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Prediction of the heart function in patients with single ventricle physiology by using a simulation model

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Introduction: In patients with single ventricle physiology, atrioventricular (AV) valve regurgitation leads to volume overload of the single ventricle and eventually may lead to heart failure. On the other hand, heart failure may lead to valve regurgitation. Symptoms and hemodynamic findings that result from primary heart failure and heart failure secondary to the AV valve regurgitation overlap. It is necessary to distinguish two pathophysiological features for guidance of the appropriate treatment. Operation of the regurgitating valve, where the regurgitation is primarily a result of ventricular dysfunction can lead to decreased cardiac output due to decreased preload and thus mortality and morbidity after operation.

Aim: The aim is to predict the ventricular function and cardiac output after surgical repair of the atrioventricular valve by using simulation model. We hypothesize that simulated and patient specific hemodynamic data agree.

Methods: Hemodynamic data of patient with HLHS and tricuspid valve regurgitation were assessed preoperatively, simulated and followed prospectively. Ventricular and valvular function was assessed before operation, one day, one week, one month and six months after operation. Simulation program APLYSIA was used to predict ventricular function after changes in valve regurgitation over time. Predicted hemodynamic data by simulation program were compared with patients follow up data.

Results: The simulated and patient specific ejection fraction and cardiac output agreed by using Aplysia as simulation program. We could simulate that first week after surgery, in 80% of patients, the ejection fraction decreased and cardiac output increased after the resolving of the AV-valve regurgitation. After one month and six months, the ventricular and atrial dimensions decreased, however, the cardiac output remained higher.

Conclusions: Simulation model Aplysia could predict the ventricular function after surgery, based on preoperative anatomical and functional variables.