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DIABETES AS A CONTRAINDICATION TO DIVING: SHOULD OLD DOGMA GIVE WAY TO NEW EVIDENCE?

Lynn Taylor and Simon Mitchell

Key Words

Diabetes, drugs, risks, safety.

Abstract

Background

Diabetics, particularly those who require insulin, are usually considered unfit to undertake compressed gas diving. This judgement has been based on concerns over hypoglycaemic events, hypoglycaemia unawareness, increased risk of DCI and ambiguity between diabetic symptoms and those of DCI. A SPUMS "Statement" released in 1992 proscribed diving by diabetics. Since this time there has been a progressive shift from prescriptive toward discretionary diving fitness evaluations, and this has been paralleled by increasing pressure from diabetics to be "allowed" to dive. We undertook a contemporaneous review of the issue.

Methods

A review was undertaken to locate relevant material. This included a Medline search, and contact with authorities known to have an interest in the issue such as Divers Alert Network (DAN) and the British Sub-Aqua Club (BSAC).

Results

Few papers published in the indexed literature address this issue. In contrast, textbooks and popular press diving publications contain numerous references. Few articles of any type contain relevant original data. The proscription against diving by diabetics is based largely on theoretical concerns, opinion and some case reports of diving accidents involving diabetics. In contrast, several data sets describing diving activity by diabetics suggest that some can dive at an acceptable level of risk. A voluntary DAN survey reported 48,663 dives by 110 diabetic respondents with only 1 case of DCI. Hypoglycaemia had been experienced by 15% of respondents at some time during diving, but no case had ended adversely. The BSAC has prospectively followed more than 230 diabetic divers who had completed 5,348 dives to November 1999. There have been no deaths, no episodes of DCI and 4 hypoglycaemic events, all of which were corrected with glucose paste. While these data must be interpreted with caution since they describe the activity of selected populations, they do suggest that focused diabetics can dive safely. There are also prospective studies addressing specific training of diabetic divers, and the occurrence of hypoglycaemia in chamber and open water dives.

Conclusions

If issues of selection and training can be addressed, it may be appropriate for SPUMS to modify its 8 year old recommendation that currently prohibits all medicated diabetics from diving.

Introduction

Diabetes mellitus, and the insulin dependent form in particular, has been described as a contraindication to diving in many major contemporary diving medicine or diving fitness texts.[1-6] Moreover, in the most recent "official" policy statement from SPUMS it was suggested that both insulin-dependent and medicated non-insulin-dependent diabetics should be advised against diving.[7]

However, there is increasing evidence that focussed and properly trained diabetics can and do dive with a low risk of diabetes-related complications. It is notable that the United Kingdom Sports Diving Medical Committee has permitted diving by selected insulin dependent diabetics since 1991.

There has been thoughtful analysis[8] and outright criticism[9] of the SPUMS diabetic diving policy from within the Society, and it is now 8 years since the policy statement was issued. The intervening period has seen a gradual shift in diving fitness assessment philosophy away from a prescriptive approach toward a more discretionary paradigm of fitness evaluation in which appropriate candidates make risk acceptance decisions after appropriate counselling. With this background, and since the theme for the 2000 SPUMS Annual Scientific Meeting is "Fitness for Diving", it is an appropriate time to review the issue of diving by diabetics.

Methods

A literature review was undertaken to locate relevant material. This included a Medline search, gleaning of references from the bibiliographies of others and contact with authorities known to have an interest in the issue, such as the Divers Alert Network (DAN) and the British Sub-Aqua Club (BSAC).

Very little material was obtained from the Medline search. In contrast, it was possible to locate many published opinions and recommendations from other sources. Unfortunately, very few papers presented any relevant original data. There seemed little merit in presenting a repetitive account of the unsubstantiated opinion encountered in the search. It follows that this review does not claim to be a comprehensive treatment of all that is written on the subject. Rather, the references cited are either those that contained relevant data, or that were important for the development of particular arguments.

Concerns about diving by diabetics

Diabetics suffer a deficiency of insulin secretion, or insensitivity to the effects of insulin, leading to an elevation of serum glucose. Although the classification is debated, diabetics are commonly divided into either of two groups: Type I or Type II. Type I diabetes typically starts precipitously during childhood but may also arise in adults. These diabetics (insulin dependent) are dependent on administration of exogenous insulin to avoid ketoacidosis. Type II diabetes typically occurs insidiously during adulthood, but this pattern of disease may also be seen in the young. These diabetics (non-insulin-dependent) are often treated with oral hypoglycaemic agents, but may also require insulin.[10] Diabetics with either form of the disease are prone to acute and chronic complications.

HYPOGLYCAEMIA

The most worrying of the acute complications in the diving context is hypoglycaemia. This is most commonly a complication of Type I diabetes, but may also occur in Type II patients. Hypoglycaemia usually results from an imbalance between those factors that lower serum glucose (insulin administration and exercise), and dietary glucose intake. If uncorrected, hypoglycaemia may cause impairment of mentation and unconsciousness.[10] There are usually early warning signs which include a cold sweat, tremor and tachycardia. However, some patients, usually Type I diabetics of long standing, suffer a phenomenon known as "hypoglycaemia unawareness". This is attributed to hypothalamic desensitisation to falling serum glucose, and results in delay or failure of the autonomic activation that produces premonitory symptoms.[11]

Slowing of thought or loss of consciousness due to hypoglycaemia could clearly have catastrophic consequences during diving. Moreover, it has been suggested that exercise and thermal stress in the underwater environment may predispose to hypoglycaemic events.[2,5] Indeed, compression and oxygen administration in a hyperbaric chamber may cause plasma glucose to fall in the absence of exercise or thermal stress.[12] Hypoglycaemia may be harder to recognise when immersed,[3] and there is the potential for confusion between the symptoms of hypoglycaemia and decompression illness (DCI).

These are not just theoretical concerns. Thomas and McKenzie reported the case of a Type I diabetic diver who missed a meal before diving and became hypoglycaemic and lost consciousness during the dive.[13] Fortunately the diver was rescued and resuscitated with oxygen and intravenous glucose. Betts reported the case of a Type I diabetic diver who surfaced and became unconscious.[14] Those attending, aware of the diver's diabetic condition, attributed the problem to hypoglycaemia. The true diagnosis of DCI was not made for some 10 hours by which time the diver was paraplegic. This latter case precipitated a prolonged ban on all diving by diabetics under the auspices of the British Sub Aqua Club.

HYPERGLYCAEMIA

Chronic poor control of plasma glucose levels predisposes to the long term complications of diabetes.[10] In the short term, high plasma glucose results in osmotic diuresis and this may lead to dehydration. Although there are data to the contrary,[15] recent high quality in vivo work supports dehydration as a risk factor for DCI (D Dromsky personal communication). Thus, hyperglycaemic diabetics may be predisposed to DCI. Untreated hyperglycaemia in Type I diabetics may lead to the life threatening condition of ketoacidosis. Diabetics with ketoacidosis are acutely unwell and unlikely to present themselves for diving.

CHRONIC COMPLICATIONS

Most diabetics will develop complications of diabetes at some stage in their lives. These complications include peripheral and autonomic neuropathy, retinopathy, nephropathy, and both macro and micro-vascular disease. A full review of the nature and implications of these complications is beyond the scope of this paper. However, it is certain that they may reduce exercise capacity and produce symptoms that could be confused with DCI. It is also possible that they might predispose to DCI. Although this is largely hypothetical rather than proven, it is often mentioned. For example, Betts suggested that increased platelet adhesiveness and aggregability in diabetics might contribute to increased risk of DCI.[14]

Has the problem been overstated?

Notwithstanding the occasional adverse case report, most of the above concerns about diving and diabetes can be described as "dogma-rich but data-free".[8] Moreover, these concerns evolved from a period when diabetic management was less refined than now and when the technology for accurate portable capillary blood glucose measurement did not exist. It is not surprising that the validity of "banning" diving by diabetics has been questioned, especially given the contemporary climate of advocacy for their participation in a wide variety of adventure pursuits.[9] In spite of the ban, some diabetics have continued to dive, or through various means have trained as divers, and there is now a growing body of data suggesting that the hazards may have been overstated.

In 1994 the Diver Alert Network published the results of a voluntary survey of diabetic divers.[16] Questionnaires were distributed to 90,000 DAN members and diabetic members were invited to anonymously provide information about their diving histories. One hundred and ten diabetic divers replied, of which 79 were using insulin to control plasma glucose. These divers had completed a total of 48,663 dives. There was only one reported case of DCI, implying that the DCI incidence among this group was lower than that calculated for the general diving population.[17] Hypoglycaemia had been experienced by 15% of the divers at least once while diving, but it appeared that no episode had ended adversely. Although not clearly stated, almost certainly, it can be assumed that few of these divers had any special training in diabetic diving. This voluntary survey data can be criticised for describing the activities of a self-selected population of survivors and for a tendency for respondents to under-report problems. Nevertheless, the apparently low rate of DCI in this group is encouraging, and the data do suggest that some diabetics dive with little apparent risk of complication.

There are more convincing (prospective) data that describe the activities of diabetic divers who have been identified and followed by the BSAC. In 1990, some years after the imposition of a ban on diabetic diving within the BSAC, an unpublished survey of BSAC members revealed that a number of diabetics had continued to dive. The survey revealed "no increased incidence of DCI", nor had any diabetic diver "suffered from hypoglycaemic attacks whilst diving".[18] This led to a decision by the BSAC to allow diving by diabetics who met strict medical criteria.[18] Relevant data about those diabetics who had registered and prospectively followed were reported by Edge et al.[19] and by David Elliott and Chris Edge at the 2000 SPUMS Annual Scientific Meeting.[20] In November 1999, 230 diabetics (aged between 19 and 69, 190 male and 90% using insulin) were being followed. This group had conducted 5,348 dives, with 1,200 dives by 1 diver. No cases of DCI had been reported. Only 4 cases of hypoglycaemia associated with diving have been reported, and all were managed without incident.

Another prospective study has investigated the fall in serum glucose that occurs during normal diving activities by diabetics. A DAN group measured serum glucose levels in a group of 16 diabetics using insulin during a one week period of unrestricted diving.[21] Most divers completed 2 dives a day to an average depth of 18 m with a total of 131 dives. The mean fall in serum glucose was 3.1 ± 2.8 mmol l^{-1} and did not differ between single or repetitive dives. No complications due to hypoglycaemia arose during or after the dives. Clearly, serum glucose levels in diabetics do fall during diving, though it is not clear which particular aspect of a dive is responsible. Edge et al. reported that there was no difference in the fall in serum glucose that occurred during and following exercise by diabetics at 1 bar and 3.73 bar (absolute) in a hyperbaric chamber.[19] These results suggest that pressure, of itself, may not be important; but factors such as thermal stress or other effects of immersion may contribute.

In addition to these surveys and experiments, purpose designed diver training regimens have been applied successfully among small groups of diabetics. The most thoroughly documented of these was published in the SPUMS Journal in 1996.[22] Lerch et al. described a 1 week customised diabetic diving course in which 7 diabetics using insulin and 7 non-diabetic trainees participated. The course emphasised the manipulation of diet and insulin administration in order to achieve a safe pre-dive serum glucose level (target 9 – 12.5 mmol l^{-1}). The diabetic divers completed 77 dives with no episodes of in-water hypoglycaemia. Daily insulin requirements tended to fall and both carbohydrate and fluid intake requirements rose over the 6 consecutive days of diving.

Notwithstanding the limitations of the data, these reports do suggest that properly selected and trained diabetics may dive without unreasonable risk. Hypoglycaemia appears to be uncommon, recognisable and easily managed, and there does not appear to be any evidence that the risk of DCI is higher in diabetics. It follows that a case can be made for a relaxation of the total ban on diving by diabetics.

The way ahead

Any suggestion that all diabetics should be allowed to dive after completing a normal diving course is not supported by the available data, and would not meet with the approval of the diving medical community. If diabetics are to dive, the focus must be on development of appropriate selection and training protocols.

SELECTION

It must be acknowledged that some diabetics with

poor control of serum glucose levels, or with diabetic complications, will not be suitable for diving. Indeed, most published selection protocols for diabetic divers focus carefully on these two issues: glycaemic control and complications.[18,22-24]

An appropriate selection protocol would begin with a diabetologist consultation. Unless also a diving physician, this practitioner would not be asked for an opinion on fitness to dive, but rather, he or she would provide a detailed report on the diabetic's level of glycaemic control and the status of any diabetic complications. This consultation should include examination for retinopathy, neuropathy, and vascular disease; and tests for renal function and microalbuminuria. The second phase of the assessment would be carried out by a diving physician who would assess the likely impact of the patient's diabetes on diving. Certain criteria would need to be met, as suggested in other protocols[18,22-24] including: the demonstration of a good understanding of the diabetic condition; no recent tendency to hypoglycaemic events or hypoglycaemia unawareness; an HbA1c within the normal to good control range; and no recent change in insulin requirements. It is unreasonable to stipulate that there must be a complete absence of diabetic complications, since there would then be debate over how assiduously one must look for them. However, the likely impact of any complications readily identified should be carefully considered. BSAC policy is to exclude candidates with detectable neuropathy, nephropathy or clinically obvious vasculopathy; whereas a mild degree of background retinopathy is tolerated.[17] In other respects, normal fitness standards would apply.

The diving physician would not be expected to teach the diabetic how to manage their diabetes in relation to diving. However, a critical component of the consultation would be the frank discussion of the particular risks implied by diabetes, to ensure the candidate goes no further in the process without being an informed risk acceptor. As practiced by the BSAC, any approval to undertake diabetic diver training should only be valid for one year. In view of the potential for change in the illness and the progressive nature of diabetic complications, diabetic divers should undergo an annual medical assessment.

TRAINING

Specific "diabetic diver" training is certain to reduce the risk of diving with diabetes, and will be mandatory if the medical profession is ever to broadly accept diabetic diving. The blueprint for such courses already exists. For example, the protocol published by Lerch et al. appears to have merit.[22] Any diabetic diver course would, as a priority, focus on the adjustment of insulin administration, carbohydrate intake and fluid consumption on the day of diving to optimise serum glucose levels and hydration. In particular, there would be a protocol for sequential pre-dive serum glucose measurement, and established procedures to be invoked in response to the readings. Post-dive monitoring would also be necessary in order to avoid delayed hypoglycaemia. The course would incorporate training in emergency procedures, such as consumption of glucose paste underwater, and administration of glucagon intramuscularly in the topside setting. Non-diabetic diving buddies would be encouraged to complete such training along with the diabetic diver, and it might be reasonable to deem such informed buddies as mandatory for diabetic divers. Qualification would be valid for only one year, and renewal dependent on completion of an annual medical assessment.

A significant conundrum in relation to training of diabetic divers relates to who would provide it. Clearly, a diving instructor with no medical training is not suitably qualified to impart the required knowledge. One plausible possibility is to develop a "diabetic diver" specialty course under the auspices of one of the major training organisations. A qualified diving instructor who has undergone specialty course instructor training would conduct the course, and the active participation of a doctor with knowledge of diving medicine would be mandatory. Precedents for such an arrangement already exist. For example, the Level 2 DAN Oxygen Instructor courses offered by DAN South East Asia Pacific are conducted by a DAN Instructor Trainer with mandatory assistance from a diving physician. It is acknowledged that such courses would be unlikely to become widely available and would be more costly. However, most focussed diabetics who wish to dive would be prepared to travel if necessary in order to obtain good training.

Summary

Despite the medical profession's discouragement of diving by diabetics and the essential non-existence of formal training in "diabetic diving", it is clear that many diabetics do dive. Moreover, although much of the data describing the activity of this group is subject to bias, it does appear that focussed diabetics may dive with an acceptably low risk of diving mishaps related to their diabetes. It follows that a revision of the medical edict against diving by diabetics may be appropriate, providing that appropriate selection and training procedures are put in place. Unfortunately, deferring any change in medical policy pending development of such procedures creates a circular argument, since they are unlikely to be developed while the medical profession remains firmly against diabetic diving. An intermediate step may be necessary. For example, if SPUMS was to acknowledge its likely endorsement of diving by carefully selected, fully informed, and properly trained diabetics, provided the protocols developed for these purposes were acceptable, this might create an impetus for development of such protocols by the training organisations. Almost certainly, any continued unselective medical ban on diving by diabetics will result in greater numbers of

diabetics who dive without any diver training, let alone "diabetic diver" training.

References

1 Thomas R and McKenzie B. *The Diver's Medical Companion*. Sydney: Diving Medical Centre, 1981; 137

2 Bove AA. Medial evaluation for sport diving. In *Bove and Davis' Diving Medicine. 3rd Edition.* Bove AA. Ed. Philadelphia: WB Saunders, 1990; 355-356

3 Edmonds CW, Lowry CJ and Pennefather JW. *Diving and Subaquatic Medicine*. *3rd Edition.* Oxford: Butterworth-Heinemann, 1992; 471

4 Mebane GY and McIvor NKI. Fitness to dive. In *The Physiology and Medicine of Diving*. *4th Edition.* Bennett PB and Elliott DH. Eds. London: WB Saunders, 1993; 53-76

5 Parker J. *The Sports Diving Medical*. Melbourne: JL Publications, 1994; 68-69

6 Seckl J. Endocrine disorders. In *Medical Assessment of Fitness to Dive.* Elliott DH. Ed. Edinburgh: Biomedical Seminars, 1994; 172-174

7 Davies D. SPUMS statement on diabetes. *SPUMS J* 1992; 22: 31-32

8 Williamson J. Some diabetics are fit to dive, but which ones? *SPUMS J* 1996; 26: 70-71

9 Sullivan M. Diabetes mellitus and the scuba environment. *SPUMS J* 1994; 24: 49-51

10 Griffith DNW, Betteridge DJ and Axford JS. In *Medicine*. Axford JS. Ed. Oxford: Blackwell Science, 1996; 131

11 Braatvedt G. Hypoglycaemia in adult patients with diabetes mellitus. *New Ethicals* 2000; April: 53-60

12 Springer R. The importance of glucometer testing of diabetic patients pre and post dive. *Undersea Biomed Res* 1991; 18 (Suppl): 20

13 Thomas R and McKenzie B. *The Diver's Medical Companion*. Sydney: Diving Medical Centre, 1981; 128

14 Betts JC. Diabetes and diving. *Pressure* 1983; June: 2-3

15 Broome JR, Kittel CL and Dick EJ. Failure of pre-dive hydration status to influence neurological DCI rate in pigs. *Undersea Hyper Med* 1995; 22 (Suppl): 52

16 Dear G de L, Dovenbarger JA, Corson KS, Stolp BW and Moon RE. Diabetes among recreational divers. *Undersea Hyper Med* 1994; 21(Suppl): 94

17 Bove AA. Risk of decompression sickness with patent foramen ovale. *Undersea Hyper Med* 1998; 25: 175-178

18 Bryson P, Edge C, Lindsay D, Wilmshurst P. The case for diving diabetics. *SPUMS J* 1994; 24: 11-13

19 Edge CJ, Grieve AP, Gibbons N, O'Sullivan F and Bryson P. Control of blood glucose in a group of diabetic scuba divers. *Undersea Hyper Med* 1997; 24: 201-207

20 Elliott DH and Edge CJ. Restricted diving for the unfit. *SPUMS J* 2001; 31 (1): 41-44

21 Uguccioni DM, Pollock NW, Dovenbarger JA, Dear G deL, Feinglos MN and Moon RE. Blood glucose response to single and repetitive dives in insulin-requiring diabetics: a preliminary report. *Undersea Hyper Med* 1998; 25 (Suppl): 52

22 Lerch M, Lutrop C and Thurm U. Diabetes and diving: can the risk of hypoglycaemia be banned? *SPUMS J* 1996 ; 26: 62-66

23 Kizer KW. Diabetes and diving. *Pressure* 1983; February: 2-3

24 Advisory Board: YMCA National Scuba Program. *Protocol for YMCA scuba divers with diabetes performing non-decompression recreational scuba dives*. YMCA, January 1995; 9

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AUDIENCE PARTICIPATION

Henrik Staunstrup (Denmark)

I am not quite clear why you want a special dive course for diabetics. Of course we should have some medical information for them and teach them how they should control their blood sugars. But why a special dive course, because the way to dive is the same for everyone?

Lynn Taylor

I think there would be some additional elements within the dive course. The actual practicalities of diving would be the same but there would be other practical aspects such as the monitoring of the blood glucose, pre- and post- dive.

Henrik Staunstrup (Denmark)

You want a non-doctor to teach them that?

Lynn Taylor

Who should teach them was one of the issues that

we put up for discussion. Lerch et al. gave them special log books where they recorded all the medical things. Monitoring hydration, making sure they do take the extra litres of fluid prior to diving and blood testing. They can be covered in the theory but I think it is better that it is done in the field, in the practical parts of the diver training as well.

David Elliott

The reason why I think the British Sub-Aqua Club has been successful is because it is a club so it is the same people, the same team, every time. They make sure that the buddy does know what to do if anything goes wrong and it is up to the diabetic to make sure of this. The essence of the BSAC approach is that it is a group dive of which one or two persons may be diabetic.

Vanessa Haller (Melbourne)

I feel that the diabetic side of the course should be taught by doctors but unfortunately endocrinologists in Melbourne all have different views about diabetics and diving and diabetics who dive all have different protocols of how they use their insulin! A protocol for diabetics diving that is agreed by all is needed.

Cathy Meehan (Cairns)

When Claudia Lutrop ran the course in Papua New Guinea they had a registered nurse, who was a diabetic educator, who did the training on how to measure the blood sugars and hydration. I think that is probably the most appropriate person to do that part of the training for the diabetic divers.

Simon Mitchell

The content of the course and what would need to be taught would not be left to people's individual opinions. It would follow the PADI paradigm of a very clearly structured course with the information that had to be disseminated clearly specified so I think the point about different opinions is important. It may well be that if the information could be put in a form that was like the PADI course materials then doctors or at least someone with paramedical knowledge would be the most appropriate person to teach it.

Henrik Straunstrup (Denmark)

If we set up a special course for diabetics, they might be regarded themselves as disabled divers, like someone who is quadriplegic. They would probably ask "Why should I have a special diving course?". They obviously need to get some medical information about how to dive with diabetes, but not a specialty course, just a normal diving course to which is added some medical information from a nurse or a doctor.

Simon Mitchell

Your point is well made, but if you look at Michael Lerch's course, which is reasonably fully described in the SPUMS Journal,[22] you will see that it is quite a complex issue teaching these people to dive from scratch in a way that we can be reasonably sure that they will do it safely. We stand by our decision that there should be a special course.

David Elliott

In that course was there a depth limit of 30 m. Could they later dive deeper than that? As far as I am concerned, they were divers with restricted diving. They were not free to go and dive any old how within the recreational envelope.

Simon Mitchell

From what I can remember, it was very similar to an open water course. So the actual depth limit at the end of that one week course was 18 m. And the other guidelines that I grabbed say everything seems to point to the actual depth limit of 30 metres thereafter. Claudia is an instructor with the International Handicap Association of Divers and so the course was run within the restraints of the guidelines of the international handicapped divers.

Henrik, just another point to your comments, part of the reason for a specific course is to embrace some of the philosophies that David has passed on from the British Sub-Aqua Club. We want to create is an environment where there is a focus on diabetic diving and perhaps non-diabetics who will be the diabetic diver's buddy in future come and form a support network of people who would all dive together. That may be part of the requirements of their diving. In order to get that kind of support network together you are going to need a special environment in which it is fostered.

Henrik Staunstrup (Denmark)

I see your point that they are going to dive in an environment like that and I fully agree with that. But I do not see the need for difference between diabetics, and how we are going to handle them in the future, and how during the last five years we have handled the asthmatics, who we teach the normal way to dive but give them guidelines when they are in our office to get a medical.

John Knight (Melbourne)

I would like to support Cathy Meehan's remark about the nurse-diabetic teaching these people. I learnt long ago that if, as a doctor, you go and talk hyperbaric medicine to a group of divers they will not believe a word unless they know that you are a diver yourself. Actually diabetics, on the whole, know much more about diabetes and how to handle it than even the doctors who tell them what to do, because they live with it. And certainly a diabetic teaching diabetics will be believed. One difficulty of doctors giving medical information to non-medical people is that we tend to lapse into jargon and lose the audience.

Lynn Taylor

One final comment on the relationship between

teaching diabetics and teaching asthmatics. I think there is a lot more practical application needed when teaching diabetics. There are two things which need to be integrated, the actual practical diving, teaching them to dive, and the theory and practice of controlling their blood sugar levels. I think that perhaps it is simpler than that for asthmatics.

THE PSYCHOMETRIC AND CARDIAC EFFECTS OF PSEUDOEPHEDRINE AND ANTIHISTAMINES IN THE HYPERBARIC ENVIRONMENT

David Taylor, Kevin O'Toole, Thomas Auble, Christopher Ryan and David Sherman

Key Words

Cardiovascular, drugs, hyperbaric research.

Abstract

STUDY OBJECTIVES

Pseudoephedrine (Sudafed®) and dimenhydrinate (Dramamine®) are often used by recreational scuba divers to avoid ear barotrauma and to control seasickness, respectively. However, these drugs have been little studied in the hyperbaric environment. This study examines the psychometric and cardiac effects of pseudoephedrine and dimenhydrinate at one (100 kPa, sea level) and three (300 kPa, 20 m) atmospheres absolute (bar).

METHODS

A double-blind, placebo-controlled, crossover trial was carried out in the monoplace hyperbaric chamber of a university hospital. Thirty active divers (mean age 38 years) were studied.

A bank of seven tests was used to assess cognitive function during four different dive combinations: placebo/ 1 bar (100 kPa, sea level), placebo/3 bar (300 kPa, 20 m depth) , drug/1 bar (100 kPa, sea level)and drug/3 bar (300 kPa, 20 m depth). Heart rate and cardiac rhythm were recorded during all compressions (dives). Repeated measures ANOVA was used to analyse the effects of drug, depth and the drug-depth interaction.

RESULTS

There were no significant, independent effects of pseudoephedrine on any of the seven psychometric tests scores ($p>0.05$), although the drug tended to increase Anxiety scores ($p=0.092$). Increased depth (pressure) resulted in a significant increase in Anxiety scores ($p=0.021$) and a significant decrease in Verbal Fluency test scores ($p=0.041$). Pseudoephedrine caused a significant increase ($p=0.036$) in mean subject heart rate while depth (3 bar) caused a significant decrease ($p=0.013$). Dimenhydrinate resulted in a significant decrease in scores of mental flexibility (Trail Making, part B) ($p<0.05$). It had no effect upon mean subject heart rate ($p>0.05$). Depth resulted in a significant decrease in Verbal Memory test scores ($p=0.001$) and a significant decrease in mean subject heart rate ($p<0.001$).

CONCLUSION

Pseudoephedrine does not cause significant alterations in psychometric performance at 3 bar pressure (300 kPa, 20 m) that might increase the risk of diving. Dimenhydrinate adversely effects mental flexibility at depth. This effect, when added to the adverse effect of depth on memory, may contribute to the dangers of diving. Depth causes significant adverse effects upon anxiety levels and semantic memory at 3 bar.

Introduction

When compressed air is breathed by the scuba diver, nitrogen narcosis (euphoria, cognitive and motor dysfunction) may be precipitated.[1,2] Narcosis may be seen at depths of 20 m (66 ft) of sea water (3 bar) or greater and can increase significantly the risk of the underwater environment, especially if the symptoms are not recognised. At shallower depths, relatively harmless sub-clinical effects of narcosis are present.[1,2] The hyperbaric environment may cause other physiological effects, including cardiac effects.[3-6] Both bradycardia and a decrease in conduction velocity have been described as effects of hyperbaric pressure on the heart.[3-6]

Many drugs, including non-prescription drugs, have undesirable side effects which may be modified in the hyperbaric environment, even at depths as shallow as 15 m (50 ft).[7,8] Nitrogen narcosis is thought to interact and change the usual side effects of these drugs.[9] Some drugs effects are potentiated, some are antagonised and others produce entirely different effects from those observed at sea level.[5,8] Unfortunately, few scientific studies have examined the effects of drugs in the hyperbaric environment and it is generally recommended that divers avoid all drugs before diving.[8]

One of the most common drugs taken by scuba divers is the decongestant pseudoephedrine (Sudafed®, Warner Welcome).[8] Pseudoephedrine alleviates nasal and sinus congestion[8,10,11] and helps to avoid sinus and middle ear barotrauma while diving.[8,10] At sea level and in normal doses, pseudoephedrine has been reported to cause side effects of mild central nervous system (CNS) stimulation including nervousness, anxiety, excitability and restlessness.[12] Cardiac side effects of tachycardia, palpitations, ventricular ectopic beats (VEs) and, rarely, atrial fibrillation have been reported.[12,13] Few studies have examined the effects of pseudoephedrine in the hyperbaric