LEFT VENTRICULAR REVERSE REMODELING WITH THE HEARTMATE II LVAD AS MEASURED BY LEFT VENTRICULAR END DIASTOLIC DIMENSIONS AND SEVERITY OF MITRAL REGURGITATION

Jeffrey A Morgan,[1] Robert J Brewer,[1] Hassan W Nemeh,[1] Scott E Henry,[1] Raghav Murthy,[1] Celeste T Williams,[2] David E Lanfear,[2] Cristina Tita,[2] Hani N Sabbah,[2] Gaetano Paone.[1] *[1]Cardiothoracic Surgery, Henry Ford Hospital, Detroit, MI; [2]Cardiology, Henry Ford Hospital, Detroit, MI.*

Purpose: We evaluated the short and mid-term effects of the HeartMate II (HM II) left ventricular assist device (LVAD) on left ventricular reverse remodeling, as measured by left ventricular end diastolic dimension (LVEDD) and mitral regurgitation (MR). **Methods:** We retrospectively evaluated our experience with the HM II LVAD between March 2006 and June 2009. 41 patients with chronic heart failure underwent implantation of a HM II as a bridge to transplant (n=31) and for destination therapy (n=10). Echocardiograms and right heart catheterizations were reviewed preoperatively and at 1-month and 6-months post-LVAD implantation. **Results:** Mean age of patients was 52.1 ± 12.1 years (range of 25–72 years) with median LVAD support time of 272 days. LVEDD significantly decreased at 1 month post-LVAD implantation from 72.6 ± 12.1 mm to 55.8 ± 15.3 mm ($p<0.001$). Similarly, severity of MR decreased significantly from 75.7% moderate or severe preoperatively to 18.2% moderate or severe at 1 month post-LVAD. These reductions were maintained at 6 months.

Table 1.

	Pre-LVAD	1-Month Postop	6 Months Postop	p
LVEDD	72.6 + 12.1	55.8 + 15.3	60.1 + 16.2	<0.0001
Severity of MR				
Mild	24.3%	81.8%	66.7%	<0.0001
Moderate	56.8%	15.2%	29.6%	
Severe	18.9%	3.0%	3.7%	
Moderate or Severe	75.7%	18.2%	33.3%	

Conclusions: These data demonstrate the ability for HeartMate II to significantly decompress the left ventricle, with significant reductions in LVEDD and severity of MR. This reverse remodeling was apparent in the early postoperative period and was sustained at 6 months.

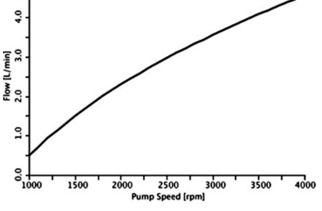
MATHEMATICAL MODEL OF AN EXTRA-CORPORAL SUPPORT SYSTEM

Alejandro Mendoza García,[1] Susanne Rösch,[2] Benedikt Baumgartner,[1] Ulrich Schreiber,[3] Stefan Eichhorn,[3] Markus Krane,[3] Alois Knoll,[1] Robert Bauernschmitt.[3] *[1]Informatics, Technische Universität München, Garching, Bavaria, DE; [2]Mechanical Engineering, Technische Universität München, Bavaria, DE; [3]Deutsches Herzzentrum München, München, Bavaria, DE.*

Purpose: Create a mathematical model of an Extra-corporal Support System (ECSS) to allow optimization and the creation of a control system. **Methods:** The ECSS was separated into its individual components consisting of a reservoir, centrifugal pump, oxygenator, blood filter, arterial cannula (20Fr. Medtronic) and venous cannula (22 Fr. Edwards lifesciences) and connecting tubbing. These components were analyzed in terms of difference in pressure between the inlet and outlet (ΔP) and flow (Q). The results were approximated with the quadratic function $\Delta P_i = Ca_i Q2 + Cb_i Q$. ($Ca_i$ and Cb_i are the constants for each component) The centrifugal pump was modeled as a constant head machine with the equation $H = \Delta P/\rho g + V^2/2g$. (H=head, ρ=density, g=gravity, V=fluid velocity) **Results:** Table 1 shows the constants of each component, a resistance factor is shown in the last column when the pump is set at a maximum speed. These components were added up to form a complete ECSS and this was compared with the real ECSS. **Conclusions:** The previous results show that the most significant resistance in an ECSS is caused by the tubing and cannulas. The comparison between the real system and the created model show a good correlation.

Table 1.

i	Component	Ca	Cb	%
1	Pump	1.4	6	11
2	Reservoir	0.45	1.3	3
3	Oxygenator	0.8	12	14
4	Filter	0.7	3	6
5	Tubing	0	25	23
6	Venous Cannula	2.8	10	21
7	Arterial Cannula	3.8	6	22



SPEED MODULATION OF THE CONTINUOUS-FLOW TOTAL ARTIFICIAL HEART TO SIMULATE A PHYSIOLOGIC ARTERIAL PRESSURE WAVEFORM

Akira Shiose, Kathleen Nowak, David J Horvath, Alex L Massiello, Leonard AR Golding, Kiyotaka Fukamachi. *Biomedical Engineering, Cleveland Clinic, Cleveland, OH.*

A programmable function generator was used to determine the optimum pulsatile speed profile necessary to create a physiologic arterial pressure waveform. Three speed profiles (sinusoidal, rectangular, and optimized [a profile optimized for generation of a physiologic arterial pressure waveform]) were evaluated. For each speed profile assessed, hemodynamic parameters were recorded at average pump speeds of 2,700 rpm and a modulation cycle of 60 beats per minute. The effects of varying systemic vascular resistance and lumped compliance on the hemodynamics were assessed. The feasibility of using speed modulation to manipulate systemic arterial pressure waveforms, including a physiologic pressure waveform, was demonstrated *in vitro*. The additional pump power consumption needed to generate a physiologic pulsatile pressure was only 8.8% of the power consumption in nonpulsatile continuous-flow mode. The induced pressure waveforms and pulse pressure were shown to be very responsive to changes in both systemic vascular resistance and arterial compliance. Speed modulation in the continuous-flow total artificial heart could enable physicians to obtain desired pressure waveforms by simple manual adjustment of speed control input waveforms. The system can also be used as a valuable tool in researching the effects of varying degrees of depulsation of the systemic circulation.

A NOVEL COUNTERPULSATION DRIVE MODE IN A CONTINUOUS-FLOW LEFT VENTRICULAR ASSIST DEVICE – EFFECT ON CORONARY CIRCULATION

Masahiko Ando,[1] Yoshiaki Takewa,[1] Takashi Nishimura,[2] Kenji Yamazaki,[3] Shunei Kyo,[2] Minoru Ono,[2] Yoshiyuki Taenaka,[1] Eisuke Tatsumi.[1] *[1]Department of Artificial Organs, Natinal Cardiovascular Center Research Institute, Suita, Osaka, JP; [2]Department of Cardiothoracic Surgery, The University of Tokyo, Bunkyo, Tokyo, JP; [3]Department of Cardiovascular Surgery, Tokyo Women's Medical University, Shinjuku, Tokyo, JP.*

Purpose: Continuous-flow left ventricular assist devices (LVADs) have greatly improved clinical outcomes of patients with end-stage heart failure, however, its positive effect on coronary circulation has not yet been clearly elucidated. We have developed a novel drive mode of a centrifugal LVAD that can change rotation speed in synchronization with the cardiac cycle. The purpose of the current study was to investigate the effect of this new drive mode on coronary perfusion. **Methods:** In 7 adult goats(63.9±12.8 kg), a centrifugal LVAD (EVAHEART, Sun Medical) was installed with an outflow cannula in the descending aorta and an inflow cannula in the apex. A conductance catheter and a tipped manometer were set up for the monitoring of the pressure-volume loop, and an ultrasonic flow probe was placed around the left main trunk of the coronary artery. At an assist rate of 50%, we compared counterpulsation mode with continuous-flow mode. **Results:** Counterpulsation mode reduced left ventricular end-diastolic pressure(LVEDP)(12.8±2.2 vs 15.5±3.7 mmHg, counterpulsation and continuous-flow, respectively; $p=0.018$) and increased coronary flow (1.78±0.7 vs 1.62±0.6 ml/min/kg, respectively; $p=0.026$). Phasic coronary flow pattern analysis revealed an upward trend of diastolic coronary flow. Diastolic systemic pressure remained unchanged. **Conclusion:** Counterpulsation mode of centrifugal LVADs can enhance coronary perfusion, possibly due to both the increase in coronary perfusion pressure and the decrease in its vascular resistance through LVEDP reduction. This novel drive mode can provide a great benefit to patients with impaired heart.