A Pharmacologic Approach to Counteract Nitrogen Narcosis During Submarine Escapes from Depths Down to 1,000 fsw

Massimo Ferrigno

Department of Anesthesiology and Perioperative and Pain Medicine
Brigham and Women's Hospital and Harvard Medical School

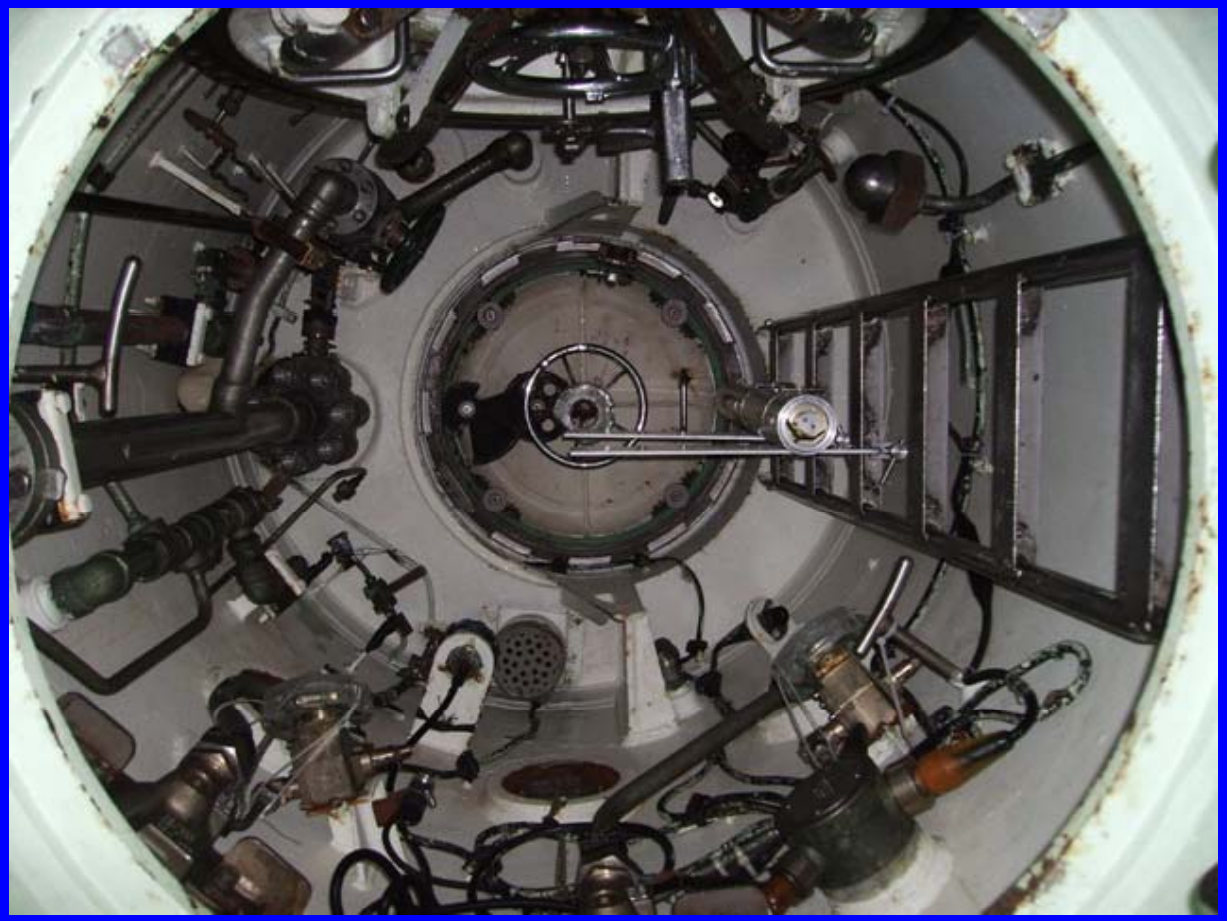
Naveed Tahir

Department of Anesthesiology
Boston University Medical Center

Chris Connor

Department of Anesthesiology, Department of Biomedical Engineering
Boston University Medical Center

Nitrogen narcosis could interfere with deep submarine escapes (600 to 1,000 fsw), particularly in the escape trunk where simple but essential tasks are required to leave the submarine and start rapid ascent



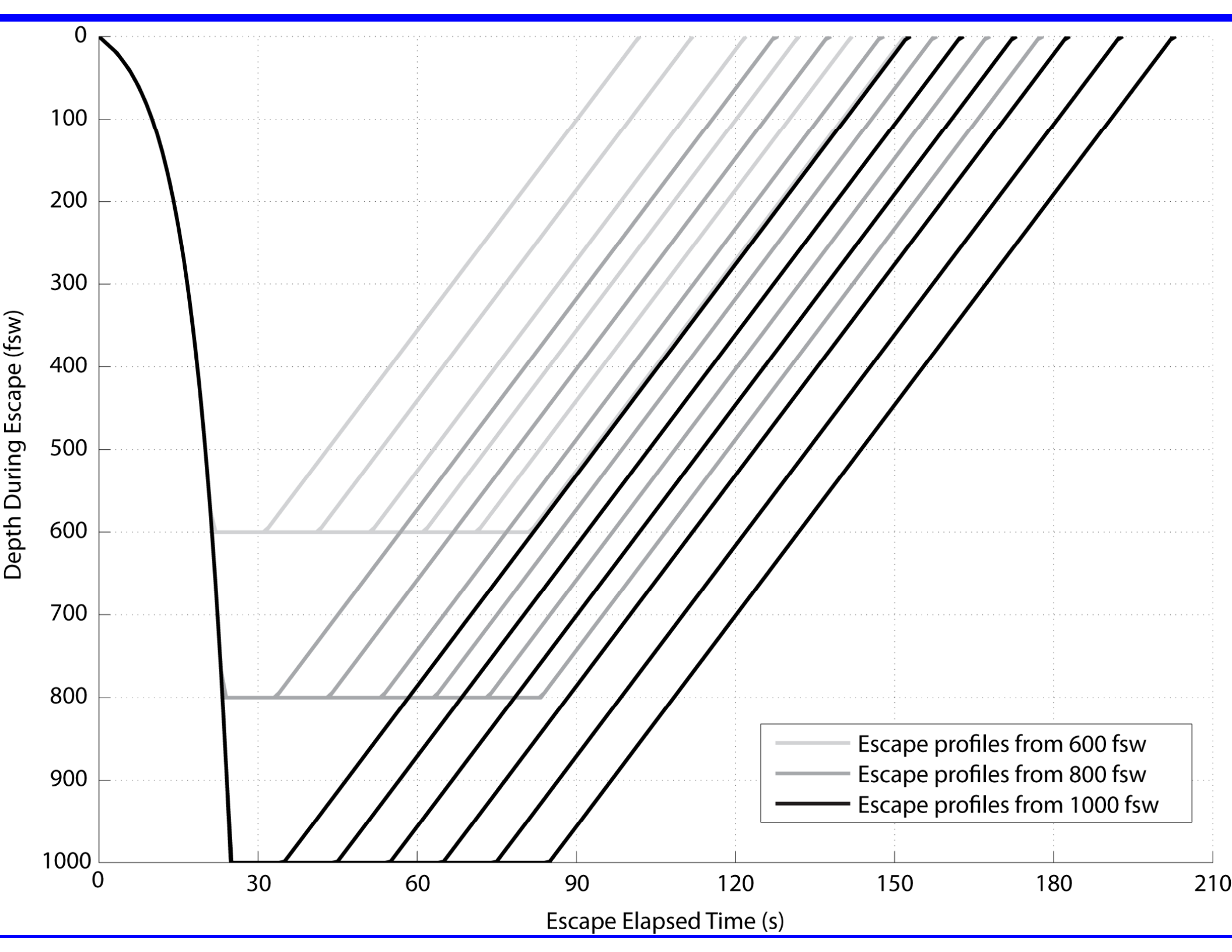
Preliminary results of our theoretical analysis of pharmacological prolongation of lungs-to-brain circulation time had suggested a protective effect against N_2 narcosis. More detailed analysis of these computer simulations is presented here.

Incapacitating nitrogen narcosis can be delayed to later stages of escapes, after leaving the escape trunk

During ascent and at the surface, SEIE (Submarine Escape and Immersion Equipment) will prevent drowning

Materials and Methods

- New computer software designed to assess the effects of changes in circulation times on N_2 uptake and distribution during extremely rapid pressure changes typical of submarine escapes
- Simulations of escapes from 600 to 1,000 fsw (with 100 fsw steps), with varying dwell times (DT) in the escape trunk (from 10 to 60s, in 10 s steps)
- Baseline cardiac output (CO) was set at 5 l/min, and it was varied from 50% to 200% in the escape simulations
- Lungs-to-brain circulation time (14 s at rest) assumed to vary inversely with CO
- Prolongation of lungs-to-brain circulation time through a reduction in CO, due to a reduction in heart rate, caused by Propranolol


0
100
200
300
400
500
600
700
800
900
1000
Depth During Escape (fsw)
0
30
60
90
120
150
180
210
Escape Elapsed Time (s)
Escape profiles from 600 fsw
Escape profiles from 800 fsw
Escape profiles from 1000 fsw

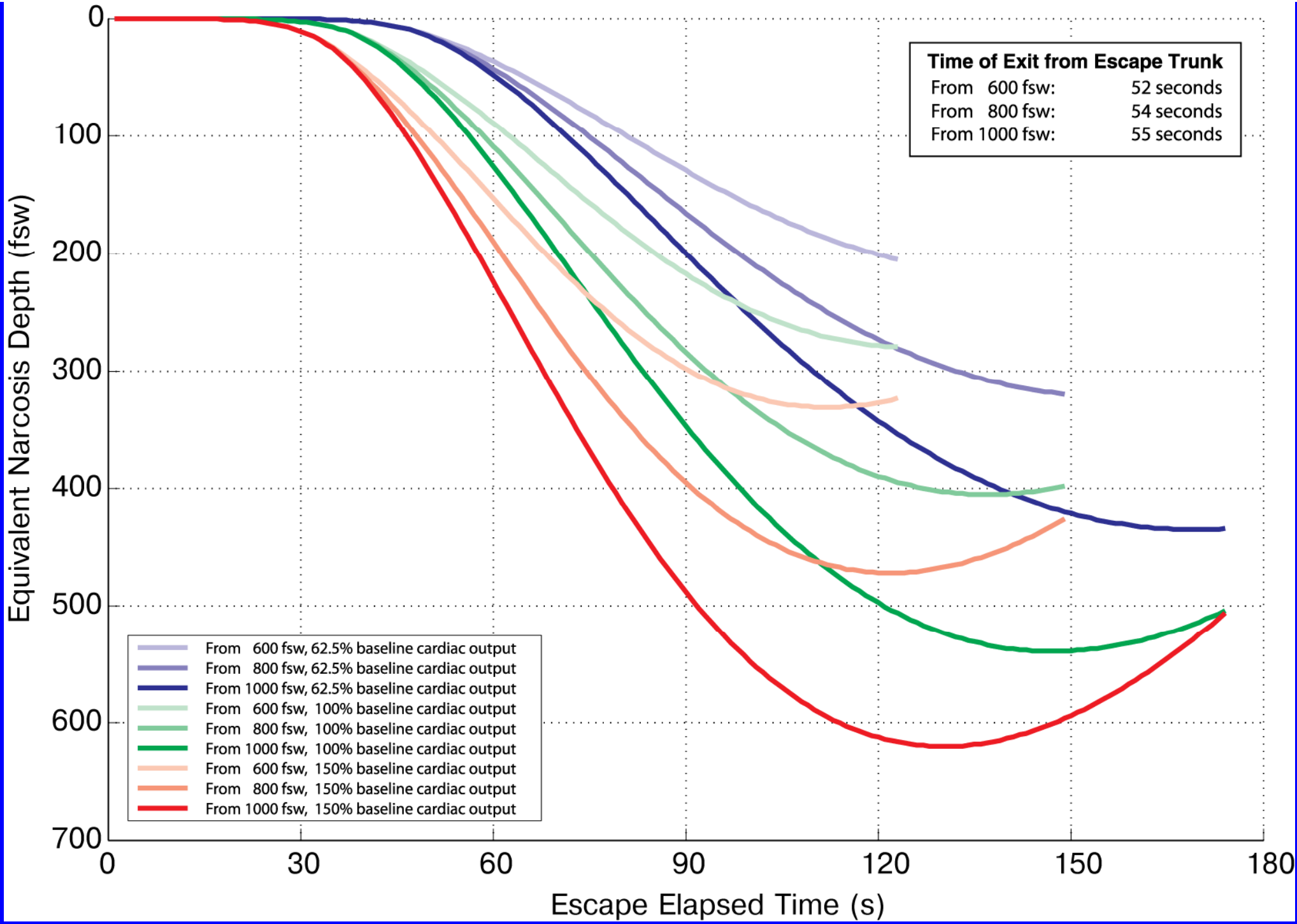
Results

Risk of N_2 narcosis expressed as Equivalent Narcosis Depth (END) in fsw, corresponding to N_2 pressure in the brain after 5 min of air diving at that equivalent depth

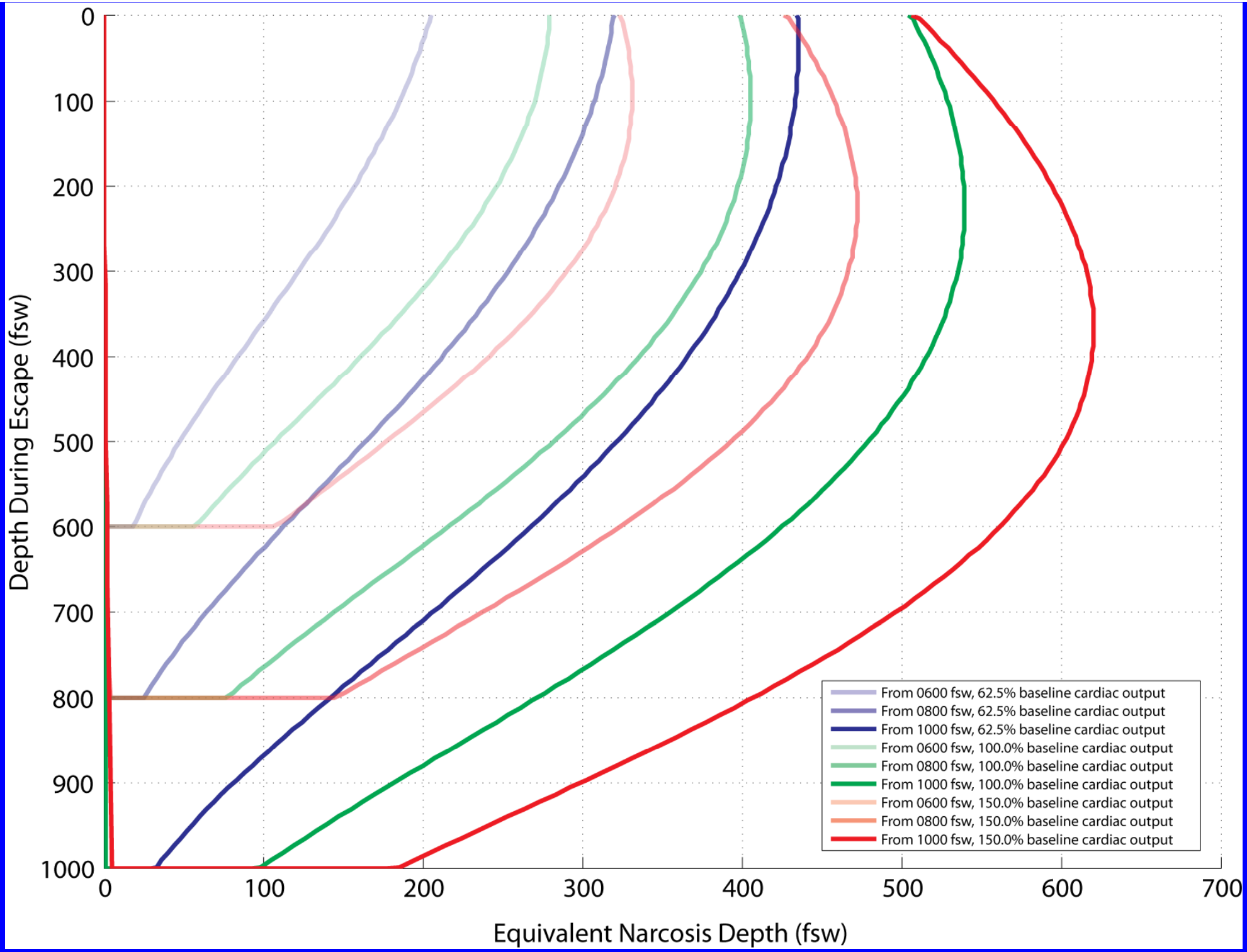
We looked at the effects of changing CO on the greatest END values (corresponding to the peak N_2 pressures) reached while in the escape trunk or during entire escapes

We also looked at Depths at which peak N_2 occurred

Prolongation of lungs-to-brain circulation time appeared to have 2 advantageous effects (which were more evident at greater escape depths and with longer DT's)



1) it reduced peak N_2 reached both in the escape trunk and during the entire course of the escape



2) it delayed peak N_2 to later stages of escapes (closer to the surface during ascent)

Risk of CNS oxygen toxicity during deep submarine escapes ?

Experimental evidence that even with exposure to extremely high oxygen pressure, a latency time to convulsions of at least 4 min

This latency described in 1981 by Burgess et al in rats exposed to 100 % O_2 down to a depth of almost 300 m.

This time (4 min) well in excess of the Dwell Times that could be expected during escapes from a DISSUB (and, actually, well in excess of the expected total duration of submarine escapes from even 1,000 ft).

More recently, Gensser and Blog did not observe any CNS O_2 toxicity in goats during simulated submarine escapes from 290 msw breathing air or hyperoxic gas (60/40 % O2/N2), despite animals' exposure to a maximum inspired pressure of O_2 of 1.8 MPa.

The same authors, in a different study, observed that two goats survived despite convulsing during ascent from 240 msw. They suggested that convulsions had not caused laryngospam.

Conclusions

Oral administration of propranolol prior to deep submarine escape could protect against N_2 narcosis, particularly in submariners with hyperdynamic circulation.

Propranolol may also have additional advantages:

- anxiety reduction
- protection against neurological manifestations of oxygen toxicity

Animal experiments should be conducted to validate this pharmacological approach.

Acknowledgments

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Questions?

Effects of Changes in CO and Lungs to Brain Circulation Times on END Prior to Leaving Escape Trunk

Cardiac Output (%)	Dwell Time (s)		
600 fsw	10	30	60
75	1	31	137
100	5	60	194
150	18	112	282
800 fsw	10	30	60
75	2	43	184
100	7	81	260
150	25	151	378
1000 fsw	10	30	60
75	2	52	227
100	9	98	322
150	30	185	468

Effects of Changes in CO and Lungs to Brain Circulation Times on END During the Entire Escape

Cardiac Output (%)	Dwell Time (s)		
600 fsw	10	30	60
75	167	235	319
100	208	279	364
150	255	331	421
800 fsw	10	30	60
75	279	354	449
100	325	405	506
150	384	472	578
1000 fsw	10	30	60
75	394	476	584
100	450	539	654
150	522	620	740