Index-Description

The Material Interactions with Biological Systems Laboratory focuses on improving the biocompatibility of biomaterials and biomedical devices, specifically in the ocular and circulatory systems. With the increasing utilization and invention of biomedical devices, the lives of countless individuals have been improved significantly. To maintain and maximize this improvement, the potentially life-threatening side-effects of such innovations, such as infection, thrombosis, and fibrosis must be understood, and through this understanding, prevented, to ensure each patient’s safety and satisfaction. Hence, this laboratory studies the interactions which occur between biomaterials and biological systems to understand the mechanisms behind these negative outcomes along with those that could theoretically arise from a biomedical device or therapeutic measure. To do so, our laboratory studies biological systems’ responses to biomedical devices and therapies on a cellular level to comprehend and identify these mechanisms and to quantitatively evaluate their biocompatibility. By understanding these mechanisms, and recognizing needs for improvement in the industry, our laboratory innovates to develop materials, therapeutics and devices with improved biocompatibility. To justify the value of our conceptions, we often develop in-vitro models to closely represent the biological systems we study to negate the necessity of testing on humans and animals. Overall, MIBS is dedicated to the improvement of therapeutics, and biomedical devices for the sake of innumerable patients on a world scale.

CPB Model Description

Cardiopulmonary bypasses (CPB) frequently result in excessive bleeding, and consequently this surgery contributes to 10-15% of the national blood demand. This is caused by complex mechanisms, and is patient-variable, making for convoluted prediction methods. However, the main causes are believed to be platelet dysfunction, hyperfibrinolysis and coagulopathy. Coagulopathy specifically, is associated with the duration and complexity of the surgery, hemodilution, anti-platelet therapies, shear stress induced by the CPB flow conditions, blood-air and biomaterial interfaces, comorbidities, heparin and protamine doses, and genetics. The prediction of this phenomena is essential as it could potentially be utilized to inform treatment decisions, signal the need for prophylactic and preventative measures, ensure the necessary blood for transfusion is prepared, and overall improve the patient’s care. Currently, platelet function testing (PFT) is the technique used to coordinate surgeries for patients on antiplatelet therapy, and to improve transfusion algorithms since CPB-induced coagulopathy is not observed by other assays. Unfortunately, this test only has a predictive sensitivity of 70%, generating a high rate of false positives, diminishing its clinical value. This is a consequence of the fact that these tests are conducted under resting conditions and the fact that platelets experience changes during surgery which preoperative testing does not account for. Consequently, a prototype was designed to mimic the stresses that blood experiences during CPBs in vitro and in the future will be used on the blood of volunteers. After comparing these results with post-operative CPB results the device will be modified to more accurately predict patient-based outcomes. If this is successful, a point-of-care testing device will be designed.

Investigation of Latanoprost Release from Contact Lens Material

In this study research was conducted to evaluate the ability of contact lenses to uptake and release glaucoma drugs in vitro. This experiment was conducted by allowing different contact lenses to soak in solutions of glaucoma drugs for 24 hours. Afterwards, the lenses were placed on one of three models, a monolayer with human corneal epithelial cells (HCECs), a multilayer with HCECs, and a PET insert without any cells. Over 48 hours, the drug diffusion was calculated for each of the contact lens types, in different mediums. Previous literature has demonstrated that this method has a low potential for drug administration, and that hydrophobic interactions between the drug and the contact lens material is the determining factor for adsorption. However, most of these studies have only been conducted on deionized water, phosphate buffered saline, and artificial tear solutions. Sources also state that the amount of drug released is also significantly greater in vivo than in vitro. In total, the results demonstrated that in cell-based in vitro models, the drug release is significantly higher than models without cells even when using different media in the no-cells model, as well as a dead-cell model. Regardless, only 2-3% of the drug adsorbed by the contact lens was released after 24 hours. Nonetheless, more drug may possibly be released from silicon hydrogels making them potentially useful for an ocular drug delivery system. Overall, this research exemplifies the importance of using cell models for studying drug release in instances where the drug must be metabolized before being diffused within the tissue. In the future, a Tear Replenishment System will be deployed to more accurately simulate the dynamic environment characteristic to the front of the eye.