LETTERS TO THE EDITOR

BLOOD SUGAR LEVELS AND HYPERBARIC OXYGEN

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Dear Editor

I was most interested to read the paper by Drs Ekanayake and Doolette in the March issue of the Journal, “Effects of Hyperbaric Oxygen Treatment on Blood Sugar Levels and Insulin Levels in Diabetics”. Although the numbers in the study are small, I commend the work done in the paper and hopefully an ongoing study at Duke University will bring more data. It is of note, that Ekanayake and Doolette’s paper is the first study of diabetics in which insulin levels have been measured in addition to plasma glucose.

A couple of areas in the paper are worthy of comment. The statement in the 3rd paragraph on Page 19 “one must be cautious about the accuracy of in chamber glucometer testing...” should extend to use of blood glucose meters outside the chamber in all HBO2 therapy patients. The accuracy of blood glucose meters (bedside and laboratory) in the setting of elevated PO2 blood samples as those found under HBO2 is variable.

In comparing 2 blood glucose meters I found with blood samples at PO2 1,200 mmHg the Precision PCx (PCx, Abbott Laboratories; Bedford, MA) to underestimate by up to 46% of the SureStepPro (SSP, LifeScan Inc; Milpitas, CA), which has been shown to be unaffected by high PO2. The Precision PCx glucose meter system is based on a glucose oxidase method, but instead of the photochemical detection used by the SSP, uses an electrochemical detection technique. This technique incorporates a mediator molecule or compound in the strip chemistry, which shuttles electrons from the oxidation of glucose to the electrode surface. This generates a current that is proportional to the amount of glucose present that is measured by the system. Because molecular oxygen can compete with the mediator molecule for electrons there is the possibility, under high PO2 conditions, of reduced electron shuttle from the mediator molecule to the electrode surface. The test strips are factory-calibrated with a fixed level of blood PO2 that is intended to be consistent with the oxygen level of most blood samples. If blood samples have relatively lower or higher PO2, test inaccuracies could result. For example, samples with hyperbaric PO2 values are more likely to have less current generated via the mediator molecule. This could in turn be falsely interpreted as a lower glucose value.

With all that in mind the current study employed a hexokinase method which, in theory, should be less affected by elevated PO2, however, in the past has also been shown to be inaccurate. A possible reason being the increased PO2 reacts allosterialy with one or more of the enzymes used in the reagent test strip so that an increased concentration of formazan (the brown coloured compound detected by the glucometer) is produced.

Other factors in the current study that would point to blood samples with a low PO2 would be using an antecubital vein especially if a tourniquet was used (not stated) and the time to measurement (not stated) but presumably at least 30 mins since measurements were performed at an adjacent Institute. However, the ultimate reassurance of accuracy was the use of control patients that showed no drop in measured glucose values with HBO2.

Although the cause of drop in blood glucose is still unclear, the authors exclusion of HBO2 stimulation of insulin secretion as the cause is implausible, since long standing type I insulin dependent diabetics do not secrete insulin. Secretion tails off over the first few months after diagnosis and can be confirmed by measuring the level of C-peptides that are cleaved during endogenous insulin secretion. Changes in insulin levels in such patients (4 out of the 5 were type I diabetics) would have to be accounted for by absorption from the injection site.

I commend the studies approach in doing the control measurements prior to commencement of HBO2. At Duke we are looking at the cumulative effect of HBO2 on diabetics during a course of therapy comparing glucose values at treatment number 1,10, 20 and 30. However, rather than an absolute drop in glucose value early data shows a reduction in range of glucose values during a course of treatment which may relate to improved monitoring, diabetic management or clinical status. As to the cause of this current studies drop in blood glucose during HBO2 I would favour the hypothesised mechanism of hypermetabolic state with increased aerobic metabolism. Although I have no data to substantiate this hypothesis the measured blood glucose in the current Duke study showed a significant drop only after 45 minutes of HBO2 and with time continued to fall. This would be consistent with an ongoing metabolic process.

Finally, to those involved in the care of diabetics undergoing daily HBO2 treatment make sure you take steps to minimise the potential inaccuracies of blood glucose meter readings. These steps include:

1. Glucometer measurement outside (not inside) the hyperbaric chamber
Venous blood sampling (not arterial or capillary) using a tourniquet to minimise PO$_2$ level.

Preferably a reliable glucometer using a measurement technique that is PO$_2$-independent, such as the SureStepPro (LifeScan Inc; Milpitas, CA) and the YSI 2300 STAT PLUS (Yellow Springs Instruments, Yellow Springs, OH). However, I cannot recommend the Precision PCx (PCx, Abbott Laboratories; Bedford, MA) and would be wary of any system that uses the glucose oxidase method with electrochemical detection techniques.

David Vote

References

3 Vote DA, Doar PO, Moon RE and Toffaletti JG. Blood glucose meter performance under hyperbaric oxygen conditions. *Clinica Chimica Acta* 2001; 305 (1-2), 81-87

Key Words

Diabetes, hyperbaric oxygen, hyperbaric research, letter.

Dr Vote’s letter has been shown to Drs Ekanayake and Doolette. Their reply is reproduced below:

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01/4/26

Dear Editor

We thank Dr Vote for his comments about our study on the effects of hyperbaric oxygen treatment on blood sugar and insulin levels in diabetics. The evidence from previous brief reports and from our small study suggests a fall in blood glucose in diabetics during hyperbaric oxygen therapy and we await with interest the results of the Duke University and Prince of Wales Hospital studies. Dr Vote’s comments are a reminder that monitoring of blood glucose during hyperbaric oxygen therapy is problematic as clearly demonstrated in his and colleagues’ careful study of two blood glucose meters. It was an oversight on our part not to give more detail of the blood sampling and analysis methods, particularly since one of us was fortunate to see a pre-print of Dr Vote’s manuscript before submitting our own.

In our study, blood was collected from the antecubital or a forearm vein as described, without a tourniquet. Samples were collected into fluoride-oxalate tubes and batch analysed by the hexokinase method under normobaric conditions following each study; the time between collection and analysis therefore differed for each sample but exceeded one hour. Samples from all four arms of our study were treated identically. Although PO$_2$ was not measured, we believe that the PO$_2$ of these samples would not have been elevated at the time of analysis and therefore not interfered with glucose measurement. As Dr Vote also points out, the use of control patients provides reassurance of accuracy. Edge’s earlier study of the hexokinase method is an important illustration of the difficulties of glucose monitoring but is not directly comparable to the present study since it showed that a glucometer inside the chamber at 3.7 bar absolute air pressure produced falsely elevated glucose readings compared to instruments outside the chamber.

We agree with Dr Vote that, in the case of insulin dependent diabetics, it is improbable that hyperbaric oxygen decreases blood glucose by stimulating endogenous insulin secretion, as has been previously hypothesised. Indeed our study provides evidence against this proposed mechanism since serum insulin did not increase during hyperbaric oxygen therapy in any of the subjects in our study.

Lalith Ekanayake and David Doolette

References

1 Ekanayake L and Doolette DJ. Effects of hyperbaric oxygen treatment on blood sugar levels and insulin levels in diabetics. *SPUMS J* 2001; 31 (1): 16-20

Key Words

Diabetes, hyperbaric oxygen, hyperbaric research, letter.
BOOK REVIEWS

ESSENTIALS OF DIVING SAFETY
Wesley Y Yapor, MD.
Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers US$ 11.95. Postage and packing US$ 7.00 Global Priority Mail. Credit card orders may be placed by phone on +1-520-527-1055 or faxed to +1-520-526-0370. E-mail <divebooks@bestpub.com>.

This is another of the Best Publishing Company Diversification Series. It is a paperback with a glossy cover, 133 pages and a basic index. It is good value for those who want to learn more about diving safely.

The author takes a belt and braces (suspenders for speakers of American English) approach to diving safety. The book is divided into three chapters, equipment, technique and travel. Each chapter is full of commonsense advice that is often ignored by many divers. The opening paragraph of chapter 1 deserves to be quoted in full. “There are a few general recommendations that should be made concerning the care of diving equipment. It is not uncommon for a diver to leave a dive site missing a piece of equipment or with an extra glove or boot that belongs to another diver. For this reason, it is recommended you label all of your gear with a permanent marker or label. Writing the owner’s initials or name on every item will simplify the identification of a diver’s equipment. A careful inventory of one’s gear should be done before departing for a dive and before anyone leaves the site.” Be careful about everything, is advice to be expected from a neurosurgeon from a teaching hospital in Chicago, who holds a US Coast Guard licence as master of a charter boat of up to 50 gross tons.

Unfortunately this excellent book is a little spoilt by a mistake on page 4 where, under the heading Weight Storage and Spare Weight the following words appear “spare weights, enough to supply two divers (about 50 lb or 110 kg)” appear. Of course all our readers know that 110 kg is 242 lb and that 50 kg is 110 lb and that 50 lb is 22.7 kg. It is an understandable mistake that someone who thinks in pounds, as United States citizens do, could have multiplied by 2.2 when dividing was required. The proof reader should have picked this howler up. However much searching for other errors of fact failed to find any. As this is the only mention of metric measurements I suggest that it be deleted from the next edition.

An example of Dr Yapor’s thoroughness is his advice about accessories. There are 31 items in his table of suggested diving accessories. It includes a First Aid kit with the notation (see section on First Aid Kit), spare tank, adhesive tape, neoprene glue and binoculars in case a search becomes necessary.

He offers sensible advice on diving from boats, including the duties of both customers and crew. He offers advice about equipment configuration, find out what suits you best, and the pros and cons of alternatives. This is one of the few books to offer a selection of actions to control one’s ascent when the weight belt comes undone. He is a believer in the Sausage Buoy as an essential accessory, because it is easier to spot than a diver’s head.

The travel chapter is short but covers altitude, air travel, equipment to take, currency, clothing and medications as well as other topics.

The appendix is the Emergency Procedures manual of the ship Myles O’Joy. This is suitable for US emergency services, but change the numbers to contact and it is good advice the world over.

I strongly recommend that all those who read this issue of the Journal get a copy.

John Knight

Key Words
Book review, diving operations, diving safety, emergency ascent, equipment, rescue, travel.

THE WHITE DIVERS OF BROOME
John Bailey
Pan Macmillan Australia, Sydney.
The publishers supplied the review copy, RRP $Aust 31.00 inc GST

The Prologue to the book is an elegantly written word picture of a postmortem examination of a diver. This prologue is well justified as it sets the scene for the fascinating true-life tale that follows. The style is that of the historian novelist, with the facts, well researched and referenced, embellished with words and action that while being fiction ring with truth and greatly add to the book.

The book is set against the backdrop of Broome in 1912 and the pearl shell collecting industry that powered the thriving town. The Master Pearlers were a group of rich, opportunistic men who had little regard for the life of the pearling lugger crews. The “White Australia Policy”, which was being imposed by the Federal Government, led to the Master Pearlers being in conflict with this policy, as they saw it as a direct threat to their profits.

The terms used in the book, I suggest, will jar any reasonable thinking persons sensibilities. They are cruel words that describe the racial mix of Broome at that time. The author was brave to include these racially prejudiced
terms, but without them the powerful message contained in this book would have been radically diluted by using more politically correct terminology.

In this era the population of Broome was as many Asians as Australians. Asian labour was cheap to hire and easy to replace. The White Australian Policy attempted to remove the Asian work force from the cane fields of Queensland and the pearling industry, which depended on these workers. The divers employed in 1912 were mainly Japanese. A Federal Government initiative, to import trained ex-Royal Navy divers and tenders, was intended to prove that the white man was superior to the coloured and end the Asian stranglehold on the pearling industry.

The experiment lasted only one season before about half of the divers were either in jail, dead from drowning or “The Bends”. From the outset the white Master Pearlers wanted it to fail and, indeed, seemingly acted to ensure this outcome. The book offers details about the diving equipment and how it was used. As far as I can tell the diving content is in the main accurate, but not without error. But this is a minor point.

The story vividly conjures up Broome, with wonderful descriptions of the segregated white and Asian ends of town. The lanes and slums, the noodle stalls, opium dens and brothels were more in keeping with Asia than Australia. Side issues about Broome society, white, Australian aboriginal and the mix of Asians, in schooling, justice and social events bring to the reader the racist, brutal existence that was Broome. Pearl shell mattered more than life.

This book is much more than a tale of pearl diving. It is a sad recollection of what it was like to live in the very prejudiced, early days of Federation. A window on the past that echoes many of the same fears and hopes held in society today. White divers of Broome is a fascinating and utterly absorbing true-life historical drama, that should be read by everyone.

Bob Ramsay

Key Words

Accidents, book review, deaths, decompression illness, equipment, history, occupational diving.

A DEMONSTRATION OF THE DIVING ENGINE

Jacob Rowe. Edited by Michael Fardell and Nigel Philips. Historical Diving Society (HDS) in association with the National Maritime Museum UK. Available from Historical Diving Society, 25 Gatton Road, Reigate, Surrey, RH2 OBH, UK. Telephone +44-(0)1737 249961.

Price £18.00. Postage and packing about £6.00 for delivery to the Australasian region.

This book is a facsimile, a complete reproduction of the earliest monograph in English on diving. The original was written about 1730. In 1980 the manuscript was purchased at auction by The National Maritime Museum from Christies in London. But this book is more than just a facsimile of a hand written document. The original text has been greatly enhanced by the addition of an introduction, a transcript of the original manuscript and biographical notes on the author. Michael Fardell and Nigel Philips are to be congratulated on their work. Until now this unfinished short text has remained unpublished.

The introduction, like all sections of the book, is extensively and well referenced. It offers the reader insight to the times and practice of the developing sunken ship salvage business of those times and they seem to have been interesting times indeed. Many questions that researchers of diving history may have about the technicalities, and indeed the feasibility, of the Lethbridge style barrel for diving have been addressed in this introduction, which also includes contemporary reports of Rowe’s exploits as a salvor.

The publishing of this monograph and its supporting material is a great step towards the proper documentation of the late 17th and early 18th century period when the proliferation of new diving equipment led to men entering the sea for prolonged periods for the first time.

The transcript of the original manuscripts allows researchers to concentrate on the words and not have to
IS SCREENING FOR PATENT FORAMEN OVALE FEASIBLE?

Jürg Wendling, C Balestra and P Germonpré

Key Words
Cardiovascular, decompression illness, equipment, medical conditions and problems, medicals, risk, safety.

Introduction

More than 50% of decompression illness (DCI) are unexpected, which means after regular dives without incidents or rapid pressure changes. As bubbles arise from the veins after most of the dives, cerebral embolism from bubbles by-passing the lungs, for instance by shunts through a patent foramen ovale (PFO), has been discussed. There are however other shunts possible and cerebral arterial gas embolism (CAGE) arising from air trapping in divers with lung pathology has also been proposed.1 In a recent study Wilmshurst demonstrated that only a negligible part of unexpected DCI cases could not be “explained” by either a PFO or a lung pathology.2

Rationale

Bove, in a retrospective study, and Germonpré, in a case control study, recently determined the increase in probability for PFO related DCI as, respectively, 2.5 and 3.7 times non-PFO probability.3,4 As almost 30% of all divers could have a patent foramen ovale, the non-diving population prevalence, one can wonder why DCI is not much more frequent than it is. Balestra demonstrated that, even with significant shunts, there is a need for an increased right-atrial pressure gradient for bubbles to pass through shunts.5 These gradients can be caused by intra thoracic pressure (ITP) rises. The investigators measured ITP by inserting a balloon tube into the oesophagus, filling the system with water and measuring the pressure in cm of water above the pressure during normal respiration. One of the most effective methods of raising ITP is a prolonged, forced Valsalva manoeuvre, but larger rises in ITP are produced by knee bends while performing a Valsalva as well as coughing and pressing down as hard as possible while holding one’s breath. Figure 1 (page 86) compares the intra thoracic pressures reached.

The test manoeuvres charted in Figure 1 were:

Control
Maximal isometric arm and chest muscles exercises: while sitting in a standard position (with knees and hips in 90° flexion) with the hands one above the other and the arms extended forward horizontally, the subject had to push down as hard as possible on a set of scales, placed on the ground, by means of a wooden stick while holding his or her breath. This test was performed three times; the mean push-down force was noted, and the mean ITP reached was used as the control ITP value for the other tested manoeuvres.

Gentle Valsalva
Valsalva manoeuvre (as usually performed by the diver to equalise middle ear pressure).

Forced Valsalva
Valsalva manoeuvre with the subject blowing as hard as possible.

Calibrated Valsalva
Valsalva manoeuvre gradually increasing ITP until the ITP reached the level of the first maximal isometric exercise.

Cough
Forceful coughing.