Do lipids or proteins in plasma reduce bubble surface tension? The interrelationships between plasma lipid and proteins, surface tension and post-dive venous gas embolism.

Nico A.M. Schellart, *Biomed Eng & Physics, Acad Med Centre, Univ of Amsterdam, Amsterdam, The Netherlands* n.a.schellart@amc.nl.

Presented at UHMS Ann. Sc. Meeting, Montreal, June 2015. Poster A8

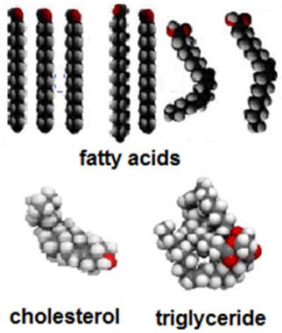
Theory & modeling

Triglycerides (TriG) and cholesterol (Ch) have inappropriate 3-D structure for micelle formation and are insoluble. Phospholipids can not form spontaneously micelles.

Molecular dissolved FFA (long chain; only nM range!) could just cover all bubbles (irrespective BG grade), but

1. takes many hours and
2. the long-chain-FFA critical micelle concentration is in mM range!

Albumin (Alb) can cover all bubbles 10^7 times.



$P_{bubble} = P_{ambient} + P_\gamma = P_{ambient} + 2\gamma/r$ *

P_γ is Laplace pressure, r bubble radius.

surfactant lowers Pγ , new $P\gamma = 2(\gamma - \Gamma)/r$.

Γ is action of surfactant. γ_{water} = 72 mN/m

Lung surfactant Γ > 40 mN/m.

* Simplified

Hypothesis

None of the lipids act as surfactant

Methods

Correlate post exposure albumin, total protein, Alb, triglycerides TriG, total Ch, molecular dissolved fatty acids FFAs, with VGB (KISS at 40, 80, 120, 160 post-dive, precordial) and with γ.

52 male divers, 40-50 years, lean, very fit,.Half fat rich **and** half fat poor meals to enlarge FFA and TriG range of plasma.
63 simulated dives (dry air-dive 21msw/40min profile).
11 with both diets (paired testing).

Main Findings

- No significant and consistent effects of lipids and proteins on surface tension ST pre- and post exposure.
- Lipids and proteins do not affect KISS.
- KISS does not correlate with γ.
- γ ca. 57 mN/m (corrected)

- hardly stabilizing effect of γ
- No KISS and within-subject rich-poor meal differences (paired t-tests, no significant correlations).
- All analyses with subjects with KISS>0: same results.

Discussion

Likely, the 15 mN/m decrease (rel water) is caused by proteins, surrounding the bubbles. Albumin is promising candidate (see e.g. milk chemistry). Albumin is in access: can cover all KM=4 bubbles in 10,000 fold!

Conclusions

1 Most likely, dive bubbles have NO lipid surfactant.

2 Probably bubbles have an albumin coating; small lowring of γ and hardly stabilizing.