Hemodynamics measured with magnetic resonance imaging in patients with congenital heart disease.

Pia Sjöberg, Dept of Clinical Physiology and Nuclear Medicine, Skane University Hospital and Lund University.

Background

Congenital heart disease affects about 1% of all children. This means that around 1000 children are born with a congenital heart defect every year in Sweden and many of these children needs surgery. Some heart defects can be corrected completely at the first operation, but some patients will need up to several operations both as children and as adults. It’s therefore of utmost importance that the basis for the decision of a possible intervention or change in other form of therapy is as good as possible.

Cardiac magnetic resonance can non-invasively and without ionizing radiation give information about the anatomy and function of the heart. Normally patients are examined at rest, but by using an ergometer specialized for magnetic resonance scanners we can study what happens when patients are physically active. Since most of these patients live an active life this information is a relevant piece of the puzzle. With 4 dimensional (velocities in three directions over time) flow measurements it’s also possible to study the kinetic energy and hemodynamic forces in the heart. Studies have shown that patients with heart failure and mitral regurgitation have disturbed intracardiac kinetic energy. Also, a recent study by Arvidsson et al have shown that patients with left ventricular dyssynchrony have different diastolic force patterns compared to healthy controls. Knowledge about the kinetic energy and hemodynamic forces in patients with congenital heart disease might help the decision making of when and how to intervene to avoid complications.

Aim of the thesis

The aim of the thesis is to assess the cardiac function with new magnetic resonance techniques at rest and exercise in patients with 1) repaired Tetralogy of Fallot (ToF) and pulmonary regurgitation (PR) and
2) patients with single ventricles and Fontan circulation. The purpose is to better individualize treatment and optimize the timing of intervention.

**Papers for the dissertation**


In paper I the kinetic energy in patients with Fontan circulation was quantified. It showed that the kinetic energy is dependent on the morphology of the ventricle and that diastolic kinetic energy indexed to stroke volume is decreased compared to controls, which might be a result of impaired ventricular filling. Article is attached.


In paper II the kinetic energy (KE) in the left and right ventricle was quantified during the complete heart cycle in patients with repaired Tetralogy of Fallot (rToF) and pulmonary regurgitation (PR). The results showed that kinetic energy is disturbed in patients with rToF and PR not only in the affected right ventricle (RV) but also in the left ventricle (LV) with preserved global function. Also, the ratio between systolic and diastolic peak KE reflects restrictive RV physiology. Finally, surgical treatment of the PR resulted in decreased systolic KE in the RV. Patients showed lower systolic KE after surgery in both ventricles compared to controls. These findings show the potential of KE as a marker of pathophysiology in rToF patients and that the combination of LCS and 4D-flow enables differentiation of ventricular inflows. Manuscript is attached.
III. Sjöberg P et al. Left and right ventricular hemodynamic forces in patients with repaired Tetralogy of Fallot assessed with 4D flow magnetic resonance imaging.

The aim of paper III is to find out if the hemodynamic forces in the ventricles of patients with repaired Tetralogy of Fallot (rToF) and pulmonary regurgitation (PR) are affected in both the left and right ventricles and if there are any change after pulmonary valve replacement. We have included 15 patients with PR after rToF, of which six also have been examined after pulmonary valve replacement. From the acquired 4D-flow acquisitions right and left ventricular hemodynamic forces will be analyzed and compared to controls. We will also study if the forces change after surgery. The analysis will start in May and a finished manuscript is planned to December 2017. Study plan is attached.

IV. Sjöberg P et al. Assessment of ventricular function at rest and exercise in single ventricle patients using magnetic resonance imaging.

The aim of paper IV is to evaluate how the ventricular volumes, cardiac output and venous return change with exercise and see how this correlates with exercise capacity. Our hypothesis is that patients have different response to physical exercise regarding flow distribution to the lungs, aortopulmonary collateral flow, ventricular function, stroke volume and thereby cardiac output and that this might explain the difference in exercise capacity between patients. Cardiac function, cardiac output and flow distributions will be assessed with cardiac magnetic resonance (MR) at rest and during physical exercise using a MR compatible ergometer. Exercise capacity will be determined by ergospirometry. The study protocol will be finalized during spring 2017. The plan is to include 24 patients. Estimated inclusion time is 1.5 year, after which analysis will start. Planed time for finished manuscript will be at the beginning of 2019. Study plan is attached.