RELIABILITY OF VGE DETECTION IN SUBCLAVIAN AREA FOR DECOMPRESSION STRESS ASSESSMENT FOLLOWING SCUBA DIVING

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1. Background

Ultrasonic detection of venous gas emboli (VGE) is commonly used in evaluation of decompression stress (ref. [1]).
Current recommendation (ref.[2]) is to use:

- Precordium (PRE) as main measurement site,
- Subclavian vein (SC) as optional additional site.

Subclavian detection is less noisy than precordial, for which the signal is affected by background noises from the valves, heart wall and blood flow.

Our study (ref. [3]) is the first to compare rigorously VGE grades from both sites as decompression stress indicators.

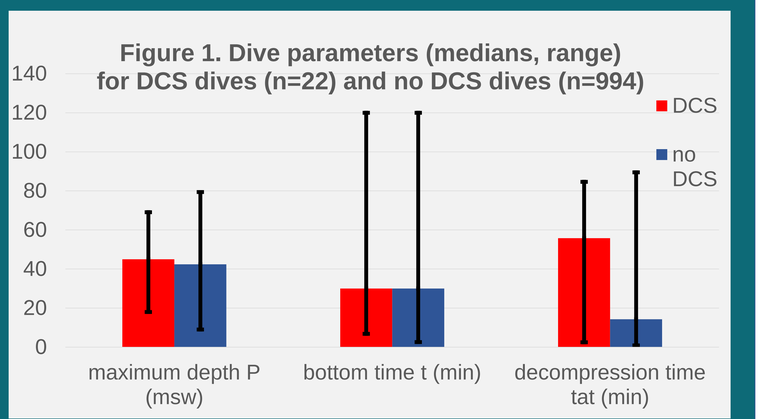
2. Data and Methods

This retrospective study examined 1,016 man-dives breathing air (including 22 DCS cases) from the DRDC dataset.

Data for each dive included:

- dive parameters: depth P, bottom time t, decompression time (Fig. 1).
- PRE and SC VGE grades on Kisman-Masurel scale.
- post-dive decompression sickness (DCS) status.

Figure 1. Dive parameters (medians, range) for DCS dives (n=22) and no DCS dives (n=994)



3. Data and Methods (cont.)

We computed:

- Hempleman's exposure index $Q=P\sqrt{t}$ (ref. [4]) to characterize exposure severity before decompression (Fig. 2).

- Binary precordial and subclavian high bubble grades (PRE HBG and SC HBG resp.) indicating maximum VGE grade III or IV at rest (Fig.3).

We modelled separately the association of the probability of DCS (pDCS) with precordial and subclavian high bubble for DCS risk ratio comparisons.

We adjusted this association to account for exposure severity through dive parameters (1) or Hempleman's index Q (2) using logistic regression for DCS risk computation:

$$\text{Logit } pDCS = a0+a1*P +a2* t+a3*tat+b*HBG \quad (1)$$

$$\text{Logit } pDCS = a0+a1*Q+b*HBG \quad (2)$$

Figure 2. Exposure index $Q=P\sqrt{t}$ (medians, range) for DCS and no DCS dives

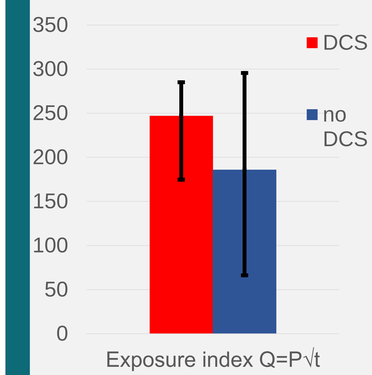
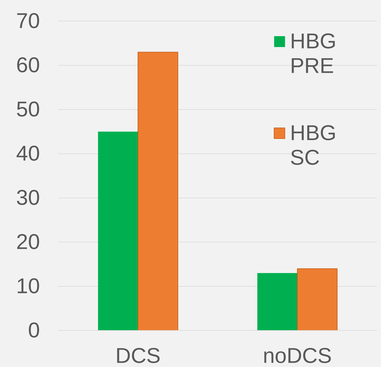


Figure 3. Precordial vs. Subclavian High Bubble Grades (%) for DCS and no DCS dives



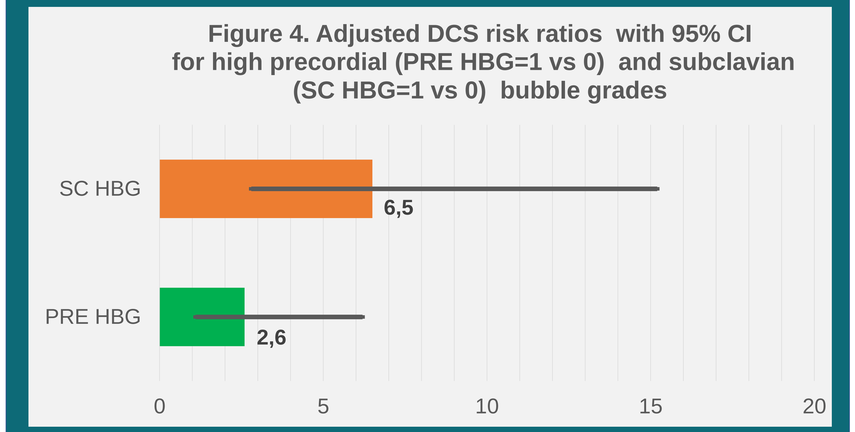
4. Results

Both models (1) and (2) gave similar results:

- Low bubble grades were associated with lower risks of DCS.
- When exposure severity was taken into account, this association was stronger for subclavian than precordial sites (Fig. 4).

- DCS risk ratio associated with 20 point increase in Q, e.g. bottom time increase from 25 to 30 min for 45 msw dive, was 1.36 [95% CI: 1.14-1.74] in both precordial and subclavian models.

Figure 4. Adjusted DCS risk ratios with 95% CI for high precordial (PRE HBG=1 vs 0) and subclavian (SC HBG=1 vs 0) bubble grades



5. Conclusion and Perspectives

The probability of DCS with high subclavian bubble grades was much greater than with precordial ones.
Our findings suggest that the usefulness of subclavian VGE detection using Doppler ultrasound in the development of safer diving has always been underestimated in the past.

Our results open a perspective for larger use of subclavian VGE measures, which could be suitable for automated VGE detection.

For safer decompression, a combined approach to risk evaluation taking into account simultaneously dive parameters and VGE grades should be developed.

6. References

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[4] Hempleman HV. Investigation into the decompression tables: a new theoretical basis for the calculation of decompression tables. Royal Naval Personnel Research Committee, Report III-Part A,UPS 131,Medical Research Council, London; 1952