Research Paper

Comparing Four Methods for Preparing the Capillary Blood Sampling Site

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ABSTRACT

Background: Capillary blood glucose measurement is one of the most important diagnostic procedures in managing and treating patients, especially those with diabetes. Since the preparation method of the capillary sampling site affects the blood glucose (BG) level, it is essential to identify the best preparation method with the least error estimation. This study compares the capillary BG level with the venous BG level after preparing the sampling site with four different preparation methods.

Methods: This quasi-experimental study has a single-group design. It was conducted on 85 nursing and midwifery students of Kashan University of Medical Sciences and Health Services, in 2022. The subjects who met the inclusion criteria were selected using convenience sampling. Capillary BG was measured from each finger using a glucometer while each finger was prepared with alcohol, water, soap and water, or no washing. Then, the venous blood sample of the same person was sent to the laboratory. The data were analyzed by SPSS software, version 22. The Friedman and Dunn post hoc tests were used to compare venous and capillary BG levels obtained using different methods. The significance level was set at $P<0.05$.

Results: There were significant differences between venous BG levels and capillary BG levels in blood sampling site preparation with alcohol ($P<0.05$). Preparation with alcohol had the highest (7.34±27.03), and the soap and water had the lowest (-0.67±14.82) estimation errors.

Conclusion: The use of alcohol to prepare the blood sampling site, which is a common practice in many healthcare facilities, may misrepresent BG levels and lead to misdiagnosis and treatment. Therefore, it is suggested that the soap and water cleaning method be used instead, which has the lowest error compared to venous BG.

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Highlights

- Measuring the precise level of blood glucose is very critical in the diagnosis and treatment of patients.
- One of the common methods of measuring blood glucose in medical settings and at home is capillary blood glucose.
- Various factors affect the capillary blood glucose level, including the preparation of the sampling site.
- Cleaning the blood sampling site with alcohol, a common preparation method may show false results.
- Based on the results of the present study, the suggested method with the lowest error estimation is washing the sampling site with soap and water.

Plain Language Summary

Measuring the capillary blood glucose with a glucometer is one of the usual methods of monitoring blood glucose in medical centers and homes. Since the blood glucose level determines the appropriate treatment method, this measurement must be done accurately. One of the most effective factors in measuring capillary blood glucose is the preparation of blood sampling sites. So, using some disinfectants or not drying these substances from the skin before taking the sample can cause errors in showing blood glucose levels. In this study, four methods of alcohol, water, without using any substance, and soap and water were compared, and the blood glucose resulting from each method was compared with the vein blood glucose level of the same person. The results showed that the best method is to wash the blood sampling site with soap and water and dry it before sampling.

Introduction

Diabetes is one of the most common chronic diseases in the world. According to the International Diabetes Federation (IDF), the number of people with diabetes in the Middle East region will increase by 96% from 2019 to 2045, a highly interesting statistic (Atlas, 2019). Diabetes comprises a series of metabolic disorders characterized by high blood glucose (BG) levels due to impaired insulin secretion or insulin action (Schalkwijk & Stehouwer, 2020).

As a public health problem, this disease is one of the most expensive and challenging endocrine disorders in the world, which increases the number of people suffering from this disease every year (Mbanya & Mbanya, 2003). Complications related to diabetes impose a great economic burden on society (Brown & Nichols, 2003). These complications fall into two categories, including macrovascular complications (cardiovascular, stroke, and peripheral vascular diseases) and microvascular complications (nephropathy, retinopathy, and diabetic neuropathy). These complications lead to disorders such as blindness, kidney failure, and numbness of the lower limbs, significantly reducing the quality of life (Cole & Florez, 2020; Bahrami Taghanaki et al., 2020).

As diabetes is a chronic disease without a definite cure, treatments focus on controlling BG levels and preventing complications (Shrivastava et al., 2013). The majority of patients fail to achieve optimal control of their diabetes, so it appears that combined drug therapy and self-management techniques are more effective in the control of this condition (Reasner & Göke, 2002; Sarkar et al., 2006). Controlling BG is essential to diabetes self-management, as it delays the onset of physical and mental complications (Ko et al., 2019). In this regard, accurate measurement of BG is very important and necessary (Pidcoke et al., 2010). There are different methods for measuring BG, such as glycated hemoglobin, fasting BG, plasma BG, and capillary BG, which are the most common.

Capillary glucometers are more rapid than other methods of measuring BG (Nasiri et al., 2016). However, objective observations show that many patients and even healthcare providers are unaware of the limitations and factors affecting capillary BG results and thus misestimate BG levels (Aynsley-Green, 1991; Olamoyegun et al., 2016).

According to the American Diabetes Association, BG measurement errors should not exceed 5%, but statistics indicate that this rate exceeds 25% (Fallah & Rostamza-

deh, 2016; Kazemi et al., 2019; Bamberg et al., 2005). One of the factors affecting the accuracy of measured BG is the preparation of the sampling site. Currently, various methods have been proposed to clean the sampling site. Some studies suggest the use of alcohol (Alzahrani et al., 2022; Dunning et al., 1994), but some consider its use to cause errors in BG estimation (Kazemi et al., 2019; Foos, 2017). In some studies, hand washing before measuring BG is considered sufficient (Hirose et al., 2011), while others consider using disinfectant after hand hygiene (Alzahrani et al., 2022).

It has been shown that the use of isopropyl alcohol and chlorhexidine gluconate in the preparation of the blood sampling site shows the level of capillary BG higher than venous BG (Kazemi et al., 2019). However, Jońca et al. (2021) reported that disinfection does not affect glucose measurements when the fluid completely evaporates. Wet finger sampling influences glucose measurement results, but the observed changes are not clinically significant (Jońca et al., 2021). It is believed that washing hands with soap and water before sampling is essential for reducing capillary BG measurement errors. If washing is impossible, a second drop of blood may be used instead (Lima et al., 2016). Another study demonstrated that using an instant hand sanitizer was compatible with the results of a BG monitor and did not affect the results of finger BG measurements. In some instances, due to the difference in the sampling area, disinfectants may not be enough to clean the skin before the BG test with a glucometer (Mahoney et al., 2011).

Despite the importance of accurate measurements of BG levels and their significant impact on patient diagnosis and treatment, the conflicting results associated with the appropriate method of preparing the sampling site prompted the researchers to conduct a study to compare capillary BG levels with venous BG levels after sampling site preparation with four different methods.

Materials and Methods

The present quasi-experimental study employed a single-group design. It was conducted on 85 nursing and midwifery students of Kashan University of Medical Sciences and Health Services, in 2021 using convenience sampling. The sample size was calculated based on a study by Foos et al. (2017). A minimum sample size of 78 people was calculated using the standard deviation of 13.49, the type I error of 0.05, and the estimation error of 3. Considering the 8% chance of sample attrition, 85 subjects were included in the study.

The inclusion criteria were as follows: Willingness to participate in the study, no contraindications for blood sampling (wounds, infections, peripheral vascular disorders, and fistulas on fingers), and a minimum of 30 minutes have passed since the last time the hands were washed or disinfected. In the next step, the objectives and methods of the study were explained in detail, and an informed consent form was obtained from the participants who met the inclusion criteria for participation in the study.

The data collection tool was a questionnaire containing demographic information, such as age, gender, underlying diseases, and smoking habits. Each preparation site method prepared capillary BG of the blood samples taken from four fingers, and each subject's venous BG levels were recorded in a table at the bottom of the same form. Before taking capillary blood samples, four fingers of each subject were prepared using different methods: Alcohol, soap and water, water, and without washing. To collect the samples, the tip of the first finger was cleaned with an alcohol swab, the second finger was cleaned with water, the third finger was not cleaned with any substance, and the fourth finger was cleaned with soap and water. After drying the puncture site, the researcher measured the BG of the first drop of capillary blood using an EasyGluco glucometer. To measure venous blood glucose, first, the sampling site in the non-dominant hand was disinfected with 70% isopropyl alcohol, and then 1 mL of blood was taken using a syringe. Venous samples were sent to the laboratory as soon as they were collected to avoid the effect of ambient temperature on the results. The Friedman test was used after data were collected and entered into SPSS software, version 22 to compare the results of the five methods of measuring capillary BG and venous BG. The Dunn post hoc test was applied to compare the two methods.

Results

The mean age of the subjects was 22.08±2.64 years. Among them, men had the highest percentage (62.3%). Six students (7.1%) were smokers, and 4.8% of the subjects suffered from underlying diseases (Table 1).

The mean BG level of the venous and capillary method using alcohol, water and soap, water, and no washing is shown in Table 2. In this research, the mean venous BG, considered as a reference, is 131.66±59.35, and the closest BG mean to it is the method of cleaning the blood sampling site with soap and water (131.91±66.94). The highest mean and standard deviation (141.08±71.37) is related to the method of using alcohol swabs.

Table 1. General characteristics of the subjects (n=85)

Variables	Category	No. (%)
Gender	Men	53(62.3)
	Women	32(37.7)
Underlying disease	Yes	4(4.8)
	No	81(95.2)
Smoking	Yes	6(7.1)
	No	79(92.9)

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Table 2. Capillary blood glucose in different preparing sampling sites and the reference venous blood glucose

Variables	Sampling Site Preparation Method	Mean±SD	Range
Capillary blood glucose	Alcohol	141.08±71.37	62-402
	Water	135.81±63.70	55-394
	Soap and water	131.91±66.94	62-439
	No washing	136.27±61.28	72-361
Venous blood glucose	-	131.66±59.35	72-379

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The percentage of error between capillary BG in different methods compared with venous BG level is presented in Table 3. The results show that the highest error percentage is related to the method of using alcohol swabs (7.34±27.03). After that, methods of not washing and using water without disinfection are associated with the most errors.

The normality of the data was not confirmed using the Shapiro-Wilks test (P<0.001). Therefore, Friedman non-parametric test was used to evaluate the differences between five BG levels. This test showed at least a significant difference between the two BG measurement methods (P=0.001). Therefore, the Dunn post hoc test was used to compare pairs of methods. The results showed a statistically significant difference between the venous BG and the capillary BG taken from the unwashed finger and the finger prepared with an alcohol swab. Also, there is a statistically significant difference between cleaning with soap and water and no washing (P<0.05). The comparison results are presented in Table 4 and Figure 1.

Discussion

Our study was designed to compare capillary BG levels in four blood sampling site preparation methods (alcohol, water and soap, water, and no washing) with venous BG levels. The study results showed higher capillary BG levels in the alcohol swab method than other methods and even

Table 3. The percentage of error between capillary blood glucose in different methods and venous blood glucose

Methods	No.	MPE	SD	Min	Max
Alcohol-vein	85	7.34	27.03	-53.42	149.52
Water-vein	85	3.47	19.63	-53.23	74.00
Soap and water-vein	85	-0.67	14.82	-46.77	78.81
No washing-vein	85	4.32	15.73	-38.71	70.83

MPE: The mean percentage error.

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Table 4. Comparing venous and capillary BG in different methods of blood sampling site preparation

Methods		Test Statistics	P
Venous BG	Alcohol	0.78	0.01*
	Water	0.48	0.46
	Soap and water	0.17	1.00
	No washing	0.85	0.004*
Alcohol	Water	0.30	1.00
	Soap and water	0.61	0.11
	No washing	-0.07	1.00
Water	Soap and water	0.31	1.00
	No washing	-0.37	1.00
Soap and water	No washing	-0.68	0.04*

*P<0.05 statistically significant.

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BG: Blood glucose.

venous BG levels. According to the study by Kazemi et al. (2019), capillary BG differed significantly from the venous BG after cleaning the site with 70% alcohol isopropyl and 2% chlorhexidine gluconate. The mean difference between these two methods was reported as 11.4 was statistically significant (Kazemi et al., 2019), while the results of some studies show that the use of alcohol does not affect capillary BG compared to laboratory BG (Alzahrani et al., 2022; Dunning et al., 1994). A study conducted by Foos et al. (2017) found that the use of alcohol swabs predicted a lower BG level in the first drop compared to the second drop (Foos, 2017).

This study showed that if hands are not washed, there is a statistically significant difference between BG levels in capillaries and venous samples (P=0.004). It has been demonstrated that the measured BG can be misinterpreted depending on what substance the hand was in contact with before the BG monitoring (Lima et al., 2016; Olamoyegun et al., 2016). In another study, capillary BG samples were measured and compared after peeling oranges, grapes, and kiwis, without any subsequent steps (i.e. cleaning the sampling site), such as washing hands with plain water and using alcohol swabs (Hirose et al.,

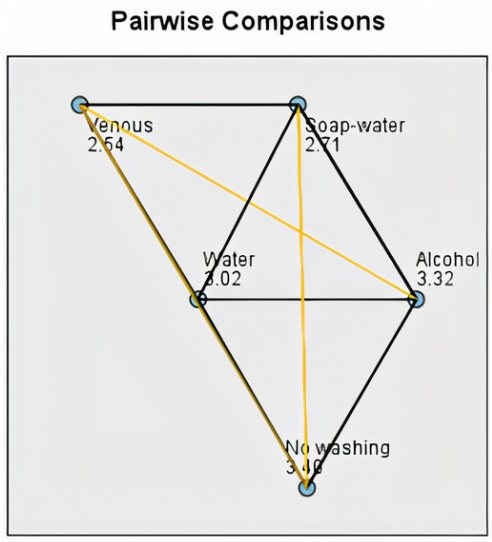

Figure 1. Relationship between venous and capillary blood glucose in different methods

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2011). Following peeling any of the fruits and washing hands, the BG levels were similar to those measured in the control subjects (no fruit handling). However, the levels after peeling fruits, followed by no washing, were abnormally and significantly higher, even when the fingertip was cleaned 5 or 6 times with an alcohol swab before blood sampling. It has been suggested that to avoid overestimating BG levels by portable monitors, hands should be washed before capillary BG measurement, particularly after the fruit has been handled (Lima et al., 2016; Olamoyegun et al., 2016).

Based on the results of the present study, the most suitable method for preparing the sampling site is using soap and water, which shows the least difference with venous BG level (the mean percentage error=0.6). Other studies have also suggested using soap and water before capillary BG sampling (Alzahrani et al., 2022; Hirose et al., 2011; Mekawy et al., 2017). Based on comparing capillary and venous BG between the 4 sampling site preparation methods, using water is the appropriate method in the absence of soap. Although alcohol swabs are commonly used in hospitals and clinical settings, they may occasionally lead to mistakes by falsely showing higher or lower BG levels. In these cases, inappropriate treatment, such as injecting a high dose of insulin, can be dangerous. Thus, it is recommended to accurately measure capillary BG along with other factors, such as using a standard glucometer device and appropriate kits maintained at the right temperature and humidity (Ginsberg, 2009), as well as washing hands with soap and water and drying them afterward. Studies have also shown that if the sampling site is not completely dried before blood collection, disinfectants may show falsely higher or lower results than the actual value (Jońca et al., 2021; Kazemi et al., 2019).

Conclusion

In conclusion, participants who did not wash their hands or used alcohol swabs before BG monitoring had significantly higher capillary BG levels than venous BG. Using soap and water yielded the lowest mean difference between capillary and venous BG levels. Therefore, it is recommended that all patients wash their hands with soap and water before measuring capillary BG. Promoting patients' awareness through innovative methods is necessary to obtain correct capillary BG samples. In addition, diabetes healthcare providers should be aware of all conditions that may affect the result of capillary BG monitoring and educate patients accordingly on the proper conditions for capillary blood sampling site preparation.

This study was conducted on 85 nursing students using high-quality digital glucometers. One of the limitations of the present study is the small number of samples. Also, taking 5 BG samples from one person simultaneously may cause stress and affect the BG level. However, the researcher tried to cause less pain and stress to the patients by quickly inserting the needle into the fingertips while taking the BG sample. To introduce less pain and stress to the subjects, it is suggested that capillary blood samples be taken from four different groups in the next studies, and the mean of each group should be compared with their venous blood sugar mean. Further studies with more samples and methods of preparing the capillary blood sampling site are recommended to confirm our findings and overcome the limitations of this study. A comparison of the blood sugar levels in the first and second capillary drops is also suggested to determine the best method.

Ethical Considerations

Compliance with ethical guidelines

The Research Ethics Committee of Kashan University of Medical Sciences and Health Services approved the study (Code: IR.KAUMS.NUHEPM.REC.1401.024). A written informed consent was obtained from the subjects before they participated in the research, and they were assured of the confidentiality of the data.

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Authors' contributions

Conceptualization: Mohammadreza Abedzadeh and Safoura Yadollahi; Data collection and presentation: Mohammadreza Abedzadeh; Data analyses: Mahboobeh Maghami; Draft preparation and study consultant: Ismail Azizi-Fini; Project administration and writing: Safoura Yadollahi; Final approval: All authors.

Conflict of interest

The authors declared no conflict of interest.

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