Optimization of Nanosensor Response for the Detection of Anthracyclines Using Machine Learning

Myesha Thahsin[1], Zachary Cohen[1], Yumna Ahmed[1], Jeremy Aguilar[1], Atara Israel[1], Ryan Williams[1*]

*Contact: rwilliams4@ccny.cuny.edu

[1]The City College of New York Department of Biomedical Engineering

Purpose:

Pharmacokinetic variables such as interindividual variation in metabolizing and eliminating drugs after first dosage makes dose selection of chemotherapeutic anthracyclines increasingly difficult. One potential solution to determining dosing levels of an anthracycline is the development of non-invasive sensors to monitor their pharmacology in vivo. Single-walled carbon nanotubes (SWCNT) have substantial potential for in vivo sensor development, as they exhibit near-infrared fluorescence in the tissue-transparent window and a robust response to their local environment. An emerging method for optimizing SWCNT sensor response is through machine learning.

Methods:

In this study, anthracyclines Daunorubicin, Doxorubicin, Epirubicin, Mitoxantrone and Idarubicin, were used to interrogate 12 SWCNT preparations wrapped with short oligonucleotide sequences. In triplicate, each combination of oligonucleotide and anthracycline were evaluated for concentrations ranging from 0.01μM - 1000μM via near-infrared fluorescence analysis in a high-throughput format. A machine learning algorithm was implemented using MATLAB's machine learning toolbox which translated DNA sequences into numerical vectors, using cross validation, which were matched with various anthracyclines for chemometric screening.

Results:

Analysis of each anthracycline-SWCNT combination revealed specific patterns of fluorescence modulation. The developed machine learning algorithm allowed for optimized prediction of responses in fluorescence signal, including changes in wavelength and intensity, for a specific combination following laser excitation and high-throughput spectroscopy.

Conclusion:

We found that such an algorithm can be utilized not only for precision medicine but also for analyzing patterns in responses of fluorescent nanosensors to a class of chemotherapeutics. We anticipate future work in developing multi-purpose nanosensors that monitor the pharmacokinetics of active pharmaceutics and potentially for disease biomarkers that measure response to drug treatment.

Keywords:

Nanosensors, Machine Learning, Anthracycline, Pharmacokinetics, Chemotherapy