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Diabetes and recreational diving: guidelines for the future

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Guidelines for diabetes and recreational diving

A workshop addressing issues of diabetes and recreational diving was jointly sponsored by the Undersea and Hyperbaric Medical Society (UHMS) and Divers Alert Network (DAN) to bring together experts and interested parties from within and beyond the international diving community. The meeting was held on June 19, 2005 in Las Vegas, Nevada, USA, following the UHMS annual scientific meeting. The objectives of the workshop were to review the existing data and, as warranted by participant support, to develop consensus guidelines to address diabetes and recreational diving. More than 50 individuals from seven nations, mostly clinicians and researchers, participated in the discussions.

Limitations: 1) The discussion was restricted to recreational diving. The issues concerning professional diving require future, separate deliberations. 2) This is a set of guidelines, not rules. The participants agreed that appropriate and justifiable differences in acceptable procedures may exist and that interest groups must have the flexibility to use the guidelines as they best serve their community's needs.

The guidelines were divided into three sections: 1) selection and surveillance of people with diabetes in scuba diving; 2) scope of diving by people with diabetes; and 3) glucose management on the day of diving. Individual divers must bear responsibility for their health and safety and for adherence to established guidelines developed to improve their protection and that of their dive partners. Divers with diabetes are encouraged to participate in relevant research studies to expand the data available concerning diving with diabetes. Anyone with questions should consult with physicians knowledgeable in both diving medicine and diabetes care.

Section 1. Selection and surveillance

Those evaluating persons with diabetes for medical fitness to dive must first ensure that no other exclusionary conditions (e.g., epilepsy, pulmonary disease) exist. The physiological demands of diving must then be considered. Coronary artery disease is a leading cause of death in the largely non-diabetic diving population. Immersion may result in increased myocardial wall stress. There may also be a reduced awareness of ischaemic symptoms. People with diabetes are at higher risk of medical complications such as myocardial infarction, angina and hypoglycaemia than the general diving population. Such risks are exacerbated by

the fact that many dive sites are quite isolated from medical aid. While only some medications increase the risk of hypoglycaemia, all persons with diabetes are at risk of secondary complications of the disease.

Recreational scuba diving may be undertaken by candidates otherwise qualified to dive who use medication (oral hypoglycaemic agents [OHAs] or insulin) to treat diabetes provided the following criteria are met.

1.1. Age 18 years and over (limit may be lowered to 16 years if special training* is available)

*special training will include dive training programs designed specifically to meet the education needs of individuals with diabetes and, desirably, to include participation by parents and/or responsible family members or guardians.

1.2. For a new diver at least three months have passed since the initiation or alteration of treatment* with OHAs or one year since the initiation of treatment with insulin. An established diver using OHAs who is started on insulin should wait at least six months before resuming diving.

*"alteration of treatment" is defined as a change in medication(s) or dosage(s) that could result in significant deviations from current status (changes likely to include only moderate change from current status would be described as "adjustment of treatment").

1.3. There should have been no episodes of hypoglycaemia or hyperglycaemia requiring intervention from a third party for at least one year, and no history of hypoglycaemia unawareness. Note: certain OHAs (e.g., metformin, acarbose), when used on their own, do not predispose to hypoglycaemia.

1.4. Glycosylated haemoglobin (HbA_{1c} - a measure of plasma glucose stability over the past two to three months) should be $\leq 9\%$ when measured no more than one month prior to initial assessment and at each annual review. If HbA_{1c} $> 9\%$ the diver should contact his/her diabetes specialist for further evaluation and modification of therapy.

1.5. There should be no: retinopathy worse than nonproliferative; significant autonomic or peripheral neuropathy; nephropathy causing proteinuria; coronary artery disease or significant peripheral vascular disease. Patients with retinopathy, peripheral vascular disease and/or neuropathy have a higher risk of sudden death due to coronary artery disease. Retinal haemorrhage could be

precipitated by small changes in mask pressure during descent and ascent or equalizing manoeuvres. Patients with neuropathy may experience exaggerated hypotension when exiting the water. Peripheral vascular disease may alter inert gas washout and predispose an individual to limb decompression sickness.

1.6. No more than two months prior to the first diving medical assessment and at each annual evaluation, a review is conducted by the candidate's primary care physician (knowledgeable in treating diabetes) who must confirm that: criteria 1.3 – 1.6 are fulfilled; the candidate demonstrates accurate use of a personal blood glucose monitoring device; and that the candidate has a good understanding of the relationship between diet, exercise, stress, temperature, and blood glucose levels.

1.7. No more than two months prior to commencing diving for the first time and at each annual review, a diving medical examination is completed, preferably by (or in consultation with) a doctor who has completed an accredited post-graduate diving medical examiner's course*. The review report completed by the primary care physician must be available. It is strongly recommended that formal evaluation for silent ischaemia be undertaken for candidates over 40 years in accordance with US American Heart Association/American College of Cardiology or equivalent guidelines. *any accredited course (one certified as fulfilling certain standards by a national and/or regional professional association) in diving medicine is acceptable

1.8. At the diving medical examination, the candidate acknowledges in writing the receipt of and intention to use the diabetic diving protocol; the need to seek further guidance if there is any material that is incompletely understood; and the need to cease diving and seek review if there are any adverse events associated with diving suspected to be related to diabetes.

1.9. Steps 1.1 – 1.8 must be completed annually, using the same physicians where possible. After the initial evaluation, periodic surveillance for silent ischaemia can be in accordance with accepted guidelines for evaluation of diabetics.

Section 2. Scope of diving

Persons with diabetes selected according to Section 1 of this document who satisfactorily complete a recognized diver training course are considered suitable for recreational diving. The following stipulations and strong recommendations regarding diving activity and methods apply.

2.1. It is recommended that dives do not involve depths greater than 30 meters of sea water (100 fsw), durations longer than one hour, compulsory decompression stops, or take place in overhead environments. The depth limit is to avoid situations in which narcosis could be confused with

hypoglycaemia. The time limit is to moderate the time blood glucose would remain unmonitored. The decompression and overhead environment limits are to avoid situations in which direct and immediate access to the surface is not available.

2.2. Divers with diabetes should dive with a buddy/leader who is informed of their condition and is aware of the appropriate response in the event of a hypoglycaemic episode. It is recommended the buddy does not have diabetes.

2.3. It is recommended that divers with diabetes avoid combinations of circumstances that might be provocative for hypoglycaemic episodes such as prolonged cold and arduous dives.

Section 3. Glucose management on the day of diving

Divers with diabetes who are selected according to Section 1 of this document, and who participate in appropriate diving activity as specified in Section 2, should use a protocol to manage their health on the day of diving. Note: the blood glucose monitoring protocols are applicable to people with diabetes whose medication may put them at risk of hypoglycaemia.

3.1. For every day on which diving is contemplated, the diver should assess him or herself in a general sense. If he or she is uncomfortable, unduly anxious, unwell in any way (including seasickness), or blood glucose control is not in its normal stable pattern, DIVING SHOULD NOT BE UNDERTAKEN.

3.2. The suggested goal for the diabetic approaching any dive is to establish a blood glucose level of at least 150 mg.dl⁻¹ (8.3 mmol.l⁻¹), and to ensure that this level is either stable or rising before entering the water. The workshop recommends that this be determined by three measurements of blood glucose, ideally taken 60 minutes, 30 minutes and immediately prior to diving. Diving should be postponed if blood glucose is < 150 mg.dl⁻¹ (8.3 mmol.l⁻¹), or there is a fall between any two measurements.

- a. Where relevant, strategic and individually tailored reductions in dosages of OHA medication or insulin on the evening prior or on the day of diving may assist in meeting these goals. Initial testing of individual protocols should be conducted under very controlled circumstances.
- b. Where relevant, a regimen of incremental glucose intake to correct inappropriate pre-dive levels or trends may assist in meeting these goals.

3.3. It is recommended that diving should be postponed or cancelled if blood glucose levels are higher than 300 mg.dl⁻¹ (16.7 mmol.l⁻¹).

3.4. Divers with diabetes should carry oral glucose in a readily accessible and ingestible form at the surface and

during all dives. It is strongly recommended that parenteral glucagon is available at the surface. The dive buddy or other person at the surface should be knowledgeable in the use of glucagon. If symptoms or indications of hypoglycaemia are noticed underwater, the diver should surface, establish positive buoyancy, ingest glucose and leave the water. An informed buddy should be in a position to assist throughout this process. Use of an "L" signal with the thumb and index finger of either hand is recommended as a signal for suspected hypoglycaemia.

3.5. Blood glucose levels should be checked at the end of every dive. Appropriate response to the measured level can be determined by the individual mindful of his or her plans for the rest of the day. It should be noted that the requirements for blood glucose status outlined in 3.2 remain

the same for any subsequent dive. In view of the recognized potential for late decrements in blood glucose levels following diving it is strongly recommended that the level is checked frequently for 12-15 hours after diving.

3.6. Divers with diabetes are strongly recommended to pay particular attention to adequate hydration on days of diving. Elevated blood glucose will lead to increased diuresis. While the data are limited, there is some evidence from divers with diabetes that an increase in haematocrit observed post-dive (suggesting dehydration) can be avoided by deliberate ingestion of fluid.

3.7. Divers with diabetes should log all dives, associated diabetic interventions and results of all blood glucose level tests conducted in association with diving. This log can be used to refine future planning in relation to diving.

Executive summary

Historically, the diving medicine community has maintained a conservative position and concluded that insulin-requiring diabetes mellitus (IRDM) should be an absolute contraindication for participation in scuba diving. Dissent for this view has grown over the last 20 years. Recognizing that a substantial number of divers are diving successfully with diabetes – either openly or surreptitiously – has led many to believe that it is time to acknowledge this fact and reexamine the position concerning diabetes and diving.

This diabetes and diving workshop was jointly sponsored by the Undersea and Hyperbaric Medical Society (UHMS) and the Divers Alert Network (DAN) to bring together experts and interested parties from within and beyond the international diving community. Co-organizers were Dr Guy Dear, Dr Neal Pollock and Ms Donna Uguccioni. The meeting was held on June 19, 2005 in Las Vegas, Nevada, USA, following the UHMS annual scientific meeting. The objectives of the workshop were to review the existing data and, if deemed appropriate by discussants, to produce consensus guidelines addressing diabetes and recreational diving. More than 50 individuals from seven nations, mostly clinicians and researchers, participated in the discussions. The list of participants and their affiliations are found at the end of the proceedings document.

Nine invited speakers described data and experience gathered from around the world. Dr Guy Dear (USA) provided the opening remarks. Mr Steve Prosterman (USVI) provided an invaluable description of his personal experience both with diabetes and with diabetes and diving. Dr Eugenio Cersosimo (USA) presented an overview of the current state of the art in clinical management of diabetes mellitus. Dr Chris Edge (UK) reviewed 14 years of data, totaling approximately 14,000 dives, from United Kingdom divers diving with diabetes. Dr Dan Lorber (USA)

represented the American Diabetes Association and presented an overview of discrimination and legal advocacy issues pertinent to persons with diabetes. The final paper appearing in this document was edited and approved by the ADA advocacy group. Ms Donna Uguccioni (USA) reviewed 12 years of data gathered through DAN-affiliated efforts, including surveys, workshops and observational studies. Dr Duke Scott (USA), the medical director for the YMCA SCUBA program, described the American YMCA program that has been used to train persons with diabetes to dive for the past 10 years. Dr Alexis Tabah (France) shared research data from two field studies on divers with diabetes conducted in France and reviewed the recently developed national regulations allowing recreational diving by persons with diabetes. Dr Warren Silberman (USA) described the US Federal Aviation Administration's nine-year-old policy allowing special issuance of medical certificates to individuals with diabetes for third-class (noncommercial) aviation licenses. Dr Simon Mitchell (NZ) closed the presentation portion of the meeting by delivering a draft list of guidelines for diving with diabetes developed from the published literature.

The edited transcript of the workshop reveals the depth of discussions and controversy surrounding each of the guidelines presented below. Some points were easily settled and others more contentious, but all were finally decided through compromise and consensus. The general level of agreement for each point is indicated in this summary.

The workshop participants agreed that the available data supported the position that at least some individuals with diabetes might reasonably be allowed to dive. There was no open dissent on this fundamental issue. The discussion focused on the specifics of who and how.

Two important issues were raised at the start of the discussion. The first concerned the scope of the deliberations. It was agreed that the discussion was to be

limited to recreational diving. The issues concerning professional diving require future, separate deliberations. The second issue concerned the nature of the product that would be produced by the group effort. It was agreed that a set of guidelines, not rules, would be generated. The participants agreed that appropriate and justifiable differences in acceptable procedures may exist and that interest groups must have the flexibility to use the guidelines as they best serve their community's needs.

The draft list delivered by Dr Mitchell served as a "straw man" to guide the discussion. The consensus guidelines, like the draft form, were grouped under three sections: selection and surveillance, scope of diving, and glucose management on the day of diving.

The **selection and surveillance** section began with general text indicating the importance of screening for other exclusionary conditions (e.g., epilepsy, pulmonary disease) and careful consideration of the context in which diving might be conducted. This includes immersion, the potential for extremely remote diving locations, and the high normal risk of cardiac involvement in diving fatalities. The section then addressed limits on age (18 years or older with the possibility of lowering to 16 years with special training), frequency of medical evaluation (at least annually), minimum periods of time from point of initiation or alteration of treatment to start or return to diving (three months from initiation or alteration of treatment with oral hypoglycaemic agents and one year since the initiation of treatment with insulin), allowable history of hypoglycaemic or hyperglycaemic events requiring third-party intervention (none within past year), hypoglycaemia unawareness (no history allowed), recent glycosylated haemoglobin (HbA_{1c}) scores (further evaluation and possibly modification of therapy recommended for values >9 percent), and secondary complications (none can be significant). The section also addressed the importance of having candidates demonstrate a good understanding of diet, exercise, stress, temperature and blood glucose levels and the need for silent ischaemia screening. Finally, the section addressed the need to have candidates agree to follow diabetic diving protocols and to stop diving and seek review for any adverse events that may be related to diabetes.

Several aspects pertaining to the minimum age for training were discussed. The merits of involving family members in training and in providing positive reinforcements to persons with diabetes were recognized. The need to be consistent with applicable public rules was also discussed.

The selection of appropriate minimum durations between initiation or alteration of treatment was contentious. Discussants favored a variety of intervals. The final wording reflected the more conservative position.

The importance of disqualification based on recent history of extreme hypoglycaemia, hyperglycaemia or

hypoglycaemia awareness were widely accepted. Similarly, the importance of a solid understanding of the disease, personal responsibility and a willingness/ability to conduct appropriate self-monitoring were all widely accepted. The option to recommend disqualification based on a history of emergency visits to hospital for any condition related to the diabetes was discussed and rejected.

The necessity for an HbA_{1c} criterion was contentious. Some felt that it was not an appropriate criterion; others preferred a range of high and low cutoff values. Key considerations included recognition that the tightest control might be associated with a greater frequency of hypoglycaemic events and the utility of the measure for counseling purposes. The final wording reflected a relatively inclusive limit.

The discussion of secondary complications of diabetes reflected the importance of monitoring and protecting the long term health of persons with diabetes. The relatively high frequency of cardiac involvement in diving incidents and the potential for accelerated development of coronary artery disease in persons with diabetes was addressed with a strong recommendation for silent ischaemia screening for candidates over 40 years of age. The guideline text regarding secondary complications and silent ischaemia screening was kept general in recognition of the limitations of available research data and potential regional/national differences in screening and evaluation standards. This section is expected to evolve as additional data become available.

The value of annual medical evaluation and the importance of the diver taking personal responsibility in managing his or her disease were generally accepted. There was discussion regarding the appropriate recommendations for physician training. While the abilities of fully trained diabetologists and diving medical officers were appreciated, practical limitations on the availability of specialty-trained physicians were also recognized. It was decided that accepting physicians knowledgeable in treating diabetes and physicians who had completed any post-graduate course in diving medicine was appropriate at this time.

The **scope of diving** section addressed limits on dive depth (100 fsw [30 msw]), decompression obligation and overhead environments, dive time (< 60 min), the need to inform dive partners of their condition and the appropriate response to adverse events, the diabetic status of the buddy diver (recommended to not have diabetes), and recommendations on avoiding situations that may promote or exacerbate hypoglycaemic events.

The discussants widely agreed that divers with diabetes should avoid situations which restrict direct access to the surface (notably dives with obligatory decompression or in overhead environments), those that could create conditions potentially confused with hypoglycaemic symptoms (specifically nitrogen narcosis), and those expected to

increase the likelihood of hypoglycaemic events (e.g., prolonged cold and arduous dives).

There was more debate regarding maximum dive times. Positions favored a variety of recommended maximums and the discretion of the individual. The final wording on the dive time reflects a compromise between the extreme views.

Options to include guidelines on a maximum number of dives to be carried out in a given day and/or a minimum surface interval between dives were discussed and rejected. The discussants widely agreed that it is important for divers with diabetes to inform their dive partners of their condition. There was more debate regarding the propriety of two divers with diabetes diving together. A comment

Table 1: Guidelines for recreational diving with diabetes - summary form¹

Selection and surveillance

- Age ≥ 18 years (≥ 16 years if in special training program)
- Delay diving after start/change in medication
 - 3 months with oral hypoglycaemic agents (OHA)
 - 1 year after initiation of insulin therapy
- No episodes of hypoglycaemia or hyperglycaemia requiring intervention from a third party for at least one year
- No history of hypoglycaemia unawareness
- $HbA_{1c} \leq 9\%$ no more than one month prior to initial assessment and at each annual review
 - values $> 9\%$ indicate the need for further evaluation and possible modification of therapy
- No significant secondary complications from diabetes
- Physician/Diabetologist should carry out annual review and determine that diver has good understanding of disease and effect of exercise
 - in consultation with an expert in diving medicine, as required
- Evaluation for silent ischaemia for candidates > 40 years of age
 - after initial evaluation, periodic surveillance for silent ischaemia can be in accordance with accepted local/national guidelines for the evaluation of diabetics
- Candidate documents intent to follow protocol for divers with diabetes and to cease diving and seek medical review for any adverse events during diving possibly related to diabetes

Scope of diving

- Diving should be planned to avoid
 - depths > 100 fsw (30 msw)
 - durations > 60 min
 - compulsory decompression stops
 - overhead environments (e.g., cave, wreck penetration)
 - situations that may exacerbate hypoglycaemia (e.g., prolonged cold and arduous dives)
- Dive buddy/leader informed of diver's condition and steps to follow in case of problem
- Dive buddy should not have diabetes

Glucose management on the day of diving

- General self-assessment of fitness to dive
- Blood glucose (BG) ≥ 150 mg.dl⁻¹ (8.3 mmol.l⁻¹), stable or rising, before entering the water
 - complete a minimum of three pre-dive BG tests to evaluate trends
 - 60 min, 30 min and immediately prior to diving
 - alterations in dosage of OHA or insulin on evening prior or day of diving may help
- Delay dive if BG
 - < 150 mg.dl⁻¹ (8.3 mmol.l⁻¹)
 - > 300 mg.dl⁻¹ (16.7 mmol.l⁻¹)
- Rescue medications
 - carry readily accessible oral glucose during all dives
 - have parenteral glucagon available at the surface
- If hypoglycaemia noticed underwater, the diver should surface (with buddy), establish positive buoyancy, ingest glucose and leave the water
- Check blood sugar frequently for 12-15 hours after diving
- Ensure adequate hydration on days of diving
- Log all dives (include BG test results and all information pertinent to diabetes management)

¹ For full text see: Pollock NW, Ugucconi DM, Dear GdeL, editors. *Diabetes and recreational diving: guidelines for the future*. Proceedings of the UHMS/DAN 2005 June 19 Workshop. Durham, NC: DAN; 2005.

was made that two divers with diabetes may be diving in a larger group. The final wording of the recommendation favored a conservative position.

The **glucose management on the day of diving** section began by noting that the blood glucose monitoring protocols are applicable to people with diabetes whose medication may put them at risk of hypoglycaemia. The section then addressed the importance of self-assessment to ensure readiness to dive, as recommended for all divers, and several procedures specific to diabetes management. Advance preparation included individually tailored pre-dive modification of oral hypoglycaemic agents or insulin and carbohydrate ingestion, attention to hydration, and critical health self-assessment prior to diving. Measurement standards included minimum pre-dive blood glucose levels (150 mg.dl⁻¹ [8.3 mmol.l⁻¹]), repeated pre-dive blood glucose measures to ensure a stable or rising trend (nominal planned monitoring at approximately 60 min, 30 min and immediately pre-dive), maximum pre-dive blood glucose levels (300 mg.dl⁻¹ [16.7 mmol.l⁻¹]), and post-dive blood glucose testing (repeated throughout a 12-15 hour post-dive period). Intervention supplies to have available included ingestible oral glucose and parenteral glucagon. Record keeping addressed logging dives, blood glucose test results and diabetic interventions associated with diving.

The discussants widely agreed on the importance of most elements in this section: a self-assessment of health preceding diving; both divers and buddies carrying a readily accessible and ingestible form of oral glucose; divers surfacing before ingesting glucose if needed; the availability of parenteral glucagon at the surface; the strategic tailoring of medication regimens in conjunction with diving (worked out in advance of diving or under highly controlled circumstances); serial pre- and post-dive blood glucose checks; incremental correction of sub-optimal blood glucose levels; adequate hydration; and the logging of dives and all information pertinent to diabetes management.

Controversy surrounded the reasonable frequency of pre-dive blood glucose measures, the need to specify pre-dive blood glucose ranges, the optimal and acceptable ranges of pre-dive blood glucose, and the appropriate duration of post-dive blood glucose monitoring. Arguments for recommending minimal obligatory monitoring and greater freedom for the diver were largely based on the record of relatively trouble-free diving by minimally monitored persons with diabetes registered in the United Kingdom. Arguments for greater obligatory monitoring and tighter controls favor the potential for the guidelines to be more useful to persons, both divers with diabetes and medical professionals, who may have less experience with diabetes management and/or diving. The final wording of the recommendations reflected the conservative position of

requiring repeated blood glucose tests and definitive minimum and maximum values.

The draft text of the guidelines was completed by the end of the workshop. The draft text was refined after the meeting by the workshop planners. The refined text and an edited transcript of the discussion were then distributed to participants electronically. Each was invited to provide comment. Changes were circulated to stimulate further electronic discussion. The guidelines provided at the beginning of this proceedings document represent the final text produced after integration of all input received. An abbreviated version of the final guidelines is in Table 1.

The participants in this workshop viewed the guidelines as a work in progress. We fully expect further refinements or even substantial modifications as our understanding of the issues involved in diving with diabetes evolves. It is important that any individual who has questions should consult with physicians knowledgeable in both diving medicine and diabetes care.

Future progress will be facilitated by efforts in two directions. The first is continued support and promotion of initiatives to collect data relevant to diabetes and diving. The second is development of programs and relationships to educate individuals with diabetes who are diving or interested in diving and those who might be professionally involved with divers with diabetes. The latter group includes certifying agencies, dive professionals, medical monitors addressing qualification issues and emergent needs, and the general diving public.

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