRISK2 score and 7.4% scored above 15%. No statistically significant differences in QRISK2 score were found between levels of scuba diving certification ($p>0.05$), however, a weak but statistically significant correlation was observed between QRISK2 score and diving experience (months since first dive; $r= 0.35$, $p=0.0001$).

Discussion

A sizeable percentage of the certified scuba diving population studied is at high risk of a cardiovascular event. Traditional CVD risk factors contributed to the QRISK2 however moderately. Targeted research is needed to assess the impact of other non-traditional risk factors, to support efforts to combat CVD in otherwise healthy scuba divers.

Keywords

QRISK, Scuba diving, Cardiovascular risk factors

Reference

Lippmann, J, Stevenson, C, Taylor, DM & Williams, J. Estimating the risk of a scuba diving fatality in Australia. *Diving and Hyperbaric Medicine* 2016;46(4):241-246

PD-11 DOUBLE CASE REPORT FOLLOWING FREE ASCENT OF TWO SEA HARVESTING DIVERS.

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Introduction / Background

Sea harvesting began with sponge diving in Turkey and continues there with diving for sea snail or sea cucumber. Sea harvesters typically use a hookah, which consists of second stage regulators connected to a low pressure air tank by a hose. In this paper we present two cases of pulmonary barotrauma and decompression sickness during sea cucumber diving.

Case Reports

Two experienced male divers, aged 32 (Diver-1) and 27 (Diver-2), performed a dive to 31 metres to collect sea cucumber using a hookah with double second stage regulators. Diver-1 had previously made a short dive to the same depth for 2-3 min to check the bottom (about 10 minutes prior). At the 25th minute both divers were out of air due to air supply failure from separation of the air filter from its supply hose. Both divers came to surface by free ascent without releasing their 10 kg weight belts. Diver-2 lost consciousness at about 10 metres and was coughing, dyspnoeic and had a massive hemoptysis at the surface. He was taken to the dive boat by Diver-1 who surfaced a few seconds earlier. Diver-2 was admitted to the intensive care unit in four hours and chest CT revealed alveolar hemorrhage. There was no abnormal neurological finding and the diver was discharged after three day observation. Follow-up chest CT revealed no pathology at one month. Diver-1 had no symptoms at the surface but developed right shoulder pain two hours later. He presented to hospital the following day with persistent pain. Full recovery followed recompression treatment on US Navy TT5 18 hours after the dive.

Discussion / Conclusions

Sea harvesting divers usually do not have proper diving equipment and training and therefore the incidence of diving diseases is high among these groups in all over the world.

Keywords

Sea harvesting, Hookah diving, Free ascent, Pulmonary barotrauma, Decompression sickness, Case report

Reference

Empirical diving techniques of commercial sea harvesters. Michael Lepawsky and Robert Wong eds. 50th Workshop of the UHMS, Undersea and Hyperbaric Medical Society Inc., 2001

PD-12 HYPOXIA IS NOT RELIABLY PREVENTED BY SETTING A 60 SECOND APNEA LIMIT DURING EXERCISE: THE FAILURE OF THE “ONE MINUTE RULE” FOR FREE DIVING

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Introduction

Breath-hold diving (BHD) continues to increase in popularity. From 2004-2015 there were 763 BHD incidents; 80% of these were fatal. Unlike SCUBA diving, there is no required formal or standardized training for breath-hold diving, making dissemination of safety protocols difficult. A recommended breath-hold dive time limit of 60 s has been put forth for amateur divers.¹ However, a time limit based only on anecdotal observation should not be the primary factor of concern for preventing underwater loss of consciousness. We hypothesize the effects of apnea time on arterial and tissue oxygenation are most likely to be primarily dependent on metabolic rate. We aimed to measure the effect of apnea time and metabolic rate on arterial oxygenation.

Methods

Fifty healthy participants (23±3 years, 22 Females) completed four periods of apnea for 60 s (or to the tolerable limit) during seated rest and during cycle ergometry at 20, 40, and 60 W. Each apnea was initiated with hyperventilation to achieve P_{ET}CO₂ of approximately 25 mmHg. Pulse oximetry and pulmonary gas exchanged were measured throughout. We defined hypoxia as SaO₂ ≤ 88%.

Results

Static and exercise (20, 40, 60 W) breath-hold break times were 57±7, 50±11, 48±11, and 46±11 s. The rise in P_{ET}CO₂ from initiation to breaking of apnea was dependent on metabolic rate (time × metabolic rate interaction; F[3,147]=38.6, p<0.0001). The same was true for the fall in SpO₂ (F[3,147]=2.9, p=0.03; (Figure 1). SpO₂ fell to < 88% on 14 occasions in eight participants, all of whom were asymptomatic.

Conclusions

Independent of the added complexities of a fall in static pressure on ascent, the effect of apnea time on hypoxia depends on the metabolic rate and is highly variable among individuals. Therefore, we contend that a recommended time limit for breath-hold diving or swimming is not useful to guarantee safety.

Reference

Butler F. A proposed 60 s limit for breath-hold diving. Proceedings of the Undersea and Hyperbaric Medical Society Breath-Hold Diving Workshop, June 20-21, 2006.

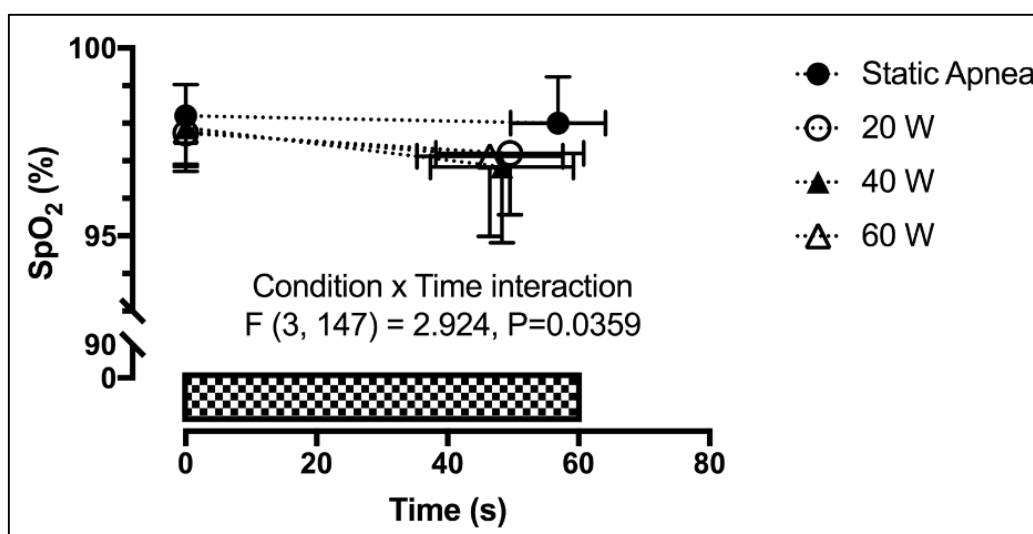


Figure 1. SpO₂ measured during a 60 s apnea across a range of metabolic rates. Checkered box represents target duration of apnea.

PD-13 DIVING, RISK, AND CANNABIS: EXAMINING A SAMPLE OF PROFESSIONAL DIVERS' VOCABULARIES OF MOTIVE FOR CANNABIS USE.

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Introduction / Background

Cannabis (marijuana) use amongst professional and recreational divers has been the subject of ongoing academic and popular debate since the 1970s. While scientific literature and professional guidelines agree cannabis use is useful information for Diving Medicine practitioners when assessing a diver's (physiological, emotional, and occupational) fitness to dive, it has been common place for Diving Medicine literature and medico-legal guidelines to adopt a relatively punitive stance towards divers' reported cannabis use. Rather than blanketing divers' cannabis use as "risky" and "reckless", this study sought to explore in greater detail the *vocabularies of motive* for cannabis use amongst a sample of professional divers. Here, *vocabularies of motive* refer to those constructions of subjective meaning which orientate behavioural conduct.

Methods

A sample of 10 medically fit and cannabis-using professional divers from South Africa were interviewed individually. The interviews were analysed by means of a thematic content analysis. Analysis of the data focused on exploring the participating divers' *vocabularies of motive* for cannabis use.

Results

From the analysis of the interview data, three overarching *vocabularies of motive* were found in this sample of divers' use of cannabis: (1) *Self-fulfilment*: Wherein the diver claims cannabis use is a means to an end; (2) *Condemnation of condemners*: Wherein the diver underscores cannabis use in relation to other divers' unsafe diving practices; and (3) *Denial of injury*: Wherein the diver argues cannabis use is permissible because nobody is (seriously) harmed.

Discussion / Conclusions

The findings of this research highlight that this sample of divers' cannabis use was psychologically circumscribed by a highly subjective yet complex system of *vocabularies of motive* which determine and pattern their cannabis use. Such *vocabularies of motive* for cannabis use have the potential to be important indicators for Diving Medicine practitioners in understanding and assessing a diver's fitness to dive.

Keywords

Cannabis use; Diving psychology; Vocabularies of motive; Fitness to dive

PH-01 NEW HYPERBARIC INFUSION PUMPS

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Background

Since the company, Fresenius[®], stopped the production of the syringe driver « Pilot », there are no hyperbaric infusion pumps currently on the market. In 2015, Arcomed[®] proposed testing two infusion pumps (Volumed[®]VT7000 and Syramed[®]SP6000) in hyperbaric conditions.

Methods

Arcomed[®] provided six devices (three of them with a Patient Controlled Analgesia (PCA) function). All devices were prepared for hyperbaric conditions by the engineering unit of the company. All testing was performed in three hyperbaric chambers. We tested the devices at a maximum HBOT pressure of 4 ATA and a deep commercial dive pressure (10.7 or 11 ATA). We performed both operational (normal running) and performance (reliability) tests. In the reliability tests we used with both low and high flow settings.

Results

The six devices work perfectly well at 4 ATA, delivering exactly the quantity and the flow requested. The three syringe pumps performed equally well at 10.7 ATA. However, the Volumed[®]VT7000 delivered 5 to 10% more flow at high pressure than was set. The PCA modes performed well at all times.

Conclusions

After many tests between 4 and 10.7 ATA, the hyperbaric syringe driver, Syramed[®]SP6000 (Arcomed[®]) was reliable and accurate in both normal mode and PCA mode. The infusion pump, Volumed[®]VT7000, was reliable at 4 ATA but it must be used with care at higher pressures.

Since these tests, both devices have obtained the hyperbaric CE mark.

Keywords:

Hyperbaric equipment testing, Infusion pump

PH-02 A NITROGEN DOSIMETER: HOW TO REDUCE THE RISK OF DECOMPRESSION SICKNESS IN HYPERBARIC ATTENDANTS

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Introduction

Decompression sickness (DCS) in inside hyperbaric attendants is relatively rare, with a reported incidence of less than one case per 10,000 compressions. The pressure, duration and frequency of the compressions undergone as well as the decompression tables used, are centre-dependent. At the end of the day, can the attendants climb to altitude or play sport? Are they completely denitrogenated?

Aim

The purpose of this work is to develop tools to ensure the safety of hyperbaric attendants. For that, it is essential to monitor the evolution of nitrogen and helium tensions, and to know the time of complete desaturation for each staff member.

Production

An individual and portable "nitrogen dosimeter" integrating the ambient pressure, time and the breathing gas mixture was developed. It works with an Haldanian algorithm (Bühlmann type) and incorporates an alarm guaranteeing a safety always higher than MT92 tables.

After each dive, the total desaturation time in air or oxygen is calculated as a function of the residual stresses of nitrogen and helium. The data from the different dosimeters can be sent in real time to a server where they are stored and possibly interpreted and displayed on an external monitor.

Discussion

While following the operative pressurization protocols in any hyperbaric facility, the "dosimeter" enables the inside hyperbaric attendants to know throughout their working day what their residual levels of nitrogen and helium are and the time necessary to achieve complete desaturation.

Conclusion

This device is easy to use and will avoid desaturation accidents and increase the comfort of staff of hyperbaric medicine centres.

Keywords

Hyperbaric attendant safety, Occupational surveillance, Prevention

References

- Pougnat and al. Health effects of Hyperbaric exposure on chamber attendants: a literature review. *Int Marit Health* 2018;69:1
Richard C, Health care worker decompression sickness: incidence, risk and mitigation. *UHM* 2017;44:6

PH-03 OXYGEN PARTIAL PRESSURES UNDER HYPERBARIC CONDITIONS IN A CHILD WITH CONGENITAL HEART DISEASE PRESENTING WITH RIGHT TO LEFT SHUNTS

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Introduction

Arterial and venous oxygen partial pressures in patients with systemic right to left shunts under hyperbaric (HBO) conditions are unknown. Here we explored these issues in a young child with congenital heart disease.

Methods

A two-year-old male child with transposition of the great vessels resulting in a right to left shunt and an O₂ saturation of 70% in room air was taken into the hyperbaric chamber to treat a skin wound due to extravasation of a 20% dextrose solution. Serial arterial and venous blood gas samples were taken while breathing both 21% and 100% O₂ and at both 1 and 2.5 ATA during the session (see Figure).

Results

PaO₂ increased when increasing pressure and when increasing FiO₂ (Figure 1). It decreased immediately during an air breathing period at 2.5 ATA and increased again immediately after the resumption of oxygen breathing. Both 2.5 ATA and 100% O₂ were necessary to reach oxygen partial pressure values above 10kPa. PaO₂ returned to pre-session values or even lower, as previously described by Weaver, after the session. PvO₂ did not increase simultaneously.

Discussion

The PaO₂ values increased with both increased pressure and increased FiO₂. The stability of PvO₂ shows that the benefit of HBO is on dissolved oxygen. We also show there is no storage of oxygen, as values returned to those at pre-session after surfacing. However, the HBO treatment was associated with healing of the wound with a skin graft. This raises the question of the mechanism of healing and outlines the potential importance of the oxygen window phenomenon.

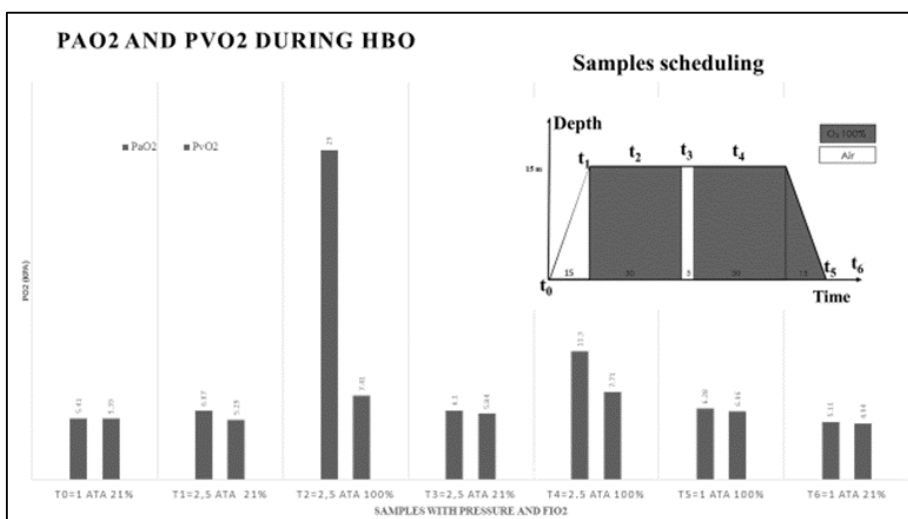
Keywords

Hyperbaric oxygen therapy, Children, Congenital heart disease, Wound healing, Oxygen pressures

Reference

Weaver LK, Howe S, Snow GL, Deru K. Arterial and pulmonary arterial hemodynamics and oxygen delivery/extraction in normal humans exposed to hyperbaric air and oxygen J Appl Physiol 2009;107:336-345

Figure 1:



PH-04 USEFULNESS OF HYPERBARIC TREATMENT TO HEAL A CRITICAL WOUND IN PEDIATRIC HEART DISEASE

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Introduction

Taking care of a child with a complex congenital cardiopathy (d-TGV) can be a challenge for any hyperbaric team unfamiliar with these pathologies. We report a case referred for hyperbaric consultation a few days after cardiac surgery.

Case report

The two-year-old male child had a cyanotic cardiopathy and after an atrioseptectomy, had an arterial oxygen saturation (SaO₂) of 70% in ambient air (45% before surgery). For surgical reasons, we had to wait for 6 months before considering performing a long-term repair. Extravasation of a dextrose 20% solution in the foot caused a severe wound which showed signs of developing necrosis. A skin graft was indicated but with no chance of success with such a low oxygen saturation. We proposed the hyperbaric chamber as a solution and it was accepted by surgeons (cardiac and plastic) and cardiologists. He successfully underwent 20 sessions of 95 min at 2.5 ATA without distress. The skin graft was performed after 11 sessions and healing was reached at the end of the 20 sessions. The child was accompanied by a nurse from the surgical ward and a hyperbaric nurse during each session. Furthermore, a woman who spoke the same language (Arabic) came with him to the entrance of the chamber and was with him for the first session. Oxygen was given by a hood device. Middle ear ventilation tubes were not needed. No secondary event occurred except an ear barotrauma which spontaneously resolved.

Discussion

This case shows that, with a good collaboration with cardiologists, and giving no stress conditions to the child, it is feasible and safe to take care of a child, even with a severe cyanotic pathology.

Keywords

Hyperbaric oxygen therapy, Children, Congenital heart disease, Wound healing



T0

After 1 month

After 2 years

PH-06 EBASS SAFETY MANAGER COURSE EVALUATION. IDENTIFICATION OF THE REQUIREMENTS FOR PROPERLY ACCREDITATION STAFF

Angeliki Chandrinou, Peter Atkey, Konstantina Gaitanou, Valeria Campanaro, Robert Houman, Peter Kronlund, Miguel Parceiro, Manuel Preto, Damianos Tzavellas

European Baromedical Association - EBAss

Introduction / Background

The aim of the European Baromedical Association (EBAss) is to encourage the integration of baromedical personnel in European hyperbaric centers by working towards standardization of education throughout Europe. This includes the provision of independently accredited examinations. EBAss also supports and encourages a safe approach to daily practice and improving methods of communication. Hyperbaric Safety Manager Certification is an indication to employers, potential employers and the regulatory agencies that an individual has the knowledge, skills, and abilities equivalent to a level of proficiency expected of a safety manager who is capable of working in a hyperbaric facility. The aim of the work to be presented was to evaluate the first safety manager (SM) course for hyperbaric personnel held in Porto in 2017.

Methods

This is a descriptive study. The sample consisted of all 14 participants in the SM course. Course evaluation self-completed questionnaires were used as the source data. These questionnaires consisted of six four-point evaluation questions asking for a response rated between 'Excellent' and 'Poor', plus five questions requiring a narrative description. Data were analyzed using the statistical package SPSS 22.

Results

The overall quality of the instruction was rated as excellent by 57.1% of respondents. Only 7.1% of the trainers were rated as not following precisely the themes of the presentations. 50% and 35% of the trainers were rated as good and excellent respectively, for their effort to remain interesting and very engaging during the presentations. 42.9% of respondents rated the program as excellent. 100% of participants appreciated the knowledge and skills gained from the course. 42.9% noted the course should be more directly related to clinical practice, employing various scenarios involving "errors" and "omissions" when operating the hyperbaric chamber. 7.1% of respondents stated it wasn't their first priority to learn how to do a presentation or produce a scientific paper.

Discussion / Conclusions

Creating a safety culture in the workplace can be difficult. EBAss/ECHM/ECB SM Course is well accepted from the hyperbaric community and it seems that it is appreciated the knowledge and skills gained.

Keywords

Quality evaluation, Training, Safety manager course

PH-07 HYPERBARIC OXYGEN FOR IDIOPATHIC SUDDEN SENSORINEURAL HEARING LOSS AND TINNITUS – A COCHRANE REVIEW UPDATE

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Introduction / Background

Idiopathic sudden sensorineural hearing loss (ISSNHL) is a disease affecting up to 20% of adults in developed countries, while the incidence of tinnitus is estimated at 15%. Both are relatively common diseases with severe consequences for the sufferer. Despite inclusion of ISSNHL in both the UHMS and ANZHMG approved lists, some controversy remains about the clinical usefulness of any response to hyperbaric oxygen therapy (HBOT). As a potential adjuvant treatment, hyperbaric oxygen therapy is not without risks to the patient.

Methods

The authors will search for new randomised and pseudo-randomised controlled trials in electronic databases, printed journals and by contacting researchers for unpublished data. Studies will be eligible for inclusion if they report any of the following outcome measures at any time:

Primary outcomes:

1. Acute ISSNHL: pure-tone audiometric documented change in hearing in response to treatment.
2. Chronic ISSNHL: pure-tone audiometric documented change in hearing in response to treatment.
3. Acute ISSNHL: relief of tinnitus. Subjective assessment of tinnitus level.
4. Chronic ISSNHL: relief of tinnitus. Subjective assessment of tinnitus level.

Where possible and appropriate, data published since the last update of this review in 2012¹ will be incorporated into meta-analyses in that previous review. We aim to provide more guidance for clinicians in deciding whether or not to treat these conditions.

Results

Results pending

Discussion / Conclusions

An updated meta-analysis will further define the evidence base of hyperbaric oxygen for this indication. Such evidence will promote appropriate use of resources, help create risk-benefit profiles for both institutions and individual patients and provide an important educational update for interested parties.

Keywords

Hyperbaric oxygen therapy, Sudden sensorineural hearing loss, Tinnitus, Evidence Based Medicine review

Reference

Bennett MH, Kertesz T, Perleth M, Yeung P, Lehm JP. Hyperbaric oxygen for idiopathic sudden sensorineural hearing loss and tinnitus. *Cochrane Database of Systematic Reviews* 2012, Issue 10. Art. No.: CD004739. DOI: 10.1002/14651858.CD004739.pub4.

PH-08 HBO FOR MIXED ARTERIAL AND VENOUS RETINAL OCCLUSION – A CASE REPORT

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Introduction

Retinal vein occlusion is an acute ophthalmologic situation that presents with sudden decrease of visual acuity and metamorphopsia. It's often associated with typical cardiovascular risk factors such as arterial hypertension, diabetes, high cholesterol levels and sometimes pro-thrombotic syndromes. In a few cases, there is a secondary central retinal arterial occlusion that further worsens the prognosis. If a few options are available for venous occlusions (anti-VEGF, laser) with acceptable results, for arterial occlusions there are no effective therapeutic approaches. We present a case of a mixed arterial and venous retinal occlusion treated with Hyperbaric Oxygen Therapy (HBOT) eight hours after onset.

Case report

A 63-year-old male was referred eight hours after a sudden monocular decrease of visual acuity (AV=0.05). His retinal and Optical Coherence Tomography (OCT) findings were compatible with mixed arterial and venous retinal occlusion. After three daily sessions of HBO (70 minutes at 2.5 ATA each), an increase in visual acuity was reported. The OCT revealed a major reduction in macular oedema. It was decided to continue daily HBO sessions. After a total of 33 HBO sessions the patient was discharged with a visual acuity of 1.0 and a normal macular profile on OCT. No anti-VEGF or laser therapy was performed.

Conclusion

Retinal vascular occlusions are an acute and dramatic group of entities that usually result in a major decrease on visual acuity. HBOT was effective in the case reported, avoiding the need of additional invasive therapies, and could be an option for such cases.

Keywords

Hyperbaric oxygen therapy, Retinal vascular occlusion, Visual acuity, Optical Coherence Tomography, Case report

PH-09 SUDDEN SENSORINEURAL HEARING LOSS AFTER SPINAL ANESTHESIA: CASE REPORT

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Background

Sudden sensorineural hearing loss (SSNHL) is defined as hearing loss of at least 30 dB in three sequential frequencies within three days. The etiology is still unclear. SSNHL after spinal anesthesia is a rare complication reported in the medical literature. Vertigo and tinnitus may be clinical implications of hearing loss after spinal anesthesia. A case of SSNHL after nonotologic surgery under spinal anesthesia is reported.

Case report

A 46-year-old male underwent ureteroscopy (URS) under spinal anesthesia. Between three and four hours after surgery the patient complained of hearing loss in the left ear with tinnitus, vertigo, nausea. Hearing was normal in the right ear. His neurologic examination was normal. His audiogram confirmed severe hearing loss (figure 1a). CT and contrast MRI images suggested normal labyrinthine and semicircular canals. His was treated with methylprednisolone, vitamin B12 and pentoxifylline. Hyperbaric oxygen therapy (HBOT) was also started within the same day with US Navy Treatment Table 9. After nine hyperbaric oxygen therapy sessions the patient tested with normal hearing in the affected ear (figure 1b).

Conclusion

The occurrence of postoperative SSNHL in nonotologic, noncardiac patients has been infrequently reported. Various potential etiologies are described. Cerebrospinal fluid (CSF) leakage is one of the possible mechanisms. Our case underwent URS under spinal anesthesia. In this regard, loss of CSF during spinal anesthesia may have caused SSNHL. There is no definitive treatment of postoperative SSNHL and hearing loss may be persistent. In this case, treatment included HBOT and the patient was discharged with complete restoration of hearing and symptom free. Physicians should be aware of SSNHL after spinal anesthesia and this study suggest combined treatment will improve outcomes.

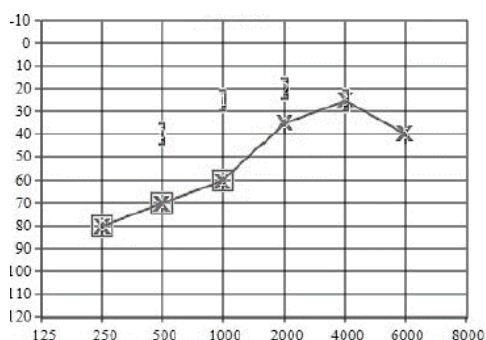


Figure 1a

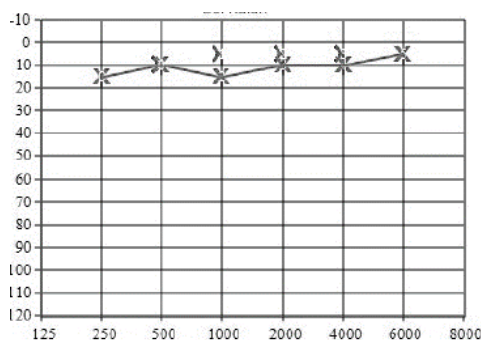


Figure 1b

Keywords:

Sensorineural hearing loss, Spinal anesthesia, Hyperbaric oxygen treatment, Case report

Reference

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