Extracorporeal Diffusive Clearance of Silicon Nanopore Membranes in a Pumpless Porcine Blood Circuit

S. Kim[1], W. Moses[2], C. Blaha[3,4], Zohora Iqbal[3], C. Chow[3], R. Kant[3], B. Chui[5], J. Park[3], K. Goldman[6] ,W.H. Fissell[4,7], S. Roy[3,4]

[1]*Department of Nephrology, UCSF*
[2]*Department of Surgery, UCSF*
[3]*Department of Bioengineering and Therapeutic Sciences, UCSF*
[4]*Silicon Kidney, LLC*
[5]*Ben Chui Consulting*
[6]*H-Cubed, Inc.*
[7]*Division of Nephrology and Hypertension, Vanderbilt University*

Background:
Silicon nanopore membranes designed for hemofiltration (HF-SNM) have demonstrated increased permeability compared to polymer membranes. Previously, we reported in-vitro data showing a 2.3-fold improvement in diffusive clearance using SNM optimized for diffusion (HD-SNM). Here we test the diffusive clearance of HD-SNM vs HF-SNM in an extracorporeal porcine model without a blood pump.

Methods:
A microelectromechanical systems fabrication technique was used to decrease the SNM thickness (HD-SNM 100μm vs HF-SNM 400μm). Polyethylene glycol coated HD-SNM (n=3) and HF-SNM (n=3) with sub-10nm pore sizes were tested in a single channel flow circuit (h=1mm). Vascular access was obtained by placing tunneled catheters within the carotid artery and jugular vein of healthy ~50kg pigs. Blood flow was achieved via the arterial-venous pressure differential (35-120ml/min). Dialysate was recirculated in a counter-current fashion (30ml) and flow rates were adjusted to ensure 0 transmembrane pressure. Dialysate creatinine concentration was measured hourly and serum creatinine was measured at time 0 and 6 hours. The pore size of each SNM was measured before and after blood exposure using hydraulic permeability.

Results:
Blood flow was achieved using only the arterial-venous pressures differential with <5mmHg pressure drop. The average plasma creatinine concentration was 1.38±0.1mg/dL. The creatinine clearance was 37±4ml/min/m2 (HF-SNM) vs 85±18ml/min/m2 (HD-SNM) at 92.5±36.6ml/min. There was no detectable albumin transport into the dialysate. The HD-SNM maintained mechanical integrity at over 250mmHg in-vitro. The pore size change following blood exposure was 1.4±2.3nm vs 1.9±1.2nm for HF-SNM and HD-SNM, respectively.

Conclusion:
This study demonstrates the successful transport of creatinine in an extracorporeal circuit without a blood pump. We also showed a ~2.3-fold improvement in diffusive clearance of creatinine using HD-SNM in a blood circuit.