Thesis Project Portfolio

Manufacture and Validation of Advanced Cell Culture Inserts

(Technical Report)

Organ Transplantation During COVID-19: How the Pandemic Altered the Transplant System's Operation

(STS Research Paper)

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Sociotechnical Synthesis

The organ transplant system performs operations that are essential to the survival of many patients, though this system is constantly under pressure due to the high demand for transplants which outweighs the system's supply of organs. The potential for tissue engineered organs to help relieve these supply shortage pressures on the organ transplant system is a topic that is discussed often, yet synthetic organs are currently only in the development stage. In the meantime, it is important to understand how current events, such as the Coronavirus SARS-CoV-2 (COVID-19) pandemic, impact the transplant system in order to continually assess the pressures placed on the organ transplant system. This is achieved through the research project: "Organ Transplantation During COVID-19: How the Pandemic Altered the Transplant System's Operation." Additionally, it is important for the tissue engineering field to improve their tools for generating synthetic tissues such that they can create more bio-mimetic tissues in order to make synthetic organs for transplantation a reality in the near future. Work towards this goal of synthetic organs is achieved through the Capstone project: "Manufacture and Validation of Cell Culture Inserts."

In the tissue engineering field, there is a need for in vitro models of tissues to better replicate the in vivo structural environment of these tissues in order to better replicate their functionalities. Cell culture plates, the current standard tool to grow cells on in a laboratory, do not provide the three-dimensional support for cells that their natural extracellular matrix (ECM) provides. The fabrication of electrospun nanofiber membranes for cell culture inserts better provide the ECM-mimicking environment that cells need in order to promote more bio-mimetic models of tissues. In order to optimize the membranes such that muscle cell growth prioritized, the membrane properties were altered to promote growing conditions favorable to muscle cells. Additionally, degradation properties of the membranes were explored in order to allow for the muscle cells to replace them membrane with their own ECM structural environment to better replicate natural muscle tissue structure and function. The impact of these optimized membranes is better skeletal muscle tissue models that can be used for applications such as drug screening and tissue function modeling, which can help to further research in the tissue engineering field.

The life-saving quality of organ transplant procedures make these operations difficult to suspend during a time of healthcare crisis, such as the COVID-19 pandemic. The organ transplant system instead must alter their operations in order to balance the need to protect their medical team and patients from COVID-19 infection and the need to perform the transplants. Understanding how these system alterations come about and how they impact the system's efficiency is crucial for improving the system's operation during the pandemic and determining how to best build a resilient organ transplant system. This understanding can be obtained by answering the question: how effective are the sociotechnical systems that impact how the COVID-19 pandemic influences organ transplantation? Identifying the key sociotechnical systems in organ transplantations and analyzing them using the risk analysis and social construction of technology (SCOT) frameworks allows for a better understanding of what changes have occurred in the organ transplant system's operations, and how the public's perception of organ transplants during the pandemic and the balancing of health risks have spurred these changes. A greater understanding of how the system has adapted to the COVID-19 pandemic can help the organ transplant system implement operational changes that work to rebuild the system as the pandemic continues to progress and post-pandemic, and prepare the system to endure a future pandemic or other healthcare crisis.

Together, these two projects highlight how both the organ transplant system and the tissue engineering field are continually growing and adapting as they strive to reach their combined goal of synthetic organs for transplantation. The COVID-19 pandemic is great example of how increased stress on the organ transplant system, and on the world in general, promotes changes within the system so that it can still work efficiently during strained times. Additionally, the development of optimized membranes for promotion of specific cell lineage tissue growth for research purposes is an example of how research tools in the tissue engineering field are constantly evolving. This evolvement allows for better understanding of tissues, more advanced models for testing and, eventually, higher quality synthetic organs that can be used for transplant applications. While synthetic organ transplantation is not a reality yet, the ability of the transplant system to adapt to stressors and maintain stability, while the constant improvements of the tissue engineering field accelerate the timeline of developing these organs, shows the potential for this goal to be reached in the near future.