Earlobe as Alternative Site Testing Option for Two-hour Postprandial Glucose Test

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Abstract- Alternative site testing options for capillary blood glucose measurement have been widely examined for their viability and accuracy to substitute the fingertip as the usual testing site. This research compared the blood glucose determination test results from the fingertip and the proposed alternative test site, which is the earlobe. Systematic bias was observed in the 30-minute and one-hour postprandial glucose level of earlobe testing. Accuracy of blood glucose taken from earlobe was observed only at two hours postprandial glucose level.

Index Terms- Glucometer, Glucose determination, 2-hour Postprandial Blood Sugar, Blood Glucose Level

I. Introduction

Blood glucose determination is one of the most common laboratory diagnostic tests. Since glucose is a major component of the blood, skin puncture is performed especially for self-monitoring of blood glucose. In the clinical laboratory, blood glucose is analyzed through fasting blood sugar (FBS), random blood sugar (RBS) or the 2-hour postprandial blood sugar (PPBS) test. Usually, PPBS tests are performed two hours after meals for the blood sugar to stabilize (Shooter, 2013). While laboratory tests are done to accurately measure blood glucose levels, it may take a while before results are released, thus many patients accept alternative such as self-monitoring devices like glucometers (Heneghan *et al*., 2012).

In blood glcucose testing, fingertips are the most commonly pricked body part for glucose determination tests because of comparable results (Bina *et al.*, 2003). But aside from the fingertips, the palm, forearm and upper arm have been used as alternative site-testing options (Freitas, 1999).

II. Objectives

The study aims to propose earlobe as an alternative site for measuring blood glucose level.

III. Methods

3.1 Selection of subjects

Forty (40) selected students of the Faculty of Pharmacy, University of Santo Tomas participated in the study. Ten (10) participants were assigned for 30-minute PPBS test and another ten for one-hour PPBS test. Twenty (20) participants were assigned for the 2-hour PPBS test. More participants were assigned for the 2-hour PPBS test since glucose determinations results are unstable as they begin to rise 30 minutes and reach their peak between 45 minutes and 1 hour after eating (Shooter, 2013). After two hours, however, the blood glucose returns to values in their normal range.

3.2 Experiment procedure

Participants were assessed based on their compliance to the requisites of the postprandial blood sugar tests, approval and consent, and health considerations. If the participant is valid for testing, PPBS test were conducted using OneTouch® UltraEasy and OneTouch® glucometer, which has 99% accuracy in measuring glucose (Clarke & Foster (2012).

The participants were asked to seat properly prior to testing because intravascular concentration of several substances may affect the result especially when standing. Skin puncture was first applied on the earlobe sterilized with cotton soaked in 70% ethanol. The puncture site was air-dried and the glucometer reading was subsequently recorded. The strip and the needle of the glucometer were replaced before puncturing the third or fourth fingertip. The fingertip was sterilized (similar to that of the earlobe) and free from dirt to avoid false concentration readings and the output measured by the glucometer was subsequently recorded. With the fingertip blood as the standard, blood glucose readings from the earlobe were compared with the results from it to analyze the accuracy of glucometer utilization.

3.3 Statistical analyses

Statistical analyses were performed using Microsoft Excel ® 2007 XLSTAT (Version 2015, Addinsoft, Brooklyn, NY, USA). Passing-Bablok regression and Bland-Altman plots were used to determine if the PPBS test results from the alternative site and the fingertip have the same results.

IV. Results and Discussion

Results showed that the 30-minute PPBS test from earlobe did not reach an acceptable agreement with the fingertip [Slope (95% CI): 8.9 to 32.1; Intercept: 0.5 to 0.8], with bias coefficient of – 8.6 [95% CI: -14.8 to -2.4] (Figure 1), indicating a systematic bias in results.

For the one-hour PPBS test (Figure 2), though the Passing-Bablok regression did not show any systematically different results [Slope (95% CI): -280.0 to 24.3; Intercept: 0.7 to 3.0], the bias coefficient differ from 0 [Bias = -22.7; 95% CI: -28.1 to -17.3], still indicating a systematic bias in the results.

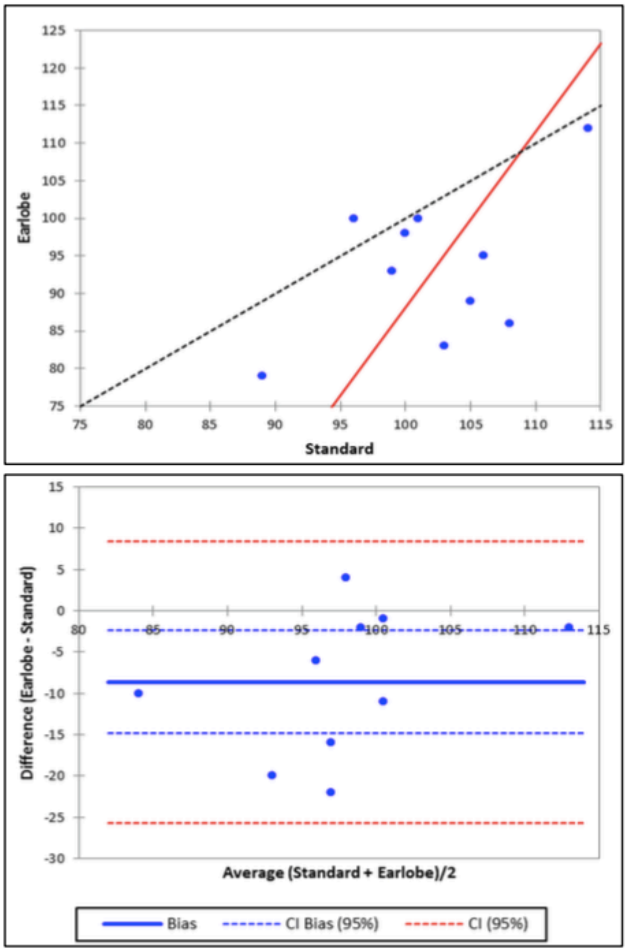

Figure 1. Passing-Bablok Regression (above) and the Bland-Altman plots (below) of Blood Glucose (in mg/dL) taken from Earlobe and the Fingertip (Standard) at 30 minute PPBS test

The results of the 2-hour PPBS test from earlobe reached an acceptable agreement with the fingertip [Slope (95% CI): -48.9 to 26.2; Intercept: 0.7 to 1.6]. Moreover, there was no evidence of systematic bias [Bias = -2.1; 95% CI: -6.0 to 1.8] (Figure 3).

Results for the 30 minute and 1-hour postprandial glucose level tests showed systematic bias due to high variability in glycemic load due to rapid changes in blood glucose concentration (Ellison *et al.*, 2002). The magnitude of differential blood glucose response may be dependent on the meal size, which is positively correlated with nonrelative difference in blood glucose response (Aguirre, Díaz & Galgani, 2006; Bolognesi & Wolever, 1996). Moreover, measurements of a single drop of blood are highly variable. As many as nine drops of blood should be collected and combined to achieve consistency of the results (Paddock, 2015). In addition, considerable differences in the earlobe and fingertip results are due to the variability in blood sugar rise with food intake (Shooter, 2013).

Other physiologic factors such as organ metabolism, exercise and stress can also affect the variability of blood glucose result (Guyton & Hall, 2000). The absolute values of glucose uptake into the body organs should follow the organ's

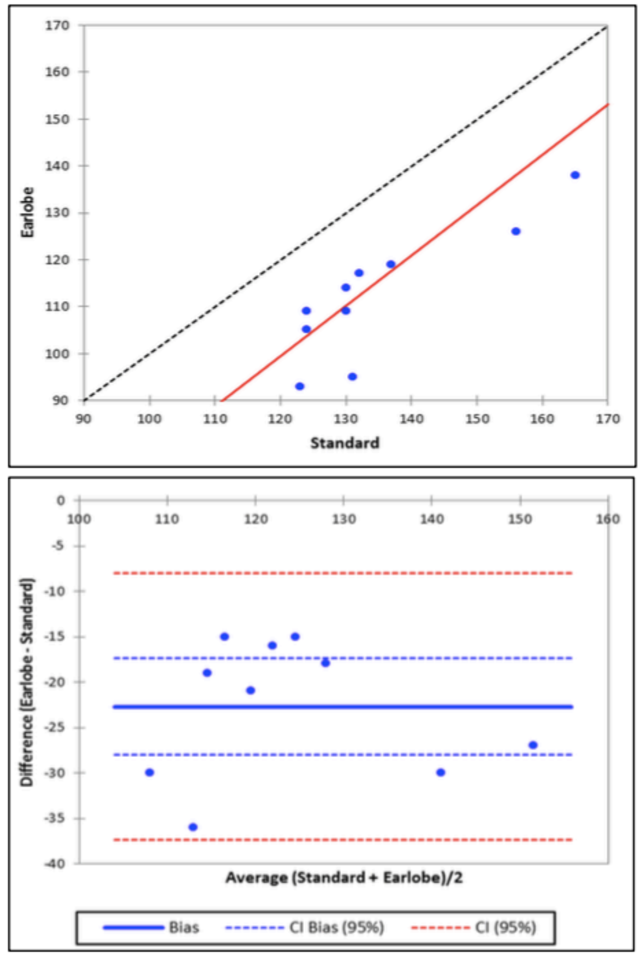

Figure 2. Passing-Bablok Regression (above) and the Bland-Altman plots (below) of Blood Glucose (in mg/dL) taken from Earlobe and the Fingertip (Standard) at 1-hour PPBS test

metabolism and, generally, the relationship between an organ's metabolism and the blood flow is directly proportional. The higher the organ's metabolism, the higher the blood flow and vice versa. The liver increases glucose release into the bloodstream in response to energy requirement after exercise. Inactive muscle requires only 15% of the blood flow even though it constitutes between 30 to 40% of the total body mass; however, during heavy exercises, due to the increased metabolic activity, muscle blood flow can increase as much as 20-fold. Since there is an increase in the blood that goes to the muscles, the blood that goes into the tissues where it is not needed at the moment decreases. Initially, the blood supply of the skin is reduced during exercise but is later increased to get rid of excess heat (Guyton & Hall, 2000). Lastly, although glucometers are used in management of blood glucose testing, it can only analyze whole blood where glucose is unstable (Nichols & Tonyushkina, 2009). Preanalytical errors and variable enzymes in strips can also affect the accuracy of glucometer results (Tenderich, 2012). Preanalytical errors resulting from poor sampling or strip storage can cause inaccuracy, as well as the varying enzymes in the strips. Exposure to humidity can decrease enzyme activity, thereby reducing the accuracy of result obtained from the glucometer (Gebel, 2012).

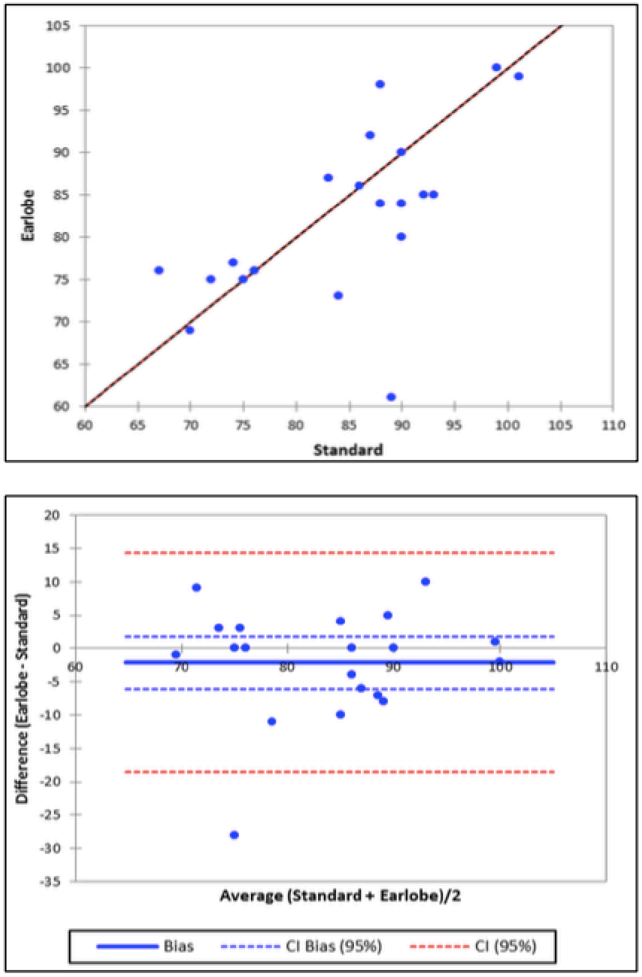

Figure 3. Passing-Bablok Regression (above) and the Bland-Altman plots (below) of Blood Glucose (in mg/dL) taken from Earlobe and the Fingertip (Standard) at 2-hour PPBS test

Thirty (30) minutes to one hour after eating are the periods where glucose levels begin to increase and reaches its peak. The 2-hour alterative testing, on the other hand, is accurate due of blood glucose stability at the said time. By this point, the concentration returns to its normal range as per the case of non-diabetic and non-hypoglycemic people. The National Institute for Clinical Excellence recommends that the target blood glucose level of non-diabetic individuals range from 72 to 108 mg/dL when fasting, and reaches up to 140 mg/dL, two hours after eating. Relative reference ranges are observed for individuals with diabetes and to the types of specimen required.

Earlobe is acclaimed to be a viable alternative site for 2-hour postprandial blood glucose (PPBG) measurement when recurrent sampling is needed as suggested (Anzalone, 2008). Furthermore, earlobe pain is found to be more tolerable and as comfortable as the other alternate site testing options like the forearm (Taylor & Toledo, 2004). Hence, earlobe glucose measurements can serve as a substitution with its exception for hypoglycemia and diabetes, which were not considered in the study.

V. Conclusion and Recommendations

Earlobe as an alternative site for testing can be used for blood glucose testing considering that two hours after meal must be observed. For future researchers who would pursue studies on this topic, the use of testing sites other than earlobe is suggested. Standardization of glucose load before blood collection will also be useful in obtaining more accurate results. Furthermore, glucose tests performed in laboratory are highly recommended.

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