Biological application of impedance spectroscopy for in vivo life sign and Non invasive Glucose Monitoring

Mark Talary, Andreas Caduff, François Dewarrat, Daniel Huber, Solianis Monitoring AG. Zurich, Switzerland

Numerous reports describe the use of non invasive glucose monitoring techniques mostly in an in-vitro setting or under controlled in-vivo conditions. Impedance spectroscopy (IS) is such a technique. Glucose level changes cause alterations in the electrolyte balance. The resulting changes in AC and DC conductivity can be analyzed using IS.

However, additional external/physiological factors can effect the measurement as well and impact on the signals registered. In our previous works, various potentially perturbing parameters have been investigated, such as blood flux (LDF), the impact of environmental/body temperature changes or the effect of different arm positions. These parameters were studied in groups with either a combination of patients with Diabetes type 1/2 (D) and/or healthy subjects (ND). In our most recent study, the relation between perfusion characteristics and the impedance behaviour was investigated. Skin perfusion in the lower forearm was controlled using an arm cuff by applying various pressure levels. An IS based differential sensor was used to measure impedance of the skin and underlying tissue, which featured the ability to achieve different penetration of the electromagnetic fields (EMF) into the various tissue layers. This was compared with an optical measurement in the visible spectrum and a comparison made with the IS sensor.

It was found that the section of the IS sensor with smaller penetration depth has a reduced response to perfusion changes compared to the section with deeper penetration. Similarly this could be compared to the optical sensor where different penetration depths were achieved by varying the separation between the optical transmitter and receivers. This indicates that further quantitative and qualitative analysis of the interaction of EMF with specific layers will help in the characterisation of biological systems. This can help to further advance improvements in approaches for continuous glucose monitoring with sensitivities to perfusion changes.