

Modelling safe decompression procedures

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Time constants (minutes)

Compartment	Nitrogen	Helium	Argon
1	0.86	0.86	0.86
2	1.87	1.87	1.87
3	3.07	3.07	3.07
4	5.31	5.31	5.31
5	12.3	12.3	12.3
6	50.6	50.6	50.6
7	69.1	69.1	69.1
8	211.3	88.7	246.8

Look first at the conditions in the tissue at the moment bubbles begin to form.

Three sets of points on the next slide:

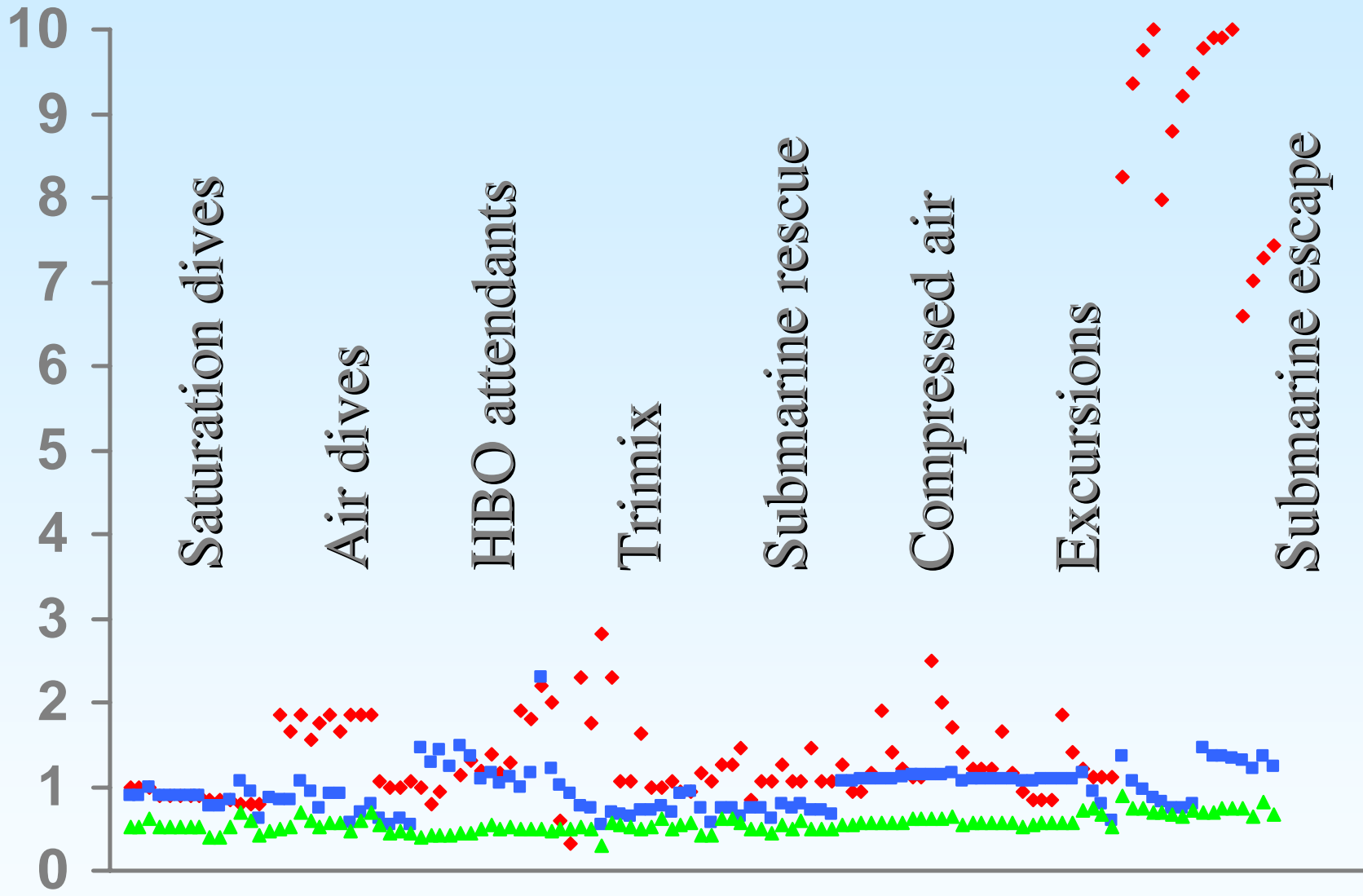
the pressure change required to make bubbles start

the arterial to tissue inert gas gradient at the moment they start

inert gas gradient corrected for oxygen window

for all of the tissues which are bubbling.

Pressure (ATA)



Before a bubble can form the total dissolved gases must at least equal surrounding pressure.

Dissolved gases are :-

oxygen,

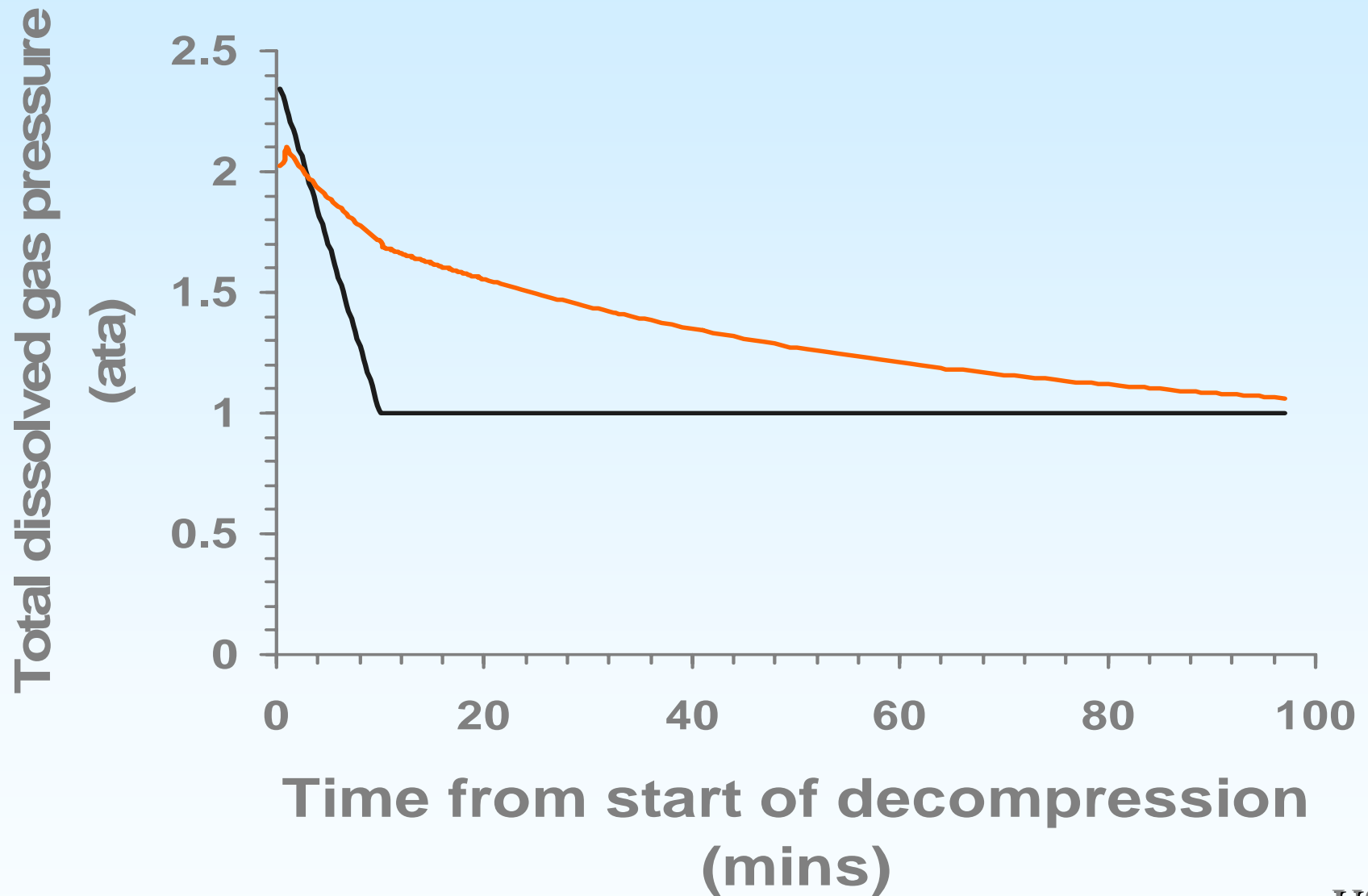
carbon dioxide

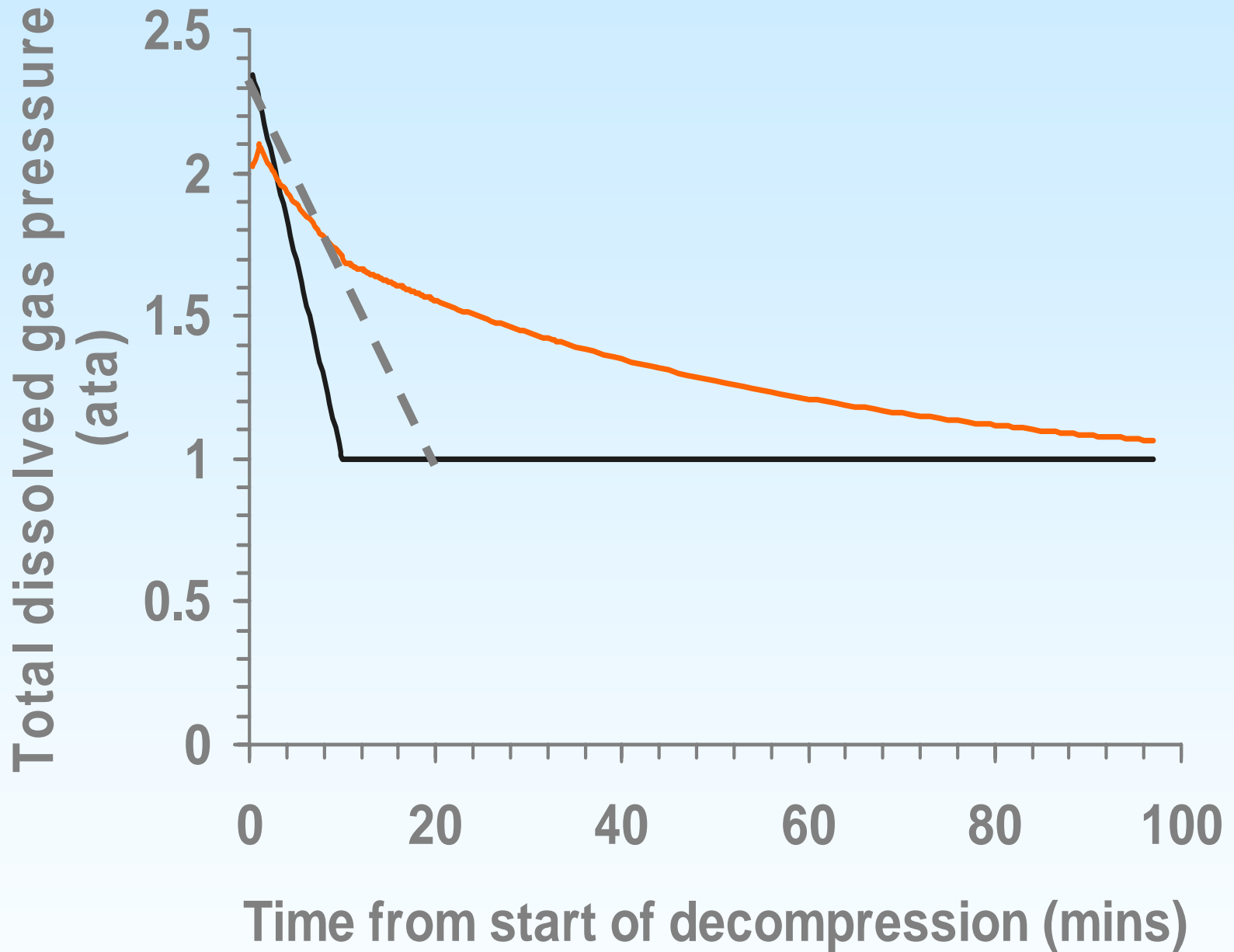
water vapour

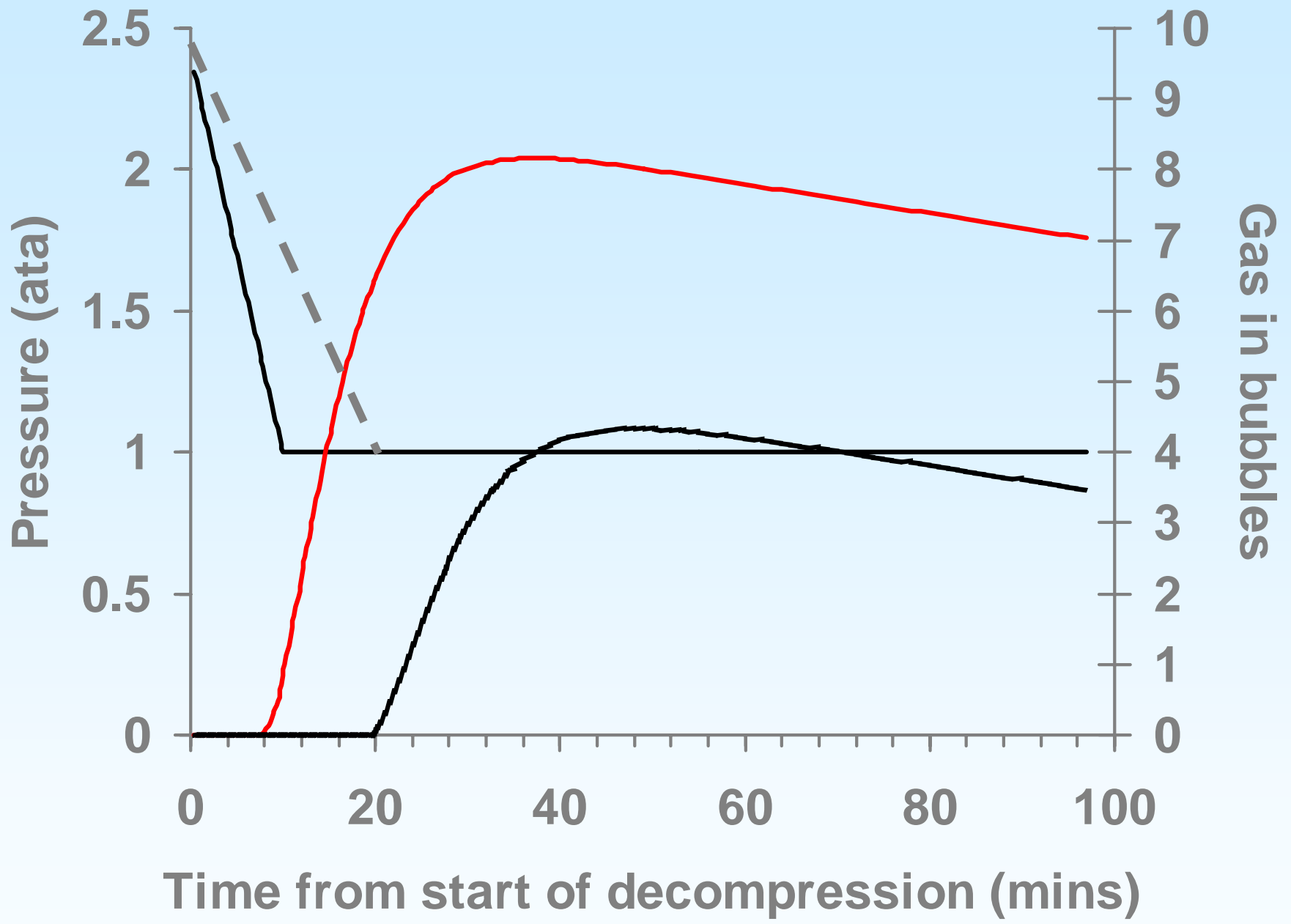
and the inert gases

e.g. nitrogen in hyperbaric air

Muscle, HBO₂ attendants after 100 mins at 14 msw







Excursion 29 msw from 100 msw

Three linear ascents, 18, 10 and 5 msw/min

18 msw/min with 3 min stop at 120 msw

10 msw/min with 3 min stop at 120 msw

Return from working excursion at 129 msw to storage depth at 100 msw

Decompression	PA bubbles	Brain bubbles
18 msw.min	100%	100%
10 msw/min	97%	84%
5 msw/min	96%	55%
18 msw/min + 3 min	97%	60%
10 msw/min + 3 min	96%	47%

Two No-D air dives

30 msw for 25 min, 40 msw for 7 mins

Linear ascent 10 msw/min and 5 msw/min

Shallow stop, at 3 msw. Duration as given in next table down on USN tables.

Deep stop, same duration as shallow stop but 10 msw from maximum depth.

Central venous gas in bubbles

Decompression	30 msw/25 mins	40 msw/7 mins
10 msw/min	100%	100%
5 msw/min	94%	85%
10m/min + deep stop	94%	104%
10m/min + shallow stop	98%	91%

From calibration of the model, predictions versus median precordial Doppler score:

the central venous gas following the 40 msw exposure corresponds to a median Doppler grade 0 for all decompressions.

for the 30 msw exposure the median Doppler grade is borderline Grade 1/Grade 2.

the different decompressions considered do not make sufficient difference to suggest a difference in score will be detectable.

Brain gas in bubbles

Decompression	30 msw/25 mins	40 msw/7 mins
10 msw/min	100%	100%
5 msw/min	75%	60%
10m/min + deep stop	76%	87%
10m/min + shallow stop	92%	84%

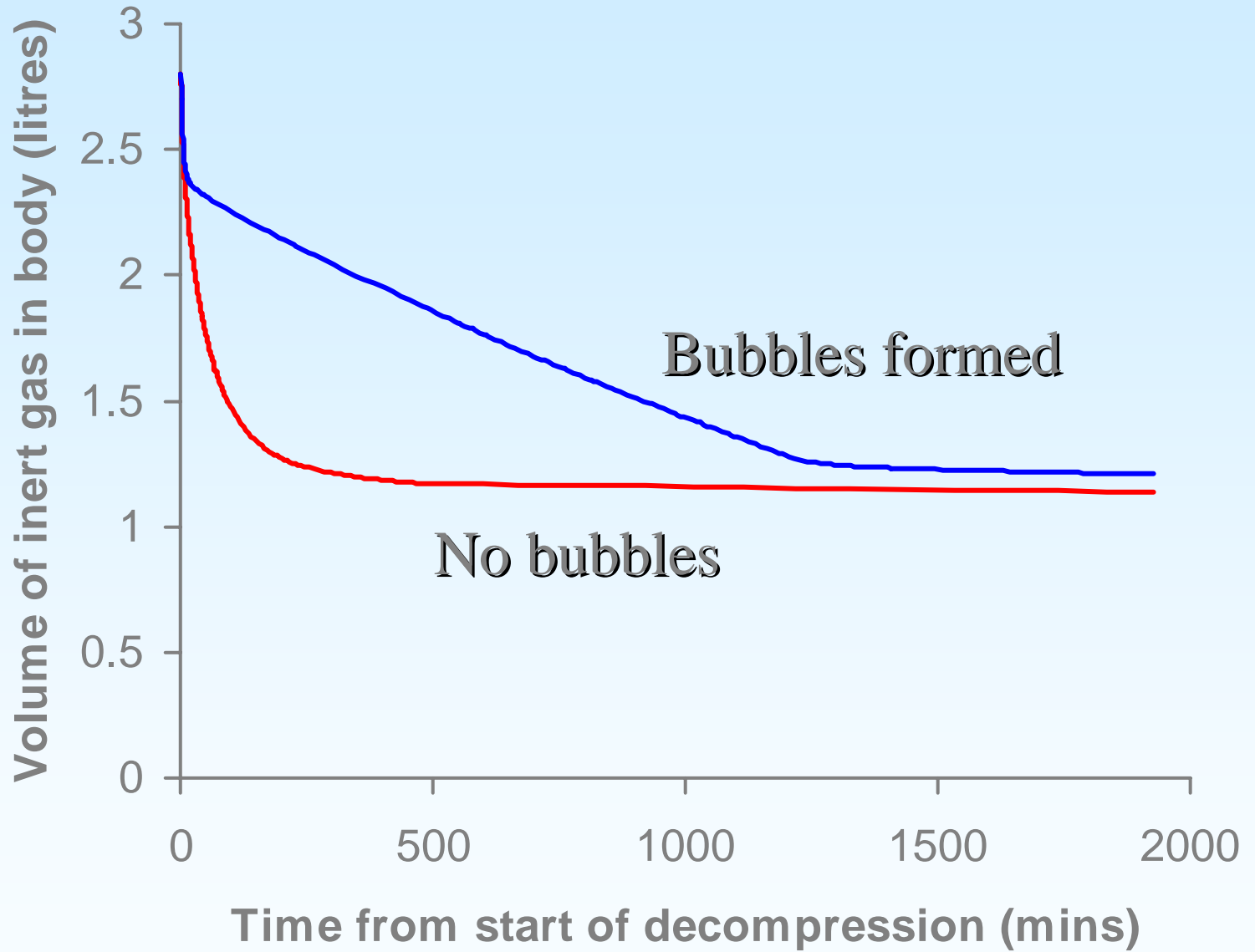
Slowing the ascent is always beneficial

Brain For these profiles the slower ascent is more beneficial than stops; for the shorter exposure the shallow stop is better than the deep; for the longer exposure the deeper stop is better.

Muscle nothing makes much improvement but the deep stop is the wrong thing for the short exposure

Muscle gas in bubbles

Decompression	30 msw/25 mins	40 msw/7 mins
10 msw/min	100%	100%
5 msw/min	99%	100%
10m/min + deep stop	99%	107%
10m/min + shallow stop	100%	99%



Gas in bubbles in central venous blood

Repeat dives --- 25 mins at 30 msw

	Gas volume $\mu\text{l/ml}$	Median grade
First dive	3.48	Doppler II
Second dive after		
1.5 hours	4.58	Doppler III
3 hours	4.31	
6 hours	3.86	
12 hours	3.56	

Total inert gas volume in body

After first dive 2.68 litres

After second dive

Surface interval

1.5 hours 2.82 litres

3 hours 2.90 litres

6 hours 2.86 litres

12 hours 2.71 litres

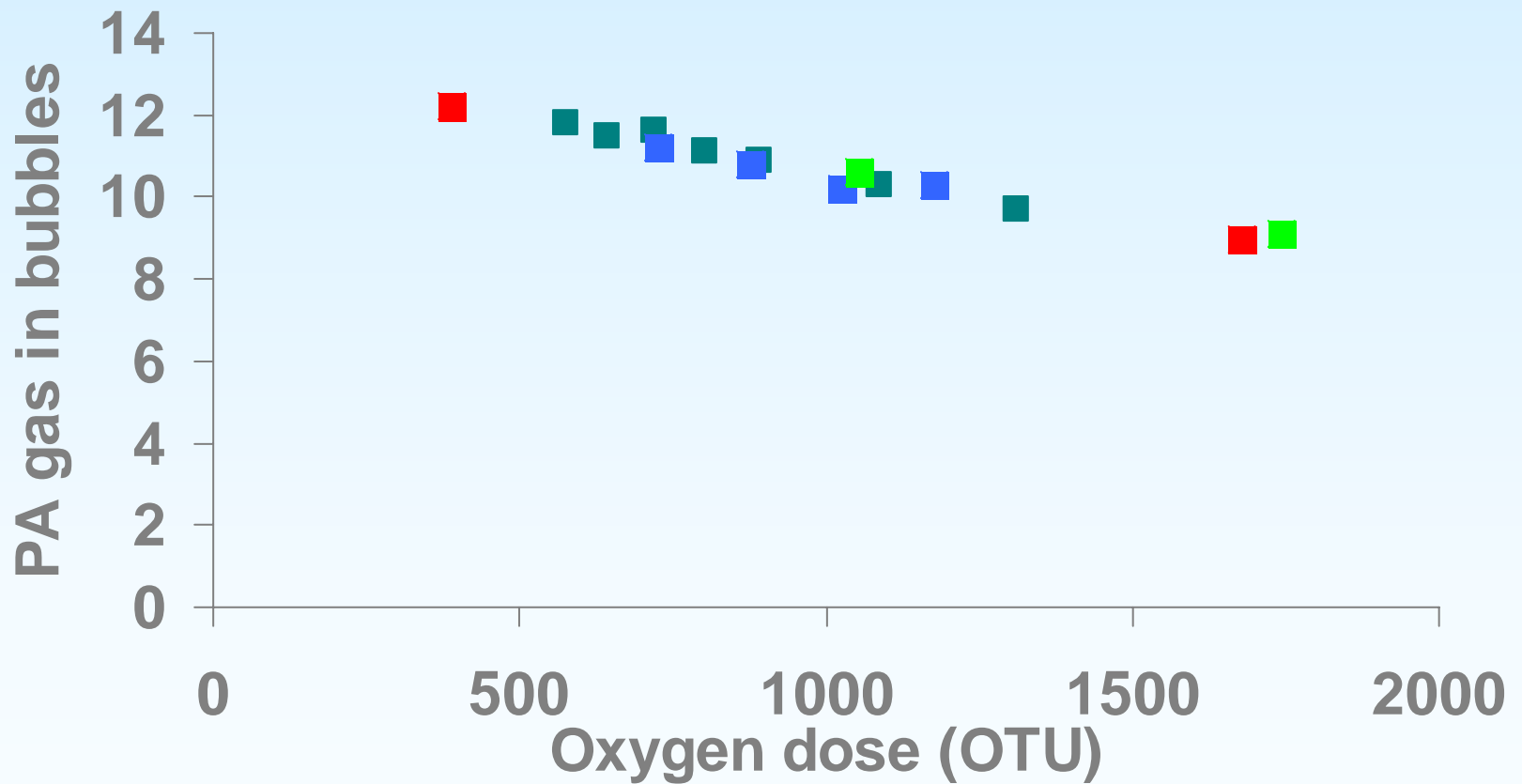
Decompression from saturation at 50 msw

Three decompression rates taking 12, 16 or 24 hours to move 50 msw

A period of breathing 2 ATA oxygen during first hours of decompression or

The oxygen breathing divided into prebreathe and during decompression

- 12 hr deco with and without Oxygen
- 16 hr deco with and without oxygen
- Oxygen on prebreathe and deco
- 24 hr decom with and without oxygen



Conclusions

The decompression procedures do play a role in prevention of dysbaric injury but so too does oxygen.

The Haldanian model is irrelevant to the formation of bubbles as are M values

Conclusions

Bubble formation begins after a certain depth change regardless of the starting depth

The inert partial pressure gradient at the time of bubble formation is not different for different tissues

Conclusions

? Deep stops better for safety than prolonged stops near the surface ?

That depends on the time and depth of the hyperbaric exposure