Short Communication

Open Access

Blood Glucose Measured at Several Time Points and Correlation with Incremental Area under the Curve

Marte KR Kjøllesdal*, Victoria Telle Hjellset and Arne T Høstmark

University of Oslo, Institute of Health and Society, Norway

Abstract

Oral glucose tolerance test (OGTT) is used as a standard to diagnose people with diabetes. However, it does not reflect the total glucose load. The aim of this study was to explore correlation between blood glucose values at different times during OGTT and the Incremental Area under the Curve (IAUC), to investigate whether there might be a time point for glucose measurement which would best represent the total glucose load. OGTT were performed in 196 Norwegian-Pakistani women, and glucose was measured fasting and every 15 minute up to 2 hours. The results indicate that fasting values are least correlated with total glucose load, but that values measured at 75, 90 and 60 minutes represent it the best. We suggest that fasting values fail to mirror total glucose load in many cases, and that 2 hour values may be inferior to earlier ones in representing glucose load. High-risk groups, such as Pakistani immigrants, may especially take advantage from improvements in methods to diagnose diabetes.

Keywords: Oral glucose tolerance Test; Incremental area under the curve; Diabetes; Glucose measurements

Introduction

Blood glucose measured at several time points and correlation with incremental area under the curve

Oral glucose tolerance test (OGTT) is used as a standard to diagnose people with diabetes or impaired glucose tolerance (IGT) [1]. The test is usually measuring blood glucose before (fasting) and 2 hours after consumption of 75 g glucose dissolved in 200 ml water. If glucose values are above given cut-offs (≥7.0 mmol/L fasting and/ or ≥11 mmol/L 2-h, WHO definition [1], the person is diagnosed with diabetes. The use of OGTT has been under discussion, much due to its impractical nature, as it requires at least 2 hours from each patient. Still, evidence is clear that many persons who are at high risk of developing diabetes may not be detected by measuring fasting glucose alone, but only when postprandial glucose is measured [2]. However, this test tells us nothing about the glucose levels between the two points of time, in other words, the total raise in blood glucose experienced by the person.

Information about the glucose values during these two hours could contribute with valuable insight about glucose tolerance and thereby also possibly future risk of diabetes. The total blood glucose response vs. time may be assessed by the Incremental Area under the Curve (IAUC).

The aim of this study was to explore the correlation between blood glucose values at different times during OGTT and the IAUC, to investigate whether there might be a time point for glucose measurement which would best represent the total glucose load.

Subjects and Method

Pakistani immigrants in Norway, and especially women, are at high risk of getting diabetes. In one part of Oslo, the prevalence has been found to be as high as 27.5% [3]. Because of this high prevalence, and relatively little knowledge on how to prevent diabetes in this group, a culturally adapted lifestyle intervention study was carried out in 2006-2008 out among Pakistani women, living in a suburban area of Oslo [4]. The women were recruited through a multi-recruitment strategy, including visits to mosques and other gatherings in the local community and by word of mouth. An Urdu speaking assistant was in charge of the recruitment. Inclusion criteria were ≥25 years and born in Pakistan or in Norway by two Pakistani parents. Exclusion criteria were history of

diabetes > 6 months, heart disease, close relative already in the project, pregnancy and not being able to walk for 1 hour. According to power calculations, 96 women in each group (intervention and control) were needed in order to explore effects of the intervention program. One hundred and ninety-eight women were recruited, and as part of the baseline measurements, OGTT was performed (75 g glucose in 200 ml of water). Glucose measurements were done every 15 minutes, using Ascensia Contour Blood Glucose Meter from Bayer HealthCare, Gothenburg. The OGTT followed a 12-h overnight fast, and was not performed if the fasting glucose value was 8 mmol/l or higher. Data from OGTT are available from 196 women.

Data was analyzed using IBM SPSS Statistics 22. Pearson`s correlation coefficient was calculated for the relationship between IAUC and glucose values every 15 minute. IAUC was calculated by the trapezoidal rule. A scatterplot was made for the relation between 75 minutes glucose and IAUC. Level of significance was set to $p=0.05$.

Results

Table 1 shows Pearson`s correlation coefficients between IAUC

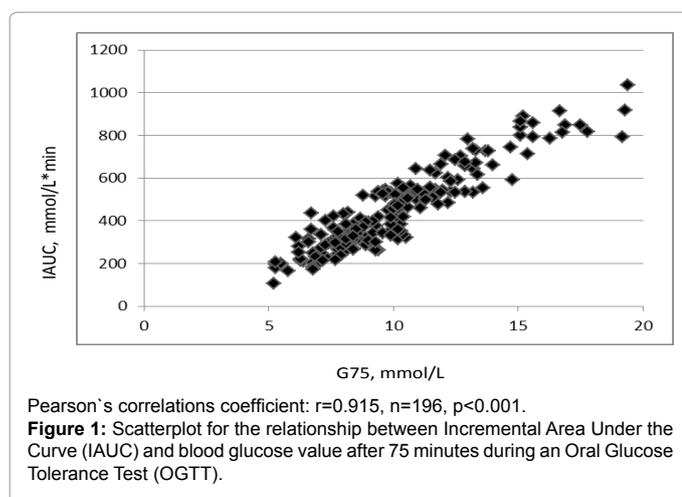|	G0	G15	G30	G45	G60	G75	G90	G105	G120
Correlation with IAUC	0.412	0.550	0.730	0.837	0.895	0.915	0.901	0.881	0.821

P-values <0.001 for all correlations

Table 1: Pearson`s correlation coefficient for the relationship between Incremental Area Under the Curve (IAUC) (mmol/L*min) and blood glucose value (G) (mmol/L) at zerotime (G0), and value every 15th minute (G15 to G120) during an oral Glucose tolerance Test (OGTT).

Pearson`s correlations coefficient: r=0.915, n=196, p<0.001.

Figure 1: Scatterplot for the relationship between Incremental Area Under the Curve (IAUC) and blood glucose value after 75 minutes during an Oral Glucose Tolerance Test (OGTT).

and glucose every 15 minute during an OGTT. Fasting glucose values had a correlation coefficient with IAUC of 0.412. After 15 minutes the correlation coefficient was 0.550, rising to 0.730 after 30 minutes. Glucose measured after 75 minutes was best correlated with IAUC, with a correlation coefficient of 0.915, followed by 90 minutes (0.901) and 60 minutes (0.895). At the end of the test, after 2 hours, the correlation coefficient was 0.821. All correlations were significant at the level of p<0.001. Figure 1 shows the scatterplot for the relation between 75 minutes glucose and IAUC. According to fasting glucose values alone, 7 women (3.5%) were diagnosed with diabetes. Taking 2-h values into account, 26 women (13.1%) were diagnosed with diabetes. There are no cut-off for the 75 minutes glucose value in use for diabetes diagnosis, but using the WHO cut-off for 2-h values (≥11 mmol/L) on 75 minute values, 58 women (29%) in the present study would have been diagnosed with diabetes.

Discussion

The present study suggests that the fasting glucose value is poorly reflecting the total glucose load and that glucose values measured at 75 minutes is best representing the IAUC. Thus, the sensitivity of the fasting value in predicting diabetes is low. Moreover, 2-h values as an indicator of glucose load and diabetes risk may be inferior to values measured at 75 or 90 minutes, even 1-h values. This finding supports research by Abdul-Ghani et al., who reported from the Botnia Study [5] and the San Antonio Heart Study [6] that glucose concentration at 1 hour predicted future diabetes better than both fasting and 2-h glucose. The authors also showed that the incremental area under the glucose curve predicted diabetes as well as 1-h glucose values [5], and that among persons with normal glucose tolerance, those whose post-load glucose concentrations returned quickly to baseline had a lower risk of future diabetes than those who had a slower fall back to baseline values [7].

Finding reliable predictors or predictive glucose values of diabetes is crucial in identifying persons at high risk, and thus defining a truly

high risk group for intervention or extra care. By doing so, preventive strategies can be more effective and give better value for the money. The findings of the present study highlight the deficient power of using fasting values alone to mirror glucose load and thereby diabetes risk. It also indicates that using glucose measured between 60 and 90 minutes can assist in this process. It may exchange the 2-h value, or it may be used together with the traditional fasting and 2-h values, to enhance the predictability of diabetes. In the case that earlier blood glucose values are as good, or even better, than 2-h, the use of e.g. 1-h values would require only half of time requested to do an OGTT, a test often considered impractical and time-consuming, which would make it easier to perform. Using the WHO cut off for 2-h values on 75 minute values, 29% of the women had diabetes. 75 minute values corresponded best with total IAUC, however, if 2-h values should be exchanged with these values, a new discussion emerges about whether the cut-off for 2-h values should be continued, or whether new cut-offs have to be developed.

The present study differ from previous studies [5-7] in that it is carried out in a Pakistani immigrant population, which has been shown to be at high risk of diabetes, and from which no similar results have been published. This high risk group may take special advantage of improvement of tools to diagnose diabetes. Thus, having previous results confirmed in this group is important. Further, previous studies have explored the association between IAUC and 1-h glucose values and future diabetes risk, while the present study points to the relationship total glucose load and current diabetes diagnosis.

We suggest that more studies include several measurements of glucose values during OGTT, in order to establish whether and which values are better predicting glucose load than the 2-h values, so that OGTT and diabetes diagnosing can be performed more easily in the future.

References

1. World Health Organization IDF (2006) Definition and Diagnosis of Diabetes Mellitus and Intermediate Hyperglycemia. Report of a WHO/IDF Consultation. Geneva: World Health Organization.

2. Bartoli E, Fra GP, Carnevale Schianca GP (2011) The oral glucose tolerance test (OGTT) revisited. Eur J Intern Med 22: 8-12.

3. Jenum AK, Holme I, Graff-Iversen S, Birkeland KI (2005) Ethnicity and sex are strong determinants of diabetes in an urban Western society: implications for prevention. Diabetologia 48:435-439.

4. Telle-Hjellset V, Kjollesdal MK, Bjorge B, Holmboe-Ottesen G, Wandel M, et al. (2013) The InnvaDiab-DE-PLAN study: a randomised controlled trial with a culturally adapted education programme improved the risk profile for type 2 diabetes in Pakistani immigrant women. Br J Nutr 109: 529-538.

5. Abdul-Ghani MA, Lyssenko V, Tuomi T, DeFronzo RA, Groop L (2009) Fasting versus postload plasma glucose concentration and the risk for future type 2 diabetes: results from the Botnia Study. Diabetes Care 32: 281-286.

6. Abdul-Ghani MA, Williams K, DeFronzo RA, Stern M (2007) What is the best predictor of future type 2 diabetes? Diabetes Care 30: 1544-1548.

7. Abdul-Ghani MA, Williams K, DeFronzo R, Stern M (2006) Risk of progression to type 2 diabetes based on relationship between postload plasma glucose and fasting plasma glucose. Diabetes Care 29: 1613-1618.