MICRO-SCALE MODELING OF FLOW THROUGH HOLLOW FIBER MEMBRANE

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Hollow fiber membranes (HFM) are used in artificial lung devices as blood oxygenation components. They consist of thousands of hollow cylindrical tubes arranged either in parallel to each other or crossed pattern. The tubes are positioned either perpendicular or angled with respect to the incoming flow. The aim of this work is to develop a realistic 3D fiber bundle model of a mini-oxygenator by directly modeling individual fiber tubes and to link the effects of the presence of the cylindrical tubes on the flow field and shear patterns to the continuum porous media model used in real-scale device design and analysis. The blood contacting surfaces of individual fiber tubes of a cubic mini-oxygenator was directly meshed in the 3D computational model. The cylinders were arranged in different patterns to obtain the overall porosity similar to a benchmark device. The blood flow in the interstitial space of the mini-oxygenator was obtained by solving the fluid governing equations with an attained fully developed flow before the cylinders. In parallel, HFM component was considered as a porous medium with pre-specified effective porosity value, and viscous and inertial resistances. The results showed that the interstitial flow field created by the presence of the tubes is different than the flow field in the continuum model where the superficial flow field and shear rates were obtained. The significance of this observation on oxygen transfer will be investigated for Newtonian and non-Newtonian fluid models regarding different cylinder arrangements. The results will be compared to the benchmark experiments.

NOVEL SURFACE COATING FOR MEDICAL DEVICES

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A scalable, closed system, hypoxic bioreactor has been developed to support the production of human extracellular matrix (hECM), which closely resembles embryonic ECM. This matrix was used as a surface coating on a commonly used biomaterial–polypropylene mesh. The hECM was covalently bonded using a proprietary commercial UV mechanism to attach hECM to polypropylene. Biocompatibility of the surface-coated versus uncoated polypropylene samples were evaluated in the murine model. Coated and uncoated 6mm biopsy punches of polypropylene were sterilized utilizing E-Beam or Ethylene Trioxide (ETO). Polypropylene implants were subcutaneously implanted following aseptic techniques in the dorsal lumbar position. Samples were explanted at two weeks and five weeks for subsequent evaluation. Surface coating of polypropylene meshes with ECM was qualitatively confirmed using anti-fibronectin immunofluorescent staining. Foreign body giant cell (FBGC) formation was evaluated at the two and five week time point using hematoxylin and eosin stained samples. At the two week time point the mean FBGC count per sample was determine to be statistically higher ($p<0.05$) for untreated polypropylene ($9.20+/-2.03$) versus treated polypropylene ($4.53+/-0.89$). These data suggest that this hECM coating may be applicable to many other types of biomaterials such as PTFE, Dacron, Nitinol, stainless steel and other common biomaterials used in medical devices.

DYNAMIC IN VITRO CALCIFICATION OF BOVINE PERICARDIUM VALVES IN A TEMPERATURE AND PH-CONTROLLED SYSTEM

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Bovine pericardium must be chemically treated for manufacturing bioprosthetic heart valves. Current methodologies based on glutaraldehyde treatment may predispose the formation of calcium apatite crystals. In vitro assays partially mimic in vivo calcification processes and thus may be used to better understand and evaluate treatment protocols. We report in this work the construction and testing of an in vitro calcification system (figure 1) which allows for controlling temperature ($37\pm0.5°C$) and pH (7,4) of the solution. Bovine pericardium prostheses were tested using a high calcium concentration solution (2.5 mM) under pulsatile flow (500 cycles per minute frequency and 80–120 mmHg pressure). After a 6 weeks testing, commercial bioprosthetic valves showed intense calcification (figure 2) as observed with histological analysis. The experimental set up was easy to implement and successfully used to evaluate differences in calcification rates obtained with distinct chemical treatments of bovine pericardium.

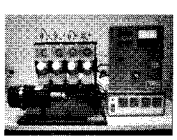

Fig 1. Pulsatile system showing chambers with mounted valves, actuator, frequency controller and temperature sensors.

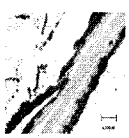

Fig 2. Calcium deposits at histologic examination (Von Kossa stain).

CAPRYLATE METABOLISM IS SEVERELY ALTERED IN LIVER FAILURE WHICH CAN LEAD TO TOXIC SERUM LEVELS IN DIALYSIS AGAINST COMMERCIAL ALBUMIN

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Background: The removal of toxins by albumin dialysis is a therapy for liver failure. However, recent tests have shown, that Caprylate, an industrial albumin stabilizer, passes from albumin dialysate into the blood. Its metabolism is slowed down in liver failure which may cause complications. **Aim:** To investigate the effect of techniques for albumin dialysis on the serum level of caprylate. **Methods:** Patients with liver failure and renal replacement therapy (RRT) where assigned to (I) single pass albumin dialysis (SPAD, n=6) in continuous veno-venous hemodialysis (CVVH) and to (II) intermittent dialysis using the MARS (n=7) both with commercial albumin, but also to (III) Clean HepAlbiN CVVH (CHANCE, n=6), identical to SPAD and to (IV) (NeoMARS, n=5),)III and IV characterized by albumin dialysate which was Caprylate depleted by prior charcoal (Hepalbin-Adsorbent) filtration. In CVVH, blood flow of 150 mL/min and dialysate flow of 900 ml/hour was used, in MARS, blood flow 250 ml/min, albumin dialysate 250 ml/min and dialysate flow 500 ml/min. Caprylate samples were taken within 5 minutes, 30 minutes and 180 minutes and detected by GCMS. **Results:** Within 180 minutes, Serum Caprylate (in umol/l, mean±SD) rose to 55 ± 27 in SPAD(I) and to 46 ± 40 in MARS(II). However, when Hepalbin was used, levels rose only to 9 ± 5 in CHANCE (III) and to only 4 ± 2 in NeoMARS (IV). **Conclusion:** Caprylate ncreased in liver failure. As it can cause renal oxidative injury and encephalopathy, albumin dialysis should be applied with caprylate free albumin.

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