Abstract: TH-PO757

Arteriovenous Mock Circulation Loop for Enhanced In Vitro Testing of an Implantable Bioartificial Kidney

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Background

Arterial mock circulation loops (MCL) are recognized as an appropriate *in vitro* alternative to cumbersome and cost-intensive animal studies for the development of blood-contacting mechanical circulatory assist devices. In contrast to an arterial pump, a silicon nanopore membrane (SNM)-based bioartificial kidney (BAK) is dependent upon arteriovenous (AV) implantation of a mechanically robust and biocompatible hemofilter. An MCL that mimics arteriovenous shunt physiology (pressure, flow rate and pressure-time curve) is an essential tool for *in vitro* refinement of the BAK. Here, we describe an AV-MCL and a corresponding bond graph mathematical model used to refine physiologic parameters of the physical setup.

Methods

An AV-MCL was prototyped using commercial off-the-shelf pneumatic and hydraulic components. Two check valves (mimicking heart valves), two vertical chambers (mimicking atrium and ventricle), and a pneumatic solenoid valve (mimicking the AV node) were used to

reproduce cardiac function. Flow resistors, a compliance chamber, and venous reservoir were used to reproduce the circulatory system. BAK prototypes were mounted in the AV MCL, and surgically implanted in an adult Yucatan pig in separate experiments. The bond graph model was used to adjust the AV-MCL parameters to reproduce the AV physiologic parameters obtained experimentally in the animal.

Results

In vivo arterial, graft and venous pressures (mmHg) were 110/69 (mean 86), 78/60 (72), and 13/6 (9), respectively. The MCL yielded arterial, graft, and venous pressures of 110/67 (mean 81), 79/48 (58), and 13/10 (11). The BAK hemofilter blood flow *in vivo* was 1032 mL/min, compared to 940 mL/min in the MCL. The pressure waveforms measured from the AV-MCL were well predicted by the mathematical model.

Conclusion

An AV-MCL was developed with a corresponding bond graph mathematical model, and successfully replicated *in vivo* AV pressure and flow conditions through BAK prototypes. The bond graph model facilitates further refinement of AV-MCL physiologic parameters, such as pressure-time waveforms. Moreover, the MCL is portable, adjustable and reusable, allowing rapid iterative *in vitro* testing of BAK prototypes. This system offers device feedback and refinement of BAK design prior to animal trials.

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