

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

S. Kim¹, W. Moses², C. Blaha^{3,4}, Zohora Iqbal³, C. Chow³, R. Kant³, B. Chui⁵, J. Park³, K. Goldman⁶, W.H. Fissell^{4,7}, S. Roy^{3,4}

¹Department of Nephrology, UCSF

²Department of Surgery, UCSF

³Department of Bioengineering and Therapeutic Sciences, UCSF

⁴Silicon Kidney, LLC

⁵Ben Chui Consulting

⁶H-Cubed, Inc.

⁷Division 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 100 μ m vs HF-SNM 400 μ m). 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 \pm 0.1mg/dL. The creatinine clearance was 37 \pm 4ml/min/m² (HF-SNM) vs 85 \pm 18ml/min/m² (HD-SNM) at 92.5 \pm 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 \pm 2.3nm vs 1.9 \pm 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.