Changes in Cardiac Autonomic Nervous Function and Stress Hormones during Heliox Saturation Dive to 4.5 MPa

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BACKGROUND

Hyperbaric bradycardia and postdive tachycardia have been reported as major adaptive phenomena of cardiovascular functions in hyperbaric environments. The most important factor in hyperbaric bradycardia has been considered to be increased PO_2 in the inspired gas. There are few reports on the relationships between autonomic nerve function and stress-related hormone's responses during such exposures.

PURPOSE

We examined whether adaptive changes in autonomic nervous and stress-related hormonal functions occur during or after heriox saturation dive to 4.5 MPa. Heliox dry saturation dive to 4.5MPa (440 msw) were conducted in 2004, 2005, and 2006.

FACILITY

Deep diving simulator (DDS) at the Undersea Medical Center (UMC), JMSDF, Yokosuka.

SUBJECT and ENVIRONMENT

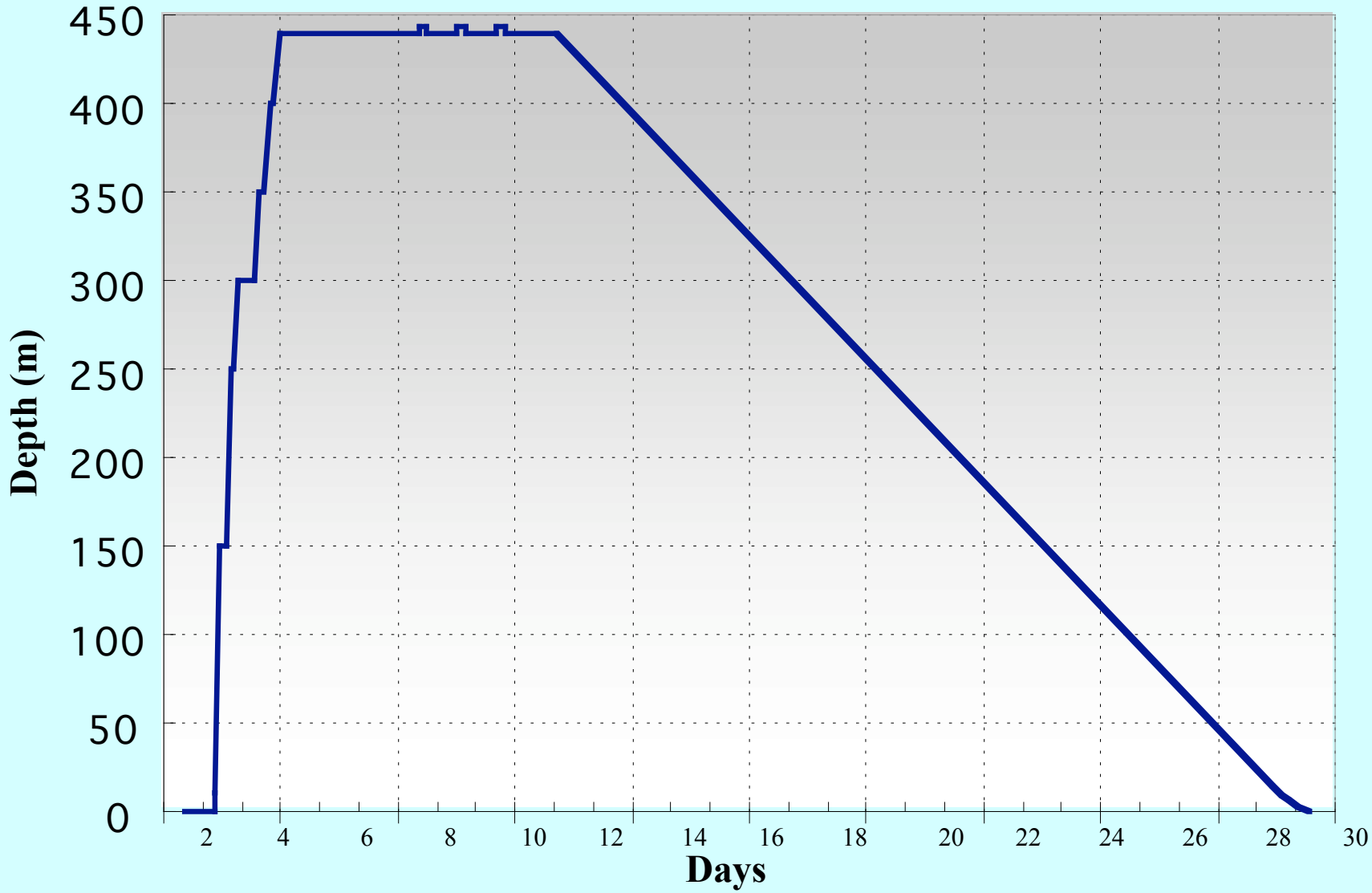
[Subjects]

A total of 18 saturation divers (mean age, 29.5±3.7SD years, range, 24～33 years).

[Ambient Environments]

Heliox dry saturation diving to 4.5 MPa under the conditions of temperature between 25.6k～32.2℃, relative humidity between 59.9～70.5%, PO_2 between 45.2～48.3 kPa (22.0 kPa during the predive and postdive), and PCO_2 below 0.4 kPa.

4.5MPa Saturation Dive Schedule (2004, 2005, 2006)



The diving consists of 5 periods, i.e., pre-dive, compression, 4.5MPa saturation decompression, and post-dive periods.

MEASUREMENTS

[Measurements]

Heart rate (HR) by ECG, systolic and diastolic blood pressures (SBP, DBP) by a sphygmomanometer. Salivary cromogranin A and cortisol.

[Attendant Circumstances]

The respiration rate of around 15 breaths/min with a metronome in supine resting position.

[Measured Time-points]

A total of 14 junctures of time during 5 different dive periods.

DATA ANALYSES

[From ECG]

Application of a FFT algorithm to continuous 128 s RR intervals derived from the re-sampling (every 0.5 s) of beat-to-beat RR intervals.⇒High frequency {0.15～0.40 Hz} power (HF_{RRI}), low frequency {0.04～0.15 Hz} power (LF_{RRI}), and the ratio of LF_{RRI} to HF_{RRI} (LF/HF).

[From Saliva]

Salivary chromogranin A (CgA) and cortisol.

WHAT'S CHROMOGRANIN A?

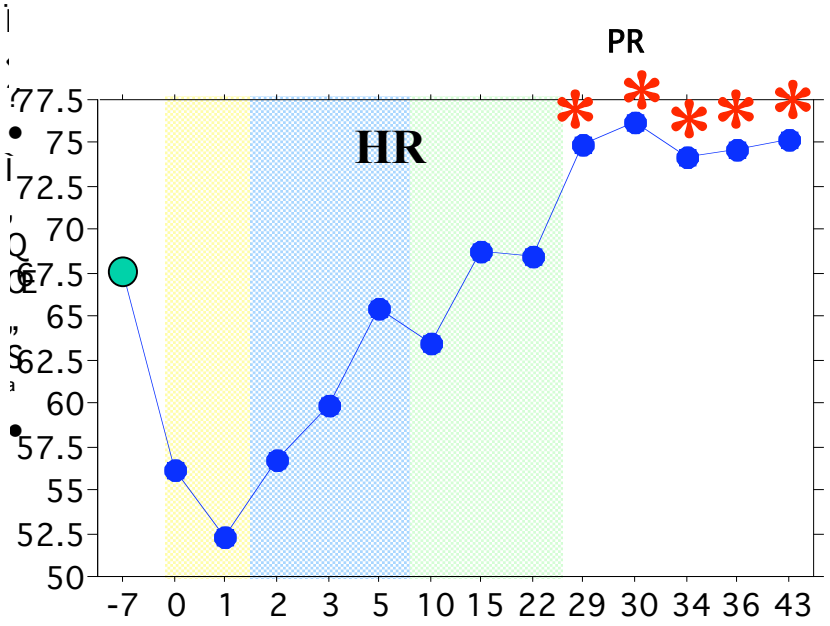
Chromogranin A (CgA) is a major protein in adrenal chromaffin cells and adrenargic neurons. CgA is stored in the chromaffin granules with catecholamines and co-released with catecholamines by exocytosis. Therefore, the elevation seems to be an index of the activity of the sympathetic-adrenal medullary system.

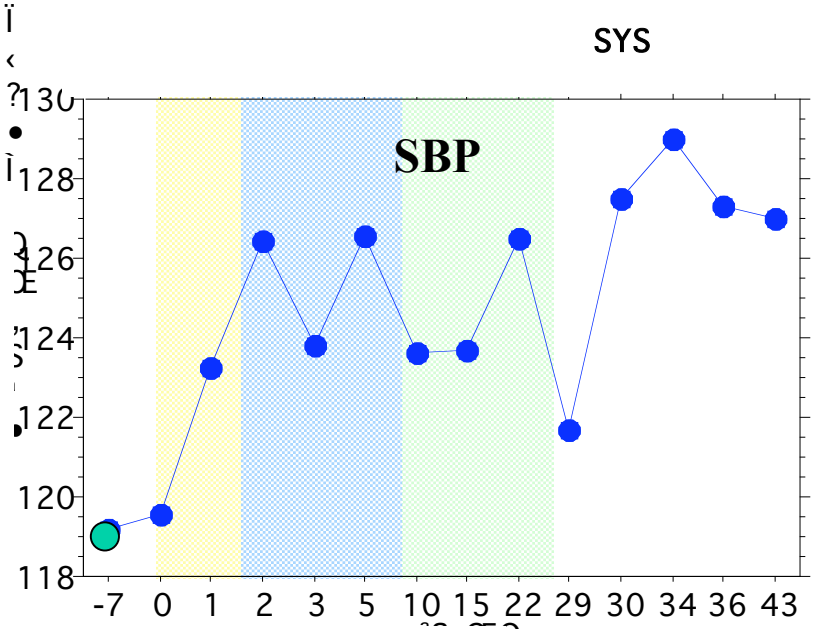
REFERENCE

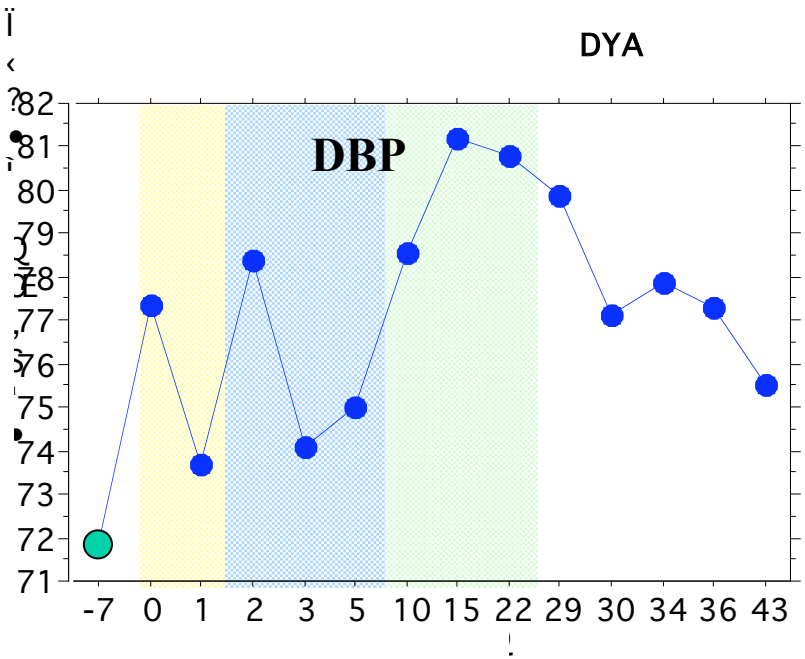
Nakane H, et al., Salivary chromogranin A as an index of psychosomatic stress response. Biomed Res 1998; 19(6):401-6.

STATISTICAL ANALYSES

One-way repeated measures ANOVA, and *post-hoc* test of Dunett's multiple comparison test (*:$P<0.05$) against the pre-dive (control) value.



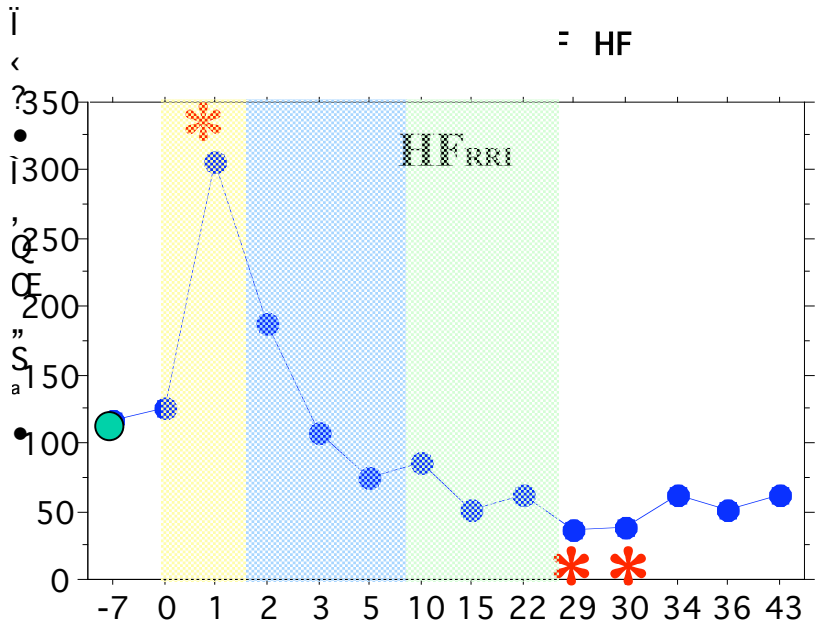


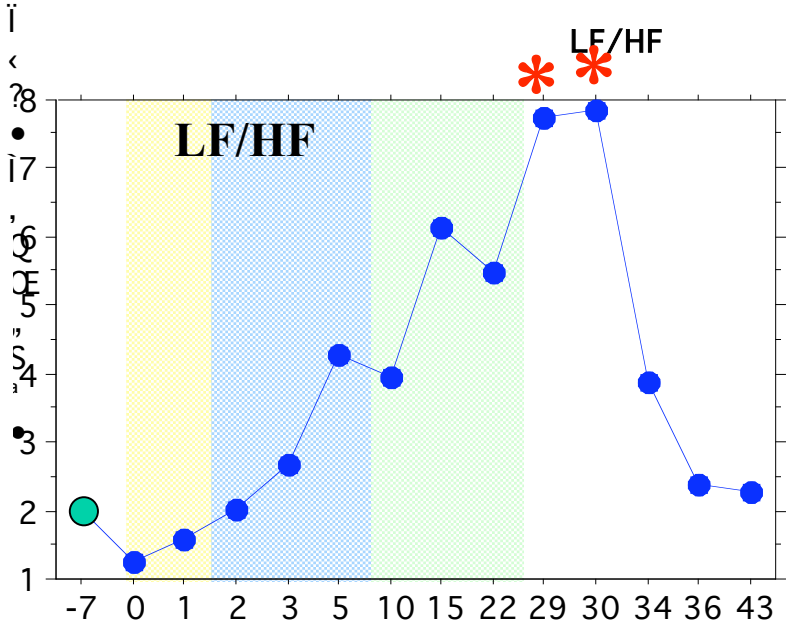


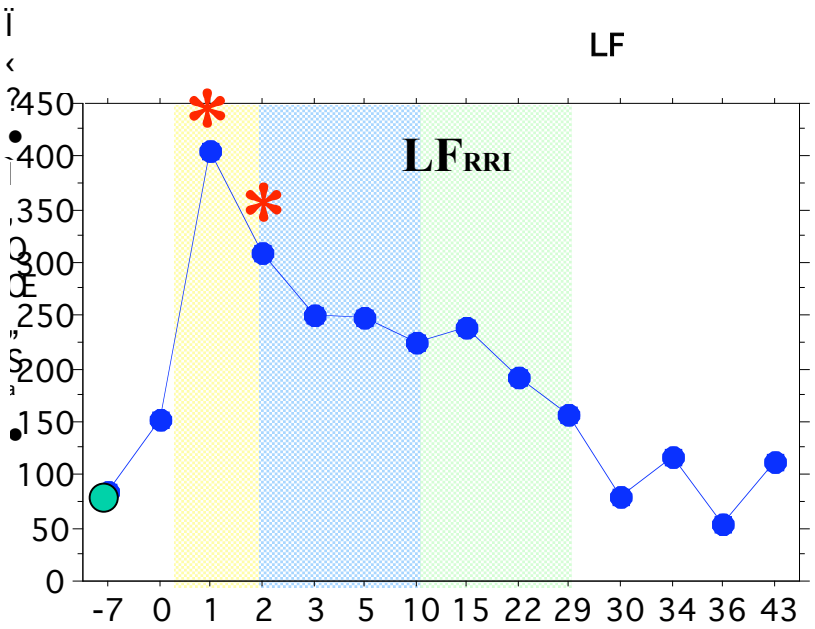
One-way ANOVA and Dunett's test as post-hoc test.

*** : *P*<0.05 vs. Pre-dive control) data**

RESULT(1) : HR, SBP, and DBP



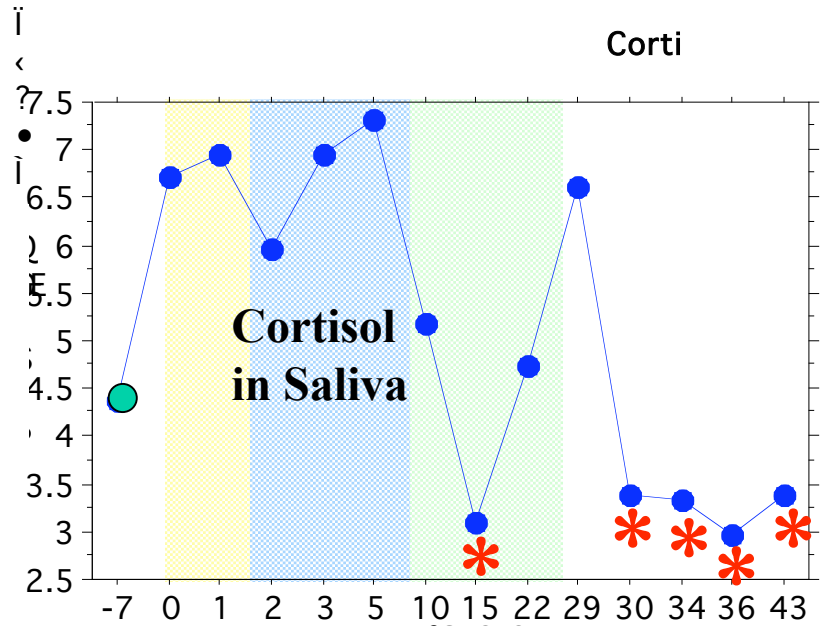


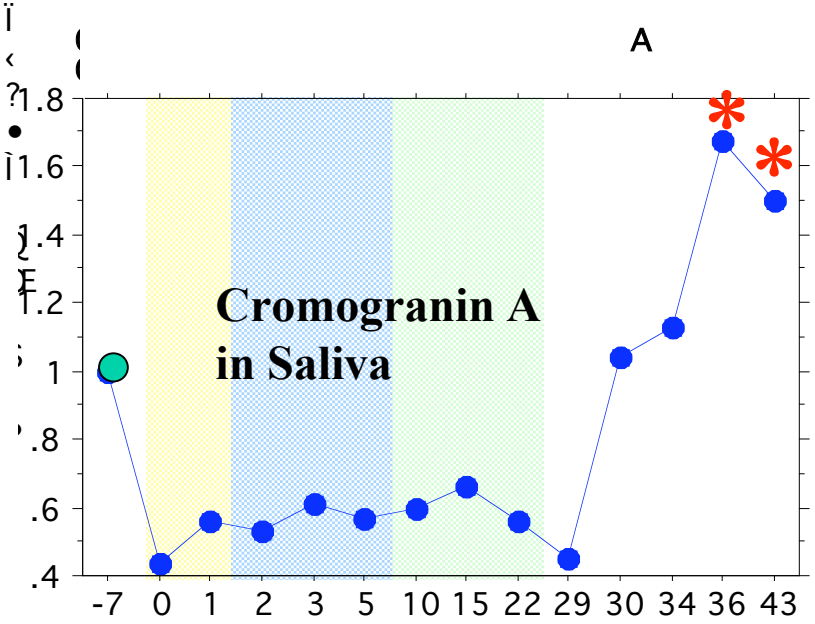


One-way ANOVA and Dunett's test as post-hoc test.

*** : *P*<0.05 vs. Pre-dive control) data**

RESULT (2) : HF_{RRI}, LF_{RRI}, and LF/HF





One-way ANOVA and Dunett's test as post-hoc test.

*** : *P*<0.05 vs. Pre-dive control) data**

RESULT (3) : Salivary Cortisol and Cromogranin A

CONCLUSIONS

The cardiac parasympathetic nervous system is the primary modulator of hyperbaric bradycardia and is clearly manifested as increase in HF_{RRI} in the compression period. Tachycardia was observed during the post-dive period as increase in LF/HF probably due to the dominant cardiac sympathetic nervous system. Most of these post-dive phenomena continued for at least two weeks after the return to normobaric daily living. However, responses in salivary cortisol and cromogranin A do not quite collaborate each other during the post-dive period.