EVOLUTION OF HEART RATE VARIABILITY BEFORE, DURING AND AFTER SPACEFLIGHT

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ABSTRACT

Introduction: Spaceflight causes changes in the cardiovascular system. These changes contribute to the occurrence of orthostatic intolerance after spaceflight. Heart rate variability (HRV) provides a non-invasive means to study the autonomic modulation of heart rate. Low frequency (LF) oscillations provide information about sympathetic modulation and baroreflex, high frequency (HF) modulation is an index of vagal heart rate modulation.

Methods: ECG was measured for at least 10 minutes in supine, sitting and standing position 45 days and 10 days before launch; and at 1, 2, 4, 9, 15, 19 and 25 days after return to earth. In space ECG was measured at day 5 and at day 8. These measurements were performed in 3 cosmonauts from the Belgian Taxi Flight. HRV indices were calculated in time and frequency domain.

Results: Measurements in supine position and sitting position did not show as high differences as the measurements in standing position. During spaceflight heart rate was significantly lower compared to the pre- and post-flight measurements in standing position (p<0.05). This was accompanied by a significant increase in the proportion of HF power during spaceflight. After spaceflight both LF and HF are extremely depressed compared to the preflight conditions (p<0.005).

Conclusion: During spaceflight autonomic modulation is characterised by a vagal predominance, while after return to earth overall autonomic modulation is extremely depressed.

1. INTRODUCTION

Microgravity has a major impact on all of the human body's systems, and the cardiovascular in particular. The main cardiovascular consequence of spaceflight is orthostatic hypotension. This occurs in more than one-half of the astronauts and cosmonauts after return to earth. Post-flight orthostatic intolerance could pose a risk in case of an emergency evacuation on landing. Spaceflight alters cardiovascular neurohumoral regulation with a blunted carotid-cardiac baroreflex[2; 3]. This could lead to inadequate increases in heart rate with standing.

In this study heart rate variability was used to assess the autonomic cardiovascular modulation. Spectral analysis of heart rate variations yields a LF component and a HF component. The LF component represents predominantly sympathetic modulation, together with baroreflex activity. The HF component represents respiratory modulated vagal activity.

The results presented are part of the RHYTHM protocol of the CARDIOCOG experiment performed during the Belgian Taxi Flight (November 2002).

The joint protocol, CARDIOCOG, consisted of 4 parts:
1. RHYTHM: (PI: André Aubert, K.U. Leuven, Leuven, Belgium): baseline measurements of heart rate variability (HRV), blood pressure variability (BPV) and spontaneous baroreflex sensitivity.
2. RESPI: (Manuel Paiva, ULB, Brussels, Belgium): influence of imposed breathing frequencies on HRV and BPV.
3. STRESS: (Claude Gharib, Lyon, France): Influence of mental stress and controlled breathing on HRV and BPV.

The purpose of this study was: 1. to study the evolution of autonomic cardiovascular control in space; 2. to follow the recovery of autonomic cardiovascular control after return to earth. The ultimate goal is to develop a model of cardiovascular changes induced by microgravity using indices of cardiovascular variability.

2. METHODS

Continuous ECG and blood pressure data were recorded pre- and post-flight in supine, sitting and standing position for 10 minutes. Sampling rate was 1000 Hz. In-flight, recordings of ECG and blood pressure were made during 10 minutes at a sampling rate of 100 Hz. This study presents the preliminary results of the ECG measurements.

Baseline data collection was scheduled at 45 and 10 days before launch. Measurements in the International Space Station were made at flight days 5 and 8. Post-flight measurements were made at 1, 2, 4, 9, 15, 19 and 25 days after return to earth. The 3 cosmonauts were used as subjects.

HRV indices were calculated in the time and frequency domain. Low frequency power was calculated from 0.04-0.15 Hz. High frequency power was calculated from 0.16-0.4 Hz.
3. RESULTS

Mean RR during spaceflight was significantly higher compared to the pre- and post-flight measurements (See Fig. 1; all p<0.005). There was no difference between the measurements at flight day 5 and flight day 8. Mean RR was also significantly shorter at R+1. Mean RR than slowly recovered, but remained significantly different from BDC measurements at L-45 up to R+19. LF power during spaceflight was depressed compared to pre-flight measurements (Fig. 2). At day R+1 LF power is decreased even more (p<0.005 compared to pre-flight data). After flight a gradual return towards pre-flight values could be observed.

**Fig. 1. Evolution of mean RR before, during and after spaceflight.**

HF power (Fig. 3) was higher in space, and extremely depressed at R+1 (p<0.05, compared to all other measurements). Also the proportion of HF was significantly increased. After spaceflight again a gradual return towards pre-flight values of HF power could be observed. Values at R+19, however were still not at the level of L-45 data (p<0.05).

**Fig. 2. Evolution of LF power before, during and after spaceflight.**

**Fig. 3. Evolution of HF power before, during and after spaceflight.**

4. CONCLUSIONS

We found a vagal predominance during spaceflight. A decrease in sympathetic modulation and an increase in vagal modulation could be observed, which is consistent with the decrease in baroreflex sensitivity observed by [3]. After return to earth, there was a decrease of autonomic heart rate modulation, both in sympathetic and vagal origin. The restoration in autonomic control reached near-baseline conditions only from 25 days after spaceflight. Also [1] found a decrease in autonomic modulation of heart rate and sub-baseline autonomic control 10 days after spaceflight.

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5. REFERENCES