

ANATOMICAL AND FUNCTIONAL CARDIAC CHANGES DURING SCUBA DIVING: AN UNDERWATER ECHOCARDIOGRAPHIC STUDY

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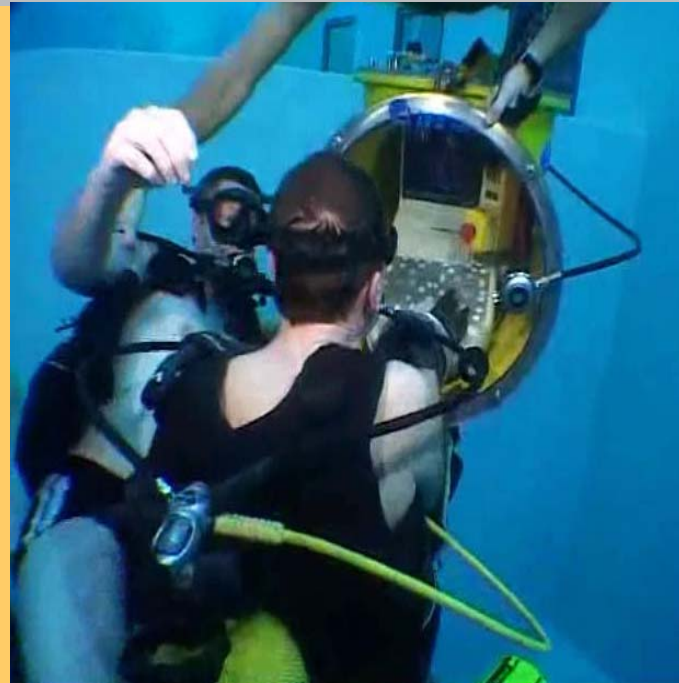
Introduction

The evaluation of cardiovascular effects of diving in humans has been hampered by the difficulties of studying fully immersed subjects. Previous ultrasonographic studies (echocardiography performed before and after a dive) showed that SCUBA diving induces anatomical and functional cardiac changes (increase of right ventricular dimension, modification of left ventricular diastolic filling), particularly evident in subjects with “silent” circulating bubbles (observed in a significant proportion of divers). Recently, a submersible Doppler echocardiographic instrument has been developed, making possible the study of humans while SCUBA diving.

Nine SCUBA divers (8 male, 1 female; age range 24-47 years) underwent a square dive (25m/25minutes) in the NEMO 33 pool (Bruxelles, Belgium), at a water temp. of 33 °C. Doppler Echocardiography was performed before the dive and during the ascent (5 meters depth).

Methods

The following parameters were obtained: diastolic and systolic left ventricular volume (LVVd and LVVs, respectively), stroke volume (SV), cardiac output (CO), right ventricular diastolic dimension (RV), left atrial (LA) and right atrial (RA) systolic dimensions, early (E) and late (A) transmitral flow velocities and their ratio (E/A), assumed as diastolic function indices.



Results

During SCUBA diving, a significant reduction of LVVd ($169.6 \pm 42.9 \text{ mL}$ vs $139.3 \pm 38.4 \text{ mL}$, $p < 0.01$) and SV ($93.2 \pm 21.2 \text{ mL}$ vs $69.6 \pm 26.4 \text{ mL}$, $p < 0.01$) was observed. A non-significant reduction of CO was also observed ($6.7 \pm 1.3 \text{ L/min}$ vs $5.4 \pm 2.4 \text{ L/min}$, $p = 0.1$). Heart rate resulted substantially unchanged during diving (72.9 ± 6.1 vs $76.3 \pm 10.2 \text{ bpm}$). No significant change was observed for RV, RA, LA as well as Doppler diastolic function indices. No subject had circulating bubbles in right heart chambers.

Discussion

The present study is, at our best knowledge, the first report on echocardiographic changes occurring during SCUBA diving. The significant reduction of diastolic LV volume and stroke volume observed during diving is not in agreement with previous reports on head-out immersed subjects (where an increase of stroke volume has been reported). On the contrary, a similar, but more pronounced, cardiovascular response has been reported in breath-hold divers. Full immersion of the body, possibly because of respiratory changes and evocation of diving reflex, seems thus to induce a hemodynamic rearrangement characterized by a reduction of LV volumes and output. The absence of significant changes in heart rate may be the result of both the physical activity performed during the ascent and the low level of vagal stimulation due to the water temperature near to the thermoneutral level. Finally, the lack of changes in RV dimension and LV diastolic function indices may suggest that they may be linked to the presence of non visible post-dive circulating bubbles.