Vector Analysis of 3D-Ballistocardiography in Zero-Gravity and Dry Immersion – A Pilot Study

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BACKGROUND
Direct 3-D acceleration ballistocardiography (BCG) is only feasible in sustained microgravity where accelerations can be measured in all directions without gravity damping and where the cardiovascular system is not in a highly transient state (like in parabolic flight). To date, the rare recordings that have been performed in microgravity were done mainly in the Russian space program during the Salut missions and “MIR” mission 2.
MATERIAL & METHODS
We analyzed a single 15 min recording of 3D-BCG performed at the end of the Spacelab-D2 mission [1, 2]. In addition we analyzed 2D-vector loops of ballistocardiography obtained during ISS-Mission 20 in one Russian cosmonaut, and compared these to 3D-BCG curves recorded on the ground during dry immersion, using a modified “Pneumocard” device.
RESULTS
The main finding of the 3D-vector analysis performed in the Spacelab-D2 mission was that the dorsoventral component (that is missing on the ground) was of the same order of magnitude as the 2 other components (1), consistent with the Russian findings. The most pronounced changes were seen during diastole when the displacement curve occurs mainly in the saggital plane (2). The 3D-vecto-ballistocardiogram recorded during dry immersion was qualitatively similar to that recorded in microgravity however the size and shape of this curve are likely altered by the damping of gravity and the dry immersion experimental setup.
CONCLUSIONS
Our preliminary data [1,2] provides evidence that the third BCG dimension is essential for a physiological interpretation and suggesting that 3D-BCG may be a useful monitoring tool in microgravity to provide insight into mechanical work changes in the heart during spaceflight. The ESA “B3D” project will investigate the potential of 3D-BCG as a non-invasive, operator independent, low cost cardiac (electrical and mechanical) monitoring system with potential applications for tele-monitoring as well as for clinical applications.

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