World as it is

How delay to recompression influences treatment and outcome in recreational divers with mild to moderate neurological decompression sickness in a remote setting

Till S Mutzbauer and Enrico Staps

Abstract

(Mutzbauer TS, Staps E. How delay to recompression influences treatment and outcome in recreational divers with mild to moderate neurological decompression sickness in a remote setting. *Diving and Hyperbaric Medicine*. 2013;43(1):42-45.)
Introduction: This retrospective review examined the influence of delay to recompression on mild/moderate neurological decompression sickness (DCS) in divers, as a pilot for an abandoned prospective study.
Methods: The medical histories of 28 divers treated at a hyperbaric facility in the Maldive Islands in the Indian Ocean were evaluated. The term 'oxygen unit' (OU; 1 OU = 1 bar (ambient pressure) x 1 min x 1.0 (inspiratory oxygen fraction)) was used to enable a quantification of administered hyperbaric oxygen. Visual analog symptom scale (VASS) scores of the worst symptom at presentation (used routinely at the clinic to quantify treatment response) were analysed.
Results: Divers presenting later than 17 hours after surfacing (the median time to treatment after surfacing for the whole group) were likely to have more intense symptoms on VASS (median 100%) than those who presented earlier for treatment (median 30%, $P = 0.02$). Total OU needed to treat divers presenting within 17 hours did not differ from those treated later ($P = 0.11$). Divers with >= 70% symptom reduction with the first hyperbaric oxygen treatment (HBOT) needed between 260 and 1,463 OU in total, whereas those with less than 70% reduction in VASS needed between 263 and 2,126 OU ($P = 0.04$).
Conclusion: Neither more HBOT nor a worse outcome of DCS could be related to delay to treatment longer than 17 hours. The amount of oxygen that had to be administered in total during the whole HBOT course was lower in cases that responded better to the initial HBOT.

Key words
Decompression sickness, recreational diving, scuba diving, resort diving, hyperbaric oxygen therapy, outcome

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Introduction

Data on the management of decompression sickness (DCS) in third-world and remote-area diving resorts are largely absent from the literature. Treatment of DCS may be delayed considerably, and this could result in the need for more intense treatment and/or a poorer clinical outcome.[1] It was thought that the grade of symptom intensity reduction during initial hyperbaric oxygen treatment (HBOT) of patients with DCS may be an indicator of the further course of the disease. Another hypothesis to be considered was that the total amount of oxygen administered would be lower in cases that respond better to the initial HBOT.

Bandos Medical and Hyperbaric Treatment Centre (BMC) is located near the capital island, Male, the Republic of The Maldives. Divers are transferred for treatment from other atolls as well as from the vicinity of the centre. Quality standards for treatment of diving injuries at BMC are controlled by the European Divers Alert Network.

Methods

A small, retrospective review of divers with mild to moderate peripheral neurological DCS (e.g., numbness, tingling or paraesthesia) treated at BMC in 2000 and 2001 was carried out. As a quality assurance review, the Maldivian authorities advised that ethical approval was not required. However, formal ethics approval for a proposed prospective randomised study based on these preliminary results was provided by the Ministry of Health, but that study never eventuated.

All divers presenting to BMC with severe type II (cardiopulmonary or neurological) or type I DCS with musculoskeletal symptoms only and cases with incomplete data were excluded. Also excluded were divers with mild/moderate DCS whose symptoms developed later than the 90% quantile for all divers, and those with a treatment delay exceeding the 90% quantile for all divers. This left two partly identical subgroups of 28 or 26 divers for analysis from a larger data pool of 81 divers presenting over the time period of the study.[2]

Data were entered anonymously into a Microsoft Excel® sheet. A visual analog symptom scale (VASS) allowed divers to rate their symptom intensity, based on the maximum (100%) perceived after onset. The most intense

Table 1
Analyses conducted on 28 or 26 divers (some data for two divers missing) with mild/moderate peripheral neurological decompression sickness; OU – 'oxygen unit'; VASS – visual analogue symptom severity expressed as a % based on the maximum (100%) at the time of admission

Variable	Group 1	Group 2	Examined parameters
Symptom intensity (VASS) change with initial hyperbaric therapy (Red_{init})	Red_{init} < 70% *n* = 8	Red_{init} >= 70% *n* = 18	Total oxygen administered (OU); time from surfacing to onset of the first symptom (t_s); time from surfacing to beginning of hyperbaric treatment (t_b)
Time from surfacing to beginning of hyperbaric treatment (t_b)	t_b <= 17 h *n* = 15	t_b > 17 h *n* = 13	OU; time from surfacing to onset of the first symptom (t_s); VASS change with initial hyperbaric therapy (Red_{init})

symptom was chosen for evaluation. The first VASS value (t_1) represents the symptom intensity before initial HBOT, t_2 the intensity after the initial HBOT and t_3 the intensity at discharge. Additionally, the reduction in symptom intensity following the initial HBOT was calculated for each diver:

$$Red_{init} = (1-t_2/t_1) \times 100\% \quad (1)$$

The term 'oxygen unit' (OU) was generated to enable a comparison between different treatments/individuals, where:

1 OU = 1 bar (ambient pressure) x 1 min x 1.0 (inspired oxygen fraction) (2)

The total oxygen dose in OU was calculated for each patient.

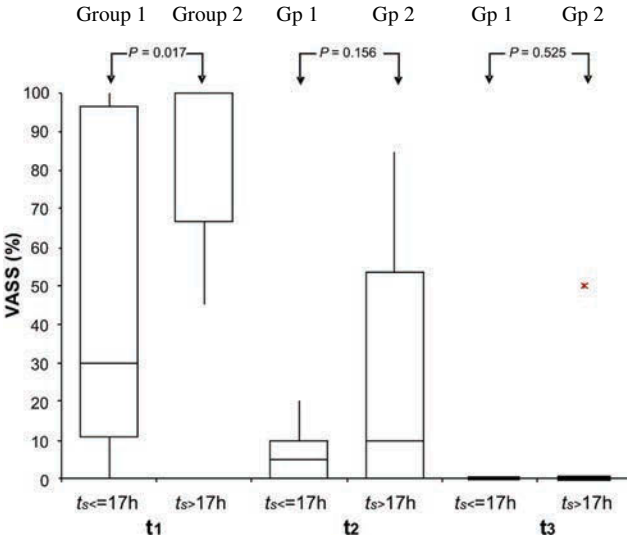
Having collected half of the available data, a provisional analysis was made. The median symptom-intensity reduction of all divers after the initial HBOT served as a cut-off value to form two groups for comparison with regard to the OU administered. Patients were also divided into two groups according to the delay between surfacing from the last dive to commencing HBOT (t_b <= 17 h and > 17 h). The total OU administered and VASS reduction were compared between these two groups (Table 1).

Differences between groups were compared using the Mann-Whitney U-Test. Statistical significance was taken at a *P*-value < 0.05.

Results

Half of the divers examined reported onset of the first symptom within one hour after surfacing; three-quarters had developed symptoms within two hours. The median time to start of HBOT was 17 hours after surfacing, in two thirds within 26 hours and in 90% within 54 hours. At the time of admission (t_1) VASS in

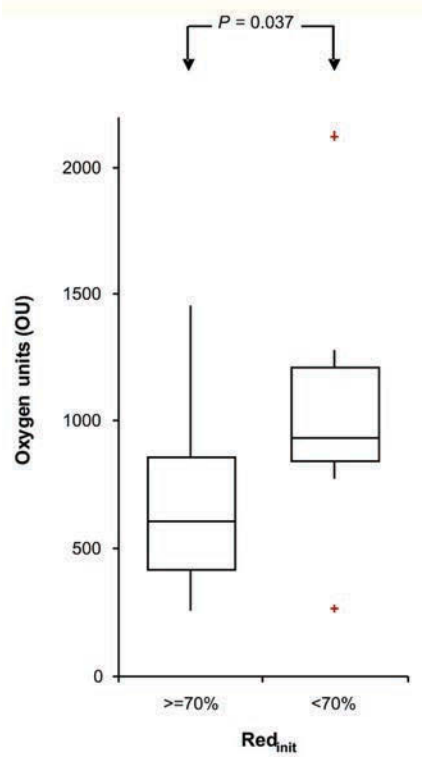
Figure 1
Box plots for intensity of symptoms VASS (%) of two groups of divers with decompression sickness divided according to the delay to treatment and the times of measuring VASS: t_1 (on admission); t_2 (end of initial hyperbaric oxygen therapy, HBOT) and t_3 (at discharge); Group 1 <=17 h, *n* = 15; Group 2 >17 h, *n* = 13; "+x" maximum (column 3); "—" median; box: interval between 25% and 75% quantiles; t_s – time from surfacing to commencing HBOT



Group 1 ranged from 0% to 100% (median 30%) and in Group 2 from 45% to 100% (median 100%) (*P* = 0.017); i.e., a higher VASS was found if the initial treatment was started later than 17 hours after surfacing (Figure 1).

The median VASS reduction after the initial HBOT was 70%. There was no difference between the two VASS groups (≤ 70% and > 70% VASS improvement) with respect to the time to onset of the first symptoms (*P* = 0.48) or the time interval until the beginning of treatment (*P* = 0.82). Total

Figure 2
Box plots for oxygen dose in two groups of divers with decompression sickness divided according to the percentage reduction in intensity of the predominant symptom during the first hyperbaric treatment (Red_{init}); Group 1 ≥ 70%, *n* = 18; Group 2 < 70%, *n* = 8; "+" maximum and minimum; "—" median; box: interval between 25% and 75% quantiles



OU required was less in patients with ≥ 70% improvement in VASS with the initial HBOT (median 604 OU, range 260 to 1,463) than in those with < 70% improvement (median 942 OU, range 263 to 2,126, $P = 0.037$; Figure 2). No differences were seen between the time-delay groups in terms of clinical outcome ($P = 0.9$) or in total OU ($P = 0.11$).

Discussion

Times to symptom onset are similar to those reported previously, with about half of all divers presenting at BMC noticing onset within one hour and 90% within six hours after their last dive.[3,4]

In cases of poor initial response, repeated HBOT may achieve a better outcome.[5] The present study, in which patients whose most severe symptom was reduced by at least 70% with the initial HBOT, needed less HBOT, is consistent with this view. It has been recommended that a patient be treated as long as no further improvement of symptoms can be observed.[6] In another study, divers who were free of symptoms after the initial HBOT were treated an average of 10 hours from onset, whereas in divers who needed more than one recompression therapy the average delay was 18 hours.[7] Increasing severity at presentation and delay to the initial treatment are reported in some studies to have a negative effect on treatment and residual symptoms, whereas in other studies neither the time to recompression nor the choice of initial hyperbaric procedure appeared to influence recovery.[8–11] In this small BMC series, those divers with a delay of more than 17 hours to treatment tended to have more intense symptoms measured on a VASS than those treated in under 17 hours, which may be an indicator of more severe tissue damage induced by the delay. However, this did not influence outcome.

Use of a simple parameter – the oxygen unit (OU) – to measure total oxygen exposure, especially as the HBOT schedules were sometimes not identical, suggested that delay also resulted in more treatment being required to achieve a satisfactory clinical outcome.

This study has several limitations. Firstly, only a small number of divers were studied. Secondly, it is difficult to determine in all divers the exact time when symptoms occur, as this may happen when the diver is asleep. The reported symptom onset may, therefore, be an unreliable parameter for studies, in contrast to the exact time of surfacing from the last dive. Thirdly, although most of the divers had received first-aid normobaric oxygen, there were no data regarding the actual duration and inspired oxygen fraction. Further, not all initial HBOT schedules were identical. Finally, dehydration was almost always an issue; however, haematocrit was not monitored. Despite these limitations, it was considered useful to report these findings from a remote area environment as such data are very limited.

Conclusion

This small study from a medical centre in the Maldive Islands does provide encouragement to remotely situated hyperbaric chambers as well as in third-world resort areas. With attention to good standards of care, satisfactory outcomes can be achieved in mild to moderate peripheral neurological DCS.

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Conflict of interest: Nil

Till S Mutzbauer, MD, DDS, is a maxillofacial surgeon and anaesthetist in private practice in Zurich. He was Assistant Operations Director, Bandos Medical Centre, Bandos, Republic of Maldives at the time of the study.
Enrico Staps, MD, is a medical officer in the Federal Armed Forces, presently at the Armed Forces Medical Centre, Ulm, Germany. He was a medical student at the time of the study.

Address for correspondence:
Dr Till S Mutzbauer
Mutzbauer & Partner
Tiefenhoefe 11
CH-8001 Zuerich
Switzerland
Phone: *+41-(0)44-211-1465*
Fax: *+41-(0)44-212-4085*
E-mail: *<mutzbauer@gmail.com>*

European Committee for Hyperbaric Medicine Workshop 2013 Diagnosis and treatment of mild DCS in remote diving destinations

Date: 22 September 2013
Timing: 1400–1900 hr
Venue: Tamarun, St Gilles les Bains, Réunion Island

Organizing Committee:
Alessandro Marroni, Ramiro Cali-Corleo, Jacek Kot

Theme:
Diagnosis and initial treatment of mild decompression sickness occurring in remote diving destinations and its eventual management at the hyperbaric facility

Programme:
- Definition of mild DCS, clinical manifestations, differential diagnosis and threshold between mild and serious DCS
- Natural history of DCS – case histories with special emphasis on delayed versus early treatment and final outcome
- Telemedicine triage and decision making for 'remote locations'
- Immediate care and in-water recompression
- Non-hyperbaric treatment: pros and cons
- Cost-benefit evaluation; liability implications of local non-hyperbaric treatment vs. standard Medevac
- (Panel Discussion and Workshop Conclusions)

For further details:
Websites: <www.ECHM.org> or <www.reunion2013.org>