Live Cell Imaging of Macrophages Incubated with Deuterated Fatty Acids Using Raman Microscopy

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During the development of atherosclerotic plaques the uptake of lipids by macrophages plays a key role. Through receptor mediated processes lipids are transported into the cells and stored in lipid droplets in the cytoplasm. The scavenger process is an uncontrolled pathway which leads to a high lipid content in the cells if the lipid concentration in the blood is elevated. Macrophages transform into foam cells but toxic lipid levels can be reached within the cell which eventually undergoes necrosis or apoptosis. If the macrophages are located in the subendothelial layer of arteries, the lipid content can be deposited within the arterial wall forming lipid-rich plaque depositions (atheroma). By thickening of the wall and rupture of the plaque, the blood flow can be disturbed or blocked completely. Atherosclerosis can therefore lead to myocardial infarction or stroke which are major causes of death in Western industrialized countries [1].

At present, the formation of cellular lipid droplets is not well understood. Raman microscopy provides the possibility to correlate microscopic information with chemical characterization through spectral analysis. To gain more insight into the uptake and metabolism of lipids, Raman microscopy of different cell types incubated with deuterated fatty acids were conducted [2,3]. The introduction of deuterium labels enables to distinguish between the fatty acid of interest and the cellular lipids. In these early experiments, cells were arrested at certain time points by chemical fixation after being incubated with palmitic or oleic acid [2]. This study presents the results obtained from fixed THP-1 macrophages incubated with deuterated arachidonic acid complexed to serum albumin. As a precursor of eicosanoids, which mediate inflammation and help during the blood clotting process, the polyunsaturated arachidonic acid plays an important role in the cellular signaling process.

New experiments were performed to generate live cell Raman images and hence to investigate the development of lipid droplets. Palmitic acid was used as a saturated fatty acid and Raman images of the same macrophage were conducted over a period of several hours. With the help of Raman microscopy, it is possible to detect an increase of palmitic acid stored in lipid droplets in a living macrophage.

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