Comparison of a handheld glucometer and a clinical biochemical analyzer to measure glucose in porcine blood samples

By: Madison Gohlke, William Nunnelley, Dr. Terry Brandebourg

My research question involved developing a sample handling method that allows a human point-of-care glucometer (POCG) to accurately measure circulating blood glucose concentrations in porcine blood. Pigs are an apt biomedical research model for humans, specifically regarding the development of obesity and metabolic disease. As in humans, the accurate measurement of blood glucose concentrations is critical for assessing metabolic status as pigs become progressively obese. Human POCGs are an expedient method for measuring blood glucose in research animals and in clinical practice; the handheld instruments are portable, inexpensive, and yield rapid results. However, glucose values measured by POCGs often differ from values measured by a biochemical analyzer, the accepted clinical laboratory standard. These discrepancies can be large enough to cause potential misdiagnosis, limiting the ability to track the emergence of obesity-induced metabolic disease in our prediabetic animals.

POCGs measure glucose indirectly by utilizing a capillary strip to draw up a small blood sample and then recording the electrical current generated by the chemical conversion of glucose in the sample to ferrocyanide. I attempted to improve the accuracy of the glucometer by manipulating the viscosity and packed cell volume of blood samples, factors that could influence sample behavior on the capillary strip. Glucose was measured with a POCG in whole blood, serum, plasma, and fluorinated plasma (fluorine is a glycolytic inhibitor which functions to stabilize glucose levels) collected from 152 pigs. These values were then compared to plasma glucose concentrations measured by a chemical bioanalyzer in samples obtained from the same animals.

As expected, glucose concentrations in whole blood as measured by POCG were highly variable and poorly correlated with plasma glucose concentration measured by the biochemical analyzer ($r^2=.34$). However, glucose concentrations as measured by POCG in serum ($r^2=.57$), plasma ($r^2=.64$), and fluorinated plasma ($r^2=.89$) were more strongly correlated with plasma glucose concentrations measured by the biochemical analyzer. Bland-Altman analysis revealed that mean differences in glucose concentrations determined by biochemical analyzer and by POCG in whole blood, serum, plasma, and fluorinated plasma were 43.5, 33.5, 12.4, and 6.9 mg/dl, respectively, mirroring the correlation analysis. These results suggest that measuring glucose with a POCG in the fluorinated plasma fraction of the blood yields a glucose value almost identical to that of a biochemical analyzer.

Finally, to validate this method under physiologically meaningful conditions, glucose values were measured in pigs that were fasted overnight to induce low blood glucose levels and again when pigs were fed to induce high blood glucose levels. Glucose values obtained by the POCG closely matched values obtained by a biochemical analyzer; differences in results fell well within a diagnostic window, and the instrument reliably identified fed and fasted animals. This indicates that a POCG may be used to accurately detect physiologically meaningful differences in porcine glucose values from fluorinated plasma samples.

This sample handling protocol improves and validates a rapid and reliable method for assessing metabolic status in pre-diabetic pigs as they become increasingly obese, allowing continued study on this research model.

Statement of Research Advisor:

Maddy discovered that significant discrepancies existed between blood glucose values obtained from pig blood depending upon the method she used to measure circulating concentrations. To address this issue, she conducted experiments to determine the effects of various sample handling methods on porcine blood glucose values obtained by a handheld point-of-care glucometer (POCG). She ultimately determined that the use of a human POCG to measure glucose concentration in fluorinated porcine plasma yields results that are most similar to those produced by a biochemical analyzer, a gold standard method in clinical settings. This supports her original hypothesis that utilizing the liquid, cell-free fraction of blood when determining porcine glucose concentrations with a POGC can increase accuracy and reliability of the glucose measurements to a degree that is comparable to methodologies utilized in clinical diagnostic laboratories. In doing so, Maddy has made an impressive and substantial contribution to the methodology the lab uses to measure a key metabolic marker.
—Terry Brandebourg, Animal Sciences