New technology measures oxygen in individual red blood cells in real time

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In an engineering breakthrough, a Washington University in St. Louis biomedical researcher has discovered a way to use light and color to measure oxygen in individual red blood cells in real time.

The technology, developed by Lihong Wang, PhD, the Gene K. Beare Distinguished Professor of Biomedical Engineering, could eventually be used to determine how oxygen is delivered to normal and diseased tissues or how various disease therapies impact oxygen delivery throughout the body.

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Red blood cells deliver oxygen through arteries, capillaries and veins to the body's cells and tissues. To date, the state-of-the-art device for measuring the amount of oxygen in the blood is through a device that clamps onto the index finger called a pulse oximeter. However, this measures only the oxygen level in the body's arteries, so doesn't give a full picture of oxygen metabolism.

The new technology that Wang developed, called photoacoustic flowoxigraphy, uses light in a novel way that allows researchers to watch red blood cells flowing through tiny capillaries, the smallest of the body's blood vessels at about the width of one red blood cell.

"By firing two laser pulses of different colors at a red blood cell 20 microseconds apart – nearly simultaneously – we hit the same red blood cell at almost the same location, so we get signals back at both colors," Wang says. "That allows us to figure out the color of the red blood cell at any given moment. By watching the color change, we can determine how much oxygen is delivered from each red blood cell per unit of time or distance. From there, we can determine the average oxygen delivery per unit length of capillary segment."

Wang and his colleagues were able to watch the red blood cells choose which direction to travel when they encountered a "fork" in the capillary, called bifurcation. The cells travel in bunches to where oxygen is most needed in the body at that time, he says.

And although the cells travel very quickly, the speed of the device —200 Hertz, or 20 3D frames per second—allows the researchers to see the cells in real time. In comparison, a film at a movie theatre moves at 30 Hertz, fast enough that they eye can't see the individual frames.

"Photoacoustic flowoxigraphy is considered an engineering feat, enabling oximetry at the most fundamental level, namely, the single-cell level," Wang says.

Wang says this technique has applications for further biological studies as well as in the clinical setting.

"There are many biomedical questions that this technology could answer: How would cancer or diabetes change oxygen metabolism? How would cancer therapy or chemotherapy affect oxygen level?" he says. "We'd like to see if we could use this technique to monitor or predict therapeutic efficacy."

Getting the technique into the hands of researchers is the next step, Wang says. He and his colleagues would like to license the technique to a company that would move it forward to make it available to biologists and physicians for applications.

More information: Wang L, Maslov K, Wang LV. Single-cell label-free photoacoustic flowoxigraphy in vivo. *PNAS* Online Early Edition, March 25, 2013.

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