Ex-vivo evaluation of cardiac performance following LV support in an isolated porcine heart model

S. van Tuijl¹, J.M.A. Stijnen¹, A. de Weger², M.C.M. Rutten³, B.A. de Mol⁴ and J. de Hart¹

¹HemoLab Cardiovascular Engineering, Eindhoven, the Netherlands, ²Leiden University Medical Center, Leiden, the Netherlands, ³Eindhoven University of Technology, Eindhoven, the Netherlands, ⁴Academic Medical Center, Amsterdam, the Netherlands

Introduction
Changes in cardiac performance following LV support to unload the failing heart are a result of hemodynamic interactions. Still little is known about interactive responses, which impedes optimal application of LVADs. Hemodynamic evaluation is enabled by an ex-vivo beating heart model.

Objective
To evaluate hemodynamic interaction of LV supported hearts using an ex-vivo beating heart model for better application of LVADs.

Methods
Hearts are isolated from slaughterhouse pigs following special protocols. Cold cardioplegic arrest is applied using STH solution. Next, the hearts are prepared for resuscitation using our multi-mode perfusion platform. Coronaries are supplied with heparinized blood via cannulae. A 2-chamber working left heart mode is chosen for intracardiac visualization using a translucent saline fluid flow. Coronary and systemic circulation are separated to prevent coronary blood mixing with the saline.

Results
An Impella® LD (Abiomed) and HeartMate® II (Thoratec) are implanted (Fig. 1 & 2).

Pre- and afterload are set such that a failing heart is simulated. Performance is monitored in terms of pressures, flow and valve kinematics for different pump speeds.

Higher pump speed results in lower peak systolic flow and higher diastolic flow. At low pump speeds back flow is observed. At high speeds aortic pressure pulse dims but diastolic pressure increases (Fig. 3 & 5).

Conclusions
- the ex-vivo heart model is an alternative to short-term animal experiments
- pre- and afterload system must include feedback control mechanism
- low pump speeds cause back flow
- high speeds cause a closed aortic valve
- unloading and pump efficiency strongly depends on failing heart conditions

Future work
- research on hemodynamic interaction for different heart conditions
- validation of the ex-vivo heart model

Acknowledgement
The authors gratefully acknowledge Evert Scholten (AMC), Ben Rodermans (UMCU) and Ballering Export CV for their support.