Overall research theme:
Gravity and Weightlessness to Understand Cardiovascular and Fluid Volume Control in Humans

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Characteristics of the research group:
The cardiovascular system and renal function in humans are sensitive to changes in gravitational stress.
Therefore, the research group utilizes gravity and weightlessness to stimulate cardiovascular reflexes and
modulate renal sodium and water handling.

The purpose of the research programme is to answer the questions: 1) How are the volume of fluid
and amount of salt detected in the human body in health and disease, 2) what are the links between the
volume and salt sensing mechanisms and the kidneys, and 3) how does gravity modulate arterial pressure
regulation.

Changes in the gravitational load on the body are induced by postures, water immersion and
weightlessness. Weightlessness can be obtained for short periods during parabolic flights and for longer
periods during spaceflight. Non-invasive techniques are used for estimation of cardiac output (foreign gas
rebreathing) and arterial pressures. Techniques for measurements of concentrations in blood and urine of
cardiovascular and kidney regulating hormones have been developed by our collaborators to understand
the neuroendocrine regulation of arterial pressure and sodium balance.

The research group has obtained experimental access to the Space Shuttle and the International
Space Station. Furthermore, the group has set up a Ph.D.-programme to investigate the mechanisms of
renal sodium and water retention in heart failure.

Running projects: Titles and abstracts:

Cardiovascular effects of moderate changes in sodium intake in heart failure

We have shown that increasing sodium intake from 70 to 250 mmol/24 h over a 4-day period increases
cardiac output and stroke volume by some 15%, when the subjects are upright seated (Damgaard et al.
2002). Furthermore, we have shown that immersing seated heart failure patients in water improves their
cardiovascular status and neuroendocrine profiles (Gabrielsen et al. 2001). Therefore, the aim of the
current study is to test the hypothesis that a moderate increase in sodium intake in heart failure patients
will increase cardiac output and arterial filling and suppres the vasoactive hormone releases. If the
hypothesis is confirmed, sodium intake should not always be restrictive in treatment of heart failure.

Methodological improvements of the foreign gas rebreathing technique for estimation of cardiac
output and oxygen uptake in humans

The foreign gas rebreathing method is a user friendly, non-invasive method for estimation of cardiac
output in humans. During a 30-s rebreathing procedure in a closed lung to bag-system, a gas mixture of
tracer gasses are mixed with air in the lungs. By measuring the concentration of the gasses through the
mouthpiece during rebreathing, the disappearance rate of the gasses into blood can be determined. By knowing the blood solubility coefficients of the tracer gasses, the amount of blood flowing through the lungs can be calculated. This is equal to cardiac output. Gas analysis is performed continuously by a newly developed equipment (Innocor, Innovision A/S) utilizing an infrared photo-acoustic technique. In this study, we are testing the limitations and advantages of the equipment in order to improve the rebreathing procedures. The work is performed in collaboration with industry.

**Prolonged effects of head-down bed rest on cardiovascular, endocrine and renal variables in humans**

Prolonged head-down tilted bed rest of 6° is a currently used model to simulate the effects of weightlessness in humans. We have previously shown that the effects of prolonged spaceflight and head-down tilted bed rest, respectively, on renal water handling is not similar (Norsk et al. 2000). In close collaboration with the German space center DLR in Cologne, we are involved in a major multinational and multidisciplinary head-down tilted bed rest study. The aim is to determine the long term effects of bed rest on sympathetic nervous activity and renal sodium and water handling. The data will then be compared to data obtained in space. By determining the mechanisms of the differences in effects of head-down bed rest and spaceflight, further insight might be gained into how gravity modulates the interaction of cardiovascular reflexes, sympathetic nervous activity and renal sodium and water handling in humans.

**Prolonged effects of weightlessness on cardiovascular, endocrine and renal variables in humans**

Five Danish experiments have been selected for the Space Shuttle and International Space Station. It is the purpose to compare the effects of spaceflight and prolonged head-down tilted bed rest on cardiovascular, endocrine and renal variables. Furthermore, it is the purpose to compare the measurements with those obtained in heart failure patients. In this way, it is the aim to gain insight into how gravity is involved in the pathophysiology of heart failure. Furthermore, it is also the purpose to gain more insight into the mechanisms of postflight orthostatic intolerance.

**Recent publications related to the projects described above:**


