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Estimation of left ventricular pressure in patients with a continuous flow LVAD

Kim Pennings1,2, Niels Petterson2, Stephanie Schampaert2, Sjoerd van Tuijl2, Frans van de Vosse2, Bas de Mol1, Marcel Rutten2
1 Academic Medical Centre, Amsterdam; 2 Eindhoven University of Technology; 3 LifeTec Group BV, Eindhoven

Aim
Long-term ventricular support with a Left Ventricular Assist Devices (LVAD) requires intensive and frequent monitoring of the patient.

Left ventricular pressure (pLV) is a good measure for LV function. In this study, we aim to assess dynamic left ventricular pressure, using the LVAD as a sensor.

Ex vivo model
The method was validated with a porcine ex-vivo beating heart model (figure 1)\(^1\). Measurements were done on four hearts supported with a Micromed DeBakey VAD and three hearts supported with a Heartmate II VAD.

Estimation left ventricular pressure
Pressure head over the LVAD (dp\(_{\text{LVAD}}\)) is estimated from pump flow with a static\(^2\) and dynamic\(^3\) pump model.

\[
p_{\text{LV}} \text{estimated} = p_{\text{ao}} + dp_{\text{outflow graft}} - dp_{\text{LVAD,estimated}}
\]

\(dp_{\text{outflow graft}}\) is the pressure drop in the outflow graft. Calculated as follows:

\[
dp_{\text{outflow graft}} = R \cdot Q + L \cdot \frac{dQ}{dt}
\]

Results
Mean left ventricular pressure was estimated using static pump characteristics (figure 2).

Conclusion
In our beating heart experiments, a reliable estimation of left ventricular pressure was possible using static or dynamic pump characteristics.

Left ventricular pressure was also estimated as a function of time using dynamic pump characteristics (figure 3).

\[
dp/dt_{\text{max}} \] maximum, minimum and mean left ventricular pressure were derived from the estimated \(p_{\text{LV}}\) (figure 4).

Conclusions
In our beating heart experiments, a reliable estimation of left ventricular pressure was possible using static or dynamic pump characteristics.

Once combined with a focused clinical study we infer that left ventricular pressure in LVAD supported patients can be monitored sufficiently reliably in case pump flow and aortic pressure are measured. This will give a good indication for unloading of the ventricle and native heart function, in case of recovery of the heart or destination therapy during long-term support.