Correlation of fasting and post meal plasma glucose level to increased HbA1c levels in type-2 diabetes mellitus

Shubham Gupta1, Priti Vijay Puppalwar2*, Anita Chalak3

12nd Year MBBS Student, Jawaharlal Nehru Medical College, DMIMS (DU), Sawangi, Wardha, Maharashtra, India
2Department of Biochemistry, Shri Vasantrao Naik Govt. Medical College (SVNGMC), Yavatmal, Maharashtra, India
3Department of Biochemistry, Jawaharlal Nehru Medical College, DMIMS, Sawangi, Wardha, Maharashtra, India

Received: 23 July 2014
Accepted: 16 August 2014

*Correspondence:
Dr. Priti Vijay Puppalwar,
E-mail: pritipuppalwar@gmail.com

ABSTRACT

Background: Various observational studies and clinical trials have demonstrated that intensive glycemic control prevents the development and progression of long term diabetic micro-vascular complications and may reduce macrovascular complications. However, there is insufficient data to determine the contribution of fasting and post meal plasma glucose to increase the percentage of HbA1C level. Therefore, it is desirable to know whether fasting or post-prandial plasma glucose level alone or in combination will be necessary in adjusting the therapy to achieve optimal HbA1C levels in type-2 diabetes mellitus. The present study was aimed to correlate fasting and post meal plasma glucose level to HbA1C level in type-2 diabetes mellitus.

Methods: 50 diagnosed uncomplicated patients of type-2 diabetes mellitus under treatment in diabetic clinic of Acharya Vinoba Bhave Rural Hospital (AVBRH) were enrolled for the study. We have used Pearson’s correlation coefficient to find the statistical significance.

Results: Both fasting as well as post-meal glucose levels were correlated with HbA1C but higher correlation was seen between fasting plasma glucose and HbA1C.

Conclusion: Our study revealed that fasting plasma glucose value appreciably contributes HbA1C as compared to post-meal glucose values.

Keywords: Diabetes mellitus, Fasting plasma glucose, Post meal plasma glucose, Glycosylated hemoglobin

INTRODUCTION

Incidence of diabetes mellitus has been increasing in urban and rural areas of India and it will be one of the major cause of death in India in 21st century. Various observational studies and clinical trials have demonstrated that intensive glycemic control prevents the development and progression of long term diabetic micro-vascular complications and may reduce macrovascular complications.

Diabetes is caused by an absolute or functional lack of insulin, which leads to increased glucose levels outside the cell. High concentrations of glucose can increase the glycation of common proteins such as hemoglobin, forming Hemoglobin \( \text{A}_{1C} \) (HbA1c). However, it is important to note that HbA1c is neither considered dysfunctional nor harmful.

Nevertheless, the concentration of HbA1c predicts diabetes complications because it reflects more harmful glycation sequel of diabetes, such as retinopathy and nephropathy, which are understood to be due to harmful advanced glycation end products. Hemoglobin \( \text{A}_{1C} \) is known to correlate with blood glucose levels over the
lifetime of the red blood cell, which is approximately 120 days.4

HbA1c expressed as a percentage of total blood hemoglobin concentration gives a good retrospective assessment of the mean plasma glucose concentration during the preceding 6-8 weeks while the recent glycemic level has the highest influence and the preceding 30 days contribute only up to 50%.5,6

A cut-off value of 6.5% HbA1c classifies diabetic subjects with a specificity of 98.7%.8 Normal level of HbA1c is 4.5-5.9%.9 There are however insufficient data to determine the contribution of fasting and post meal plasma glucose to the percentage of HbA1c level. Hence it is desirable to know whether fasting or post prandial plasma glucose level alone or in combination will be necessary in adjusting the therapy to achieve optimal HbA1c levels in type-2 diabetes mellitus.10

Hence, the present study was planned to correlate fasting and post meal plasma glucose level to increased HbA1c level in type-2 diabetes mellitus patients.

Aim

The present study was aimed to correlate fasting and post-prandial plasma glucose with HbA1c in type-2 diabetes mellitus.

Objectives

1. To find out whether fasting or post prandial plasma glucose level alone or in combination will be necessary in adjusting the therapy to achieve optimal HbA1c levels in type-2 diabetes mellitus.

2. HbA1c being a costly test, whether strict monitoring and control of FPG or PPG can help the clinicians to have an economical alternative test, compared to HbA1c for glycemic control of their uncomplicated diabetic patients.

METHODS

Study type

Observational study.

Study design

Fifty diagnosed patients of type-2 diabetes mellitus under treatment in diabetic clinic of Acharya Vinoba Bhave Rural Hospital (AVBRH) were enrolled for the study.

Study sample

Total 3 ml of blood (fasting) and 1 ml of blood (post meal) 2 hours after the meal was collected after informed and written consent from diagnosed patients of type-2 diabetes mellitus under treatment in diabetic clinic of Acharya Vinoba Bhave Rural Hospital (AVBRH).

Following investigations were carried out on auto-analyzer (Rx Daytona, random access analyzer).

Table 1: Investigations on auto-analyzer.

<table>
<thead>
<tr>
<th>Test</th>
<th>Bulb</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting plasma glucose (FPG)</td>
<td>Fluoride</td>
<td>GOD-POD method11</td>
</tr>
<tr>
<td>Post-meal plasma glucose (PPG)</td>
<td>Fluoride</td>
<td>GOD-POD method11</td>
</tr>
<tr>
<td>Glycosylated hemoglobin (HbA1c)</td>
<td>EDTA</td>
<td>Immunoturbidimetric method12</td>
</tr>
</tbody>
</table>

Quality control

Clinical biochemistry laboratory at AVBRH routinely observes external as well as internal quality control.

Statistical analysis

Mean, standard deviation and coefficient of correlation was done by SPSS17.0 statistical software.

Inclusion criteria


Exclusion criteria

Diabetic patients suffering from other chronic diseases.

RESULTS

Fifty uncomplicated patients of type 2 diabetes mellitus (NIDDM) who were on antidiabetic drugs were enrolled for the study. Mean and Standard Deviation of Fasting and Post-meal plasma glucose level and glycated Hb are found to be higher, mean of fasting plasma glucose level (165.30 mg/dl), post-meal glucose level (258.44 mg/dl), and glycated Hb (8.47%) was found to be increased which is being shown in Table 2.

Table 2: Mean and standard deviation of fasting and post-meal plasma glucose levels and glycated hemoglobin (HbA1c).

<table>
<thead>
<tr>
<th></th>
<th>N=50</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPG</td>
<td>165.30 ± 41.97 mg/dl</td>
<td></td>
</tr>
<tr>
<td>PPG</td>
<td>258.44 ± 70.70 mg/dl</td>
<td></td>
</tr>
<tr>
<td>HbA1c</td>
<td>8.47 ± 2.92%</td>
<td></td>
</tr>
</tbody>
</table>

Glycated hemoglobin levels in 20% of patients were <6.5% while 80% had values >6.5% (Table 3). Highly positive correlation was found between FPG and PPG with glycated Hb (Figure 1 and Figure 2). Moreover,
correlation coefficient of fasting plasma glucose level was found highly significantly positive with HbA1C (Figure 1). Also FPG and PPG are highly significantly positively correlated with each other as shown in Table 4.

**DISCUSSION**

India leads the world with largest number of diabetic subjects, earning the dubious distinction of being termed the “diabetes capital of the world”. According to the Diabetes Atlas 2006 published by the International Diabetes Federation, the number of people with diabetes in India currently around 40.9 million is expected to rise to 69.9 million by 2025 unless urgent preventive steps are taken. 13, 14

Brig Waqar Azim (2011), estimated through his work that PPG has a stronger correlation with HbA1C as compared to the FPG so a strict monitoring and control of PPG can help the clinicians to have an economical alternative test, compared to HbA1c for glycemic control of their uncomplicated diabetic patients. 14

India being a developing country having large number of poor people, everybody cannot frequently afford for a bit costly test like HbA1C, hence the knowledge of correlation of fasting plasma glucose and post meal plasma glucose with glycated hemoglobin will be helpful in the management of type-2 diabetes mellitus to achieve optimal glycemic control.

In this study, we correlated HbA1C with fasting as well as post meal plasma glucose in type-2 diabetic patients. Both fasting and post-meal plasma glucose levels were found to be positively correlated with HbA1C (Figure 1 and Figure 2). Moreover fasting plasma glucose level was found to be highly positively correlated with HbA1C (r = 0.685). This is in accordance with Bonora E (2001), 15 M. Saiedullah, S. Begum et al. (2011), 16 Louis Monnier (2003). 17

This result is also in accordance with Matthew Riddle et al., 18 who concluded that with oral therapies alone at baseline, participants with HbA1C <8.0% had 76% contribution from basal hyperglycemia and after intensifying therapy with insulin the HbA1C reduced and there was change in this relationship. All 50 patients in present study were on oral therapies and their mean HbA1C (8.47%) correlated more significantly with fasting plasma glucose as compared to post meal plasma glucose.

Monnier L, Colette C (2006), 19 reviewed previous studies of diurnal glycemic profiles and concluded that relative contribution of postprandial plasma glucose to HbA1C was high (70%) in patients with fairly good control of diabetes (HbA1C <7.3%) and decreased progressively (30%) with worsening diabetes (HbA1C >10.2%) whereas the contribution of fasting plasma glucose showed a gradual increase with increasing levels of HbA1C.

Our results are not in accordance with Masram et al., 20 Waqar Azim et al., 18 Rosediani M21 who revealed that

**Table 3: Distribution of diabetic patients based on HbA1C levels.**

<table>
<thead>
<tr>
<th>HbA1C level</th>
<th>Number</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (&lt;6.5%)</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>High (&gt;6.5%)</td>
<td>40</td>
<td>80</td>
</tr>
</tbody>
</table>

**Table 4: Showing correlation coefficient of fasting and Post- meal plasma glucose levels with each other.**

<table>
<thead>
<tr>
<th></th>
<th>FPG</th>
<th>PPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPG</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>PPG</td>
<td>0.879**</td>
<td>1</td>
</tr>
</tbody>
</table>

**Figure 1: Showing correlation between fasting plasma glucose level and HbA1C (r = 0.685).**

**Figure 2: Showing correlation between post-meal plasma glucose level and HbA1C (r = 0.623).**
PPG has a stronger correlation with HbA\textsubscript{IC} as compared to the FPG.

Bonora et al.\textsuperscript{15} evaluated the extent of plasma glucose excursions with meals, the relations between plasma glucose levels at different times of the day, i.e. before and 2-3 hour after breakfast, lunch and dinner, and the relations between the latter and HbA\textsubscript{IC} in non-insulin-treated type 2 diabetic subjects and concluded that although HbA\textsubscript{IC} is more related to pre-prandial than postprandial plasma blood glucose levels monitoring of glucose control and evaluation of the efficacy of treatment cannot be restricted to fasting glucose and or HbA\textsubscript{IC}. Indeed, both fasting glucose and HbA\textsubscript{IC} are poor indicators of glucose levels at other times of the day, especially those occurring in the postprandial state.

A systematic review on “Guidelines for management of post meal glucose” recommends that although control of fasting hyperglycaemia is necessary, it is usually insufficient to obtain optimal glycaemic control. Post meal hyperglycaemia is associated with increased risk of retinopathy, increased carotid intima thickness, oxidative stress, inflammation and endothelial dysfunction. Hence targeting both post-meal and fasting plasma glucose is an important strategy for achieving optimal glycaemic control.\textsuperscript{22}

In present study although FPG is more correlated with HbA\textsubscript{IC} than PPG, but both are significantly correlated with HbA\textsubscript{IC}. This suggests that correcting both will help to achieve a good glycemic control. Thus, if one aims at controlling plasma glucose not only in the fasting state but throughout the day to achieve better long-term metabolic control (HbA\textsubscript{IC}) and minimize the risk of chronic diabetic complications, glucose monitoring cannot be limited to fasting or pre-prandial glucose monitoring but correcting glucose levels all throughout the day will result in a greater reduction of HbA\textsubscript{IC}, as in the DCCT\textsuperscript{23} or the Kumamoto Study.\textsuperscript{24}

**Implications of study**

The above study will be helpful in -

1. Correlating fasting glucose level or post meal glucose level alone or in combination with HbA\textsubscript{IC} in order to achieve optimal HbA\textsubscript{IC} level for therapy of diabetes mellitus.

2. Early detection of hyperglycemia and achieving good glycemic control in type-2 diabetes mellitus patients in order to prevent the complications of disease, morbidity and mortality.

**Study limitations**

The present study was carried out in a small sample size. Plasma glucose and HbA\textsubscript{IC} determinations were carried on a single day whereas several glucose determinations over a period of several weeks can be better correlated to HbA\textsubscript{IC} than a single or a few glucose determinations on a single day.

**CONCLUSION**

Fasting plasma glucose and post meal plasma glucose both are significantly positively correlated with HbA\textsubscript{IC} and fasting plasma glucose is highly significantly and positively correlated with HbA\textsubscript{IC} than PPG. Thus correcting either fasting plasma glucose or post meal plasma glucose or both will help to achieve a good glycemic control in uncomplicated patients of type 2 diabetes mellitus. Estimating fasting plasma glucose test could be an economical alternative test to HbA\textsubscript{IC} for glycemic control of uncomplicated diabetic patients.

Early detection of hyperglycemia & good glycemic control can prevent complications & further decreases morbidity and mortality.

**ACKNOWLEDGEMENTS**

We highly acknowledge ICMR sts for providing us such a wonderful platform to explore our research talent at Undergraduate level and for encouraging us to enhance our knowledge about a particular subject.

**Abbreviations**

HbA\textsubscript{IC}: Glycosylated hemoglobin, FPG: Fasting plasma glucose, PPG: Post-meal plasma glucose, GOD-POD: Glucose oxidase peroxidase, NIDDM: Non-insulin dependent diabetes mellitus.

**Funding:** The study was funded by ICMR sts

**Conflict of interest:** None declared

**Ethical approval:** The study was approved by the institutional ethics committee

**REFERENCES**


