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Investigating the accuracy of blood glucose testing by glucometer in patients referred to the emergency department

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Abstract

Objectives: *Hypoglycemia is a medical emergency, and timely diagnosis and treatment are critical due to its potential long-term complications. Given that glucometers are widely used in the emergency department for patient triage and diagnosis of hyper and hypoglycemia, this study was conducted to investigate its accuracy in comparison with serum blood glucose testing.*

Method: *This study was a retrospective cross-sectional study conducted in 2023 using hospital data of patients referred to the emergency department of an academic hospital. Demographic and clinical data were collected and recorded using information contained in the patients' records. The collected data were analyzed using SPSS27 software.*

Result: *Of 240 patients included,192 were non-diabetic and 48 were diabetic. The mean and standard deviation of the age of the subjects was 54.40 ± 19.30 years. In this study, 132 cases were female (about 55%) and 108 cases were male (about 45%). The Spearman correlation coefficient between the standard laboratory test and the glucometer test was 0.896.*

Conclusions: *Good correlation was observed between the glucometer and the standard enzymatic method of blood glucose measurement, which supports the use of glucometers in home settings.*

Keywords: Diabetes, Blood Sugar, Glucometer, Standard Laboratory Method.

Introduction

According to the World Health Organization, type 2 diabetes is a global epidemic, with the number of people with diabetes increasing from 108 million to 422 million between 1980 and 2014. The prevalence of the disease is increasing, especially in low- and middle-income countries. In 2019, it was estimated that diabetes was the direct cause of death for 1.5 million people [1.[It is estimated that the number of diabetic patients will exceed 592 million by 2035, with a global prevalence of 10.1% [2[. In Iran, the prevalence of diabetes in adults aged 25–70 years was reported to be 11.9% (2011), representing a 35% increase compared to 2005. It is estimated that approximately 9.2 million Iranians will likely have diabetes in 2030 [3].

Tests to measure blood sugar were developed more than 100 years ago, and hyperglycemia was then established as the only recommended criterion for diagnosing diabetes [4 .[For decades, diabetes has been diagnosed by measuring fasting blood glucose (FPG) or, rarely, by the oral glucose tolerance test (OGTT). Hyperglycemia is the established chemical manifestation of diabetes. However, fasting and 2-hour OGTT measurements only measure a single moment in time. Furthermore, the two assessments required to confirm the diagnosis may be misleading in describing a chronic and complex clinical condition. Therefore, the diagnostic tool for assessing chronic hyperglycemia rather than intermittent hyperglycemia is preferred. Therefore, glycosylated hemoglobin (HbA1C) assessment is superior to fasting plasma glucose (FPG) in relation to chronic complications [5.[On the other hand, emergency blood sugar determination is essential in patients with loss of consciousness or neurological symptoms who are referred to the emergency department. Therefore, monitoring blood sugar in an accurate and prompt manner is vital in the emergency department.

Methods

This descriptive-analytical retrospective study was conducted at an academic tertiary hospital to identify relation between glucometer test results and laboratory measurement of serum sugar during January 2023–December 2023. All patients referred to emergency department of the hospital were included in the study, children and pregnant women were excluded from the study. To ensure data quality, random samples of submitted case report forms were reviewed. The blood sugar recorded in the hospital file measured based on a laboratory test and the glucometer test on the triage sheet were obtained and documented in a questionnaire by trained research assistant. The patients' charts were filled by emergency trained attending or fellow physician. This questionnaire was approved by the first executor of the project as an expert. In case of incomplete file, the patient was removed from the study. It should be noted that all glucometer measurements were performed with the same device available in the emergency room (Glucometer with Emperor blood glucose monitoring system model, made in Japan).

The data was computerized and statistically analyzed using SPSS27. The most important characteristics were described as numbers (percentage) for qualitative variables and means (standard deviation) for quantitative variables. The correlation coefficient was used to measure the accuracy of the glucometer test compared to the laboratory test. The Rock curve was used to determine sensitivity, specificity, positive and negative predictive value.

All tests were analyzed at a statistical significance level of less than 0.05. The design was approved by the Ethics Committee of University of Medical Sciences.

Results

Of 240 patients included, 48 were diabetic. The majority of cases, 132 (55%) were female and 108 (44%) were male. The mean and standard deviation of the age was 54.40±19.30 years. The mean and standard deviation of the age of the subjects by gender were 55.60±19.45 years and 53.42±19.19 years for men and women, respectively, and no statistically significant difference was found between the ages of men and women (p value=0.670).

In this study,out of 240 patients 48 had diabetes, 14 of whom were men and 34 of whom were women Fig 1.

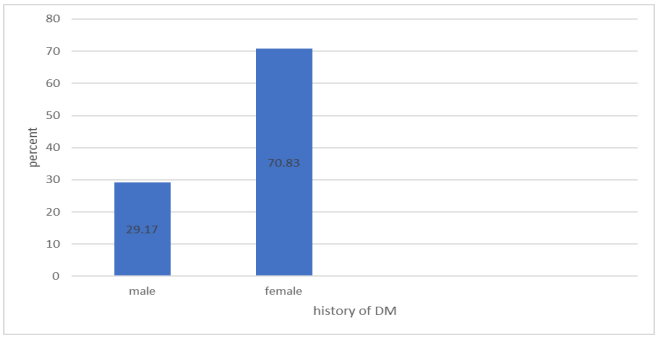

Fig 1. Frequency of history of diabetes by gender

The prevalence of diabetes in the 30-45 age group (35.42%) is higher than other age groups Fig 2.

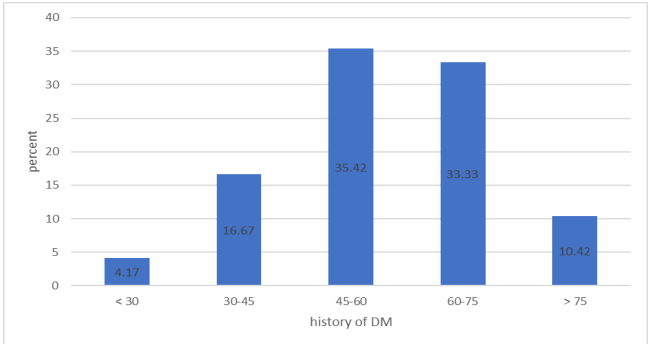

Fig 2. Frequency of history of diabetes by age group

The leading causes for emergency room visits among diabetic patients was weakness and lethargy (about 12%), followed by hyperglycemia (about 10 percent) Fig 3.

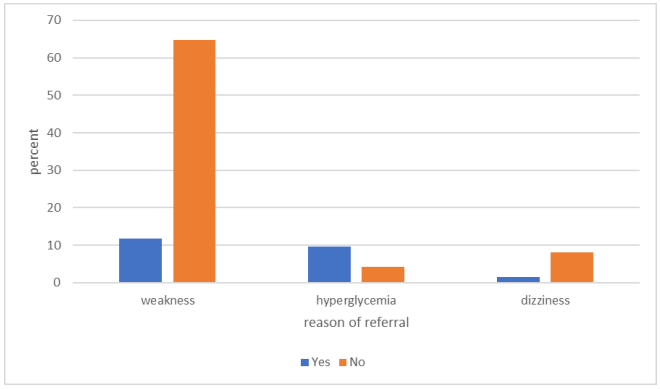

Fig 3. Frequency of reasons for emergency department visits in diabetic patients.

In this study, 14 out of 108 men (about 13%) and 34 out of 132 women (about 26%) had diabetes. Based on the chi-square test, there was no significant difference between gender and diabetes (P=0.14). Of 25 patients under 30 years of age, 2 (about 8%) had diabetes. In the age group of 30-45 years, 8 out of 70 patients (about 11%), in the age group of 45-60 years, 17 out of 49 patients (about 35%), in the age group of 60-75 years, 16 out of 62 patients (about 26%), and in the age group of over 75 years, 5 out of 35 patients (about 14%) had diabetes. According to the chi-square test, there was no significant difference between age and the incidence of diabetes (P=0.08) table 1.

comorbidity Individual characteristics		History of DM		Other comorbidities		P-value
		number	Percent (%)	number	Percent (%)	
Gender	Male	14	13	94	87	0.14
	female	34	25.8	98	74.2	
Age	< 30	2	8.3	22	91.7	0.08
	30-45	8	11.4	62	88.6	
	45-60	17	34.7	32	65.3	
	60-75	16	25.8	46	74.2	
	>75	5	14.3	30	85.7	

Table1. -Individual characteristics of patients according to their underlying medical history based on the Chi-square test

The results of blood sugar tests were not normally distributed, and nonparametric tests such as Spearman's coefficient was used to analyze the correlation between these two variables.

variable	Correlation rate	p. value
Glucometer results	0.896	< 0.001
Lab results	0.896	< 0.001

Table 2. Spearman test to examine the correlation between glucometer results and laboratory blood sugar results in non-diabetics

As can be seen in the table above, the results of the laboratory blood sugar and the blood sugar measured by the glucometer are directly related to each other (correlation = 0.896) and a significant relationship is also found between them (p.value < 0.001).

variable	Correlation rate	p. value
Glucometer results	0.490	< 0.001
Lab results	0.490	< 0.001

Table 3. Spearman test to examine the correlation between glucometer results and laboratory blood sugar results in diabetics

As can be seen in Table above the laboratory blood sugar result and the glucometer blood sugar have a direct and partial relationship with each other. (Correlation = 0.490) and a significant relationship is also found between them (p. value = 0.001).

In this study, considering the laboratory method of blood sugar testing as the criterion and the blood sugar level above 126 mg/dl (7 mmol/L) as the index of hyperglycemia [9,[based on the normal distribution function, the sensitivity and specificity of the blood sugar test by glucometer is 77.1% and 80.2% respectively. Also, the precision coefficient (area under the Rock curve) is 0.840. The positive and negative predictive values of the glucometer test based on the Rock curve and the percentage of diabetic patients in the total sample size is 49.3%, and 93.3% respectively fig 4.

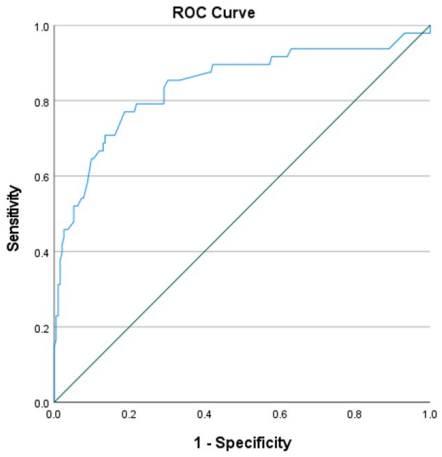

Fig 4. Variable performance characteristic curve diagram of blood sugar result of glucometer for diabetics

Discussion

In our study 240 patients were included,48 of whom were diabetic. The majority of the cases, 132 (55%) were female and 108 (44%) were male. The mean and standard deviation of the age was 54.40±19.30 years. The mean and standard deviation of the age by gender were 55.60±19.45 years and 53.42±19.19 years in men and women, respectively, and no statistically significant difference was found between the ages of men and women (p. value=0.670).

In our study, the correlation coefficient between the results of glucometer measurement and the laboratory method in non-diabetic individuals was 0.490 and in diabetic individuals was 0.896. In the study by Khakpour et al, this coefficient was 0.972.[6.[In

our study a significant correlation was observed between blood sugar measurement by glucometer and laboratory method. (P. Value <0.001).

In the studies of Khakpour et al. [6,[Ollal et al. [39] and Jamal al-Din et al. [8 [the correlation coefficients were also reported as 0.97, 0.93 and 0.93 respectively. In some studies the correlation coefficients of these two variables are reported lower [10-12 .[These differences in the reported correlation between these two variables could be due to differences in the sampling process, including the time interval between performing the glucometer test and the laboratory method and other effective environmental conditions.

In our study the sensitivity and specificity of the glucometer test for blood sugar were 77.1% and 80.2% respectively and positive and negative predictive values were 49.3%, and 93.3% respectively. In a study by Cerletti et al. [13 [conducted on 50 people (28 women and 22 men) with a mean age of 39.6 ± 11.3, the positive predictive value of glucometer was 100% and its negative predictive value was 90.6%. Also, their correlation rate was excellent, but the concordance of methods and devices was not statistically significant.

A study in France on 5 different models of glucometers showed that 65% of the results read by glucometers differed by more than 10% from the results of the standard method [14.[In the study by Rasouli et al [15 %86.5 [of the results read by glucometers differed by more than 10% from the standard laboratory method.

Given the retrospective nature of this study, it is impossible to rule out the effect of confounding factors such as underlying diseases which may cause differences in results compared to other studies. Hu et al. [16 [in their study of the accuracy of measuring blood glucose in infants with glucometers reported that some factors such as anemia and polycythemia can affect the response of glucometers and cause a clear difference from the laboratory method.

There are differences in the sampling site (capillary or venous). Boyd et al. [17 [reported that capillary blood gives a better response than venous blood.

According to our study, the use of glucometers can be effective for monitoring capillary blood sugar. However, due to the specific settings of each of these devices in the manufacturing plants, it seems that there is always a slight difference from the standard laboratory method of measuring blood sugar. This difference is greater in some conditions such as hemoconcentration or when venous blood is used for measurement [16,17].

Although glucometers are cost-effective, some researchers do not recommend using these devices alone in the long term, but recommend using both methods (glucometer and standard laboratory method) [18,19].

Conclusion

The results of this study, in comparison with other studies showed that glucometers are generally considered to be a suitable and reliable tool for blood sugar monitoring in diabetic patients and also for acute determination of blood sugar in critically ill patients presenting to the emergency department but there is a noticeable difference in the accuracy of their performance that should be determined with the help of comparative differences with laboratory standards in a large volume (by research method)

so that ultimately more reliable and accurate glucometers can be introduced to diabetic patients for daily blood sugar measurement and monitoring. There is also no significant difference between the average values measured by the glucometer compared to the laboratory. It is important for ward nurses and laboratory samplers to know this and observe it for hospitalized patients so that there is no need to take blood from the patient frequently.

Ethical approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Funding

None

Declaration of competing interest

The authors deny any conflict of interest in any terms or by any means during the study.

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