

Name of research institute or organization:

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**Cardiovascular Prevention & Rehabilitation, Swiss Cardiovascular Centre Bern, University Hospital (Inselspital), 3010 Bern**

Title of project:

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Safety and tolerance of high altitude exposure (3454 m) in non-acclimatized patients with chronic heart failure

Project leader and team:

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Project description:

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**Purpose:** Although patients with chronic heart failure (CHF) are in general limited in their physical performance, some of them are able to improve with an optimal medical treatment and exercise training. Subsequently, in the course of recovery of an active lifestyle, questions about the possibility and safety of high altitude exposure emerge. At present, patients with stable CHF symptoms are most of the time discouraged to expose themselves to altitudes beyond 2500 m. However hardly any data exist about safety and exercise tolerance of such an altitude exposure in CHF patients. In the Swiss alps, it is quite easy to reach altitudes >3000m by modern transport systems and these touristic destinations are very popular also for CHF patients.

The pathophysiology of heart failure is characterized by a reduced pump function due to a variety of diseases, coronary artery disease being the most important. As a compensatory mechanism, heart rate is increased at rest and during exercise. However, whether the cardiac output reserve in CHF patients is enough to safely reach high altitudes and what is the impact of high altitude on physical performance is unknown. The aim of this study was therefore to assess safety and exercise tolerance in stable CHF patients.

**Methods:** Our study population included 29 non-acclimatized patients (four women, mean age  $59.3 \pm 9.6$  years) with stable CHF in NYHA functional class II (peak  $\text{VO}_2$   $18.5 \pm 3.5$  ml/min/kg) due to systolic dysfunction and an ejection fraction (EF) of  $28.8 \pm 5.3\%$ . Patients suffered predominantly from ischemic cardiopathy (n=19) and 11 patients were carriers of an internal cardioverter defibrillator (ICD). To be included, patients with an EF <40% had to be able reach a peak  $\text{VO}_2$  >50% of the predicted value (limit to severely reduced exercise capacity), and to be stable for at least 3 months under optimized medical therapy. Exclusion criteria were NYHA functional class III and IV, signs of ischemia during a cardiopulmonary exercise test at low-land, uncontrolled arterial hypertension (>180/100 mmHg at rest), valvular heart disease classified as severe, or severe chronic obstructive pulmonary disease (FEV1 <60% of the predicted), pulmonary hypertension (peak pulmonary artery pressure >50 mmHg) and disabling musculo-skeletal or vascular disease.

Figure 1: Cardiopulmonary exercise testing



All patients underwent a symptom limited cardiopulmonary exercise test with gas analysis, a non-invasive cardiac output measurement during a second maximal exercise stress test, an echocardiography, and a 24h-ECG recording (c.f. Figures 1-4).

Within three weeks after the baseline evaluation, patients were exposed to high altitude via rapid ascent by public transportation from Bern (540m) up to the Jungfrauoch (3454 m) with a 4-5 hours stay at high altitude. All baseline examinations were repeated at high altitude.

All patients completed the trial and both, rapid ascent and a 4 to 5h stay at 3454 m were well tolerated. None of the subjects had to return prematurely to low-land and no exercise induced cardiac ischemia, severe dyspnea or symptomatic hypotension occurred. Two patients felt dizzy after a standard meal for about 1 hour. At altitude, peak  $\text{VO}_2$  was 22.2% lower ( $14.4 \pm 3.6$  vs.  $18.5 \pm 3.5$  ml/kg/min,  $p < 0.001$ ) and mean resting heart rate significantly higher ( $83.3 \pm 13.4$  vs.  $74.3 \pm 12.3$  bpm,  $p < 0.001$ ) compared with lowland. There was no statistically significant difference of premature ventricular contractions ( $92 \pm 150/h$  at 540 m vs.  $111 \pm 196/h$  at 3454 m,  $p = 0.284$ ), measured over a time period of 8h. 1 patient developed a sustained, but self limited ventricular tachycardia during maximal exercise at the Jungfrauoch.

Conclusion: Patients with stable CHF in NYHA functional class II and non severely reduced exercise capacity (peak  $\text{VO}_2 > 50\%$  of the predicted) tolerate an altitude exposure of 3454m well, even during exercise. The reduction of exercise capacity amounts to 22.2%.

Key words:

Chronic stable heart failure, high altitude, exercise tolerance, safety

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Figure 2: Non-invasive cardiac output measurement



Figure 3: ECG-Recording



Figure 4: Echocardiography

