Non-Invasive Blood Flow Measurements Using Ultrasound Modulated Diffused Light

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Capillary blood flow is a critical parameter for determining tissue vitality. Existing optical methods for measuring blood flow such as Diffuse Correlation Spectroscopy (DCS), Laser Doppler, spatial-temporal image correlation spectroscopy (NIR-STICS) and Speckle Imaging suffer each from drawbacks, such as shallow sampling volumes, complexity and expense of apparatus. Ultrasound based methods such as Ultrasound Doppler are used for monitoring directional flow in relatively big blood vessels and are problematic when applied to capillary flow.

We present a novel non-invasive method for measuring blood flow based on the acousto-optic effect. Blood flow within the sampled volume disturbs the photons' temporal correlation and therefore the spectral component of light fluctuating at the Ultrasound frequency decreases as flow increase, while the spectral width around the ultrasound frequency broadens. A cross correlation of the sampled light with the emitted ultrasound pattern provides a measure of flow within the sampled volume. The benefits of the presented method are: localized measured volumes, continuous real time measurement, simplicity of apparatus and ease of operation.

We demonstrate the ability of the method to detect flow of scattering fluid using a calibrated flow phantom model. Fluid flow was generated by a calibrated syringe pump and the phantom's sampled volume contains millimeter size flow channels (10% fluid by volume). Results demonstrate linear dependence of flow as measured by the presented technique (FI) to actual flow values with $r=0.97$, $p<0.001$.

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