Microfluidic based electrochemical sensors and biosensors for real-time neurochemical monitoring of the injured human brain.

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Traumatic brain injury is a major cause of death and disability in all age groups and the leading cause in working people. Deterioration of patients often occurs during the 5-10 day post injury while they are intensive care unit (ICU), and is due to ‘secondary’ brain injury. We have previously shown that complex phenomena such as the development of secondary brain injury can be detected on the ICU and potentially understood by combining data from a range of real-time measurements made in the brain tissue at risk from secondary injury (1,2). In this presentation we discuss the design, construction and first clinical data from a new electrochemical clinical instrument specifically targeted at the detection of pathological ‘secondary insults’ to at risk brain tissue.

At the heart of the system is neurochemical measurement. We sample the extracellular space using a CE marked microdialysis probe. The dialyse liquid stream (1–2 microlitre / min) is then carried to the bedside analysis unit in either continuous flow or, for greatly improved temporal response, using 30 nl droplets formed using FC40 fluorocarbon oil, giving digital microdialysis. Neurochemical analysis takes place at the patient bedside using electrochemical sensors and biosensors within a microfluidic analysis device. Potassium ion concentrations are measured using 300 micron diameter valinomycin based ion-selective electrodes. Glucose and lactate levels in the microdialysate are measured using biosensors based on a 320 micron integrated amperometric electrochemical cell. These biosensors use an electropolymerised non-conductive film of polyphenol as a selectivity layer combined with PEG based enzyme entrapment. The microfluidic chip / sensor combination is built into a microfluidic circuit-board that also has computer controlled valves and micro-syringe pumps (LabSmith). This allows routine 5 point autocalibration under computer control. Custom instrumentation and event detection software that highlights adverse changes to the clinical care team then completes the instrument.

The talk will highlight the challenges of carrying out electrochemistry on the ICU and show how electrochemical data can be combined with other real-time measurements to detect changing brain pathology.

References