In-Line Blood Analyzer For Premature Infants

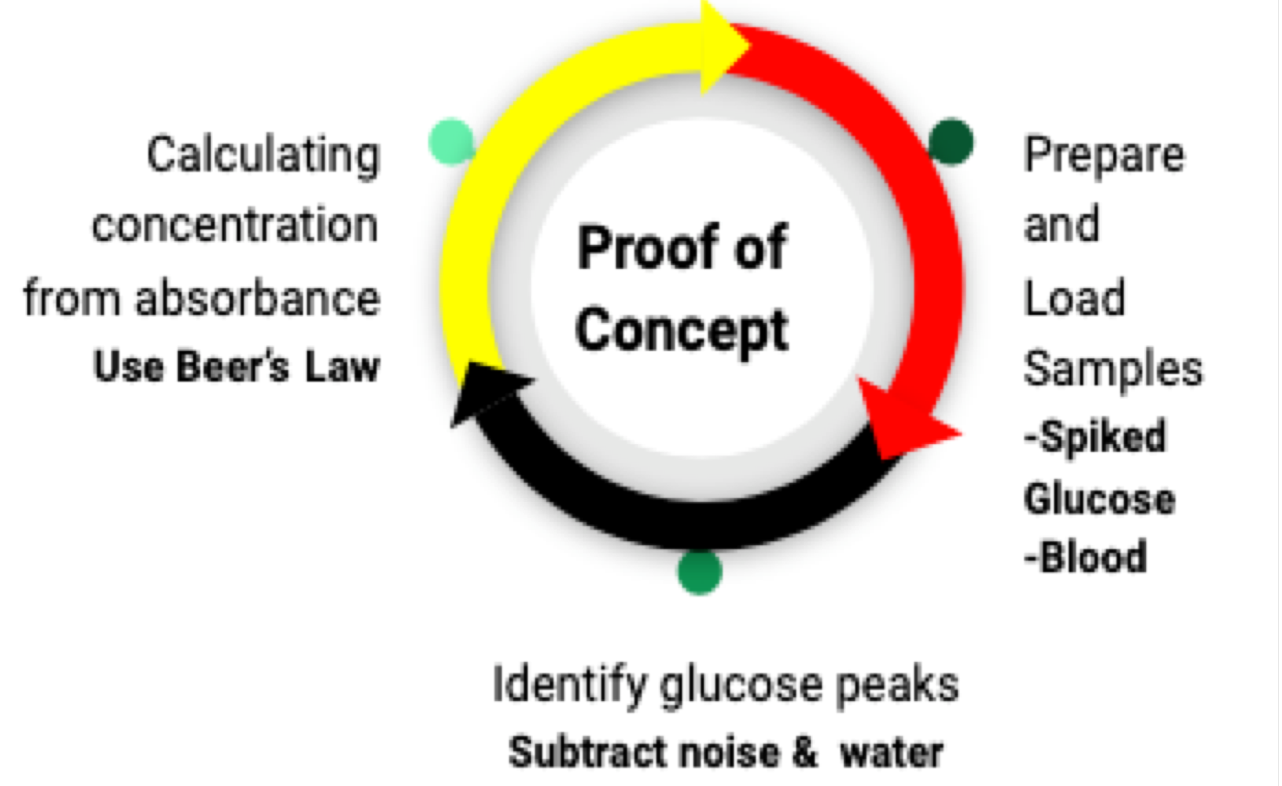
Sarah Asfari, James Fookes, Adam Herskovits, Devon Parsons, Cristina Tous

Advisor(s): Dr. Silvina Matysiak, The Fischell Department of Bioengineering, University of Maryland / Dr. Sripriya Sundararajan, MD, UMD School of Medicine

Motivation/Objective

Blood analyte levels of premature babies need to be continuously monitored, but lowered blood levels can cause more stress on babies leading to life-threatening shock. A very low birth weight infant has a very small circulating blood volume, typically having only 80-100ml /kg, and they can lose large volumes of blood to laboratory testing in the first few weeks of their life[1]. The current methods require about 5 ml of blood to be taken for each test, and numerous tests can be conducted in a given day[2]. New devices have been created to reduce the amount of blood that is needed for each test, but this still introduces the risks associated with taking a blood from such a small infant. We aim to create a device that can measure the blood analytes in premature babies without the need to remove blood from them.

Methods

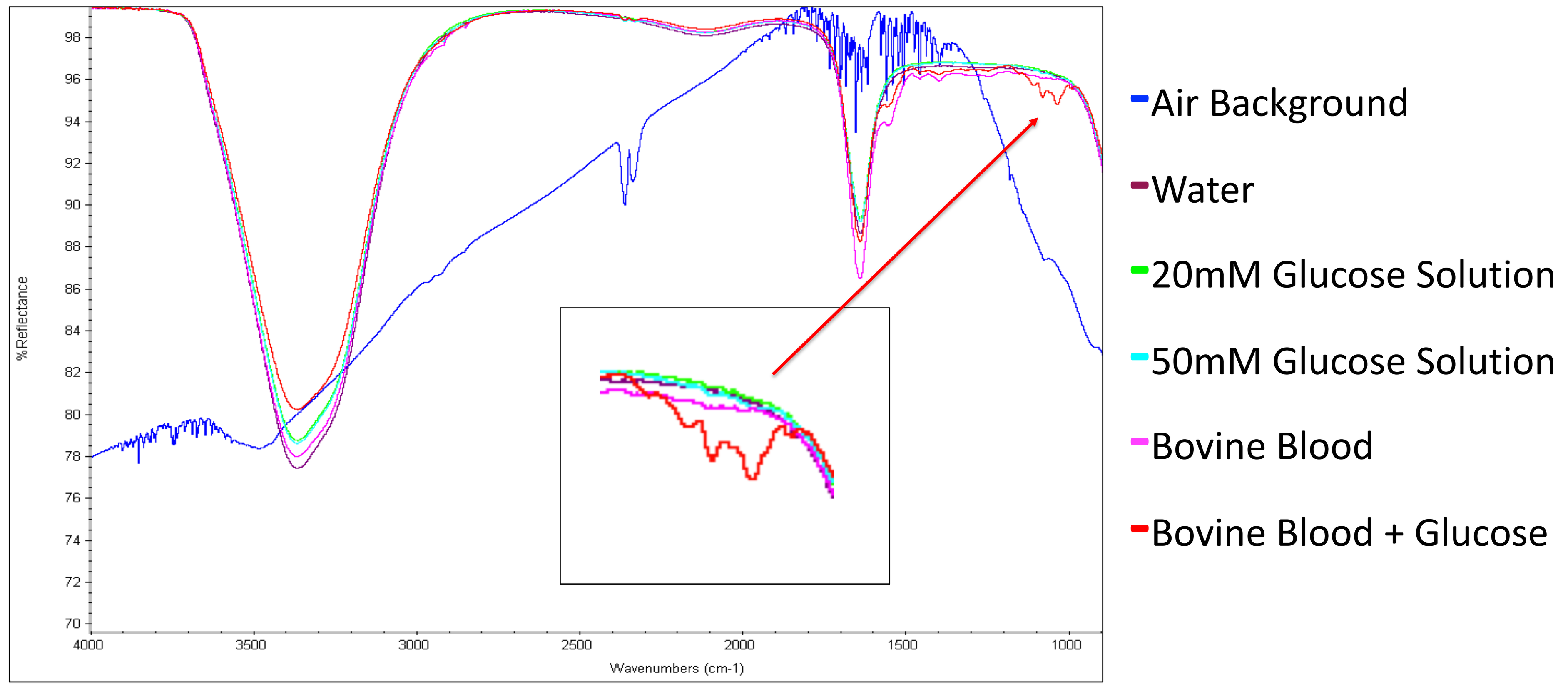


Ethical Implications

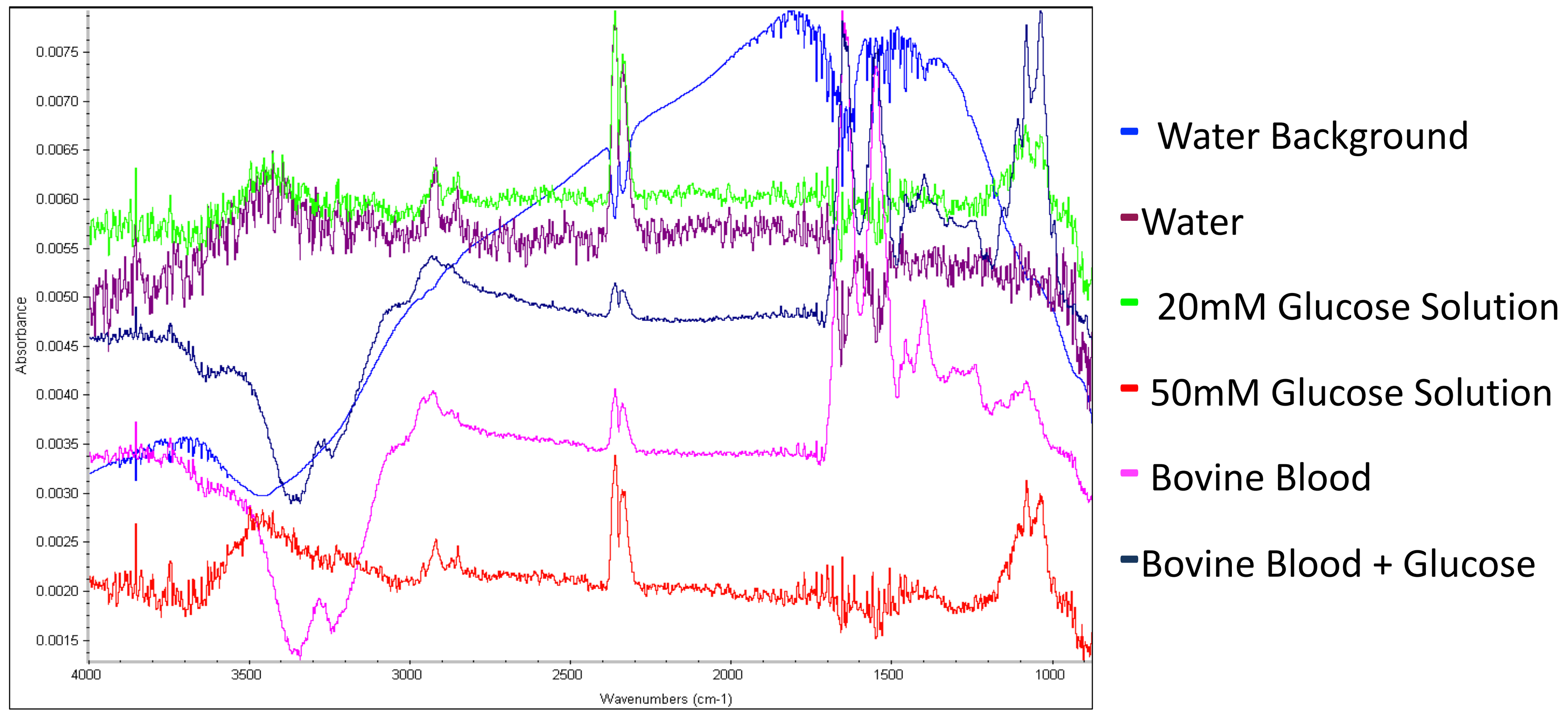
Our project strives to reduce blood withdrawal from neonates which will reduce the amount of stress placed on a premature infant's aerobic system. We additionally want to reduce the amount of blood transfusions which will reduce the chance of the baby going into life threatening shock. This will improve the premature baby's chance at living a normal, healthy life in the future.

Results

FTIR with Air Background



FTIR with Water Background

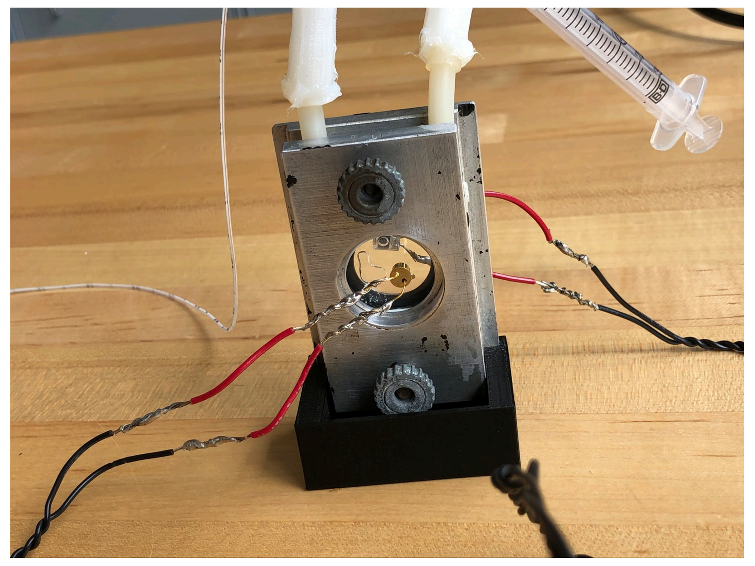


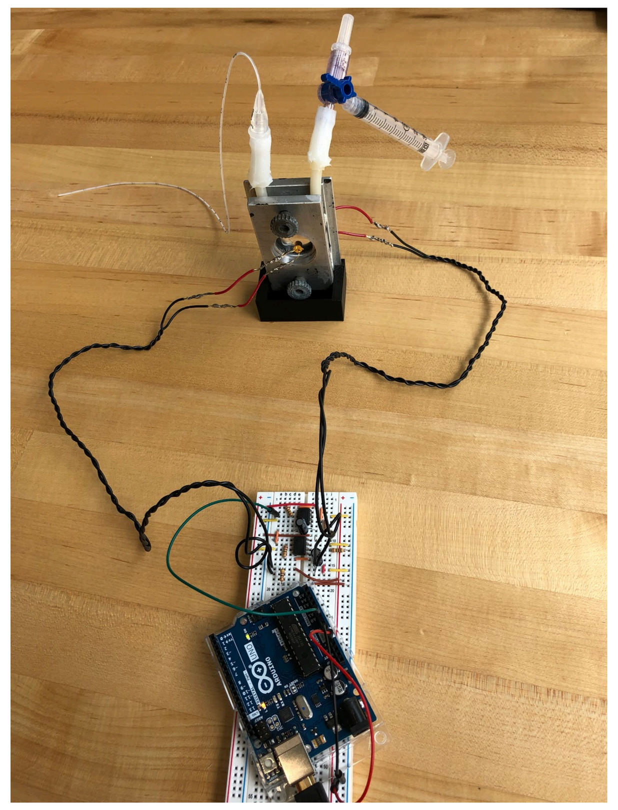
From the graphs obtained using the FTIR machine, a difference in peak intensity can be observed between the samples. Not much can be determined from the air background graph, other than that blood and glucose share similar peaks. Glucose can be seen in peaks present at wavenumbers of 1012 and 1081 in the figures above, which are known values for glucose peaks[3]. On the water background graph, both the regular blood and blood+ 4 wt% glucose have peaks that are higher than that of water but lower than the pure glucose solutions'.

Concentration of glucose can be determined using Beer's Law. The equation $A = \epsilon l c$, the molar extinction coefficient for glucose can be determined, given that A, l, and c are known values. From experimental data, it was determined empirically that ϵ is roughly 0.023. This means that, given the measure absorbance of an unknown sample of glucose solution, concentration can be calculated using $C = A/(l*\epsilon)$.

Conclusions

- Proof of concept demonstrated using Infrared light sensor instead of FTIR system due to cost restraints
- In-line analyzer was designed with Arduino, infrared sensor, infrared light source, and specialized flow through cuvette
- Blood samples were loaded by applying a suction using an inline syringe to eliminate blood loss
- Concentration of analytes calculated using Beer's Law with measured absorbance values





Internal components of device without the outer housing. Image on the left is the flow-through cuvette and sensors. Image on the right is the general set up.

Future Work

Given more time and a larger budget, this project could be furthered by:

- Replacing the infrared sensor with an FTIR sensor, which would enable the ability to detect all desired analytes
- Calibration testing to increase precision and accuracy of concentration calculations
- Improving accuracy of detection, and focusing the range of detection to target specific analytes while filtering out most of the background

Significant References

1. Vincent, J. L. et al. Anemia and blood transfusion in critically ill patients. Jama 288, 1499-1507 (2002).
2. The blood volume of infants, Sisson, Thomas R.C. et al. The Journal of Pediatrics , Volume 55 , Issue 4 , 430 – 446.
3. Smith, B. C. (2017). An IR Spectral Interpretation Potpourri: Carbohydrates and Alkynes. *Spectroscopy, 32*(7). Retrieved May 5, 2019, from http://www.spectroscopyonline.com/ir-spectral-interpretation-potpourri-carbohydrates-and-alkynes.