Aortic Valve Function Under Assistance of a Physiologically Controlled CF-LVAD

S. Bozkurt, F.N. van de Vosse and M.C.M. Rutten

Introduction
Continuous Flow Left Ventricular Assist Devices (CF-LVADs) generally operate at a constant speed in the patient. If the left ventricular pressure is continuously less than the aortic pressure the aortic valve (AV) remains closed over the cardiac cycle. In this study, blood flow through the AV was controlled by applying a feedback control to the CF-LVAD to generate intermittent flow through the AV.

Methods
Experiments were done in a model controlled mock circulation system. A polyurethane valve without sinus cavities was used as the aortic valve. A Micromed HeartAssist 5 was used as the CF-LVAD in the experiments (Fig. 1). The heart rate was kept at 80 bpm in the experiments.

Proportional-Integral (PI) control was applied to the input of the Micromed HeartAssist 5. Kp and Ki gain values were 5 and 0.1 respectively. Instantaneous flow rate through the AV was used as the reference flow rate to control the CF-LVAD flow (Fig. 2). 1/2, 1 and 3/2 of the flow rate of the AV was used as the reference flow rate respectively.

Results
Before the control application, pathological conditions were obtained in the mock circulation system (Fig. 3).

Systolic left ventricular and aortic pressures remained below 90 mmHg over a cardiac cycle. Mean flow rate through the AV was 3.85 L/min. In the Micromed HeartAssist 5 assisted mock circulation, systolic aortic pressure did not change much. However, diastolic aortic pressure increased with increasing reference flow rates (Fig. 4).

Discussion
The applied control strategy showed a good control on the mean pump flow. The duty cycle of the AV decreased with increasing reference flow rates which can be interpreted as the possibility to control flow through the AV, and thus AV motion. However to obtain a better control on the instantaneous flow rate a different control strategy must be applied.