Abstract:

Background: Target-controlled infusion anesthesia is used worldwide to provide user-defined, stable, blood concentrations of propofol for sedation and anesthesia. The drug infusion is controlled by a microprocessor that uses population-based pharmacokinetic data and patient biometrics to estimate the required infusion rate to replace losses from the blood compartment due to drug distribution and metabolism. The objective of the research was to develop and validate a method to detect and quantify propofol levels in the blood, to improve the safety of propofol use, and to demonstrate a pathway for regulatory approval for its use in the USA.

Methods: We conceptualized and prototyped a novel “smart” biosensor-enabled intravenous catheter capable of quantifying propofol at physiologic levels in the blood, in real time. The clinical embodiment of the platform is comprised of a “smart” biosensor-enabled catheter prototype, a signal generation/detection readout display, and a driving electronics software. The biosensor was validated in vitro using a variety of electrochemical methods in both static and flow systems with biofluids, including blood.

Results: We present data demonstrating the experimental detection and quantification of propofol at sub-micromolar concentrations using this biosensor and method. Detection of the drug is rapid and stable with negligible biofouling due to the sensor coating. It shows a linear correlation with mass spectroscopy methods. An intuitive graphical user interface was developed to: (1) detect and quantify the propofol sensor signal, (2) determine the difference between targeted and actual propofol concentration, (3) communicate the variance in real time, and (4) use the output of the controller to drive drug delivery from an in-line syringe pump. The automated delivery and maintenance of propofol levels was demonstrated in a modeled benchtop “patient” applying the known pharmacokinetics of the drug using published algorithms.

Conclusions: We present a proof-of-concept and in vitro validation of accurate electrochemical quantification of propofol directly from the blood and the design and prototyping of a “smart,” indwelling, biosensor-enabled catheter and demonstrate feedback hardware and software architecture permitting accurate measurement of propofol in blood in real time. The controller platform is shown to permit autonomous, “closed-loop” delivery of the drug and maintenance of user-defined propofol levels in a dynamic flow model.

Reference:

Chaum E, Lindner E. A “Smart” Biosensor-Enabled Intravascular Catheter and Platform for

Dynamic Delivery of Propofol to “Close the Loop” for Total Intravenous Anesthesia. Mil Med. 2021 Jan 25;186(Suppl 1):370-377. doi: 10.1093/milmed/usaa470. PMID: 33499544.