Electrochemical Sensors in Medicine: Meeting Needs for the 21st Century

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Over the past 30 years, miniaturized potentiometric and amperometric sensors for ions (K^+, Ca^{++}, Na^+, Mg^{++}, Cl^-, H^+), gases (O_2 and CO_2), and nutrients/metabolites (glucose, lactate, creatinine, urea) have revolutionized the practice of critical care medicine by providing tools to measure an array of physiologically important species, simultaneously, in small volumes of undiluted whole blood. Indeed, all modern whole blood analyzers used in hospitals worldwide now employ such electrochemical sensor arrays as either single-use or multi-use devices for near-patient testing, especially in operating rooms, emergency rooms, intensive care units, etc. Further, nearly all glucometers now use electrochemical measurement principles to provide accurate glucose concentrations for millions of diabetic patients each and every day, both in the hospital and at home. A brief overview of these existing electrochemical sensor technologies that have already had such a great impact in medicine will be provided during the introduction of this lecture.

At the same time, there remain a number of unmet needs in medicine where electrochemical devices could still play important analytical roles. Therefore, in the major portion of this presentation the following ongoing research projects will be highlighted: 1) recent efforts to utilize electrochemical sensors for measurement of polyionic drugs and associated contaminants (including the anticoagulant heparin, low-molecular weight heparin, and inflammatory oversulfated chondroitin sulfate (OSCS) contaminants in biomedical heparin preparations); 2) research related to the development of implantable electrochemical sensors for ions, gases, glucose, etc. that emit low levels of nitric oxide (NO) (a potent anti-platelet and antimicrobial agent) and that can potentially be used to continuously monitor critical care species intraveneously in ICU patients with improved accuracy; and 3) the possibility of measuring glucose levels in tiny volumes of tear fluid with electrochemical enzyme electrode devices, as a simple less-invasive monitor of blood glucose levels for patients with Type 1 diabetes.