Towards Early Diagnosis of Congestive Heart Failure using a Multiplexed Immunosensor

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Abstract

Objective: This study aims to design and develop a multiplexed biosensor for the simultaneous detection of B-type natriuretic peptide (BNP), N-terminal proBNP (NT-proBNP), and cardiac troponin-I (cTn-I). The clinical relevance of this biosensor lies in its ability to provide concurrent measurements of these prominent biomarkers, offering a comprehensive assessment of cardiac function, which facilitates early diagnosis and stage-specific monitoring of congestive heart failure (CHF).

Methods: The fabricated biosensor is integrated with four interdigitated electrodes (IDEs) and microwells as a multiplexed well design on a printed circuit board (PCB) with a soft gold finish. The IDEs were functionalized and immobilized with their bio-recognition element, i.e., monoclonal antibodies, to detect the binding of biomarkers using carbodiimide-based surface chemistry. Non-faradaic electrochemical impedance spectroscopy (EIS) was used to evaluate antibody-antigen binding using a portable impedance analyzer (Sensit Smart) for varying concentrations of biomarkers in PBS, corresponding to the three stages of CHF.

Results: The impedance of antibody-coated wells and PBS-spiked antigen samples for each biomarker was measured at a frequency spectrum from 100 Hz to 100 kHz. The calibration dose response (CDR) across all concentrations showed statistical significance between stages 1 and 2 for two biomarkers (p=2.53e-6 for BNP, p=2.13e-5 for NT-proBNP), between stages 2 and 3 for all three biomarkers (p=4.6e-7 for BNP, p=0.001 for NT-proBNP, p=0.03 for cTn-I), and between stages 1 and 3 for all three biomarkers (p=1.39e-6 for BNP, p=0.0001 for NT-proBNP, p=0.01 for cTn-I). We envisage conducting experiments on blood plasma samples to validate the findings of this proof-of-concept study.

Keywords

Congestive heart failure, Early diagnosis, Cardiac Biomarkers, Multiplexed biosensor, Non- faradaic Electrochemical Impedance Spectroscopy (nF-EIS).