Elevated capillary blood glucose in the emergency department suggests a higher probability of underlying diabetes or prediabetes

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ABSTRACT

Background: In the emergency department (ED), patients with no prior history of diabetes and with hyperglycemic capillary blood glucose (CBG) levels, an opportunity exists to detect undiagnosed diabetes. High glycosylated hemoglobin (HbA1c) levels in these patients could indicate underlying diabetes or prediabetes. Aim: To determine whether hyperglycemia in patients coming to ED without a history of diabetes is associated with elevated HbA1c levels. Methods: A prospective correlational study of adults aged 18 years and more, presenting to ED with random CBG more than 140 mg/dL were enrolled. The patients with a history of diabetes were excluded. HbA1c levels were checked in these patients and correlation was analyzed. Results: A total of 107 patients were enrolled and CBG levels were correlated with HbA1c levels ($r = 0.71$, $P < 0.0001$). The median glucose and median HbA1c levels were 201 mg/dL and 6.3%, respectively. The median time elapsed since last meal was 5 h (25-75% interquartile range, 4-9 h). Overall, 42.1% of the cases had elevated HbA1c levels $\geq 6.5\%$ while as 40.2% showed HbA1c levels between 5.7% and 6.4%, which means 82.2% were either diabetic or prediabetic by HbA1c criteria. Conclusion: CBG has a good correlation with HbA1c. Therefore, in ED, HbA1c should be considered in patients with CBG more than 140 mg/dL with no prior history of diabetes in order to uncover hidden diabetes/prediabetes and to exclude stress hyperglycemia.

Key words: Capillary blood glucose, diabetes, glycosylated hemoglobin, hyperglycemia, prediabetes

INTRODUCTION

In 2000, India topped the world with the highest number of people suffering from diabetes mellitus (31.7 million).[1] The prevalence of diabetes is predicted to double globally from 171 million in 2000 to 366 million in 2030. Furthermore, it is predicted that diabetes mellitus may afflict up to 79.4 million individuals in India by 2030.[2,3] Diabetes is a disease that may be present years before it is detected and diagnosed.[4] By the time the diagnosis is
made, micro-vascular and macro-vascular changes are already present. This may lead to increased morbidity as the ill-effects of this disease progress without patient’s knowledge.

An opportunity exists to detect undiagnosed diabetes in the emergency department (ED) when hyperglycemia is found on capillary blood glucose (CBG). A confirmatory test of glycosylated hemoglobin (HbA1c) may help determine whether these patients have true diabetes or stress-induced hyperglycemia. HbA1c provides a weighted representation of blood glucose levels over the preceding 3 months and does not require the patient to fast or undergo glucose challenges. Furthermore, HbA1c is not substantially affected by acute illness and is independent of stress-induced hyperglycemia. American Diabetes Association recommends HbA1c as a diagnostic test, and hence high HbA1c levels in ED patients would indicate diabetes or prediabetes. If high HbA1c is uncovered, then patients would be treated as “diabetic” and would need treatment for diabetes as well. This will in turn reduce the morbidity, mortality and length of stay in the hospital. In this study, we analyzed the relationship between high CBG levels and HbA1c for diagnosis of hidden diabetes or prediabetes in ED patients.

METHODS

Study design and setting

The study was carried out in ED of a Tertiary Care Center. Patients who presented to the ED between January 01, 2014 and January 31, 2015 were eligible. A prospective correlational study of adults aged 18 years and more, presenting to ED with random CBG more than 140 mg/dL were enrolled. The patients with a history of diabetes were excluded. Also, excluded were the patients who were pregnant; those on steroids for last 1-month; those who were referred from other hospitals with intravenous infusion of glucose; those who had uncomplicated liver disease or chronic kidney diseases; patients with iron deficiency anemia; hemolytic anemia as well as the patients with recent blood loss or transfusion because in these conditions, HbA1c give false results. The study was approved by the Ethics Committee of the Hospital, and written consent was obtained from each patient or their relative.

Study protocol

CBG was checked by the glucometer (Accu-Check Performa). The skin of the finger was cleansed with water/spirit and dried, pricked with a sterile sharp needle and the blood was collected onto a test strip. Furthermore, a venous blood sample was collected to measure HbA1c using D10 BIO-RAD by high-performance liquid chromatography and correlation were analyzed with CBG values. The patients were classified as per the American Diabetes Association guidelines, according to which, the HbA1c levels ≥6.5% represent diabetes. Furthermore, HbA1c levels between 5.7% and 6.4% indicate prediabetes and values <5.7% are considered as nondiabetic. The cutoff values for CBG were taken 140 mg/dL as according to American Diabetic Association, any blood glucose in hospitalized patients >140 mg/dL is defined as hyperglycemia.

Statistical analysis

All statistical analyses were performed using Graphpad prism software. Correlations were performed using linear regression and Pearson correlation coefficients (r) were calculated. Two-tailed P values were calculated to check the significance and P < 0.001 are considered statistically significant. The basic descriptive statistics was used to summarize the data.

RESULTS

The characteristics of patients enrolled in ED are given in Table 1. Of the 107 enrolled patients, 62% were male, and 38% were female with a mean age of 58 ± 13.54 years. The average duration since last meal was 6 ± 4.67 h and the median time elapsed was 5 h (25%-75% interquartile range, 4-9 h). CBG levels and time since last meal were correlated, and there was no correlation observed (r = −0.01, P = 0.92).

The correlation between CBG levels and HbA1c is described in Figure 1. The correlation was linearly related, and the linear regression line had a correlation coefficient of 0.71 (P < 0.001). The range of CBG and HbA1c was 143-530 mg/dL and 4.5-14.7% respectively. The mean CBG and mean HbA1c levels were 232 ± 91.97 mg/dL and 7.12 ± 2.1% respectively. The median value of CBG and HbA1c was 201 mg/dL and 6.3%. Overall, 42.1% of the cases had elevated HbA1c levels ≥6.5% while as 40.2% showed HbA1c levels between 5.7% and 6.4%.

| Table 1: Patient characteristics | Values |
|---------------------------------|--------|
| Characteristics                 | Values |
| Age (years)                     | Mean±SD 58.10±13.54 |
| Gender                          |        |
| Male n (%)                      | 66 (62) |
| Female n (%)                    | 41 (38) |
| Race                            | Indian |
| Previous medical history        |        |
| Hypertension n (%)              | 52 (48.6) |
| Others n (%)                    | 12 (11.2) |
| Duration since last meal (h)    | Mean±SD 6.65±6.67 |

*Total number of patients enrolled were 107. SD = Standard deviation*
DISCUSSION

Diabetes mellitus is clearly a major health problem that needs addressing at all levels. A large number of patients with diabetes remain undiagnosed. It has been seen that the patients with undiagnosed diabetes or prediabetes are at a similar risk of hypertension, dyslipidemia, stroke, coronary artery disease, peripheral vascular disease as those with diabetes.\textsuperscript{[14-16]} This explains the importance of early diagnosis of diabetes and prediabetes because the adverse outcome depends on the duration of hyperglycemia, and there are various interventions to prevent these complications.\textsuperscript{[14-16]} Although stress can increase glucose through counter-regulatory hormones, there are studies which suggest that hyperglycemia during an illness is more often due to undiagnosed diabetes rather than the stress alone.\textsuperscript{[17-19]}

Though the role of ED is, to provide emergent and urgent care for medical and surgical problems but sometimes chronic illnesses are incidentally diagnosed. Failure to recognize early warning finding for chronic diseases, e.g., diabetes can delay diagnosis and result in the development of irreversible complications.

Diabetes also referred as “silent disease” requires active and opportunistic screening efforts to diagnose the disease before it progresses to fatal damages of the patients.\textsuperscript{[20,21]} Diagnosing diabetes in the ED requires testing that is easy to perform and provide rapid results. Among the current diagnostic tests for diabetes which include HbA\textsubscript{1c}, fasting plasma glucose and glucose tolerance test,\textsuperscript{[12]} the HbA\textsubscript{1c} does not require fasting and is relatively unaffected by transient hyperglycemia.\textsuperscript{[7,22]} Various studies have analyzed the relationship between HbA\textsubscript{1c} and other glucose levels for screening undiagnosed diabetes.\textsuperscript{[23-25]} Ginde\textsuperscript{et al.} correlated ED glucose and HbA\textsubscript{1c} and observed that 29% had abnormal HbA\textsubscript{1c} and 51% had borderline HbA\textsubscript{1c}.\textsuperscript{[24]} In another study by Charfen\textsuperscript{et al.}, all at risk subjects with a random ED blood glucose >150 mg/dL were later diagnosed with prediabetes or diabetes.\textsuperscript{[25]}

In this study, an elevated HbA\textsubscript{1c} was used as a marker for diabetes which is recommended by American Diabetes Association for diagnosis of diabetes.\textsuperscript{[12]} Comparative

![Figure 1: Correlation between capillary blood glucose levels and glycosylated hemoglobin values. (CBG = Capillary blood glucose, HbA\textsubscript{1c} = Glycosylated hemoglobin)](image)

Table 2: Overall CBG and HbA\textsubscript{1c} values in ED patients

| Mean CBG level (mg/dL) ± SD | Mean HbA\textsubscript{1c} value (%) ± SD | HbA\textsubscript{1c} <5.7 n (%) | HbA\textsubscript{1c} 5.7-6.4 n (%) | HbA\textsubscript{1c} ≥6.5 n (%) |
|-----------------------------|------------------------------------------|-------------------------------|-------------------------------|-------------------------------|
| 232±91.97                   | 7.12±2.1                                  | 19 (17.8)                     | 43 (40.2)                     | 45 (42.1)                     |

CBG = Capillary blood glucose, HbA\textsubscript{1c} = Glycosylated hemoglobin, ED = Emergency department, SD = Standard deviation

Table 3: CBG and HbA\textsubscript{1c} values in ED patients-additional stratification (CBG, HbA\textsubscript{1c}, ED)

| CBG (mg/dL) | n (%) | Mean CBG level (mg/dL) ± SD | Mean HbA\textsubscript{1c} value (%) ± SD | HbA\textsubscript{1c} <5.7 n (%) | HbA\textsubscript{1c} 5.7-6.4 n (%) | HbA\textsubscript{1c} ≥6.5 n (%) |
|-------------|-------|----------------------------|------------------------------------------|-------------------------------|-------------------------------|-------------------------------|
| 141-199     | 53 (49.5) | 171.0±17                    | 6.18±1.07                                | 14 (26.4)                     | 28 (52.8)                     | 11 (20.7)                     |
| 200-299     | 36 (33.6) | 231.0±23.93                 | 6.72±1.32                                | 5 (13.9)                      | 15 (41.7)                     | 16 (44.4)                     |
| ≥300        | 18 (16.8) | 413.1±65.65                 | 10.63±2.33                               | 0 (0)                         | 0 (0)                         | 18 (100)                      |

CBG = Capillary blood glucose, HbA\textsubscript{1c} = Glycosylated hemoglobin, ED = Emergency department, SD = Standard deviation
analysis of HbA1c and CBG levels showed that a clinically relevant percentage of patients have undiagnosed diabetes. We found that the patients in ED with no previous history of diabetes and with CBG more than 140 mg/dL, 82.2% were either diabetic or prediabetic by HbA1c criteria (42.1% were diabetic and 40.2% were prediabetic). Hence, ED can uncover a large proportion of those diabetic and prediabetic patients who would otherwise remain undiagnosed, which in turn will decrease the morbidity and mortality as well as the length of stay in the hospital. In this way, ED can help in the fight against diabetes.

**Limitations**
The study was performed at a single academic center, which may limit the generalizability of the results. Prolonged fasting leads to lower glucose values, and it is possible that some of the patients in the ED had lower glucose values due to prolonged fasting which were not included in the study.

**CONCLUSION**
This study suggests that CBG has a good correlation with HbA1c. In ED, HbA1c should be considered in patients with high CBG and with no prior history of diabetes in order to uncover hidden diabetes/prediabetes for early diagnosis and treatment.

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**Conflicts of interest**
There are no conflicts of interest.

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