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OPENING WELCOME

The Southern African Undersea and Hyperbaric Medical Association is absolutely delighted and privileged to welcome Professor David Elliott and his wife, June, as well as Dr Robert Warriner III to our Fourth Biennial Conference. SAUHMA and the Southern African Society for Aerospace and Environmental Medicine (SASAEM) collaborate on annual meetings, alternating in running them.

This year it is again the turn of SAUHMA and we look forward to a really vibrant meeting on diving medical issues, as well as an update on both the controversial and the currently accepted uses of hyperbaric oxygen therapy. SAUHMA as an organization has literally sailed from strength to strength and is now the authoritative body in diving and hyperbaric medicine in Southern Africa with worldwide affiliations and international acceptance.

The association continues to strive to provide ethical, appropriate, effective and safe treatment to our diving and hyperbaric patients. Our quest is for still further improvement in hyperbaric training, standards of practice, physician credentialing, chamber safety and safe sport and commercial diving practice. Many of these aspects will be covered in the presentations.

On behalf of SAUHMA I heartily welcome all delegates to Durban for another truly wonderful conference. I know it will be both fascinating and enlightening.

Allan Kayle, MD, PhD

President of SAUHMA

21 September 2001

EXECUTIVE COMMITTEE MEMBERS

- **President:** Dr Allan Kayle
- **President Elect:** Dr Frans Cronjé
- **Past President:** Dr Campbell MacFarlane
- **Treasurer:** Mr Francois Burman
- **Secretary** Ms Antoinette Walters
- **Medical Practitioner** Dr Gerhard van Niekerk
- **Medical Practitioner** Dr Pieter Landsberg
- **Medical Practitioner** Dr Andy Branfield
- **Hyperbaric Nurse** Sr Bridget Thomson
- **Paramedic Representative** Sr Liz Ferguson
- **Hyperbaric Technician** Mr Mike Clark
- **Gauteng Representative** Dr Martin Bednarek
- **Western Cape Representative** Dr Cleeve Robertson
- **Eastern Cape Representative** Dr Peter Schwartz
- **Kwa-Zulu Natal Representative** Dr André Groenewald
- **Free State Representative** Dr Peet van der Vyfer
- **Mpumalanga Representative** Dr Frans Fourie
- **Orthopaedic Consultant** Dr Buks Maré
- **Surgical Consultant** Dr Richard Moolman
- **Critical Care & Anaesthesia Consultant** Dr David Papendorf
- **ENT Consultant** Dr Maurice Hockman
- **Divers Alert Network Liaison** Ms Shane Duffey
- **Occupational Health & Safety Consultant** Mr Fanie Kruger
- **Technical Safety Consultant** Mr Francois Burman

ORGANISING COMMITTEE

Frans Cronje, MD

Mike Marshall, MD

Antoinette Walters

Allan Kayle, MD

CONFERENCE VENUE & ACCOMMODATION ORGANISERS

Riverside Hotel Conference Center

SPONSORS

**Smith & Nephew
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Medical Distributors – Radiometer

**Baric Sale
Clinical Hyperbaric Services
National Hyperbaric Services
Propshine**

DAN Southern Africa

**Afrox – Glynnwood Hospital
Bayer**

INTERNATIONAL GUEST SPEAKERS

- ***Prof David Elliott:***

- *leading international expert on diving fitness and occupational diving medicine.*

Prof Elliott is providing a comprehensive update on important and controversial aspects of diving medical fitness, as well as dive accident prevention and decompression illness management.

- ***Dr Robert Warriner III:***

- Medical Director of one of the largest Hyperbaric Therapy Providers in Texas – Wound Care Group –
& Head of the UHMS Taskforce on Reimbursement*

Dr Warriner is providing a critical overview of the science supporting the current use of hyperbaric oxygen therapy and the way in which it forms an adjunct to wound care and surgical practice.

SOUTHERN AFRICAN UNDERSEA & HYPERBARIC MEDICAL ASSOCIATION

FOURTH BIENNIAL DIVING MEDICINE CONFERENCE

21 - 23 SEPTEMBER 2001

THE RIVERSIDE HOTEL CONFERENCE CENTRE -- DURBAN

GENERAL INFORMATION

HEADQUARTERS

Registration, information and all sessions will be held at RIVERSIDE HOTEL CONFERENCE CENTRE, Durban.

REGISTRATION

Thursday 20 September 17h00 - 19h00(early)
Friday 21 September 07h00 - 08h30

09h00 - 10h30	<i>Scientific papers</i>
10h30 - 11h00	Refreshments
11h00 - 13h00	<i>Scientific papers</i>
13h00 - 14h00	Lunch
14h00 - 15h30	<i>Scientific papers</i>
15h30 - 16h00	Refreshments and exhibitions
16h00 - 17h00	<i>Scientific papers</i>
19h00 for 19h30	Meet the speakers cocktail function

SESSIONS

Friday 21 September 07h00 - 17h00
Saturday 22 September 07h00 - 17h00
Sunday 23 September 07h00 - 13h00

*For additional registration forms and information contact **Ms Antoinette Walters**
012 334-2567 (phone)
012 335-9994 (fax)*

EXHIBIT INFORMATION

Exhibits will be on display in main auditorium
Friday 21 September 07h00 - 17h00
Saturday 22 September 07h00 - 17h00
Sunday 23 September 07h00 - 13h00

SATURDAY 22 SEPTEMBER 2001

08h00 - 08h30	Refreshments
08h30 - 10h30	<i>Scientific papers</i>
10h30 - 11h00	Refreshments
11h00 - 13h00	<i>Scientific papers</i>
13h00 - 14h00	Lunch
14h00 - 15h30	<i>Scientific papers</i>
15h30 - 16h00	Refreshments and exhibitions
16h00 - 17h00	<i>Scientific papers</i>
19h00 for 19h30	Banquet

SUNDAY 23 SEPTEMBER 2001

PROGRAMME

FRIDAY 21 SEPTEMBER 2001

07h00 - 08h30 Registration
08h30 - 09h00 Opening welcome

08h00 - 08h30	Refreshments
08h30 - 10h00	<i>Scientific Papers</i>
10h00 - 10h30	Refreshments
10h30 - 13h00	<i>Scientific Papers</i>
13h00	Conference concludes

SCIENTIFIC PROGRAM

Friday 21 September 2001			
1	07:00-08:30	Registration at Riverside Hotel Conference Centre	
First Session		Chairperson: Dr Allan Kayle – President of SAUHMA	
2	08:30-09:00	Opening Welcome	Dr Allan Kayle <i>President of SAUHMA</i>
3	09:00-10:00	Diving for the Unfit? Anyone can do it	Prof David Elliott
4	10:00-10:30	Workshop: Diving fitness	<i>Diving Medical Panel:</i> Prof David Elliott; Dr Allan Kayle; Col Gerhard van Niekerk; Dr Andy Branfield; Dr Pieter Landsberg; Dr Frans Cronje
5	10:30-11:00	Refreshments	
Second Session		Chairperson: Dr Frans Cronje – President-Elect of SAUHMA	
6	11:00-12:00	Causes, presentation and prevention of in-water accidents, drowning, and decompression illness	Prof David Elliott
7	12:00-13:00	Case presentation & discussion	<i>Diving Medical Panel:</i> Prof David Elliott; Dr Allan Kayle; Col Gerhard van Niekerk; Dr Andy Branfield; Dr Pieter Landsberg; Dr Frans Cronje
8	13:00-14:00	Lunch	
Third Session		Chairperson: Col Gerhard van Niekerk – Officer Commanding Institute for Maritime Medicine	
9	14:00-15:00	Triage, management of DCI and options for recompression	Prof David Elliott
10	15:00-15:30	Case presentation & discussion	<i>Diving Medical Panel:</i> Prof David Elliott; Dr Allan Kayle; Col Gerhard van Niekerk; Dr Andy Branfield; Dr Pieter Landsberg; Dr Frans Cronje
11	15:30-16:00	Refreshments	
Fourth Session		Chairperson: Dr Robert Warriner – UHMS	
12	16:00-16:30	Fitness to resume diving, long term effects of diving	Prof David Elliott
13	16:30-17:00	Case presentation & discussion	<i>Diving Medical Panel:</i> Prof David Elliott; Dr Allan Kayle; Col Gerhard van Niekerk; Dr Andy Branfield; Dr Pieter Landsberg; Dr Frans Cronje
End of Day 1			

Saturday 22 September 2001				
14	08:00-08:30	Refreshments & Exhibits		
Fifth Session		Chairperson: Dr Pieter Landsberg – SAUHMA Council Member		
15	08:30-08:50	Hyperbaric Oxygen Therapy (HBO) in South Africa - Update	Dr Frans Cronje, <i>President-Elect SAUHMA</i>	
16	08:50-09:20	HBO in the USA: Where are we going?	Dr Robert Warriner	
17	09:20-10:00	Survival Strategies for Hyperbaric Oxygen Therapy	Dr Robert Warriner	
18	10:00-10:30	Hyperbaric Chamber Safety: The Risk Assessment Process	Mr Francois Burman – <i>Technical Advisor of SAUHMA & author of the RAG</i>	
19	10:30-11:00	Refreshments & Exhibits		
Sixth Session		Chairperson: Dr Andy Branfield – SAUHMA Council Member		
20	11:00-11:30	DAN Southern Africa – Update	Dr Frans Cronje, <i>Executive & Medical Director - DAN SA</i>	
21	11:30-12:00	Patent Foramen Ovale: its possible role in DCI	Dr Frans Cronje, <i>Executive & Medical Director - DAN SA</i> Dr Hermie Britz – <i>Assistant Medical Director – DAN SA</i>	
22	12:00-12:10	Case Report: PFO in a Commercial Diver	Dr Jonathan Rosenthal <i>Medical Director National Hyperbaric Services</i>	
23	12:10-12:30	Occupational Diving Medicine on the West Coast	Sr Bridget Thomson <i>CDOC</i>	
24	12:30-13:00	Naval Diving	WO Frans Mostert SA Navy Diving Center Simon's Town	
25	13:00-14:00	Lunch		
Seventh Session		Chairperson: Dr Martin Bednarek – SAUHMA Council Member		
26	14:00-14:20	HBO Update: Session 1 Acute Indications	Carbon Monoxide Poisoning	Dr Robert Warriner
27	14:20-14:40		Acute Ischaemia & crush injuries	Dr Robert Warriner
28	14:40-15:10		Acute Infection	Dr Robert Warriner
29	15:10-15:30		Compromised Flaps & Grafts	Dr Robert Warriner
30	15:30-16:00	Refreshments & Poster Session		
Eighth Session		Chairperson: Dr David Papendorf – SAUHMA Council Member		
31	16:00-16:20	HBO Update: Session 2 Chronic Indications	Diabetic Wounds	Dr Robert Warriner
32	16:20-16:40		Late Radiation Injury	Dr Robert Warriner
33	16:40-17:00		Chronic Infection	Dr Robert Warriner
End of Day 2				

Sunday 23 September 2001

34	08:00-08:30	Refreshments & Poster Session		
Ninth Session		Chairperson: Francois Burman – SAUHMA Council Member		
35	08:30-08:50	HBO Update: Session 3: Controversial Issues	Cerebral Palsy	Dr Robert Warriner
36	08:50-09:10		Chronic Neurological Damage	Dr Robert Warriner
36	09:10-09:30		Acute Stroke	Dr Robert Warriner
37	09:30-10:00		HIV/ Aids	Dr Robert Warriner
39	10:00-10:30	Refreshments & Poster Session		
Tenth Session		Chairperson: Dr Frans Cronje – President Elect SAUHMA		
40	10:30-11:00	SASAEM's Position on HIV & Flying	Genl. Kenneth Ingham <i>President of SASAEM</i>	
41	11:00-11:30	Panel Discussion on Controversial Indications	<i>Hyperbaric Medicine Panel:</i> Dr Robert Warriner Dr Allan Kayle Dr Frans Cronje Col Gerhard van Niekerk Dr Mike Marshall Dr Jonathan Rosenthal Dr Conrad Dorfling Dr Louis Leipoldt Dr Herman van Rooyen	
42	11:30-12:00	The Way Forward	Dr Robert Warriner	
43	12:00-12:10	President's Report - Summary	Dr Allan Kayle – <i>Outgoing President of SAUHMA</i>	
44	12:10-12:20	Treasurer's Report	Mr Francois Burman	
45	12:20-13:00	Election of New Executive Committee	Dr Frans Cronje – <i>New President of SAUHMA</i>	
End of Day 3 – Conference Concludes				

ABSTRACTS

MEDICAL ASPECTS OF DIVING – DAVID ELLIOTT

The assessment of medical fitness for an individual intending to dive, whether for work or recreation, is rarely easy. The available guidance from authorities such as the navy, sports diving agencies and government bodies contain a number of pass / fail criteria and recommendations. These may provide useful advice for some but for many individuals the deciding factors are not obvious and a decision will depend on the training, experience and judgment of the examining doctor.

Historically, the navies of the world were the first to lay down medical standards for their divers. Many of these are based on what are predominantly theoretical considerations. A navy can afford to select only “perfect specimens” for training and later also to remove from diving those who acquire some medical or other condition which might impair their underwater safety or effectiveness. In achieving a good record in the avoidance of medical complications during diving, the navies have set standards that may have been unnecessarily high. Probably they also eliminated many who could have dived in safety. In contrast, recreational divers, who can choose when and where to dive, have not been subject to strict regulation and some, by insisting on their rights of personal freedom, have demonstrated that, in some circumstances at least, safe diving is compatible with medical conditions which would certainly exclude them from military diving.

Between these extremes of regulation and liberality are the non-military working divers. Their fitness is assessed against published standards that were based upon those used for naval divers and which, since then, have developed much further. In the United Kingdom, the Health and Safety Executive (HSE) issued guidance on the medical examination of divers that has been used successfully for many years and similar standards now exist in many other countries.

This conference serves the purpose of revisiting the critical elements of fitness assessment that is essential for the health and safety of the diver. Medical conditions that could affect in-water safety can affect any category of diver and experience from recreational divers is proving to be the foundation of much of the discussions regarding diving as a whole. In addition to diving fitness, the impact of diving, its dangers and its consequences will be the focus of much of the presentation. As those attending the conference bring with them their own experience in performing dive medical assessments and managing diving injuries and diseases, the presentations have been structured to provide and promote opportunities for interactive discussion.

It is my hope that this conference will provide an opportunity to review and discuss these issues and thereby arrive with a practical and useful approach to diving medical fitness assessment and the management of diving injuries.

HYPERBARIC OXYGEN IN THE USA: WHERE ARE WE GOING?

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Chief Medical Officer Praxis Clinical Services, Anaheim, CA USA

Healthcare delivery in the United States, particularly as it relates to the application of new, often expensive, technology, is clearly at a crossroads. This certainly applies to hyperbaric oxygen treatment as it does to a number of other modalities whose primary applications are for the treatment of patients with problem wounds. Additionally, the somewhat jaded history of past uses of hyperbaric air and oxygen treatment in the United States have created a challenging climate for legitimate practitioners in spite of the growing body of solid basic science and clinical evidence to support a mainstream role for hyperbaric oxygen treatment. In this session I will review the current state of hyperbaric oxygen treatment in the United States and briefly discuss the problems facing us today and in the future.

- I. The search for credibility and acceptance.
- II. The growing use of hyperbaric oxygen treatment for “off-label”, non-FDA approved, indications.

- III. Divisions within the hyperbaric medicine community.
 - IV. The impact of the “rush” to evidenced-based medicine and its effects on hyperbaric oxygen treatment.
 - V. The Office of the Inspector General Report on hyperbaric oxygen treatment.
 - VI. Fiscal limitations within the American healthcare delivery system and their impact on hyperbaric oxygen treatment.
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HYPERBARIC OXYGEN: SURVIVAL STRATEGIES NOW AND FOR THE FUTURE

Robert A. Warriner III M.D., FACA, FCCP, CWS
Medical Director Southeast Texas Center for Wound Care and Hyperbaric Medicine, Conroe, TX USA
Chief Medical Officer Praxis Clinical Services, Anaheim, CA USA

Responding to the OIG report, issues of appropriateness, consistency, and quality:

Department of Health and Human Services, Office of Inspector General

HYPERBARIC OXYGEN THERAPY: Its Use and Appropriateness

October 2000 OEI 06-99-00090

FINDINGS

Questions persist concerning the appropriate usage of hyperbaric oxygen therapy.

- Hyperbarics is most commonly used to treat wound related problems.
- Costs per individual are very high.
- Individual outcomes vary greatly.

Potential for expansion exists within the hyperbaric industry.

- Medicare payments and providers steadily increased from 1995 to 1998.
- Utilization varies between geographic regions.

\$14.2 million was paid in error for hyperbaric treatments (of the \$49.9 million allowed charges for outpatient hospitals and physicians).

- The discrepancy between indications recommended by the hyperbaric community and those acceptable for Medicare reimbursement contribute to the inappropriate billing.
- Diagnosis codes are sometimes used inappropriately to obtain reimbursement for uncovered indications.
- Some providers did not provide sufficient documentation to justify Medicare reimbursement.

An additional \$4.9 million was paid for treatments deemed to be excessive.

Our review raised several quality of care concerns.

- Another \$11.1 million was spent on treatments of questionable quality.
- Physician attendance remains a point of contention. Our review indicates physician attendance is strongly correlated with quality of care and the reduction of inappropriate billing. Many facilities do not require physical physician attendance.
- Training requirements may provide a means of promoting quality care.
- Many carriers and intermediaries play only a limited role in assuring the quality of hyperbaric care.

Some carriers and intermediaries do not apply edits and appropriate medical review standards to ensure compliance with the CIM 35-10.

HCFA's guidance for this procedure is limited.

- Many carriers (68%) and intermediaries (54%) have no local medical review policy or payment guidelines independent of the CIM 35-10.
- Carriers and intermediaries vary in how they interpret and implement CIM 35-10.
- Standards of care have not been incorporated into HCFA's guidance to reduce over-utilization. Many hyperbaric practices are started with little information on proper utilization or reimbursement policies. Many billing physicians and facilities have little HBO2 experience. Many facilities do not independently substantiate the diagnostic basis for treatment. An absence of documentation guidance combined with the inadequacy of medical records found in this review suggests this area needs attention.

- The role of the hyperbaric physician is unclear. The duties implicit in billing the 99183 hyperbaric code are unclear. The definition of “attendance” is unclear.

OIG RECOMMENDATIONS

Our results show that a significant percentage of HBO2 is provided inappropriately. HBO2 should either never have been used (not a covered diagnosis), excessive treatments were provided, or documentation of services was not available.

To address concerns raised in this report, we recommend that the Health Care Financing Administration:

- Initiate its national coverage decision process for HBO2. The review is requested because (1) questions persist concerning the appropriate usage of HBO2, (2) there are program integrity issues surrounding significant inappropriate payments, and (3) there are conflicting carrier and intermediary policies. Considering the overlap of HBO2 with other wound-care procedures, this review might consider HBO2 within the broad context of wound care and in terms of its relative cost-effectiveness. Improve policy guidance:
 1. Provide clear descriptions of covered conditions;
 2. Propose additional ICD-9 codes as needed to more closely parallel covered conditions;
 3. Establish a clear physician attendance policy;
 4. Consider establishing training requirements;
 5. Consider incorporating clinical standards of patient selection and treatment protocols designed with the aid of hyperbaric physicians; and,
 6. Specify medical record documentation requirements.
- Improve oversight:
 1. Require contractors to initiate edits and medical review procedures which insure that uncovered diagnoses are not paid and high treatment thresholds are subject to review.
 2. Explore the establishment of a registry of facilities and/or physicians providing HBO2 to improve communication and facilitate monitoring.

Responding to evidenced-based medicine reviews of the application of hyperbaric oxygen treatment...do we have the data to support what we do?

BlueCross BlueShield Association Assessment Program
 Volume 14, Number 13, August 1999
 Volume 14, Number 15, December 1999
 Volume 14, Number 16, December 1999
 Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III
 Blue Cross Blue Shield Association Technology Evaluation Center

Medicare Services Advisory Committee, Australia (Commonwealth Minister for Health and Aged Care)
Hyperbaric Oxygen Therapy
 November 2000
 MSAC applications 1018 – 1020, Assessment report

BRITISH JOURNAL OF MEDICINE
 Clinical Evidence, Dereck Hunt and Hertzell Gerstein, June, 2001 Issue 5

American Diabetes Association (April 7-8, 1999) Consensus Development Conference on Diabetic Foot Wound Care
 Diabetes Care 22(8) 1354-1360, 1999

Cochrane Review
 The Cochrane Library, Issue 3, 2001

Undersea and Hyperbaric Medical Association
 Oxygen Therapy Committee Report, 1999

Generally accepted definitions of the relative value of levels of evidence:

Corresponding to AHCPH Guideline Level of Evidence A

- Supportive evidence from well conducted randomized controlled trials including 100 patients or more.

- Supportive evidence from well-conducted randomized controlled trials that included fewer than 100 patients.
- Supportive evidence from well-controlled cohort studies.

Corresponding to AHCPR Guideline Level of Evidence B

- Supportive evidence from a well-conducted case-control study.
- Supportive evidence from poorly controlled or uncontrolled studies.
- Conflicting evidence with the weight of evidence supporting the recommendation.

Corresponding to AHCPR Guideline Level of Evidence C

- Expert opinion

HYPERBARIC OXYGEN TREATMENT FOR CARBON MONOXIDE POISONING

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BlueCross BlueShield Association Assessment Program

Volume 14 (2), August 1999, volume 14 (15), December 1999, volume 14 (16), December 1999

Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III

Blue Cross Blue Shield Association Technology Evaluation Center

- Hyperbaric oxygen treatment for carbon monoxide poisoning not evaluated.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

- “A Cochrane systematic review failed to demonstrate a significant reduction in neurologic sequelae following HBOT for carbon monoxide poisoning. Additional rigorous studies are required to examine the efficacy of HBOT on other outcomes and in distinct patient subsets.”

Cochrane Review

The Cochrane Library, Issue 3, 2001

- “There is no evidence that unselected use of HBO in the treatment of acute CO poisoning reduces the frequency of neurological symptoms at one month. However, evidence from the available randomized controlled trials is insufficient to provide clear guidelines for practice. Further research is needed to better define the role of HBO, if any, in the treatment of carbon monoxide poisoning. This research question is ideally suited to a multicentre, randomized, double-blind controlled trial.

CD Scheinkestel, M Bailey, PS Myles, K Jones, DJ Cooper, IL Millar, DV Tuxen. Hyperbaric or normobaric oxygen for acute carbon monoxide poisoning: a randomized controlled clinical trial. *MJA* 1999; 170:203-210. Our prospective, randomized controlled trial of CO-poisoned patients of all severities attempted to address the shortcomings of previous studies by incorporating sham treatments for the NBO group, blinded outcome assessment and extensive neuropsychological assessment. Our HBO protocol was designed to provide the maximum potential advantage for HBO therapy based on currently available knowledge. When compared with three days of normobaric oxygen, we could find no evidence that treatment with HBO was beneficial to outcome and therefore do not recommend its use.

VS.

LK Weaver, RO Hopkins, S Churchill, KJ Chan, AH Morris, TP Clemmer, CG Elliott, JF Orme, FO Thomas, D. Habersock Pulmonary/Critical Care Medicine, LDS Hospital and University of Utah, Salt Lake City, Utah 84143. Outcomes of acute carbon monoxide poisoning treated with hyperbaric or normobaric oxygen. Abstracts of the UHMS Annual Scientific Meeting Sessions, June 14-16, 2001, San Antonio, TX.

INTRODUCTION: Decisions regarding use of hyperbaric oxygen therapy (HBO2) in acute carbon monoxide (CO) poisoning are difficult because of lack of double-blind randomized clinical trial (RCT) data.

METHODS: Double-blind RCT in acute CO poisoning. Inclusions: <23 hrs from CO exposure to randomization, age > 15 years, not pregnant. Stratification on: Age < or > 40 years); hrs from CO poisoning to chamber (< or > 6); history of unconsciousness (LOC). All patients were treated 3x at 6-12 hr intervals in a monoplace chamber with HOB2 or normobaric oxygen (NBO2). Neuropsychological tests (NPT) were administered immediately after

treatments 1 and 3. CO poisoning questionnaires, functional outcome tests and the NPT were given at 2 and 6 weeks after CO poisoning.

RESULTS: 152 patients were enrolled in the RCT (LOC=49%, mean COHb=25%). 95% completed follow-up. HBO2-treated patients had decreased neuropsychological sequelae (25% v. 46%, p= 0.007), self-reported memory difficulties (45% v. 61%, p= 0.058), and Attention / Concentration problems (47% v. 64%, p = 0.039). Pre-chamber cerebellar dysfunction was associated with neuropsychological sequelae (Odds ratio = 5.71, p = 0.004). HBO2 decreased neuropsychological sequelae after adjustment for pre-chamber cerebellar dysfunction and stratification (Odds ratio = 0.45, p = 0.029). In patients with any of the following: LOC, COHb > 25%, Age > 50 yrs, a metabolic acidosis (base excess < -2 mEq/L), HBO2 improved outcome. In patients with none of these 4 criteria, HBO2 did not improve outcome. The HBO2 group tolerated chamber therapy better (96% v. 82%, p= 0.002).

CONCLUSIONS: HBO2 improved outcome following acute CO poisoning. We recommend HBO2 therapy in acute CO poisoning in symptomatic patients who are < 24 hrs from poisoning, plus any of the following: LOC, COHb > 25%, Age > 50 yrs, or a metabolic acidosis. Supported by Desert Foundation (Grants #247, 275, and 305), LDS Hospital.

Additional References:

- Ducasse JL, Celsis P, Marc-Vergnes JP. Non-comatose patients with acute carbon monoxide poisoning: hyperbaric or normobaric oxygenation? *Undersea Hyperb Med* 1995; 22: 9-15.
- Gorman DF, Clayton D, Gilligan JE, Webb RK. A longitudinal study of 100 consecutive admissions for carbon monoxide poisoning to The Royal Adelaide Hospital. *Anaes Intens Care* 1992; 20: 311-316.
- Goulon M, Barois A, Rapin M, et al. Carbon monoxide poisoning and acute anoxia due to breathing coal gas and hydrocarbons. *J Hyperbar Med* 1986; 1: 23-41.
- Mathieu D, Nolf M, Durocher A, et al. Acute carbon monoxide poisoning: risk of late sequelae and treatment by hyperbaric oxygen. *J Toxicol Clin Toxicol* 1985; 23: 315-324.
- Mathieu D, Wattel F, Mathieu-Nolf M, et al. Randomized prospective study comparing the effect of HBO versus 12 hours NBO in non-comatose CO poisoned patients: results of the interim analysis. *Undersea Hyperb Med* 1996; 23 Suppl: 7.
- Myers RAM, Snyder SK, Emhoff TA. Subacute sequelae of carbon monoxide poisoning. *Ann Emerg Med* 1985; 14: 1163-1167.
- Raphael J, Elkharrat D, Jars-Guinestre M, et al. Trial of normobaric and hyperbaric oxygen for acute carbon monoxide intoxication. *Lancet* 1989; 2: 414-419.
- Roche L, Bertoye A, Vincent P. *Comparison de deux groupes de vingt intoxications oxycarbonees traitees par oxygenenormobare et hyperbare. Lyon Med* 1968; 49: 1483-1499.
- Thom SR, Taber RL, Mendiguren II, et al. Delayed neuropsychologic sequelae after carbon monoxide poisoning: prevention by treatment with hyperbaric oxygen. *Ann Emerg Med* 1995; 25: 474-480.
- Willms SJ, Turner F, Kerr J. Carbon monoxide or smoke inhalations treated with oxygen (hyperbaric vs normobaric): 118 reviewed. *Undersea Biomed Res* 1985; 12 Suppl: S56.

HYPERBARIC OXYGEN FOR ACUTE ISCHEMIAS AND CRUSH INJURY

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BlueCross BlueShield Association Assessment Program

Volume 14 (2), August 1999, volume 14 (15), December 1999, volume 14 (16), December 1999

Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III

Blue Cross Blue Shield Association Technology Evaluation Center

- “One well-designed randomized placebo-controlled double-blinded study of 36 patients reported the results of HBO treatment in severe crush injuries of the limb. Patients were at risk of limb amputation. These data, in combination with background evidence from uncontrolled case reports and case series, are considered sufficient to permit conclusions regarding the effect of adjunctive HBO therapy on the health outcomes of patients with these life- and limb-threatening injuries. Favorable results with the use of adjunctive HBO therapy were demonstrated in the one randomized placebo-controlled double-blinded study involving 36 patients with severe crush injuries of the limb. The study reported a significant decrease in the rate of repeat surgical procedures, including amputations, and an improved rate of complete wound healing in patients treated with adjunctive HBO therapy as compared to placebo-treated patients. There is a strong physiological rationale for the use of hyperbaric oxygen in acute traumatic ischemias and there are data from animal models to suggest its positive effect. There is also background evidence from the clinical case reports and case series that suggest positive limb salvage results. The favorable findings of the randomized controlled trial, supported by a strong base of background evidence, are sufficient to determine that HBO therapy as an adjunct to standard surgical and medical management improves the health outcomes of patients with life- and limb-threatening acute traumatic ischemias as compared to standard management alone. Hyperbaric oxygen therapy for acute traumatic peripheral ischemias is recommended

for the treatment of life- or limb-threatening injuries. In these cases, HBO therapy is used as an adjunct to comprehensive surgical and medical management. The additional of HBO therapy to standard management has been shown to improve the health outcomes of patients with severe traumatic ischemias. The results obtained using hyperbaric oxygen therapy for acute traumatic ischemias are likely to be achievable outside the investigational setting. Results comparable to those reported in the literature can be expected when patients are treated in the context of comprehensive surgical and medical management for these injuries.”

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

Soft tissue injuries: acute ankle sprains

- “A single study provided no evidence to support the use of HBOT for acute ankle sprains.” Soft tissue injuries: crush injuries
- “Soft tissue injuries: crush injuries...A single study found that exposure to HBOT benefited patients with crush injuries of the lower limbs, although this benefit was mainly reported in terms of decreasing surgical interventions rather than decreased healing time. Studies examining a broader range of outcomes in larger populations are required to generate firmer and more generalizable conclusions.”

Cochrane Review

The Cochrane Library, Issue 3, 2001

- Hyperbaric oxygen treatment for acute traumatic ischemias and crush injury not reviewed.

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HYPERBARIC OXYGEN FOR ACUTE INFECTIONS

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BlueCross BlueShield Association Assessment Program

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Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III

Blue Cross Blue Shield Association Technology Evaluation Center

Clostridial myonecrosis

- “The body of available information is considered adequate to permit conclusions regarding the effects of HBO on the health outcomes of patients with gas gangrene. While there are no controlled prospective studies of HBO therapy and gas gangrene, there are numerous retrospective series that have reported the mortality outcomes of gas gangrene patients treated with standard care plus adjunctive HBO. Outcomes were reported for 903 patients across 17 clinical series. Due to the widespread and conventional use of HBO therapy for gas gangrene, limited information is available on the mortality outcomes of patients treated with standard care alone (no HBO). Five retrospective reviews involving 118 patients were identified. Additionally, three retrospective reviews of 133, 41, and 24 patients offered same-study comparisons of HBO-treated patients. The mortality associated with HBO treatment is substantially lower than that associated with standard care; the difference in mortality between the two modes of treatment is sufficiently different to increase confidence that the results were not skewed by patient selection bias and that HBO treatment is effective. The retrospective evidence is further supported by a strong physiologic

rationale and controlled animal data suggesting that adjunctive HBO significantly reduces the mortality associated with gas gangrene. A prospective clinical study in which HBO is purposefully withheld in some patients is not ethical, given the accumulated evidence suggesting the effectiveness of HBO in reducing mortality when used in combination with surgical and medical management. There is sufficient evidence to conclude that hyperbaric oxygen therapy is a beneficial adjunct to the standard surgical and medical management of gas gangrene. The average mortality rate of gas gangrene patients treated with standard care plus HBO therapy was 22% across 17 clinical series involving 905 patients. In contrast, 5 clinical series of 118 patients treated with standard care alone averaged 51% mortality. Although not well controlled, 3 retrospective reviews offered same study comparisons of HBO-treated and non-HBO treated patients. Each of the papers presented similar results and suggested that the addition of HBO therapy to standard management leads to more favorable mortality outcomes (22% versus 45%, n=133, 31%, n=41; and, 27% versus 56%, n=24). The results obtained using hyperbaric oxygen therapy for clostridial myonecrosis have been obtained in multiple settings and are likely to be achievable outside the investigational setting. Results comparable to those reported in the literature can be expected when adjunctive hyperbaric oxygen therapy is used in combination with comprehensive surgical and antibiotic management and supportive critical care.

Necrotizing soft-tissue infections

- “There are some retrospective data to suggest that HBO may have a positive impact on health outcome, but there are also retrospective data to suggest that it has no impact on outcome. Four clinical series retrospectively compared the outcomes of patients treated with HBO to controls who did not receive HBO. Two reviews (n=54 and n=37) failed to show that adjunctive treatment with HBO statistically reduced mortality when used in conjunction with conventional surgical and antibiotic therapy. The other two studies (n=29 and n=26) observed a favorable and statistically significant effect on survival when HBO was added to standard management. Interpretation of the evidence is complicated by the overall weak methodology employed by the 4 reports. Problems include the small sample sizes and the retrospective designs. The review periods were lengthy (range 7-12 years), and treatment outcomes may have varied merely because of growing surgical experience, advances in critical care medicine, and the development of more effective antibiotics over time. In two studies, data interpretation is further complicated by the inclusion of patients with clostridial myonecrosis in the study population, a different clinical entity from necrotizing soft-tissue infections that requires its own analysis of HBO effectiveness. In the absence of controlled prospective data and given the conflicting findings reported in the retrospective data, the available evidence is considered insufficient to determine the effect of HBO therapy on the health outcomes of patients with necrotizing soft-tissue infections.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

Necrotizing soft tissue infections: general

- “Overall, there was some indication that HBOT improved survival in patients with necrotising soft tissue infections. However, one study indicated the number of operations was increased in the intervention group. The studies addressing these conditions looked at different populations of patients and their research designs were dissimilar. This made it difficult to quantify the effects of HBOT. However, any final judgment should be reserved until more conclusive evidence is available.”

Necrotizing soft tissue infections: necrotizing fasciitis

- “The studies collected looked at different populations, the sample sizes were small, and information about the HBOT intervention was inadequate. The studies presented little firm evidence to support the use of hyperbaric oxygen therapy for necrotizing fasciitis.”

Necrotizing soft tissue infections: Fournier’s gangrene

- “A single study suggests patients with Fournier’s gangrene will benefit from exposure to HBOT. However, there is some concern about the possibility of systematic differences affecting the outcome. More rigorous studies in different settings and examining more varied outcomes are required to provide more generalizable evidence to confirm a positive effect.”

Cochrane Review

The Cochrane Library, Issue 3, 2001

- Hyperbaric oxygen treatment for acute infections not evaluated.

Differential Diagnosis And Treatment Of Common Necrotizing Soft Tissue Bacterial Infections

	Crepitant Anaerobic Cellulitis	Progressive Bacterial Synergistic Gangrene	Necrotizing Fasciitis	Nonclostridial Myonecrosis
Incubation	> 3 days	2 weeks	1-4 days	Variable, 3-14 days
Onset	Gradual	Gradual	Acute	Acute
Toxemia	None or slight	Minimal	Moderate to marked	Marked
Pain	Absent	Moderate	Moderate to severe	Severe
Exudate	None or slight	None or slight	Profuse serosanguinous	Dishwater pus
Odor to exudate	+/- Foul	+/- Foul	Foul	+/- Foul
Gas	Abundant	May be present	Usually not present	Not pronounced
Muscle	No change	No change	Viable	Marked change
Skin	Little change	Shaggy ulcer, gangrenous margins	Pale red cellulitis	Minimal change
Mortality	5-10%	10-25%	30%	75%
Mortality	5-10%	10-25%	30%	75%

TREATMENT				
	Crepitant Anaerobic Cellulitis	Progressive Bacterial Synergistic Gangrene	Necrotizing Fasciitis	Nonclostridial Myonecrosis
Antibiotics	Yes	Yes	Yes	Yes
Surgery	I&D	I&D	I&D	Muscle removal
Adjunctive HBO	No	Yes (severe cases)	Yes (compromised host)	Yes

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Clostridial myonecrosis

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Necrotizing fasciitis

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HYPERBARIC OXYGEN FOR COMPROMISED FLAPS AND GRAFTS

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- “The evidence consists of a single randomized controlled trial of 48 patients. The paper reported that adjunct treatment with HBO improved the survival of split skin grafting as compared to no adjunct treatment. However, the subjects may no represent “compromised” patients. No selection criteria were employed and the investigators accepted all patients presenting for split skin grafting regardless of size or situation of graft or underlying etiology. Therefore, it is difficult to generalize these results to truly compromised grafts. Additionally, the surgical and perioperative advances that have taken place since 1967 limit the application of these results to current therapy. No further primary evidence from controlled trials was found in the literature. Background evidence based on animal models is inconsistent. Some

controlled laboratory experiments demonstrate improved graft and flap survival while others do not. There are a few case reports and one uncontrolled clinical series that report favorable results. Based on the patient selection questions surrounding the randomized controlled study and the inconsistent results found in experimental studies, the evidence is considered insufficient to support the use of adjunctive HBO therapy in compromised skin grafts or flaps. Insufficient data are available to determine if adjunctive hyperbaric oxygen therapy improves the health outcomes of patients with compromised skin grafts or flaps.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

- Hyperbaric oxygen treatment for this indication not evaluated.

Cochrane Review

The Cochrane Library, Issue 3, 2001

- Hyperbaric oxygen treatment for this indication not evaluated.

Hyperbaric Oxygen Treatment in Compromised Free Flaps/Replants

<i>Flap Compromise Condition</i>	<i>Application of Hyperbaric Oxygen Treatment</i>
Healing	No
Low arterial inflow	Yes
Complete arterial inflow occlusion	No (surgical attempts to reestablish flow indicated)
Venous outflow occlusion	No (possibly with leeching)
Skin ischemia reperfusion (>8hrs)	Yes
Muscle ischemia reperfusion (>4hrs)	Yes
Any secondary ischemia	Yes
Established necrosis	No

Hyperbaric Oxygen Treatment in Pedicled Flaps

<i>Flap Compromise Condition</i>	<i>Application of Hyperbaric Oxygen Treatment</i>
Random flap ischemia	Yes
Low arterial inflow	Yes
Venous congestion	Yes (only with leeching)
Irradiated recipient tissue bed	Yes (best accomplished prior to grafting)
Established necrosis	No

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HYPERBARIC OXYGEN FOR DIABETIC WOUNDS

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Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III

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Chronic non-healing wounds

- “Health outcomes were reported in the literature for 154 patients with chronic non-healing wounds. In the available reports, the study population consisted of patients with adequately perfused ulcers of the lower extremity. Selection criteria varied but generally included patients at risk of lower extremity amputation due to full-thickness ulcers of 6-12 months’ duration without signs of healing despite appropriate medical and surgical management. All reports were controlled clinical trials. Three studies were randomized and involved 70, 30, and 16 patients respectively. Two non-randomized controlled trials reported the results of 28 and 10 patients, respectively. Overall, 138 wounds were chronic diabetic ulcers and 16 were chronic non-diabetic ulcers. Sufficient data are available to permit conclusions regarding the effect of HBO therapy on health outcomes of patients with chronic non-healing wounds. Favorable results with the use of HBO therapy were demonstrated in 5 studies involving 154 patients. All wounds were of the lower extremity, were adequately perfused, and most wounds (89%) were chronic diabetic ulcers. The studies reported a significant decrease in the rate of major amputation for patients treated with standard wound care alone. Two randomized studies reported improved amputation rates for patients treated with HBO versus patients receiving standard wound care alone (9% versus 33% and 13% versus 47%). An additional non-randomized study reported similar results (11% vs 40%). HBO-treated patients also demonstrated significantly decreased wound surface area as compared to control patients according to one randomized study of 16 patients and one non-randomized study of 10 patients. There is sufficient evidence to support the adjunctive use of HBO in the treatment of adequately perfused chronic non-healing wounds of the lower extremity in combination with standard wound care. Patients who have received standard wound care plus HBO have shown fewer amputations and improved wound healing rates and in comparison to similar patients treated with standard wound care alone. Hyperbaric oxygen therapy for chronic non-healing wounds is recommended only for the treatment of adequately perfused wounds that are truly refractory to conventional medical and surgical treatment. In these cases, HBO therapy is used as an adjunct to standard wound care. The addition of HBO therapy to the standard wound care regimen has been shown to improve the health outcomes of patients with chronic non-healing wounds. The results obtained using hyperbaric oxygen therapy for chronic non-healing wounds have been obtained in multiple settings are likely to be achievable outside the investigational setting. Results comparable to those reported in the literature can be expected when patients are treated in the context of a good wound care program.”

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

Diabetic wounds

- “The similar characteristics of the collected studies and their statistical homogeneity provided some confidence in the effects of HBOT on specific outcomes. Major amputations were less likely in diabetic patients with chronic ulceronecrotic lesions who were exposed to HBOT compared to those receiving comparison therapies only. For these patients there was some indication that HBOT promoted wound healing and reduced length of hospital stay, but also increased the risk of minor amputations. These last few outcomes represent inferences drawn on a smaller population group, with wide margins of error, and further studies are required. These results, in the light of low uptake rates of the technology for this particular indication, generally indicate there is potential for this technology in the treatment of diabetic wounds.”

Non-diabetic wounds

- “There is some indication that exposure to 100 percent oxygen in a hyperbaric chamber for lengths up to a month was associated with decreases in the area of chronic, non-diabetic wounds. However, the evidence comes from just one study, which included small numbers of relatively tightly selected subjects and examined only one outcome measure. More studies in different settings, examining more varied outcomes (e.g. absolute wound healing) are required to provide more generalizable evidence of a treatment effect.

Cochrane Review

The Cochrane Library, Issue 3, 2001

- Hyperbaric oxygen treatment for this indication not reviewed.

British Journal of Medicine, Clinical Evidence

June, 2001 Issue 5

- “For diabetic foot ulcer, likely to be beneficial...Systemic Hyperbaric oxygen
 Limited evidence from two small RCT’s suggests that systemic hyperbaric oxygen reduces the risk of foot amputation in people with severe infected foot ulcers. Two small RCT’s have found that, compared with routine care, systemic hyperbaric oxygen reduces the risk of foot amputation in people with severe infected foot ulcers.
 Benefits: We found one systematic review (search date 1998, 1 RCT) and one additional RCT. The RCT in the review (70 people with severe infected diabetic foot ulcers) compared usual care (aggressive debridement, broad spectrum intravenous antibiotics, revascularization if indicated, and optimized glycemic control) versus usual care plus daily 90-minute sessions of systemic hyperbaric oxygen at 2.2-2.5 atmospheres. Participants either had full thickness gangrene or abscess, or a large infected ulcer that had not healed after 30 days. After 10 weeks, rates of major amputation were significantly lowered in the intervention group (8.6% vs. 33% in the control group; RRR 74%, 95% CI 16% to 92%; ARR 24%, 95% CI 4% to 45%; NNT 5, 95% CI 2 to 23). The additional RCT (30 people with chronic infected foot ulcers) compared usual treatment (including debridement, intravenous antibiotics, and optimized glycemic control) versus usual treatment plus four treatments with hyperbaric oxygen over 2 weeks. It found no significant reduction of the risk of major amputation in the intervention group (ARR + 33%, 95% CI -1.6% to + 68%). Harms: In the larger RCT, two people developed symptoms of barotraumatic otitis, but this did not interrupt treatment. Comments: The additional RCT may have been too small to rule out a clinically important effect.”

American Diabetes Association (April 7-8, 1999) Consensus Development Conference on Diabetic Foot Wound Care

Diabetes Care 22(8) 1354-1360, 1999

- “There are no randomized controlled trials supporting the use of hyperbaric oxygen therapy to treat neuropathic diabetic foot wounds (see above). Given the limited evidence of positive results in select groups of patients with severe wounds, additional randomized clinical trials are warranted. It is reasonable, however, to use this costly modality to treat severe and limb- or life threatening wounds that have not responded to other treatments, particularly if ischemia that cannot be corrected by vascular procedures is present.”

Summary of Clinical Series of Non-Healing Lower Extremity Wounds Treated With Hyperbaric Oxygen

Author	Citation	Study Design	HBO	Control	Outcomes
Davis, JC	Clin Pod Med Surg, 1987, 4(2):429-437	Uncontrolled retrospective review, all diabetes	168	NA	All patients with Wagner III-IV wounds, 118/168, 70%, healed primarily or with toe amp or TMA, 50, 30%, failed requiring BKA or AKA, “failures in patients with large vessel disease at or above the ankle not amenable to surgical correction”
Baroni G, et al	Diabetes Care, 1987, 19(12): 81-86	Controlled prospective study of HBO vs conventional care involving 28 consecutive patients, all diabetes, strict metabolic control, daily debridement, all presenting with Wagner IV	18	10	HBO group 17/18 symptomatic neuropathy, 6/18 symptomatic macroangiopathy, all gangrenous lesions of forefoot, control group 9/10 symptomatic neuropathy, 4/10 symptomatic macroangiopathy, 16/18 healed, 2/16 BKA, 13%, in HBO group, 1/10 improved, none healed, 4/10, 40%, BKA in control group
Cianci P, et al	Journal Hyperbaric Medicine, 1988, 3(3): 127-141	39 consecutive patients with foot wounds, 49% diabetic, 51% limb threatening, 41% had prior vascular surgery with persistent wound healing failure	39	NA	Overall limb salvage rate (TMA or less) 35/39, 90%, diabetes and need for revascularization increased risk of failure (only 75% successful if diabetes and revascularization for limb threatening lesion), total hospital charges of \$36,706

Oriani G, et al	Journal Hyperbaric Medicine, 1990, 5(3): 171-175	Retrospective, inpatient study, matched controls by refusal to enter chamber, non blinded, non randomized, all diabetes	62	18	59/62, 95%, of HBO group healed, 5% amputated, 12/18, 66%, of controlled group healed, 33% amputated
Wattel FE, et al	Journal Hyperbaric Medicine, 1991, 6(4): 263-267	Retrospective but consecutive series, no controls, all with diabetes	59	Na	52/59 healed, 7/59 required amputation, no differences between successes and failures except healed group had higher TcPO2 values during HBO (786+/- 258 healed vs 323+/-214 failed)
Oriani G, et al	Journal Hyperbaric Medicine, 1992, 7(4): 213-221	Retrospective, consecutive patients, all diabetes, includes patients in Oriani 1990 above but no additional controls	151	NA	130/151, 86% healed with HBO, 21/15, 14% failed with HBO
Doctor N, et al	Journal Postgraduate Medicine, 1992, 38(3): 112-114	Prospective, randomized, controlled, all diabetes	15	15	Control of infection quicker in HBO group (19 + cultures to 3+ cultures compared to 16 + cultures to 12 + cultures), major amputation rate 2/15, 13%, in HBO group vs 7/15, 46%, in control group
Hammarlung C, Sundberg T	Plastic Reconstructive Surgery, 1994, 93: 829-833	Randomized, prospective, double-blinded controlled trial, HBO vs conventional care for leg ulcers, no diabetes	8	8	HBO group (30 treatments) showed mean decrease of wound areas at weeks 2, 4, 6 of 6%, 22%, 35.7% compared to control group values of 2.8%, 3.7%, and 2.7%
Stone JA, et al	Diabetes, 1995, 44(supp 1): 71A	Retrospective, 469 consecutive patients, all diabetes, grouped on the basis of hypoxic TcPO2 into HBO + growth factors and growth factors alone	87	382	Patients referred for HBO had statistically significantly larger wounds, more wounds per patient, and greater percentage (31 vs 19%) initially recommended for amputation, limb salvage in HBO group 72%, in non HBO group 53%
Faglia E, et al	Diabetes Care, 1996, 19(12): 1338-1343	Consecutive series, all diabetes, prospective, randomized, controlled	35	33	31/35 Wagner III-IV, 3/35, 9%, in HBO group (mean 39 treatments) underwent major amputation, 28/33 Wagner III-IV, 11/33, 33%, in control group underwent major amputation
Cianci P, Hunt TK	Wound Repair and Regeneration, 1997, 5: 141-146	24 month mean follow up of previously healed Wagner III-IV limb threatening foot wounds, all diabetes (41 patient subset of 101 consecutive patients)	41	NA	20/41, 49%, had undergone prior revascularization, 35/41, 85%, had initial limb salvage, 28/35 could be contacted for late follow up, 1/28 had undergone a BKA, 27/28, 96%, remained healed, HBO healed group had excellent durability (compared to Steed, Wound Rep Reg, 1996, 4: 230-233, report from platelet growth factor study in diabetic foot ulcers, 16/36, 44%, healed in 20 week trial, follow up mean 25 months, only 5/16, 31%, remained healed)
Zamboni WA, et al	Undersea Hyperbaric Medicine, 1997, 24(3): 175-179	Prospective, controlled, grouped by refusal to undergo HBO, all diabetes, followed rate of wound closure over 7 week period, HBO group had higher initial percentage of osteo	5	5	"Vascular evaluation is the first priority to correct treatable vascular lesions." 4/5, 80%, in HBO group (mean 30 treatments) showed ultimate healing with the remaining 1/5 receiving a successful calcaneal flap, 4/5, 80%, in control group had persistent non healing
Hanna GP, et al	Journal American College of Cardiology, 1997, 30: 664-669	Prospective assessment of consecutive patients with infrapopliteal transcatheter angioplasty coupled with simultaneous HBO for distal limb salvage in diabetes	29	NA	TcPO2 < 40mmHg associated with poor healing, TcPO2 changes better predictor of ultimate outcomes than ABI, at 6 months 23/29, 79%, had complete healing, 3/29 had failed recanalizations with subsequent BKAs, 2/29 had BKAs despite successful recanalization due to persistent severe osteomyelitis, 1/29 expired from AMI with healing wound
			606	463	Totals in each group exclude non-diabetic patients as much as determinable and the 41 patients from the Cianci long-term follow up, bipedal limb salvage rate in HBO group 430/606, 71%, vs. 244/463, 53%, control group
Fife C, et al	Submitted for publication	Retrospective 4 center review, all patients had diabetes, received HBO	971	NA	717/971, 74%, were improved, chronic renal failure and higher Wagner scores predicted poorer outcomes

HYPERBARIC OXYGEN FOR LATE RADIATION INJURY

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Blue Cross Blue Shield Association Technology Evaluation Center

- Hyperbaric oxygen treatment for this indication not evaluated.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

Osteoradionecrosis: prevention

- “A single study provides some evidence that exposure to HBOT is more efficacious than penicillin in the prevention of osteoradionecrosis in this population of patients. The patient sample is representative of the potential target population to which inferences are to be applied.”

Osteoradionecrosis: treatment

- “One study provides some evidence of the efficacy of HBOT in the treatment of osteoradionecrosis. More evidence from properly randomised clinical trials focussing on other outcomes will be needed to determine the effectiveness of HBOT for this indication.”

Soft tissue radionecrosis treatment

- “No articles met inclusion criteria for consideration of hyperbaric oxygen treatment for this indication.

Cochrane Review

The Cochrane Library, Issue 3, 2001

- Hyperbaric oxygen treatment for this indication not evaluated.

Management of Osteoradionecrosis by Stage

Stage I: All patients are placed in stage I except those with advanced disease.

- If there is improvement after 30 HBO treatments, they continue to 40.
- If there is no improvement after 30 HBO treatments, they advance to Stage II

Exceptions to progression to Stage II include patients with:

- Pathophysiologic fractures
- Fistulas
- Radiographic evidence of osteolysis to the inferior border

These patients progress directly to Stage III treatment and usually require discontinuity resection.

Stage II: Patients who have not responded to initial 30 HBO treatments.

- All have transoral sequestrectomy followed by 10 more HBO treatments for total of 40
- Non-responders advance to Stage III

Stage III: Patients with pathologic fracture, oral/ cutaneous fistula, or radiographic evidence of full thickness usually go to require mandibular resection.

When resection is required, reconstruction is performed through a strictly transcutaneous approach 10-12 weeks later. 10 HBO treatments can be provided immediately following reconstruction. Prosthetic rehabilitation can begin 3 months after completion of reconstruction.

Prevention of ORN

- Requires multidisciplinary team approach
- Pre-radiation
 - Tooth removal (allow 21 days pre-radiation)
 - Constructing fluoride carriers
 - Prophylaxis, plaque, caries control
 - Patient education
- Dosage >6000 cGy, remove teeth directly in field

- Post-radiation
 - 20 HBO treatments pre extraction
 - 10 HBO treatments post extraction

Marx-University Of Miami Protocol For Maxillofacial Reconstruction & Elective Surgery In Irradiated Tissues

- 20 HBO treatments of 100% oxygen at 2.4 ATA for 90 minutes
- Reconstructive surgery or other elective surgery
- 10 postsurgical HBO treatments of 100% oxygen at 2.4 ATA for 90 minutes

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HYPERBARIC OXYGEN FOR CHRONIC INFECTION

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BlueCross BlueShield Association Assessment Program

Volume 14 (2), August 1999, volume 14 (15), December 1999, volume 14 (16), December 1999

Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III

Blue Cross Blue Shield Association Technology Evaluation Center

Chronic refractory osteomyelitis

- “Evidence is available from one prospective case-controlled study of 28 patients. This study was unable to demonstrate any beneficial effect on healing outcome with HBO therapy. Patients treated with standard care plus HBO demonstrated a 79% complete healing rate versus 90% for patients treated with standard care alone. The high degree of healing success achieved in the control group seems to indicate that the patient sample was not truly refractory to standard surgical and medical management. The evidence is insufficient to permit conclusions regarding the effects of adjunctive HBO, in combination with standard surgical and medical management, on the health outcomes of patients with chronic refractory osteomyelitis. The evidence is insufficient to determine if adjunctive hyperbaric oxygen therapy, in

combination with standard surgical and medical management, improves the health outcomes of patients with chronic refractory osteomyelitis. The evidence is insufficient to determine whether adjunctive hyperbaric oxygen therapy, in combination with standard surgical and medical management, is at least as beneficial as standard surgical and medical management alone for chronic refractory osteomyelitis.”

Intra-cranial cerebral abscess

- Hyperbaric oxygen treatment for this indication not evaluated.

Chronic invasive fungal infections

- Hyperbaric oxygen treatment for this indication not evaluated.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

Osteomyelitis

- **“The regime of HBOT reported in the single identified study does not seem to be beneficial to patients diagnosed with osteomyelitis in terms of their length of hospital stay, the treatment successes and the risk of recurrence following therapy. However this regime is atypical in several respects of HBOT regimes used for other indications, calling into question the extent to which the findings may be generalizable.”**

Intra-cranial cerebral abscess

- Hyperbaric oxygen treatment for this indication not evaluated.

Chronic invasive fungal infections

- Hyperbaric oxygen treatment for this indication not evaluated.

Cochrane Review

The Cochrane Library, Issue 3, 2001

Osteomyelitis

- Hyperbaric oxygen treatment for this indication not evaluated.

Intra-cranial cerebral abscess

- Hyperbaric oxygen treatment for this indication not evaluated.

Chronic invasive fungal infections

- Hyperbaric oxygen treatment for this indication not evaluated.

Esterhai JL, Pisarello J, Brighton CT. (1987). Adjunctive hyperbaric oxygen therapy in the treatment of chronic refractory osteomyelitis. *J Trauma*, 27 (7):763-768.

vs.

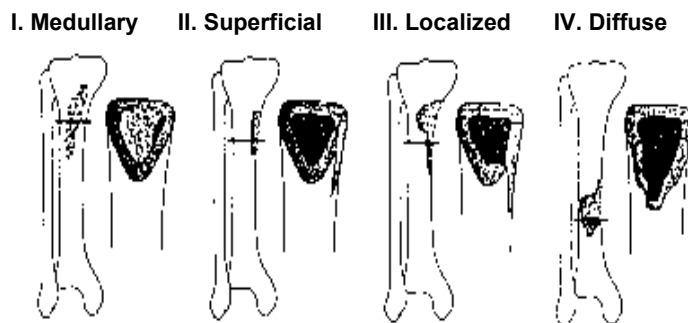
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Adjunctive hyperbaric oxygen treatment in CROM indicated for Cierny-Mader Stage III / IV BI.

Cierny-Mader Classification of Osteomyelitis--Anatomical Description

Anatomic Stage	Description
Stage I	Medullary osteomyelitis
Stage II	Superficial osteomyelitis
Stage III	Localized osteomyelitis
Stage IV	Diffuse osteomyelitis

Anatomic staging is accomplished by physical inspection of the wound, radiographic studies.



Cierny-Mader Classification of Osteomyelitis--Physiologic (Host) Description

Physiologic (Host) Type	Description
A Host	Good immune system and delivery
B Host	Compromised locally (Bl) or systemically (Bs)
C Host	Treatment worse than the disease

The host is classified on the basis of the presence or absence of factors affecting immune surveillance and response, metabolism, local vascularity, etc.

Systemic Factors (Bs)	Local Factors (Bl)
Malnutrition	Chronic lymphedema
Renal or hepatic failure	Venous stasis
Diabetes mellitus	Major vascular compromise
Immune deficiency	Local hypoxia
Malignancy	Vasculitis
Extremes of age	Extensive local scarring
Immunosuppression	Radiation fibrosis
Smoking	Peripheral neuropathy

Cierny G, Mader JT. Adult chronic osteomyelitis. *Orthopedics* 7(10):1557-1564, 1984.

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HYPERBARIC OXYGEN FOR CEREBRAL PALSY

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Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III

Blue Cross Blue Shield Association Technology Evaluation Center

- Hyperbaric oxygen treatment for this indication not evaluated.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

- Hyperbaric oxygen treatment for this indication not evaluated.

Cochrane Review

The Cochrane Library, Issue 3, 2001

- Hyperbaric oxygen treatment for this indication not evaluated.

United Cerebral Palsy Research & Educational Foundation

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Washington, DC 20036-3602

Research Fact Sheet on Hyperbaric Oxygen Therapy in the Treatment of Brain Injury

Report of a Meeting

On July 25-28, 2001

- “The reports presented at this meeting of improved function and cerebral circulation cannot be disregarded by labeling them as “observations by biased advocates”. These observations by skilled clinicians and parents need to be explored by appropriate scientific studies that meet the standards of modern research. One study, the Montreal study, clearly indicates that room air delivered at a low level of increased atmospheric pressure (1.35 ATA) gives identical results to 100% oxygen delivered at increased pressure (1.75 ATA). At this time, there is still no scientifically acceptable evidence that HBOT is useful in the treatment of disabilities associated with cerebral palsy. The following questions remain to be answered:
 - Is HBOT (oxygen level? Pressure level?) useful in the treatment of disabilities associated with cerebral palsy?
 - Is hyperbaria alone (pressure level?) useful in the treatment of disabilities associated with cerebral palsy?
 - Is oxygen supplementation alone (oxygen level?) useful in the treatment of disabilities associated with cerebral palsy?

Sufficient clinical experience does exist to support the need for additional controlled studies exploring these questions in a scientifically acceptable manner (i.e. randomized, double-blind trials). Air delivered in a hyperbaric chamber at 1.0 ATA can serve as a control. Another issue also requires study: the suggestion that there are “idling” neurons in the brain years after injury that become active after the use of HBOT. At this time, there is no evidence that this is true. However, there are methods available to test this hypothesis: PET brain imaging or metabolic magnetic imaging. These quantitative methods of measuring focal brain metabolism can be applied before & after HBOT and will answer the question.”

J-P Collet, M Vanasse, P Marois, M Amar, J Goldberg, J Lambert, M Lassonde, P Hardy, J Fortin, SD Tremblay, D Montgomery, J Lacroix, A Robinson, A Majnemer, and the HBO-CP Research Group. Hyperbaric oxygen for children with cerebral palsy: a randomized multicentre trial. *Lancet* 2001; 357: 582-86
Background The use of hyperbaric oxygen for children with cerebral palsy has spread worldwide, despite little scientific evidence of efficacy. We did a randomized trial to assess the efficacy and side-effects of this form of therapy in children with cerebral palsy.

Methods 111 children with cerebral palsy aged 3-12 years were randomly assigned hyperbaric oxygen (n=57) or slightly pressurized room air (n=54). All children received 40 treatments over 2 months. Hyperbaric oxygen treatment was 1 h in 100% oxygen at 1.75 atmospheres absolute (ATA); children on slightly pressurised air received air at 1.3 ATA (the lowest pressure at which pressure can be felt, thereby ensuring the maintenance of masking). The main outcome measure was gross motor function. Secondary outcomes included performance in activities of daily living, attention, working memory, and speech.

Findings For all outcomes, both groups improved over the course of the study, but without any difference between the two treatments. The score on the global gross motor function measure increased by 3.0% in the children on slightly pressurised air and 2.9% in those on hyperbaric oxygen. The mean difference between treatments was -0.40 (95% CI -1.69 to 0.90, p=0.544). Other changes were seen in speech, attention, memory, and functional skills. Ear problems occurred in 27 children treated by hyperbaric oxygen and in 15 treated with hyperbaric air (p=0.004).

Interpretation In this study, hyperbaric oxygen did not improve the condition of children with cerebral palsy compared with slightly pressurized air. The improvement seen in both groups for all dimensions tested deserves further consideration.

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HYPERBARIC OXYGEN IN CHRONIC NEUROLOGICAL DISORDERS

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BlueCross BlueShield Association Assessment Program
Volume 14 (2), August 1999, volume 14 (15), December 1999, volume 14 (16), December 1999
Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III
Blue Cross Blue Shield Association Technology Evaluation Center
Multiple sclerosis

- Hyperbaric oxygen treatment for this indication not evaluated.

Late effects of stroke

- Hyperbaric oxygen treatment for this indication not evaluated.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia
Hyperbaric Oxygen Therapy, November 2000
MSAC applications 1018-1020 Assessment Report

Multiple sclerosis

- The studies do not consistently demonstrate any beneficial effect of HBOT on clinical outcomes of multiple sclerosis. There is little evidence to support the use of HBOT for this indication at this time.

Cardiovascular disease conditions: cerebrovascular disease

- The collected evidence examines only a small number of clinical outcomes. In these end-points, the effectiveness of exposure to HBO is conflicting. There is evidence of small improvements in functional status, but these are seen a year after therapy is initiated. Whether these changes are scale-independent is questionable. Of potential concern is the evidence that exposure to HBO may be no better than placebo or sham therapy. The review concluded that no firm and generalizable evidence is available to support the use of HBOT for cerebrovascular disease at this time.

Cochrane Review

The Cochrane Library, Issue 3, 2001

Multiple sclerosis

- Hyperbaric oxygen treatment for this indication not evaluated.

Late effects of stroke

- Hyperbaric oxygen treatment for this indication not evaluated.

Proposed but largely unsubstantiated mechanisms for HBO action in multiple sclerosis (modified from Jain):

- Increased oxygen diffusion into areas of focal neural edema
- Reduction of perineural edema
- Stabilization of the blood-brain/neural barrier

Proposed but largely unsubstantiated mechanisms for HBO action in chronic cerebral ischemia (modified from Jain):

- Reversal of ischemic “penumbra” with activation of dormant neurons
- Improved cerebral metabolism
- Improved distribution of cerebral blood flow
- Stabilization of the blood-brain barrier
- Increased oxygen tension in cerebrospinal fluid

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Multiple sclerosis

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HYPERBARIC OXYGEN FOR ACUTE BRAIN INJURY AND STROKE

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Acute traumatic brain injury

- “The available evidence is insufficient to conclude that adjunctive treatment with HBO has a favorable effect on improving the health outcomes of patients with severe traumatic brain injury. The available evidence consists of two randomized controlled studies of 60 and 168 patients each. The first study, conducted in 1976, found that treatment with HBO did not result in better survival as compared with conventionally treated controls. While HBO-treated patients demonstrated somewhat better survival outcomes than control patients, the differences were not statistically significant. Subsequently, a larger and more rigorously designed study found that HBO improved mortality outcomes, particularly in the subset of severe patients who can be expected to have poor survival outcomes. Both studies agreed that the functional outcomes of survivors were not improved with the addition of HBO to the treatment regimen. The evidence suggests a beneficial survival effect on severe TBI patients treated with HBO. However, none of the available studies compared HBO therapy to current conventional methods for TBI management. The evolution of management in severe TBI has included a number of therapeutic advances involving the delivery of pre-hospital resuscitation and care, pharmaceutical options, immediate evacuation of mass lesions, and perhaps most significantly, the widespread use of intra-cranial pressure monitoring (ICP). The use of ICP monitoring in acute TBI has led to the earlier detection of intra-cranial mass lesions, has limited the indiscriminate use of treatments to control ICP (which themselves can be harmful), and can decrease ICP through the drainage of cerebral spinal fluid and thus improve cerebral perfusion. The evolution of TBI management may have obviated the use of HBO in this population, particularly given its potential for oxygen toxicity. Although no adverse effects related to HBO treatment were reported in the evidence

review, oxygen under pressure is toxic. HBO can lower the seizure threshold and affect central nervous system control of respiration. Collectively, these circumstances may have rendered HBO obsolete as a potential therapeutic modality in the treatment of acute TBI. The evidence is insufficient to determine if adjunctive hyperbaric oxygen therapy, in combination with standard surgical and medical management, improves the health outcomes of patients with acute traumatic brain injury.

Spinal cord injury

- “The evidence is considered insufficient to determine that adjunctive HBO therapy improves the health outcomes of patients with spinal cord injury. No controlled studies on the adjunctive use of HBO in treatment of spinal cord injuries were identified. The evidence consists of three small uncontrolled case series involving 48 patients with a range of spinal cord injuries. Overall, the results of adjunctive treatment with HBO were not favorable. None of the series was able to convincingly demonstrate improvement in motor or other neurological function with the addition of HBO to the treatment regimen. Furthermore, the available evidence dates back to the 1970s. With the exception of a few case studies published in the Japanese hyperbaric medicine literature, no papers published within the last decade were found on this topic. The use of HBO therapy for the management of spinal cord injury was never widely accepted. The lack of good experimental or clinical evidence of benefit may have rendered the treatment obsolete. The evidence is insufficient to determine if adjunctive hyperbaric oxygen therapy, in combination with standard surgical and medical management, improves the health outcomes of patients with spinal cord injuries.

Acute stroke

- Hyperbaric oxygen treatment for these indications not evaluated.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia
Hyperbaric Oxygen Therapy, November 2000
MSAC applications 1018-1020 Assessment Report

Acute traumatic brain injury

- Hyperbaric oxygen treatment for this indication not evaluated.

Spinal cord injury

- Hyperbaric oxygen treatment for this indication not evaluated.

Acute stroke

- Hyperbaric oxygen treatment for this indication not evaluated.

Cochrane Review

The Cochrane Library, Issue 3, 2001

Acute traumatic brain injury

- Hyperbaric oxygen treatment for this indication not evaluated.

Spinal cord injury

- Hyperbaric oxygen treatment for this indication not evaluated.

Acute stroke

- Hyperbaric oxygen treatment for this indication not evaluated.

Proposed mechanisms for HBO action in acute neurological injury (modified from Jain):

- Favorable alterations in cerebral metabolism
- Favorable alterations in cerebral blood flow
- Stabilization of the blood-brain barrier
- Increased oxygen tension in the cerebrospinal fluid
- Preservation of marginally perfused ischemic neurons
- Prevention of ischemia reperfusion injury

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Acute traumatic brain injury

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HYPERBARIC OXYGEN FOR HIV/AIDS

Robert A. Warriner III M.D., FACA, FCCP, CWS

Medical Director Southeast Texas Center for Wound Care and Hyperbaric Medicine, Conroe, TX USA

Chief Medical Officer Praxis Clinical Services, Anaheim, CA USA

BlueCross BlueShield Association Assessment Program

Volume 14 (2), August 1999, volume 14 (15), December 1999, volume 14 (16), December 1999

Hyperbaric Oxygen Therapy for Wound Healing—Parts I, II, III

Blue Cross Blue Shield Association Technology Evaluation Center

- Hyperbaric oxygen treatment for this indication not evaluated.

Medical Services Advisory Committee (MSAC), Department of Health and Aged Care, Australia

Hyperbaric Oxygen Therapy, November 2000

MSAC applications 1018-1020 Assessment Report

- Hyperbaric oxygen treatment for this indication not evaluated.

Cochrane Review

The Cochrane Library, Issue 3, 2001

- Hyperbaric oxygen treatment for this indication not evaluated.

Proposed but largely unsubstantiated mechanisms for HBO action against HIV infections (modified from Jain):

- Oxygen free radical species in combination with mild hyperthermia (38.5C) may penetrate the lipid covering of "free" HIV viral particles
- HBO may augment host immune response to certain opportunistic infections
- HBO may have an immune stimulating effect
- Amelioration of drug-induced neuropathy
- Amelioration of HIV-associated fatigue

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HYPERBARIC OXYGEN: THE WAY FORWARD

Robert A. Warriner III M.D., FACA, FCCP, CWS

Medical Director Southeast Texas Center for Wound Care and Hyperbaric Medicine, Conroe, TX USA

Chief Medical Officer Praxis Clinical Services, Anaheim, CA USA

The future of HBO therapy is in our own hands. What we do today, affects tomorrow...

INTERNATIONAL GUEST PRESENTERS CURRICULUM VITAE

David H. Elliott, *O.B.E.*

Date of Birth: 19th August 1932, England

Educated: The King's School, Canterbury
St. Bartholomew's Hospital Medical College
Magdalen College, Oxford

Qualifications: 1956 MB BS Honours (London)
1958 Diploma in Obstetrics
1964 Doctor of Philosophy (Oxford)
1973 Member, Faculty of Community Medicine
1975 Member, Royal College of Physicians (London)
1978 Member, Faculty of Occupational Medicine
1978 Accredited in Occupational Medicine
1983 Fellow, Royal College of Physicians (Edinburgh)
1983 Fellow, Faculty of Occupational Medicine
1989 Fellow, Royal College of Physicians (London)
1990 Member, Faculty of Public Health Medicine

Prizes & Awards: 1956 Brackenbury Scholarship, St Bartholomew's Hospital
1973 Commendation, Secretary of the United States Navy
1975 Stover Link Award, Undersea Medical Society
1975 O.B.E.
1975 Gilbert Blane Gold Medal, Royal Navy
1981 Oceaneering International Award, Undersea Medical Society
1995 Expro Technology Award, Shell U.K. Exploration and Production
1996 Charles W. Shilling Award, Undersea & Hyperbaric Medical Society
1996 International Award for Advances in Diving Medicine and Safety, Diver Alert Network, Europe
1998 Colin McLeod Award of The British Sub-Aqua Club

Curriculum vitae:

In 1956, on completion of House Physician, House Surgeon and Senior House Officer posts at St. Bartholomew's Hospital, joined the Royal Navy in 1958. Served in various ships and naval hospitals. Spent 3 years at Oxford working for Doctorate.

In 1964 qualified as a Ships Diving Officer and took the Navy's Clearance Diving course. From 1965 participated in deep diving trials, HMS RECLAIM, and was medical officer for many experimental deep oxy-helium dives in which unprecedented problems arose demanding new and speedy solutions. Also was surface medical officer for the first submarine escapes made at sea by buoyant ascent from 500 feet breathing compressed air. The derived experience and several years of research in the Royal Navy in deep and shallow diving led to a number of original publications relating to diving accidents and decompression sickness.

In 1968 became the Senior Medical Officer for the Admiralty Experimental Diving Unit. Served as Senior Medical Officer (Underwater) at the Royal Naval Medical School and at the Royal Naval Physiological Laboratory.

In the 1960's taught on a number of courses for the National Association of Underwater Instructors (now part of the British Sub Aqua Club) and was President of the BSAC South sea Branch.

For several years was on 24-hour call to give advice on the management of medical emergencies in naval and civilian diving including those arising from the first years of the North Sea offshore diving industry. Gained invaluable experience from some uniquely difficult cases upon which current practice is still based.

Director of the Royal Navy's courses of underwater medicine and physiology.

Conducted the first cross-sectional survey of aseptic bone necrosis in divers. The results from naval divers were confirmed some years later by the Medical Research Council project among civilian commercial divers.

During the late 1960's, participated in a number of pioneering dives within the Royal Navy, the United States Navy and with Professor Buhlmann of Zurich (the researcher responsible for Keller's pioneering 1000 ft. dive in 1962). Other research was related to shallow air diving, testing decompression tables and investigating the effects of semi-closed circuit breathing apparatus.

1969 to 1997. Member of the Decompression Sickness Panel of the Medical Research Council.

In 1970 served for 3 years as an Exchange Officer with the United States Navy at the Naval Medical Research Institute Bethesda, Maryland, continuing in decompression sickness research with extensive publications.

1970 to 1975, served on the Executive Committee, Undersea Medical Society.

1972 to 1973. President, the Undersea Medical Society.

1973, on return to the U.K., continued as Senior Medical Officer to the Royal Navy diving research programme. Adviser to the Medical Director-General (Navy) in Physiology, and Consultant in Underwater Medicine.

1973 to present. Member, Diving Medical Advisory Committee, a multinational committee founded to resolve medical problems arising in the North Sea.

1973 to present. Member, the European Diving Technology Committee, an international tripartite committee founded to harmonise Health & Safety procedures in European diving.

1974 to 1988, served on Executive Committee, European Undersea Biomedical Society

In 1976, on retirement from the Navy joined Shell International as the Group Adviser in Diving. This was a non-medical appointment supervising Shell's extensive air and mixed-gas diving programme and the supporting deep diving research. It included bid evaluation and subsequent safety audits of commercial diving contracts in many overseas operating companies and, in particular, advising world-wide on the Health and Safety management of diving, including aspects of the installation of the Cognac platform (New Orleans).

1977, January. Loaned by Shell to the Norwegian Government to investigate what is still the deepest known underwater fatality, 1050 fsw, and to supervise the safe recovery of Taylor Diving's A-frame from that incident.

1979 to 1982. President, European Undersea Biomedical Society.

- 1980 to 1988. The Shell Group Adviser in Applied Physiology. The principal task was to complete the deep diving research programme with Professor Buhlmann of Zurich and undertake practical operational evaluation of new deep diving procedures to 500m (1,600 ft). These were conducted in Norway at NUTEC (the Norwegian Underwater Institute) and at sea in support of the Statpipe project and of Shell's Deep Submergence Intervention study. At this time the emphasis in diver health had become focussed on the allegation of subtle long-term neurological consequences, a controversial topic which has since been aired in many law courts. Other tasks in applied physiology included the study of accidental cold water immersion and survival-at-sea. One of the highest priorities for health and safety in relation to the offshore worker concerned the protection of passengers in a helicopter ditching. Professor Elliott was named with Eric Bramham, a diving engineer, in the patent by Shell as the joint developer of "*Air Pocket*", a simple aid for underwater escape from an inverted helicopter now in service in the North Sea and elsewhere.
- 1983, appointed as Chief Medical Officer, Shell U.K Ltd. While this marked the end of some 20 years practically full time in diving, the continuing task of Group Adviser in Applied Physiology meant that 20% of the time was still spent on diving activities. The new task was a senior appointment in occupational medicine, covering all aspects of the company's offshore, refining, chemical, agrochemical, research, marketing and distribution activities at the time of the introduction of the Control of Substances Hazardous to Health (COSHH) Regulations.
- 1978 to 1990. Chairman, the Diving Medical Advisory Committee (DMAC) of U.K., Norway, Sweden, Denmark and the Netherlands.
- 1981 to 1993. Chairman, the Medical Research Council's Decompression Sickness Panel.
- 1984 to 1990. Member, the Norwegian Medical Research Council (NAVF) Deep Diving Project Board.
- 1985 to 1988. Professor, Institute of Occupational Medicine, University of Aberdeen (Personal Chair).
- 1986 to 1997. Member, Underwater Physiology Sub-Committee of the Royal Naval Personnel Research Committee
1988. Appointed as the Shell Professorial Research Fellow, Robens Institute of Industrial Health & Safety, University of Surrey. In this post continued as Shell Adviser on Applied Physiology and as lecturer on Health & Safety Management to the Shell Group. Particular research tasks at this time related to the long-term neurological health effects of diving.
- 1988 to present. The Civilian Consultant in Diving Medicine to the Royal Navy.
- 1998 to 1991. Consultant in Occupational Health to the German State laboratory GUSI-GKSS near Hamburg for a 3-year series of research dives to between 300 and 500 metres (1000 & 1600 feet). My emphasis was on the prevention and detection of subtle neurological and pulmonary deficits.
- 1988 to 1997. Member, Cold Environment Sub-Committee of the Royal Naval Personnel Research Committee.
- 1989 to 1994. Member, Norwegian Medical Research Council (NAVF) Steering Committee for the Arctic Biomedical Research Programme.
- 1991 to 1998. Chairman, the European Diving Technology Committee (by now a 15-nation committee with government, industrial, trades union and medical representation and with the continued objective of the harmonisation of operational, safety and medical legislation in diving throughout Europe).
1991. Member, Breathing Equipment Sub-Committee of the Royal Naval Personnel Research Committee.

1991 to present. Scientific and medical adviser to the Association of Offshore Diving Contractors, now part of the International Marine Contractors Association (IMCA).

1993 to present. Visiting Professor of Occupational Medicine at the Robens Institute, now the European Institute of Health and Medical Sciences, University of Surrey.

1999 to present. Chairman of the Task Force "Breath-hold, Scuba and Hose Diving" for the Consensus Conference 2001 in the Netherlands, and the "World Congress on Drowning, 2002"

2000, June. Convenor and chairman, UHMS scientific meeting "The Management of Acute Decompression Sickness", Stockholm.

2000, July. Invited contributor, Space Medicine Committee: I.O.M. Conference for NASA on "Health Care in a Remote Hostile Environment", U.S. Academy of Sciences, Woods Hole, USA.

2000, September. Founding Fellow, European College of Baromedicine, University of Malta.

Robert Arundale Warriner, III, M.D., FACA, FCCP

Specialty: (Primary) Anesthesiology, Subspecialty Training: Critical Care Medicine, Aerospace Medicine
(Secondary) Diving and Hyperbaric Medicine

Born 16 March, 1950, New Orleans, LA.

Married, Two Children

Spouse: Medical Social Worker

Revised: September 4, 2001

1. CURRENT POSITION

Medical Director, Southeast Texas Center for Wound Care and Hyperbaric Medicine, Columbia Conroe Regional Medical Center, Conroe, Texas

President, Southeast Texas Hyperbaric Medicine Center, P.A.

Chief Medical Office, Praxis Clinical Services

Member, Department of Surgery, Conroe Regional Medical Center

2. PRIOR MILITARY ASSIGNMENTS

18 April, 1983, to 1 June, 1984

Chief, Anesthesia Service and Medical Director, Cardiopulmonary Laboratory, USAF Hospital Luke, Luke AFB (TAC), AZ. 85309

1 July, 1980, to 17 April, 1983 Staff Anesthesiologist and Director, Surgical Intensive Care Unit, Wilford Hall USAF Medical Center, Lackland AFB (AFSC), TX. 78236

20 May, 1972 Commissioned 2nd Lt, USAF Res, as Distinguished Military Graduate, Det 320, USAF ROTC, Tulane University, New Orleans, LA. Completed military service obligation having attained the rank of Major, USAF MC

3. EDUCATION

Undergraduate

1968-1972 Tulane University, New Orleans, LA.

1972 B.S., cum laude, in Cellular and Developmental Biology

Medical

1972-1976 Vanderbilt Medical School, Nashville, TN.

1976 M.D.

Postgraduate Medical

1976-1977 Intern, Surgery Categorical, Alton Ochsner Medical Foundation, Ochsner Foundation Hospital, New Orleans, LA.

1977-1978 Resident, Anesthesiology, Alton Ochsner Medical Foundation, Ochsner Foundation Hospital, New Orleans, LA.

1978-1979 Chief Resident, Anesthesiology, Alton Ochsner Medical Foundation, Ochsner Foundation Hospital, New Orleans, LA.

1979-1980 Clinical Fellow in Anesthesiology and Critical Care Medicine, Respiratory-Surgical Intensive Care Unit and Department of Anesthesia, Beth Israel Hospital and Harvard Medical School, Boston, MA.

Additional Training

1980 Compression Therapy Supplemental Team Training (B30ZY9300-008), Hyperbaric Medicine Division, USAF School of Aerospace Medicine, Brooks AFB, TX.

1981 Aerospace Medicine Primary Course (B30BY90351-000), USAF School of Aerospace Medicine, Brooks AFB, TX.

1982 Compression Therapy Team Training (B30ZY9300-007), Hyperbaric Medicine Division, USAF School of Aerospace Medicine, Brooks AFB, TX.

1987 Anaesthesia for Developing Countries and Difficult Locations, Nuffield Department of Anaesthetics, The Radcliffe Infirmary, University of Oxford, England. (Course in Residence)

1988 Course on Hyperbaric Medicine, Southwest Texas Methodist Hospital, San Antonio, TX and the Undersea & Hyperbaric Medical Society

- 1989 Fitness for Professional Diving, The United Kingdom Health and Safety Executive, Biomedical Seminars and the Undersea and Hyperbaric Medical Society, Honolulu, HI.
- 1989 NOAA/UHMS Physician's Training in Diving Medicine Course XV, Seattle, WA.
- 1989 Introduction to Hyperbaric Medicine and Monoplace Chambers, Columbia, SC. (UHMS Education Committee Course Reviewer)
- 1990 Diving Accident Management (DAN/UHMS/NOAA), Durham, NC.
- 1990 Pulmonary Fitness to Dive, Birmingham, AL. (UHMS)
- 1990 Medical Support for Deeper Diving, Birmingham, AL. (UHMS)
- 1990 Medical Aspects of Diving Accidents and Illnesses, The Netherlands and Italy. Completed all requirements for DMAC/17, the training recommendations of the Diving Medical Advisory Committee and STANAG 1227 MED (NAVY), the NATO Standardization Agreement on minimum qualifications for non-specialist medical officers in support of diving operations.
- 1992 Neurological Fitness to Dive, Bethesda, MD, (UHMS)
- 1998 UHMS Annual Scientific Meeting, Seattle, WA
- 1999 Hyperbaric Medicine 1999, Columbia, SC
- 1999 Symposium on Advanced Wound Care, Anaheim, CA
- 1999 Symposium on Transitional Research in Wound Care, Minneapolis, MN
- 1999 UHMS Annual Scientific Meeting, Boston, MA
- 2000 Hyperbaric Medicine 2000, Columbia, SC
- 2001 UHMS Annual Scientific Meeting, San Antonio, TX

4. BOARDS AND LICENSURES AND CERTIFICATIONS

Board Certifications

1 July, 1977

Diplomate, National Board of Medical Examiners

3 April, 1981

Consultant in Anesthesiology, American Board of Anesthesiology

31 August, 1993

Diplomate in Hyperbaric Medicine, American Board of Hyperbaric Medicine

Fellowships

26 February, 1982

Fellow, American College of Anesthesiologists

29 December, 1982

Fellow, American College of Chest Physicians

14 November, 1997

Fellow, American College of Hyperbaric Medicine

Licensures

17 June, 1976 - Current

State of Louisiana, Board of Medical Examiners (#I3588)

15 June, 1979 Commonwealth of Massachusetts, Board of Registration and Discipline in Medicine, Temporary Certificate (#70693)

3 December, 1980 - Current

State of Texas, Board of Medical Examiners (#F-8726)

3 June, 1983 State of Arizona, Board of Medical Examiners (#I4036)

Certifications

22 February, 1991

Approved Diving Operations Doctor, Health and Safety Executive, Medical Division, United Kingdom (Doctor's Reference Number 25-00-14)

17 July, 1998

Certified Wound Specialist, Diplomate of the American Academy of Wound Management

5. PROFESSIONAL ORGANIZATIONS

1977 American Society of Anesthesiologists

1978 Society of Cardiovascular Anesthesiologists

1980 Society of Critical Care Medicine

1981 International Anesthesia Research Society

The American Society of Regional Anesthesia

The Society of Neurosurgical Anesthesia and Neurologic Supportive Care

- Texas Society of Anesthesiologists
- 1982 Undersea and Hyperbaric Medical Society
 - 1990 Member of Education Committee
 - 1998 Executive Committee, Member at Large
- 1988 Member, American College of Hyperbaric Medicine
- 1989 Overseas Member, The Association of Anaesthetists of Great Britain and Ireland
- 1989 American Diabetes Association
- 1989 South Pacific Underwater Medicine Society
- 1990 National Association of Diver Medical Technicians
- 1990 Corporate Member, Diver's Alert Network (DAN), Southeast Texas Hyperbaric Medicine Center
- 1990 Corporate Member, Association of Diving Contractors (ADC), Southeast Texas Hyperbaric Medicine Center, P.A.
- 1990 International Congress on Hyperbaric Medicine
- 1990 European Undersea Biomedical Society
- 1991 The Wound Healing Society
- 1993 Aerospace Medical Association
- 1997 Association for the Advancement of Wound Care
- 1997 Southern African Undersea and Hyperbaric Medical Association

6. HOSPITAL AND PROFESSIONAL APPOINTMENTS

- 1976-1979 Ochsner Foundation Hospital, New Orleans, LA.
 - Resident
- 1979-1980 Beth Israel Hospital, Boston, MA. Fellow in Anaesthesia and Critical Care Medicine
- 1980-1983 Wilford Hall USAF Medical Center, Lackland AFB (AFSC), TX.
 - Staff Anesthesiologist
 - Director, Surgical Intensive Care Unit
 - Physician Coordinator for Advanced Cardiac Life Support Training
- 1980-1983 Hyperbaric Medicine Division, USAF School of Aerospace Medicine, Brooks AFB, (AFSC) TX.
 - Supplemental Compression Therapy Team Member (1980-1982)
 - Compression Therapy Team Member (1982-1983)
- 1980-1983 Medical Center Hospital, Montgomery County Hospital District, Conroe, TX.
 - Associate Staff, Department of Anesthesiology
 - Chairman, Department of Anesthesiology (1981-1982)
- 1983-1984 USAF Hospital Luke, Luke AFB (TAC), AZ.
 - Chief, Anesthesia Service Medical Director,
 - Cardiopulmonary Laboratory
 - Flight Surgeon
- 1984-1990 Medical Center Hospital, Montgomery County Hospital District, Conroe, Texas,
 - Active Staff and Vice-Chairman, Department of Anesthesia
 - Medical Director Intensive Care Unit, Trauma and Critical Care Services
 - Medical Director Respiratory Therapy
 - Chairman, Department of Anesthesia
- 1989 Medical Director, Southeast Texas Center for Wound Care and Hyperbaric Medicine, Conroe, TX
 - Member, Department of Surgery
- 1993 Montgomery County Hospital District Emergency Medical Services
 - Medical Director
- 1987-1989 Consultant Anesthesia, Baptist Medical Centre, Ogbomoso, Nigeria
- 1997 Hermann Hospital, Houston, TX
 - Member, Division of Emergency Medicine, Department of Surgery

7. PUBLICATIONS

- (1) Mizell M, Ramsey DE, Warriner RA, Spencer R. Laboratory development and use of the American opossum *Didelphys virginiana*. Am Zool. 1970; 10: 354 (Abstract)
- (2) Lamberth EL, Warriner RA, Batchelor ED. Effect of metabolic acidosis and a alkalosis on human platelet aggregation induced by epinephrine and ADP. Proc Soc Exp Biol Med. 1974; 145: 743-746.

- (3) Warriner RA, Nies AS, Hayes WJ. Severe Organophosphate poisoning complicated by alcohol and turpentine ingestion. *Arch Environ Health*. 1977; 32: 203-206.
- (4) Douglas JR, Warriner RA. Analgesia and anesthesia for vaginal delivery. *The Perinatal Monitor (Ochsner Medical Institutions)*. 1979; 2: 1-2.
- (5) Burgess GE, Cooper JR, Marino RJ, Peuler MJ, Warriner RA. Laryngeal competence after tracheal extubation. *Anesthesiology*. 1979; 51: 73-77.
- (6) Douglas JR, Warriner RA, Burgess GE, Harmon DE, Mills NL. Cardiovascular support with intravenous microdrip therapy: A practical approach for the clinician. *J LA State Med Soc*. 1979; 131: 175-179.
- (7) Levy DL, Warriner, RA, Burgess GE. Fetal response to cardiopulmonary bypass. *Obstet Gynecol*. 1980; 56: 112-115.
- (8) Walker WT, Mockeridge AC, Warriner RA, Kronberg GN. Arterial oxygen tension during incentive spirometry. *Crit Care Med*. 1981; 9: 198 (Abstract).
- (9) Warriner RA. Hemodynamic monitoring. In: Kilgore TL, ed. *Critical care manual core curriculum*. San Antonio: Wilford Hall, USAF Medical Center, 1982: 11-30.
- (10) Warriner RA. Airway management. In: Kilgore TL, ed. *Critical care manual core curriculum*. San Antonio: Wilford Hall USAF Medical Center 1982: 68-85. (II)
- (11) Warriner RA. Mechanical ventilation. In: Kilgore TL, ed. *Critical care manual core curriculum*. San Antonio: Wilford Hall USAF Medical Center, 1982: 86-105.
- (12) Gallagher TJ, Alexander G, Berman LS, Keefer R, Tabelaing BB, Tonnesen A, Warriner RA. Self-education and evaluation program of the American Society of Anesthesiologists, Task Force on Respiration Single Topic Examination and Critique.
- (12) Editor, *Pressure Points*, Southeast Texas Center for Wound Care and Hyperbaric Medicine.
- (13) Pontani BA, Warriner RA, Tyrrel A, Ricken K, Pliner E, Kennedy M, Barnum S. Hypoglycemia as a Complication of HBO Therapy: Who is at Risk and When. *Undersea & Hyperbaric Medicine Journal*, 1994, 21:33-34.
- (14) Pontani BA, Tolat D, Warriner RA. AV Graft Steal Syndrome in ESRD Hemodialysis Patients: Assessment by Transcutaneous Oximetry and Laser Doppler Fluximetry. *Undersea & Hyperbaric Medicine Journal*, 1998, 25:44.
- (15) Warriner RA, Warriner AE, Pontani BA. Response of Dermal Blood flow to Cigarette Smoking determined by Transcutaneous PO₂ (TcPO₂) and Laser Doppler Skin Blood Flow (LDSBF) Measurement. *Undersea & Hyperbaric Medicine Journal of the Undersea and Hyperbaric Medical Society, Inc.*, 1998, 25:23
- (16) Pontani BA, Warriner RA, Newman RK, Ruttle M. Delayed Neurological Sequelae after Hydrogen Sulfide Poisoning Treated with Hyperbaric Oxygen Therapy: A Case Report. *Undersea & Hyperbaric Medicine Journal*, 1998:25:10.