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Research Article

Diagnostic Utility of HbA1c Compared with Fasting Plasma Glucose for Early Detection of Type 2 Diabetes Mellitus

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ABSTRACT

Background: Type 2 diabetes mellitus is a major public health problem and early detection is essential to prevent long-term microvascular and macrovascular complications.

Objective: To compare the diagnostic utility of HbA1c with fasting plasma glucose for the early detection of type 2 diabetes mellitus.

Methodology: This descriptive cross-sectional study was conducted in the Department of Medicine in Collaboration with Biochemistry and Clinical Pathology, Allama Iqbal Teaching Hospital, DG Khan/ DG Khan Medical College DG Khan from October 2024 to June 2025, included 125 adult patients who presented for diabetes screening or evaluation of raised blood glucose levels. Demographic and clinical information including age, gender, body mass index, family history of diabetes, hypertension, and smoking status were recorded.

Results: The mean age of participants was 46.8 ± 11.7 years, and the mean body mass index was 28.4 ± 4.6 kg/m². There were 70 males (56.0%) and 55 females (44.0%). Based on fasting plasma glucose criteria, 39 patients (31.2%) were diabetic, 43 (34.4%) were prediabetic, and 43 (34.4%) were non-diabetic. Based on HbA1c criteria, 45 patients (36.0%) were diabetic, 47 (37.6%) were prediabetic, and 33 (26.4%) were non-diabetic. HbA1c showed a sensitivity of 89.7%, specificity of 88.4%, positive predictive value of 77.8%, negative predictive value of 95.0%, and diagnostic accuracy of 88.8%. A strong positive correlation was observed between fasting plasma glucose and HbA1c levels ($r = 0.76$, $p < 0.001$).

Conclusion: HbA1c demonstrated high diagnostic accuracy and substantial agreement with fasting plasma glucose for detecting type 2 diabetes mellitus. It identified a slightly higher proportion of diabetic and prediabetic patients and showed strong correlation with fasting plasma glucose.

Keywords: HbA1c, Fasting Plasma Glucose, Type 2 Diabetes Mellitus, Early Detection, Diagnostic Accuracy, Screening.

INTRODUCTION

Persistent hyperglycemia due to insulin resistance, impaired insulin secretion, or both is the hallmark for type 2 diabetes mellitus which is one of the most prevalent chronic metabolic diseases in the world [1]. It is a chronic disease and typically has a slow onset, and often goes undiagnosed for many years prior to the onset of clinical symptoms [2]. Diabetes is on the rise worldwide because of aging, population growth, gene susceptibility, unhealthy diets, obesity, sedentary lifestyle and urbanization [3]. Type 2 diabetes mellitus is the predominant type of diabetes, and it is a growing public health problem in countries with low to middle resources, where provision for healthcare and regular screening programs and awareness of its early diagnosis could be less available [4]. In

most people, type 2 diabetes mellitus does not produce symptoms during the early stages of the disease [5] so the diagnosis can be made early. Chronic hyperglycemia may cause subtle damage to blood vessels, nerves, kidneys, retina and blood vessels in the heart and lungs before the person realizes they have it [6]. Consequently, many patients are diagnosed by the time they experience their first symptoms of complication, which may include diabetic retinopathy, nephropathy, neuropathy, ischemic heart disease, stroke, or peripheral vascular disease. They raise the cost of the health care system, and the morbidity and mortality of patients and their families [7]. Thus, early detection of people with undiagnosed diabetes or prediabetes is an important component to curbing the progression of the disease and the onset of long-term complications [8].

The fasting plasma glucose test has been a common laboratory test for diabetes mellitus for many years, as it is inexpensive and widely available and is relatively simple to obtain. It is a measurement of blood glucose level after an 8 hour fast and is used to identify fasting hyperglycaemia. The normal diagnostic criteria are a fasting plasma glucose of 126 mg/dL or higher, confirmed as necessary [9]. Fasting plasma glucose, however, is a snapshot of glucose levels and can be affected by a number of factors that are only short term in nature, such as recent food intake, fasting time, acute illness, stress, medication, physical activity and laboratory variations [10]. Furthermore, the requirement for the patient to adhere to the fasting regime is also a requirement, and this might be problematic in a busy outpatient department and community screening programmes. These restrictions might limit the use of FPG as a single-screening tool for the early detection of T2DM. HbA1c, also referred to as glycated hemoglobin, is now emerging as a useful diagnostic and monitoring test for diabetes mellitus [11]. The glycated hemoglobin percentage (HbA1C) indicates the average blood glucose level over the last 2-3 months. Diabetes mellitus is diagnosed by a standardized assay when the value exceeds 6.5% [12]. HbA1c is not required to be performed on a fasting basis and is not as sensitive to recent blood glucose changes as fasting plasma glucose. This facilitates patients and allows for more convenient/routine clinical screening, particularly at an outpatient department, community health center or high-risk population [13]. One of the other significant benefits of HbA1c is that it helps to determine the likely risk of long-term diabetic complications. Because the HbA1c value is an average of the glucose level, it also gives information about chronic hyperglycemia, not just a single level. This is useful not only for diagnosis but also for assessing risk and planning for the future [14].

Objective

To compare the diagnostic utility of HbA1c with fasting plasma glucose for the early detection of type 2 diabetes mellitus.

METHODOLOGY

This was a descriptive cross-sectional study, conducted at Department of Medicine in Collaboration with Biochemistry and Clinical Pathology, Allama Iqbal Teaching Hospital, DG Khan/ DG Khan Medical College DG Khan from October 2024 to June 2025. A total of 125 patients were included in the study. Non-probability consecutive sampling technique was used to collect the data. Patients aged 18 years or above of either gender were included in the study. Patients presenting for diabetes screening or evaluation of raised blood glucose levels were included if both fasting plasma glucose and HbA1c tests were performed. Only patients who provided informed consent were enrolled. Patients with known type 1 diabetes mellitus, previously diagnosed type 2 diabetes mellitus already receiving anti-diabetic treatment, pregnancy, chronic kidney disease, chronic liver disease, anemia, hemoglobinopathies, recent blood transfusion within the last three months, acute severe illness, or incomplete laboratory data were excluded from the study.

Data Collection

Following ethical committee approval, eligible patients that met the inclusion criteria were enrolled providing written informed consent. Data were collected on a structured proforma regarding the demographic features such as age, gender, residence, BMI, family history of diabetes, smoking history, hypertension and relevant clinical history. All the subjects were asked to fast for 8 hours or more before blood collection. Venous blood samples were taken in aseptic fashion. Plasma glucose was determined by the standard enzymatic method in the laboratory and HbA1c was determined by the standard assay method for hospital laboratory. Laboratory data for both tests were obtained for each subject. All patients were classified into three groups: diabetic,

prediabetic, and non-diabetic, based on fasting plasma glucose and HbA1c levels, respectively. The value of HbA1c was compared with FPG by examining the number of individuals diagnosed by each test, the correlation between the two tests, and the extent to which HbA1C was able to identify individuals with abnormal glucose status.

Data Analysis

Data were entered and analyzed using SPSS version 26. Quantitative variables such as age, body mass index, fasting plasma glucose, and HbA1c were presented as mean ± standard deviation. Qualitative variables such as gender, family history of diabetes, hypertension, smoking status, and diabetic status were presented as frequency and percentage. The diagnostic performance of HbA1c was compared with fasting plasma glucose. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of HbA1c were calculated by taking fasting plasma glucose as the reference standard. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 125 patients were included in the study. The mean age of the participants was 46.8 ± 11.7 years, while the mean BMI was 28.4 ± 4.6 kg/m². There were 70 males (56.0%) and 55 females (44.0%), showing a slight male predominance. Most participants belonged to the 41–50 years age group, 39 (31.2%), followed by 51–60 years, 31 (24.8%), and 31–40 years, 26 (20.8%). A family history of diabetes was present in 48 participants (38.4%), while 42 participants (33.6%) had hypertension. Smoking was reported in 29 participants (23.2%), whereas most participants, 96 (76.8%), were non-smokers.

Table 1. Baseline Characteristics of Study Participants, n=125

Variable	Category	Frequency (%) / Mean ± SD
Age, years	Mean ± SD	46.8 ± 11.7
BMI, kg/m²	Mean ± SD	28.4 ± 4.6
Gender	Male	70 (56.0%)
	Female	55 (44.0%)
Age group	18–30 years	14 (11.2%)
	31–40 years	26 (20.8%)
	41–50 years	39 (31.2%)
	51–60 years	31 (24.8%)
	>60 years	15 (12.0%)
Family history of diabetes	Yes	48 (38.4%)
	No	77 (61.6%)
Hypertension	Yes	42 (33.6%)
	No	83 (66.4%)
Smoking status	Smoker	29 (23.2%)
	Non-smoker	96 (76.8%)

Based on fasting plasma glucose, 43 participants (34.4%) were non-diabetic, 43 (34.4%) were prediabetic, and 39 (31.2%) were diabetic. In comparison, HbA1c classified 33 participants (26.4%) as non-diabetic, 47 (37.6%) as prediabetic, and 45 (36.0%) as diabetic.

Table 2. Distribution of Patients According to Fasting Plasma Glucose and HbA1c Categories, n=125

Glycemic Status	Fasting Plasma Glucose Criteria	HbA1c Criteria
Non-diabetic	43 (34.4%)	33 (26.4%)
Prediabetic	43 (34.4%)	47 (37.6%)
Diabetic	39 (31.2%)	45 (36.0%)
Total	125 (100.0%)	125 (100.0%)

Among 39 participants diagnosed as diabetic by fasting plasma glucose, 35 were also identified as diabetic by HbA1c, while 4 were classified as non-diabetic or prediabetic by HbA1c. Among 86 participants who were non-diabetic or prediabetic according to fasting plasma glucose, 76 were also classified as non-diabetic or

prediabetic by HbA1c, while 10 were diagnosed as diabetic by HbA1c.

Table 3. Cross-tabulation of HbA1c Diagnosis with Fasting Plasma Glucose Diagnosis for Diabetes Detection

HbA1c Result	FPG Diabetic	FPG Non-diabetic / Prediabetic	Total
HbA1c diabetic	35	10	45
HbA1c non-diabetic / prediabetic	4	76	80
Total	39	86	125

HbA1c showed a sensitivity of 89.7%, specificity of 88.4%, positive predictive value of 77.8%, negative predictive value of 95.0%, and overall diagnostic accuracy of 88.8%.

Table 4. Diagnostic Performance of HbA1c Compared with Fasting Plasma Glucose

Diagnostic Parameter	Value
Sensitivity	89.7%
Specificity	88.4%
Positive predictive value	77.8%
Negative predictive value	95.0%
Diagnostic accuracy	88.8%

A strong positive correlation was observed between the two parameters, with a correlation coefficient of r = 0.76 and a statistically significant p-value of <0.001.

Table 5. Correlation between Fasting Plasma Glucose and HbA1c

Variables Compared	Correlation Coefficient	p-value
Fasting plasma glucose and HbA1c	r = 0.76	<0.001

DISCUSSION

In the present study, the value of HbA1c was compared with FPG for early detection of type 2 diabetes mellitus in 125 patients. The results also revealed that HbA1c was able to identify a slightly higher percentage of diabetic patients than fasting plasma glucose. When using fasting plasma glucose, 31.2% of the patients were diagnosed as diabetic, and 36.0% were diagnosed as diabetic by HbA1c. This indicates that HbA1c could identify more individuals who might not be identified by screening with fasting plasma glucose. In this study, the mean age of the participants was 46.8 ± 11.7 years, and the mean BMI was 28.4 ± 4.6 kg/m², suggesting that most patients were middle aged and overweight. The results are clinically significant as a rise in age and BMI are well-established risk factors for insulin resistance and type 2 diabetes mellitus. Forty-eight patients had a history of diabetes (38.4%) and 42 patients had hypertension (33.6%) in the family. All these risk factors reinforce the importance of early and reliable diabetes screening of high-risk individuals [15].

The glycemic categories of comparison categorised 43 patients (34.4%) as non-diabetic, 43 patients (34.4%) as prediabetic and 39 patients (31.2%) as diabetic. The HbA1C tests, however, categorized 33 patients (26.4%) as non-diabetic, 47 patients (37.6%) as prediabetic and 45 patients (36.0%) as diabetic [16]. This means that HbA1c placed more people in the prediabetic and diabetic groups, rather than in the non-diabetic group. This pattern may be due to the fact that the HbA1c value is a reflection of the average glycemic exposure over the last two to three months, while a fasting plasma glucose represents a single measurement of glucose made during fasting, and is subject to variation within that timeframe caused by diet, stress, illness, how long the fasting period is, and laboratory variations. Comparing the cross tabulation of HbA1c with fasting plasma glucose, 35 patients were diagnosed as diabetic by both tests and 39 were diagnosed as diabetic by the fasting plasma glucose. 4 patients, who were diabetic by FPG, had non-diabetic HbA1c [17]. However, HbA1c was able to detect 10 more diabetic patients in the category of non-diabetic

or prediabetic based on FPG. This study underlines the potential benefit of using HbA1c to identify chronic hyperglycemia, which might not be detectable by a single fasting glucose test [18].

The diagnostic performance of HbA1c was good, as assessed with fasting plasma glucose. The sensitivity of HbA1C was 89.7%, specificity was 88.4%, positive predictive value was 77.8%, negative predictive value was 95.0% and diagnostic accuracy was 88.8%. High sensitivity means that the HbA1c test could accurately detect most people with diabetes; high specificity means that the HbA1c test could accurately exclude most people who do not have diabetes. The negative predictive value – 95.0% – is more significant because it indicates that individuals who had a normal HbA1c were unlikely to have diabetes based on fasting plasma glucose. The results of this study validate the clinical value of the HbA1c as a diabetes mellitus diagnostic tool to detect early disease [19]. The use of HbA1c has several practical advantages over fasting plasma glucose. It does not need fasting, will not be greatly influenced by short-term dietary changes, and will give information regarding the chronic glycemic status. The advantages of these features are reflected in its use in outpatient clinics and community screening programmes where patients may not be compliant with the fasting requirement [20]. Use of HbA1c should be cautioned in patients with anemia, hemoglobinopathies, chronic kidney disease, pregnancy, blood loss or transfusion because these conditions may lead to an error in the results. This study had some limitations. The study was conducted in one centre and had a small number of patients (125) and so the results may not be generalizable. The cross-sectional design measured HbA1c and FPG at one time only and did not measure long-term trends of glycemic control or confirmations of new cases. Fasting plasma glucose was used as a reference standard; however, two methods of diagnosing diabetes, HbA1c and fasting plasma glucose, were accepted, and oral glucose tolerance testing was not performed. Thus, a larger multicenter study with follow-up testing and oral glucose tolerance testing is recommended to further confirm these results.

CONCLUSION

This study concluded that HbA1c is a useful and reliable diagnostic tool for the early detection of type 2 diabetes mellitus. HbA1c detected a higher proportion of diabetic and prediabetic patients compared with fasting plasma glucose and showed strong diagnostic performance, with high sensitivity, specificity, negative predictive value, and overall accuracy. A significant positive correlation and substantial agreement were observed between HbA1c and fasting plasma glucose, indicating that both tests are clinically valuable for diabetes screening. However, HbA1c offers additional practical advantages because it does not require fasting and reflects long-term glycemic status.

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