

A new class of biophysical models for predicting the probability of decompression sickness in scuba diving

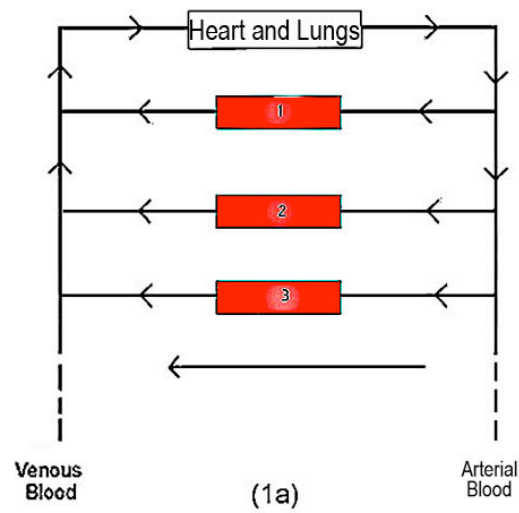
Saul Goldman

Department of Chemistry and the Guelph-Waterloo Physics Institute, University of Guelph, Guelph, Ontario, N1G 2W1, Canada.

e-mail: sgoldman@uoguelph.ca

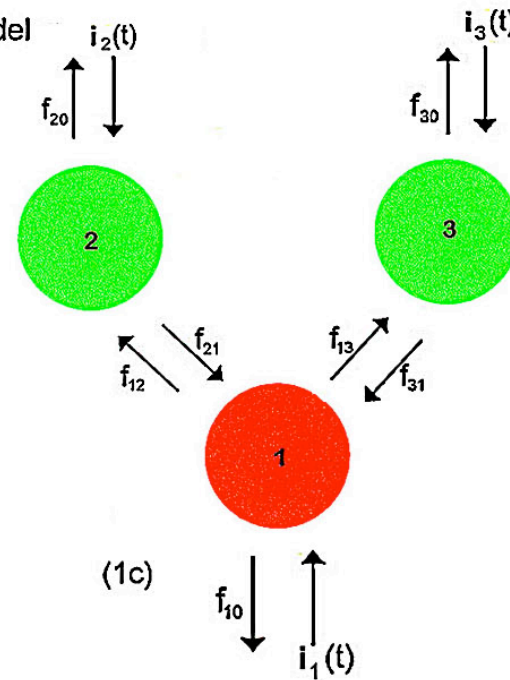
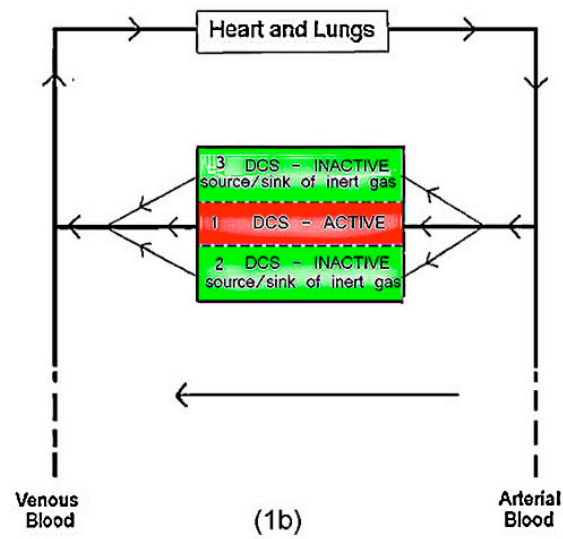
Web: <http://www.chemistry.uoguelph.ca/goldman/>

Articles in PresS. J Appl Physiol (April 19, 2007).
doi:10.1152/japplphysiol.00315.2006



Independent Parallel Model

Interconnected Three-Compartment General Model



RELATED EARLIER WORK

MF Morales and RE Smith, “Competitive Parallel Arrangement” (1944-48).

John A Jacquez, “Compartmental Analysis in Biology and Medicine” (1985).

RD Vann, In “Mechanisms and Risks of Decompression” (1990), a cartoon of lipid and DCS-prone tissue exchanging inert gas.

Kidd-Stubbs and the DCIEM 1983 series compartment models.

DJ Doolette *et. al.*, Multiexponential models for data on sheep (1998-2005).

THE PROBABILISTIC APPROACH TO DECOMPRESSION MODELING DEVELOPED BY PK WEATHERSBY et al IS USED

$$P_{N_2}(DCS) = 1 - \exp(-R)$$

$$r_i(t)$$

$$Q(N_2; solution)$$

$$c_i p_i(t) - P_0(t) - B$$

ASSUMPTIONS

$$P_0(t)$$

$$R_j$$

(1) Linear kinetics, i.e. rate of dissolved

$$Q(N_2; bubbles)$$

?

$$p^1$$

CALIBRATION OF THE MODELS

Square profiles only with air as the breathing mixture was used for all the calibrations. 725 man-dives, with average hit rate approx 11%.

This was done to test model robustness, i.e. the capacity of the models to extrapolate beyond the calibration regime.

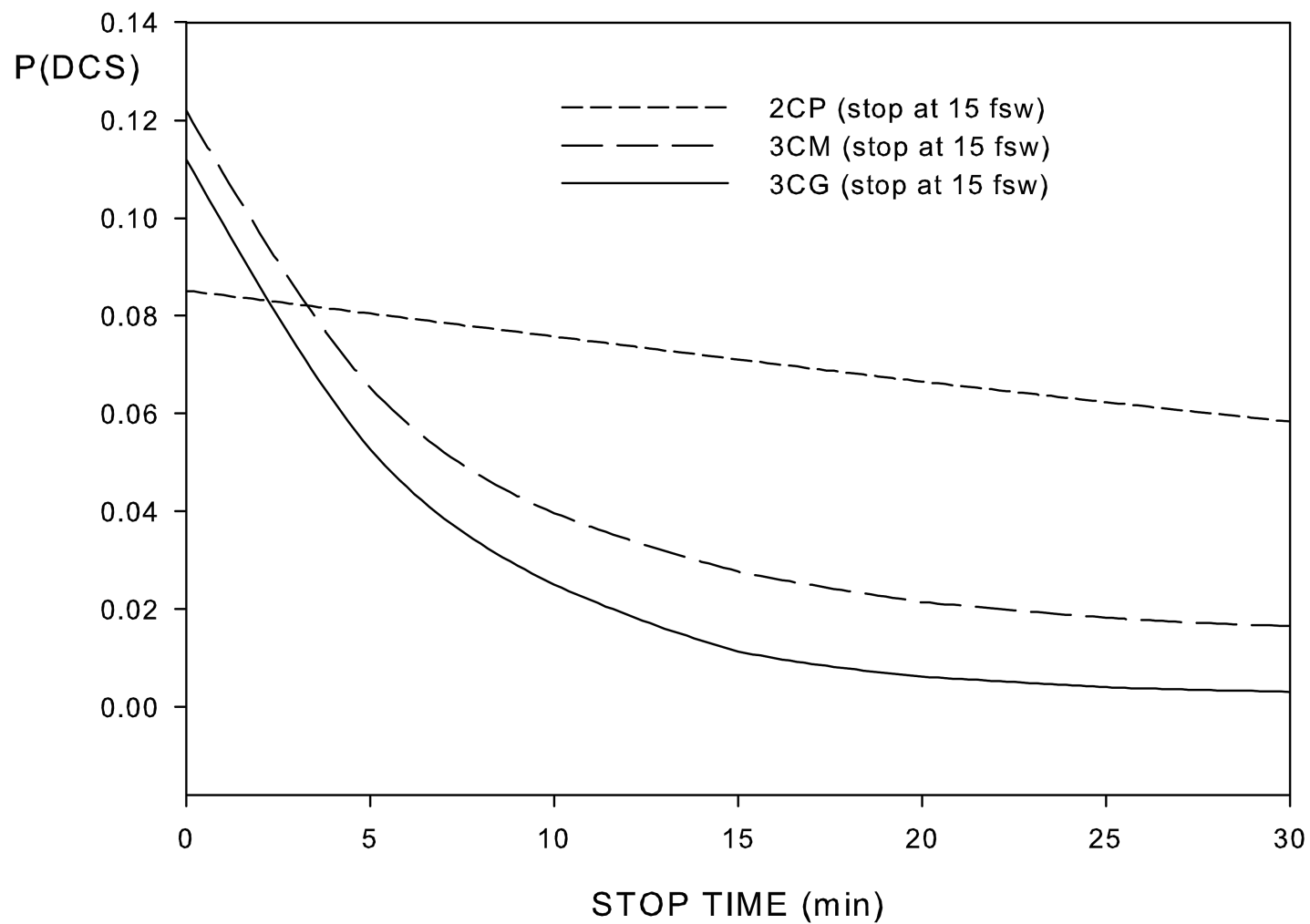
“Maximum Likelihood” was used to determine the model parameters.

Extrapolation to very low-risk profiles. Data: “Phase (1+2A+2B)”

Model	2CM	2CG	2CP	3CM	3CG
POC (%)	0.	0.	.01	25	93

EFFECT OF STOP TIME ON P(DCS)

DIVE: 120 fsw, 30 min



CONCLUSIONS

1. The 3CM and 3CG models extrapolate beyond the calibration regime much more accurately than does the 2CP model. These models were calibrated using the identical dataset, made use of the same risk function, were based on linear kinetics, and had the same number of adjustable parameters (4).
2. The greater rate of risk abatement during a safety or decompression stop predicted by the interconnected models is due to their relatively rapid initial washout rate of nitrogen from their central risk-bearing compartment.
3. The P(DCS) calculations with the interconnected models can be done very rapidly and accurately. The time for a P(DCS) calculation for a single profile is in the range (.001-.01) seconds using a standard (2.8GHz) PC.