SPUMS ANNUAL SCIENTIFIC MEETING 1999

FIELD IDENTIFICATION OF DECOMPRESSION SICKNESS

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Key Words

Clinical diagnosis, decompression illness, investigations, occupational diving.

Background

The diagnosis of decompression illness, distinguishing divers who have the disease from those who do not, is important for treatment decisions. A similar binary classification of decompression sickness (DCS) has been used in the validation of decompression schedules. Decompression schedules are tested under medical supervision and the outcome for each diver is classified as DCS or no-DCS. Each decompression schedule is accepted as "safe" after a pre-determined number of DCS free dives.

There are several problems with this approach to validation of decompression schedules. Firstly, between fulminant DCS and absence of symptoms there is a spectrum of diving outcomes that may escape appropriate binary classification. The diagnosis for DCS is not straightforward as there is no definitive diagnostic test so diagnosis is based on history, signs and symptoms.[1] Unfortunately the signs and symptoms of DCS are similar to those of many other disorders.[2] Exemplifying these difficulties, diving medical specialists in three hyperbaric medicine units in Australia were asked to indicate diagnosis for decompression illness (yes, no, uncertain) for divers, following the first hyperbaric treatment where this occurred. The diagnosis of uncertain decompression illness was given for 15 of 100 divers. Secondly, it is typical to accept each decompression schedule after 20 DCS free dives, according to binomial theory this results in 95% confidence intervals for the true incidence of DCS for the schedule of 0-17%. 366 DCS free dives for each schedule would be required to establish an incidence of less than 1% with 95% confidence.

One method to reduce the requirement for test dive numbers is the development of statistically based decompression schedules that utilise non-linear regression procedures to fit models to observations of depth/time diving profiles and DCS outcome data.[3] Test dive depth/time profiles do not need to be identical because it is the underlying model and not specific schedules that is validated. Therefore, test dives need not be part of a purpose designed testing program. Although these techniques have been applied to data collected during carefully monitored test diving programs, the widespread use of depth/time recorders by occupational and recreational divers might allow the collection of objective depth/time profile data in the field. Although the data will not be of the quality collected from controlled trials, such depth/time profile data could provide a useful source of data for decompression model calibration if diving health outcome could be reliably measured in the field.

Health outcome measurement for statistical decompression tables

CONTROLLED TRIAL DATA COLLECTION

Statistically based decompression models have so far been selected retrospectively by best fit to military diving exposure.[4,5] In these databases outcome is coded as DCS or no-DCS, and can be assigned values of 1 and 0 respectively. Therefore, modelling techniques were developed appropriate to this binary outcome. For each depth/time profile, the model predicts the probability (a value between 0 and 1) of DCS. This approach has the same requirements as traditional validation techniques of a definitive diagnosis for DCS. Also, the degrees of freedom of binary modelling procedures are constrained by the number of the least frequent outcome,[6] in this case DCS. Since DCS is rare, many dives have to be monitored to collect sufficient numbers of incidents of DCS to allow fitting of complex decompression models. It has been recognised that the dives that produce "marginal" symptoms of DCS, but were not definitively categorised, contain valuable information. Subsequently, marginal DCS symptoms have been included within binary modelling techniques, typically ranked at a value of 0.1, resulting in a quasi-multinomial approach.[4] Statistically based decompression models have also been fitted to ultrasonic Doppler venous bubble scores,[7] which alleviates the need for definitive diagnosis of DCS. Bubble scores have been assigned to three ranks and modelled using similar techniques.

FIELD DATA COLLECTION

The capability of the modern generation of diver-carried decompression computers to record and then unload depth/time profiles to deskbound computer has provided a potential source of decompression data from the field. Such data must be carefully audited for accuracy and matched to a valid and reliable evaluation of diving health outcome. For field data collection there are two choices for measuring diving health outcome, evaluation of divers by field data collectors or diver self-assessment. In either case, reliable identification of DCS by those without specialist

medical training is unlikely. Therefore, field data collection requires a measure of diving outcome without need to identify DCS.

FIELD DATA COLLECTORS

Trained field data collectors can collect diving health outcome data that can be later evaluated by those with the necessary specialist skills. Diver's Alert Network (DAN) is using this approach to collect recreational decompression data in Project Dive Exploration.[8] In DAN Europe's Project Safe Dive/Dive Exploration,[9] some field data collectors make ultrasonic Doppler recordings of venous bubbles from some divers. However, the bulk of health outcome data collected in Project Dive Exploration is from interview of the participating divers by trained volunteer field data collectors. Adverse health outcome is documented on an incident report form that comprises a checklist of 18 symptoms including time of onset, location, evolution, and a free description of how the symptom arose.

SELF ASSESSMENT

Divers may be reluctant to report symptoms of DCS for a variety of reasons.[10] Self-assessment allows for data to be de-identified; circumventing some economic and peer pressures against reporting. Clearly, even in the case of de-identified data, divers are unlikely to be able or willing to self-diagnose DCS. An alternative is for divers to list any unusual symptoms, whether related to DCS or not. The problem associated with such free response is that it is variable process: a possibly vague confused idea or symptom must be brought to awareness, a decision made to communicate this symptom, and then the symptom must be put into words. Additionally, at the stage of coding free responses, the coder must decide how to score these responses.

Using standardised questions and standardised responses can circumvent these problems associated with free responses. Routine self-assessment following every dive can also eliminate the need to evaluate significance of symptoms in the decision to report. Health status can be reliably measured in the field by standardised, self-administered, multi-item inventories.[11]

Diver Health Survey

A short-form, multi-item inventory of standardised questions and responses (diver health survey) was developed to measure health status following decompression.[12] The format of the nine explicit questions and responses are similar to the Medical Outcomes Study Short Forms.[11,13] Nine explicit items cover five general concepts indicative of health status[11] (physical functioning, role limitation, general health perception, bodily pain, and vitality), six common symptoms of DCI[2] (pain, paraesthesia, weakness, vitality, rash, and balance/ dizziness), and time of onset of symptoms relative to diving activity. There is space for unsolicited health comments and an unscored record-keeping item. A response to each of the nine explicit items is chosen from four check boxes with semantic anchors representing ranks of 0 through 3. Additional symptoms listed at item 11 are scored 1 each to a maximum of 3. The item scores are summed to give the final score.

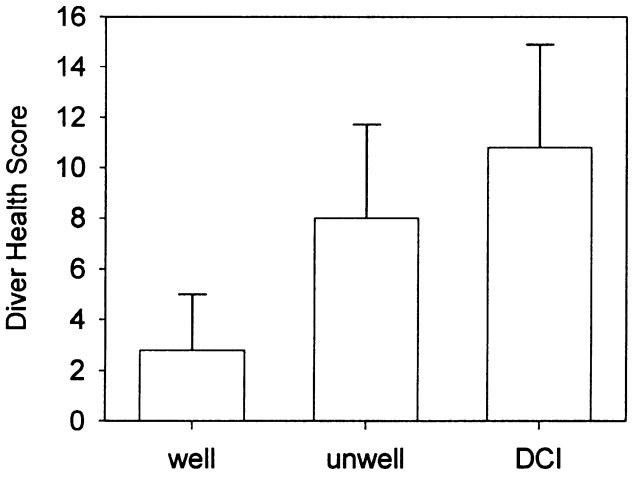

Figure 1. Mean diver health survey scores for nine well and 12 unwell divers diagnosed as without DCI and 48 divers diagnosed as having DCI. All groups have significantly different scores (ANOVA and *a priori* contrast, $P<0.05$). Error bars are plus 1 standard deviation.

Psychometric testing of this diver health survey show that it is a valid measure of decompression related health outcome and is sufficiently reliable for collection of grouped data for decompression model calibration.[12] Figure 1 shows the diver health survey scores from well divers diagnosed without DCS, divers with health complaints diagnosed as not DCS, and divers diagnosed with DCS.

The diver health survey has been used for collection of decompression data and decompression model calibration for occupational tuna farm divers,[14] and data collection is in progress for recompression chamber inside attendants. In these programs, no attempt is made to categorise dives as resulting in DCS or not, decompression health outcome is the untransformed diver health survey score. Such summative scales are approximately linearly related (interval data) to the attribute being measured;[15] in the case of the diver health survey this is decompression health outcome. An interval health score has advantages over a binary classification for describing diving outcome.

For decompression model calibration, normally distributed residuals about interval data allow use of a variety of non-linear estimation procedures. Furthermore, assigning a score to every outcome rather than relatively few incidents of DCI increases model degrees of freedom, relaxing restriction on the number of model parameters or allows fitting of models to smaller data sets.

Summary

Field data collection of diving depth/time profiles and health outcome data may prove a valuable source of data for decompression model calibration. Definitive diagnosis for DCS is not always straightforward and is not feasible for field data collection. Health outcome for field decompression data can be collected as symptoms by either field data collectors or by self-assessment. A diver health survey has been developed that allows valid, reliable self-assessment of decompression outcome for decompression data collection.

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