

SSK04-06

Cardiac Effects of Prolonged Apnea in Elite Divers Investigated with Comprehensive Cardiac Magnetic Resonance

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PURPOSE

Apnea diving is getting more and more popular as a recreational sport activity and performance of apnea divers has been constantly rising in the recent years. Prolonged apnea leads to the so-called diving response (i.e. bradycardia, reduced cardiac output, peripheral vasoconstriction) which burdens the heart and leads to changes in circulation. This study investigated the effects of prolonged apnea to the heart and hemodynamic alterations using comprehensive cardiac magnetic resonance imaging (CMR).

METHOD AND MATERIALS

We investigated 17 (15 male, 2 women) elite divers using CMR at 1.5T before, during, and after apnea in air. Subjects performed two sessions: in the first cardiac function (left ventricular end-diastolic volume (LV-EDV), end-systolic volume (LV-ESV), ejection fraction (LV-EF), fractional shortening (FS)) was repeatedly measured using steady state free precision (SSFP) imaging in SAX and VLA; in the second blood flow was measured in both common carotid arteries (ACC) using phase contrast imaging. Apnea was performed in maximal inspiration.

RESULTS

Mean breath hold duration was 297 ± 52 s in the cardiac session and 276 ± 78 s in the flow session. Maximal apnea time reached was 8:03min. Over time, apnea (AP) resulted in a progressive increase of LV-EDV (baseline: 131 ± 33 ml; AP: 190 ± 35 ml; $p < 0.0001$), slight decrease of LV-EF (baseline: 63 ± 10 %; AP: 58 ± 8 %; $p = 0.0112$) and a consecutive increase of LV-ESV (baseline: 49 ± 20 ml; AP: 80 ± 18 ml; $p < 0.0001$). FS as a parameter of regional function also decreased significantly during apnea (baseline: 35 ± 5 %; AP: 25 ± 5 %; $p < 0.0001$). Flow measurement revealed an increase of blood-flow to the brain (left ACC; baseline: 5.0 ± 2.0 ml; AP: 12.8 ± 6.4 ml; $p = 0.0026$; right ACC; baseline: 5.1 ± 2.2 ml; AP: 12.4 ± 6.3 ml; $p = 0.0009$).

CONCLUSION

This work reveals that prolonged apnea results in massive hemodynamic changes to the heart and an increase of blood-flow to the brain as expected from the diving reflex. In particular, apnea leads to a transient cardiac dilation, decrease of LV-EF and fractional shortening, a similar pattern as seen in patients with systolic heart failure.

CLINICAL RELEVANCE/APPLICATION

This study shows that prolonged apnea has tremendous effects to the heart and the vascular system; therefore moderate trained subjects, especially with known medical conditions, should perform maximal apnea with caution.