Development of a Reproducible Endothelialized 3D Hydrogel Channel to Study Cerebral Cavernous Malformation

Mapping the Nonhuman Delegates of Cardiovascular Disease Prevalence in Virginia Through the Lens of Actor Network Theory

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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Executive Summary

Cardiovascular disease (CVD) remains the leading cause of death in the United States, with disproportionately high mortality in low-income communities due to systemic barriers. My capstone research explores this issue through two interconnected components: a technical investigation into the biology of cerebral cavernous malformations (CCMs), and a sociotechnical analysis of the nonhuman actors that shape CVD disparities in Virginia. The technical component aimed to design a reproducible in vitro model of cerebral microvasculature to study how mechanical and genetic factors contribute to CCM progression. Using a Norbornene-modified Hyaluronic Acid (NorHA) hydrogel, we fabricated a 3D perfusable channel system mimicking brain tissue stiffness. Rheological testing confirmed that a 2% NorHA formulation closely approximated the target viscoelastic properties of brain tissue. However, cell adhesion trials revealed that bovine aortic endothelial cells (BAECs) adhered more readily to a stiffer 3% hydrogel, suggesting a tradeoff between physiological mimicry and cell compatibility. Fluorescent dye (FITC-dextran) assays were used to visualize solute diffusion, validating the model's permeability function, although limitations in imaging and calibration prevented precise quantification. These findings establish a foundation for future iterations that could incorporate genetic knockdown of CCM-related genes and enable dynamic flow studies under shear stress. The sociotechnical research employed Bruno Latour's Actor-Network Theory (ANT) to map how infrastructural, geographic, and economic actors influence CVD outcomes across Virginia. By analyzing county-level data on poverty, food insecurity, insurance coverage, and CVD mortality, I identified how gaps in infrastructure contribute to health disparities. For example, counties like Buchanan experience significantly higher CVD mortality due to weak translation of policy into lived, networked conditions.