Research Article In-line Blood Analyzer for Premature Infants

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The health and development of a premature infant in the neonatal intensive care unit (NICU) is currently assessed by measuring the concentration of various analytes at any given time. The typical analytes that are measured include: lactate, oxygen saturation, glucose, urea, creatinine, sodium, potassium, magnesium, and calcium. Blood testing is currently used to determine the concentration of these analytes. These blood tests require a new 5 milliliter sample to be taken each time the concentration of an analyte is to be determined. The accumulation of these blood draws during the early postnatal period can result in the infant losing an estimated 10-20 mL of blood/kg per week, or 15%-30% of their circulating blood volume in the first weeks of life. This loss in blood volume commonly results in the premature infants becoming anemic, and also places a large amount of stress on their aerobic, skeletal, and cardiovascular systems. We eliminated the need for blood withdrawal by designing an in-line blood analyzer that determines analyte concentration using Fourier Transform Infrared Spectroscopy (FTIR). The analyzer consists of a catheter line from the premature infant attached to one input of a flow through cuvette. The other input of the cuvette contains a port for a syringe to be attached. The blood can be drawn into the cuvette by applying suction via a syringe. The flow through cuvette can then be placed into an opaque box containing the FTIR spectrophotometer, which will measure the amount of light absorbed by the blood sample. The concentration of the blood analytes are then determined by inputting the absorption values into Beer's law. The concentration of specific analytes are targeted by using absorption values of peaks at specific wavelengths that are known to be characteristic of a molecule. Once the concentration is determined, the blood can be returned back into the infant's body by pushing down on the plunger of the syringe. Due to cost restraints, an FTIR spectrometer could not be obtained. An infrared Arduino photodiode was used as a placeholder for the FTIR spectrometer to demonstrate proof of concept. The specific peaks for glucose were determined to occur at wavenumbers of 1012 cm-1 and 1081 cm-1, and isolated by subtracting out the spectrums of other analytes found in blood. Additionally, the extinction coefficient to be used in Beer's law to determine the concentration of glucose was calculated to be 0.023 ,and the path length of L·mm mmol our design was found to be 4mm. Overall, we have succeeded in designing the framework for a novel way to measure the concentration of various analytes in the blood of a premature infant that does not require them to experience any loss in blood volume. The analyzer can be improved upon to accomplish the entire objective of detecting the concentration of all analytes by installing the proper FTIR sensor, and isolating the appropriate peaks, as was done for glucose.