Placenta-on-a-chip: Microsensor simulates malaria in the womb to develop treatments

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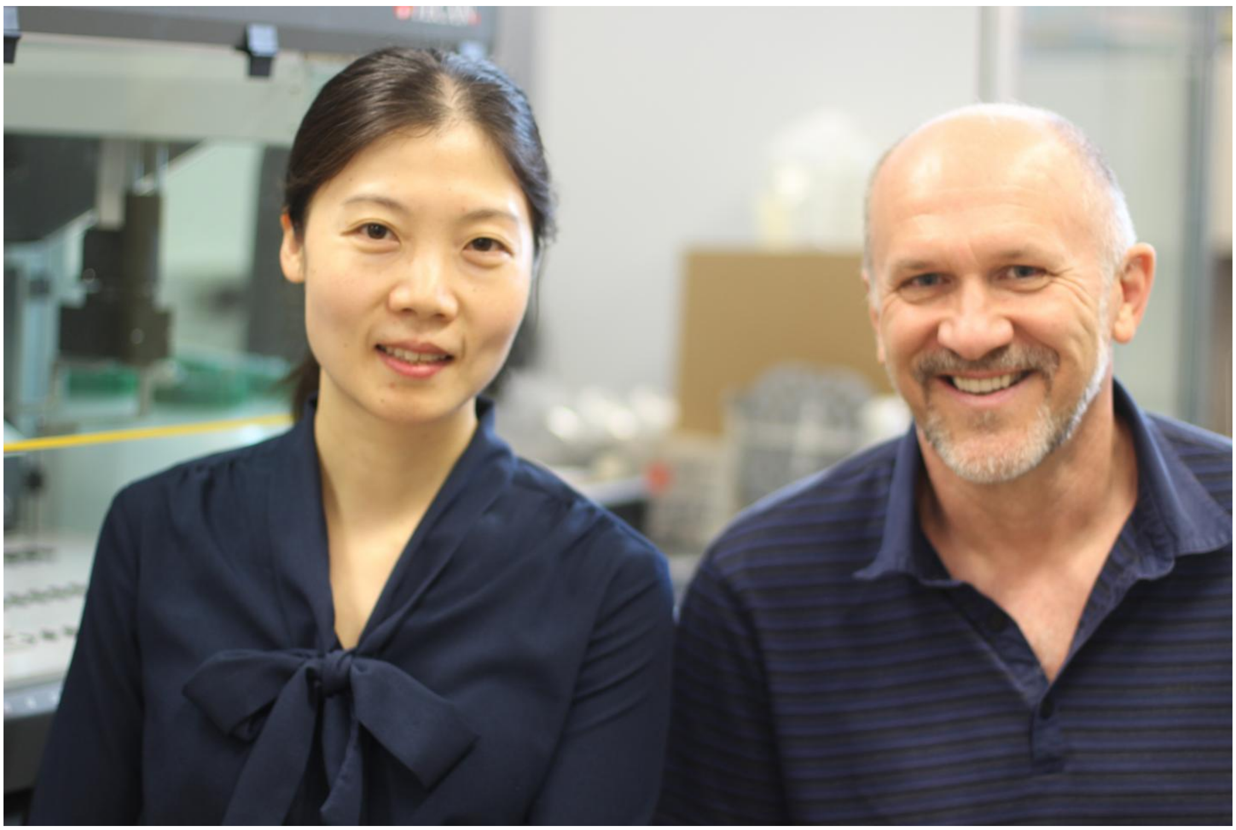

Sarah Du, Ph.D., principal investigator of the grant and an assistant professor in the Department of Ocean and Mechanical Engineering in FAU's College of Engineering and Computer Science, and Andrew Oleinikov, Ph.D., associate professor of biomedical science in FAU's Charles E. Schmidt College of Medicine. Credit: Florida Atlantic University

Malaria, one of the most severe public health problems, affected 212 million people worldwide in 2015. This life-threatening disease is caused by parasites that are transmitted to humans through the bites of infected female Anopheles mosquitoes. Though malaria usually cannot be transmitted from mother to baby in utero, both might be affected because malaria-infected red blood cells adhere to blood vessels in the placenta, resulting in about 10,000 maternal and 200,000 newborn deaths annually. Those hit hardest are in developing and subtropical countries, especially in sub-Saharan Africa.

By combining microbiology with engineering technologies, researchers from Florida Atlantic University are developing a first-of-its-kind 3D model that uses a single microfluidic sensing chip to study the complicated processes that take place in malaria-infected placenta as well as other placenta-related diseases and pathologies. They have received a two-year, $400,000 grant from the National Institutes of Health to develop this technology, which will mimic the microenvironment of placental malaria, specifically the maternal-fetal interface.

"There are a number of challenges in studying the biology of the human placenta in its natural form or in situ because of ethical reasons as well as accessibility," said Sarah Du, Ph.D., principal investigator of the grant and an assistant professor in the Department of Ocean and Mechanical Engineering in FAU's College of Engineering and Computer Science. "That is why there is such a great need for a placental model that can be used for research purposes."

With malaria, parasites are released during a mosquito bite into the bloodstream and infect liver cells. They then reproduce in the liver cells, burst, and cause thousands of new parasites to enter the bloodstream and infect red blood cells. They reproduce again in the red blood cells, destroy them and move on to destroy other uninfected blood cells. The most dangerous form of malaria is P. falciparum. If left untreated, those infected with the disease could die.

Du, together with her mentor and grant multi-principal investigator, Andrew Oleinikov, Ph.D., associate professor of biomedical science in FAU's Charles E. Schmidt College of Medicine, came up with the idea of developing a Placenta-on-a-Chip device using embedded microsensors. They are designing this device to provide real-time monitoring of vascular cell well-being and nutrient circulation across the barrier between mother and fetus, and under the influences of the malaria parasite to see how it responds to various drug treatments.

Placenta-on-a-Chip will be able to simulate actual blood flow in vitro and mimic the microenvironment of the malaria-infected placenta in this flow condition. Researchers will be able to closely examine the process that takes place as the infected red blood cells interact with the placental vasculature and to identify interventions that reverse parasite-infected erythrocyte adhesion that is found in placental tissue.

"We want to advance the understanding of human diseases down to the single cell level and ultimately develop new treatments to combat devastating diseases like malaria," said Oleinikov. "I have been studying infectious diseases including malaria since 2004, and became interested in researching the cellular and pathological events that occur in women when they get infected with malaria, especially during their first pregnancy when both mother and fetus are most vulnerable."

Year one of the research will focus on the effects of malaria on the mother, and year two will focus on the effects of malaria on the fetus. The microfluidics developed by FAU's College of Engineering and Computer Science will produce micro-scaled devices to allow researchers to get a closer look at cells and their interaction before, during and after being infected by malaria.

"Bringing together outstanding scientists from different disciplines is critical to advancing research as well as improving the quality of life for people across the globe," said Javad Hashemi, Ph.D., professor and chair of FAU's Department of Ocean and Mechanical Engineering. "With this National Institutes of Health grant Drs. Du and Oleinikov will be able to continue developing this important sensing platform. Their efforts will help to reveal the molecular details of placental malaria pathology and other placental pathologies with the ultimate goal of alleviating as well as preventing the spread of infectious diseases."

Provided by Florida Atlantic University

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