UNIVERSITY of HOUSTON | ENGINEERING

Department of Biomedical Engineering

Friday, May 15th, 2020

11:00 AM

Defense held online via Zoom

Kian Torabian

PhD Dissertation Defense

Dr. Sergey Shevkoplyas, Faculty Advisor

"Microfluidic Device Design Informed by Red Blood Cell Morphology for Global Blood Diagnostics and Banking"

Abstract

Just as blood diagnostic tests are ubiquitous in the clinic, blood component transfusions are among the most commonly performed medical procedures at the bedside. The many devices designed to process blood often rely on microscale flow of the complex non-Newtonian fluid. With approximately 40 percent of human blood comprised of red blood cells, flow dynamics are largely influenced by these relatively dense particles. Their delicate biconcave shape is essential to their deformability, aggregability, and overall viability, allowing them to bend, shear, expand, and stack as they navigate the microvasculature to deliver oxygen to surrounding tissues. As a result, shape and its many surrogates not only serve as biomarkers for their quality, but also can be exploited improve diagnostic and blood banking devices.

In this work we study red blood cells with altered morphology in various forms of sickle cell disease and in animal models with uniquely adapted vascular systems, and use our findings to develop three devices with applications in diagnostics and banking: a simple gravity-based device to replace industrial centrifuges that wash stored red blood cells prior to transfusion, a multi-layered microfluidic platform to separate whole blood into its component blood transfusion products, and a paper-based diagnostic device for the altered hemoglobin molecule responsible for sickle cell disease. We explore the limitations and challenges associated with current technologies used to study red blood cell deformability and aggregation, ranging from micropipettes to ektacytometers and aggregometers, with respect to balancing diagnostic robustness, methodological throughput, and access and affordability. Additionally, we take advantage of inexpensive and biomimetic microfluidic platforms to inform a design process for global health applications, considering the potential scope of these devices to improve access to some of the most widely used biomedical tools.

Zoom link:
https://uofh.zoom.us/j/91817369436?pwd=VE03NjBwU0ZVMXhPWnNSZFJiQ2oxZz09

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