Regular Doppler monitoring is necessary to map the progression of venous gas emboli evolution post-dive.

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Introduction

- Doppler bubble monitoring is a useful and practicable tool for the detection of 'silent' bubbles (those that do not result in signs or symptoms of DCS) to help assess the risk of DCS, so long as **equipment**, **procedures** and **classification** of bubbles are standardised to provide comparable inter-research group data (1).
- In recent decompression physiology papers there has been a trend towards making only a few measurements at around 30 and 60 min post dive, despite guidelines suggesting that the ideal procedure (dependent on dive profile) would include measurements every 20 min post dive, for at least 2 hours (1).
- If measurements are not made prior to 30 min post-dive or after 1 hour, then the onset and peak of bubbling may actually be missed and the monitoring rendered inadequate, particularly in studies where a full picture of bubble evolution is necessary for the interpretation of the results.

Methods

Over 15 years, we have collected a large amount of post-hyperbaric exposure Doppler data from dive profiles including:

- submarine escape dives
- saturation dives
- saturation plus submarine escape dives
- bounce dives

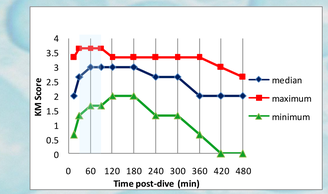
Most of these data were recorded at regular intervals immediately post-dive and often continued until bubble evolution had ceased, using the Kisman Masurel method of scoring (2). This allows a full picture of bubble evolution to be mapped.

We aimed to make a retrospective analysis of these data to determine the natural history of VGE evolution across all types of dives, and so to indicate how just how effective measurements made between 30—90 min post-dive are in characterising bubble evolution and peak scores.

The data displayed in the graphs to the right are representative of some of our studies. Both human and animal subjects were used.

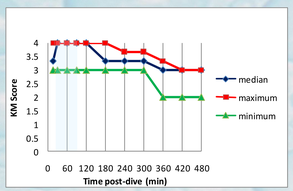
Doppler data from various dive profiles showing median, maximum and minimum recorded KM Scores

Saturation (8 m, 24 h, n = 21)



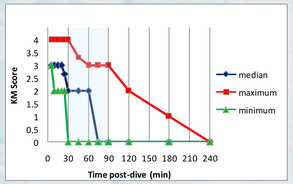
180 kPa saturation (24h) dive data.

Saturation (8 m 24 h) + escape (240 m) (n = 15)



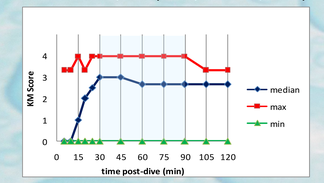
180 kPa saturation (24h) + 2500 kPa simulated submarine escape on air dive data.

Escape (240 m, n = 7)



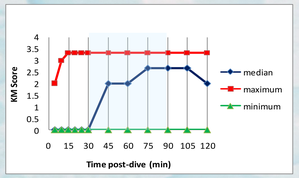
2500 kPa simulated submarine escape on air dive data.

Bounce dive, flex (18 m, 100 min, n = 9)



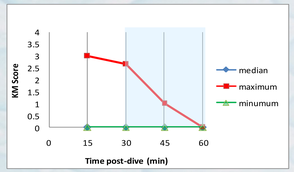
280 kPa for 100 min, decompression on US Navy table 18. Data from NO pre-dive prophylaxis trial, control group.

Bounce dive, rest, (18 m, 100 min, n = 9)



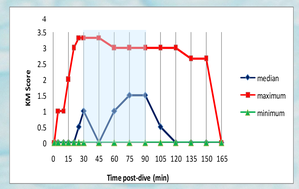
280 kPa for 100 min, decompression on US Navy table 18. Data from NO pre-dive prophylaxis trial, control group.

Bounce dive, flex, tri-mix (60 m 15 min, n = 5)



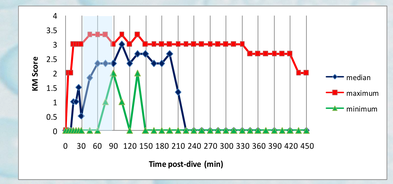
700 kPa for 15 min. Data collected during open water dives using a semi-closed tri-mix set.

Bounce dive, (18 m 100 min, n = 10)



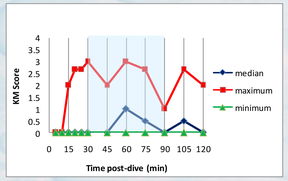
280 kPa for 100 min, decompression on RN Table 11 MOD. Data from pre-exercise trial, control data, measurements at rest.

Bounce dive, (18 m 100 min, n = 10)



280 kPa for 100 min, decompression on RN Table 11 MOD. Data from pre-exercise trial, exercise 2 h before dive data, measurements at rest

Bounce dive, bed rest (18 m 100 min, n = 8)



280 kPa for 100 min, decompression on US Navy table 18. Data from bed rest trial, data collected during bed rest, measurements at rest.

Pale blue delineated areas denote the most common time zone for Doppler measurement in recent studies, from 30 to 90 minutes post dive.
Unless otherwise stated, all dives are chamber dives on air.

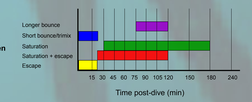
Results

Observation of our collection of data show that in general:

- Escape dives - median peak Doppler scores occur between 5 – 20 min post-decompression.
- Saturation plus escape - median peak bubble scores tend to occur between 20—30 minutes post-dive and may persist for up to 2 h post-dive.
- Saturation dives - median peak scores occur from 30 min to 3h.
- Various bounce dive profiles - when the bottom time was short and dive relatively deep, then bubbles evolved swiftly after decompression (e.g. Tri-mix dives with 15 to 20 min bottom time revealed maximum scores at 15 min; bubbles had disappeared at 60 min).

Longer bottom times at shallower depths (e.g. air dives to 18m for 100 min) tended to produce median peak bubbling at 75 – 115 min for rest measurements.

Activity before, during and after the dive and pharmaceuticals may also influence the timing of both onset and peak VGE. For example, movement before a measurement stimulated bubbling at little earlier at around 30—60 min during 18 m 100 min bounces.



Scematic illustrating the typical periods at which median peak KM Doppler scores may occur and then persist over, for different types of dive profile.

Conclusion

- From observation of our data, it can be seen that there is great variation in the onset, peak and disappearance of Doppler detectable VGE across individuals and dive profiles.
- Therefore, it is not advisable to assume that every dive can be characterised by monitoring VGE within a short period (e.g. 30–60, or even 90 min post-dive).
- Given the difficulty in forecasting the behaviour of bubble evolution, long intervals between measurements are also not ideal. Regular monitoring improves the worth of the data.

References
1—Nishi RY, Brubakk AO & Eftedahl OS. Bubble detection. In: Bennett and Elliott's Physiology and Medicine of Diving, Saunders, 2003.pp 501—529.
2—Kisman KE, Masurel G and Guiller MR. Bubble evaluation code for Doppler ultrasonic decompression data. Undersea Biomed. Research. 5: 28, 1978.