Predicting Glucose Sensor Behavior in Blood Using Transport Modeling: Relative Impacts of Protein Biofouling and Cellular Metabolic Effects

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Abstract

Background:

Tissue response to indwelling glucose sensors remains a confounding barrier to clinical application. While the effects of fully formed capsular tissue on sensor response have been studied, little has been done to understand how tissue interactions occurring before capsule formation hinder sensor performance. Upon insertion in subcutaneous tissue, the sensor is initially exposed to blood, blood borne constituents, and interstitial fluid. Using human whole blood as a simple *ex vivo* experimental system, the effects of protein accumulation at the sensor surface (biofouling effects) and cellular consumption of glucose in both the biofouling layer and in the bulk (metabolic effects) on sensor response were assessed.

Methods:

Medtronic MiniMed SofSensor glucose sensors were incubated in whole blood, plasma-diluted whole blood, and cell-free platelet-poor plasma (PPP) to analyze the impact of different blood constituents on sensor function. Experimental conditions were then simulated using MATLAB to predict the relative impacts of biofouling and metabolic effects on the observed sensor responses.

Results:

Protein biofouling in PPP in both the experiments and the simulations was found to have no interfering effect upon sensor response. Experimental results obtained with whole and dilute blood showed that the sensor response was markedly affected by blood borne glucose-consuming cells accumulated in the biofouling layer and in the surrounding bulk.

Conclusions:

The physical barrier to glucose transport presented by protein biofouling does not hinder glucose movement to the sensor surface, and the consumption of glucose by inflammatory cells, and not erythrocytes, proximal to the sensor surface has a substantial effect on sensor response and may be the main culprit for anomalous sensor behavior immediately following implantation.

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Abbreviations: (ANCOVA) analysis of covariance, (PBS) phosphate-buffered saline, (PPP) platelet-poor plasma, (SEM) scanning electron microscope

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