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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.<sup>1-6</sup> 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.<sup>7</sup>

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<sup>8</sup> and outright criticism<sup>9</sup> 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 bibliographies 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.<sup>10</sup> 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.<sup>10</sup> 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.<sup>11</sup>

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.<sup>2,5</sup> Indeed, compression and oxygen administration in a hyperbaric chamber may cause plasma glucose to fall in the absence of exercise or thermal stress.<sup>12</sup> Hypoglycaemia may be harder to recognise when immersed,<sup>3</sup> 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.<sup>13</sup> 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.<sup>14</sup> 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.<sup>10</sup> In the short term, high plasma glucose results in osmotic diuresis and this may lead to dehydration. Although there are data to the contrary,<sup>15</sup> 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.<sup>14</sup>

### 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”.<sup>8</sup> 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.<sup>9</sup> 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.<sup>16</sup> 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.<sup>17</sup> 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”.<sup>18</sup> This led to a decision by the BSAC to allow diving by diabetics who met strict medical criteria.<sup>18</sup> Relevant data about those diabetics who had registered and prospectively followed were reported by Edge et al.<sup>19</sup> and by David Elliott and Chris Edge at the 2000 SPUMS Annual Scientific Meeting.<sup>20</sup> 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.<sup>21</sup> 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  $3.1 \pm 2.8$  mmol l<sup>-1</sup> 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.<sup>19</sup> 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.<sup>22</sup> 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<sup>-1</sup>). 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.<sup>18,22-24</sup>

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<sup>18,22-24</sup> 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.<sup>17</sup> 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.<sup>22</sup> 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.

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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