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# A comparision between blood glucose concentration measured in capillary and venous blood using glucometer and measurements in venous plasma using Auto analyser

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**Keywords:**
Capillary Whole Blood
Blood Glucose
Venous Blood Glucose
Glucometer
Plasma

**ABSTRACT**

There are several methods for laboratory measurement of blood glucose. The detection, identification and quantification of glucose in blood has played a vital role in the diagnosis and management of patients suffering from disorders of carbohydrate metabolism and is one of the most frequently performed determinations in clinical chemistry. Aim: The purpose of this study is to the Compar between different methods of blood glucose estimations in venous whole blood, capillary whole blood by glucometer, and plasma glucose estimation by Auto analyser. Materials and Methods: A 60 adult patients were randomly selected and included in the study, to measure the blood glucose. Blood samples were collected from all persons (fasting 10/12-hour overnight), whether a known case of diabetes or not. Venous whole blood glucose, Capillary whole (Finger prick) blood glucose estimation was done by glucometer; and venous plasma glucose estimation was done by auto analyzer in laboratory. Results: Means of Venous Whole blood glucose level measurements and finger-prick blood glucose level measurements were the highest, 146.63±10.16 mg/dL and 143.80±9.73 mg/dL, respectively, which indicates that the means were higher than that of Venous plasma glucose level measurements, but this rise was statistically insignificant when compared to the Venous plasma glucose level measurements 120.67±8.88 mg/dL. The percentage statistically insignificant elevations of blood glucose concentrations in capillary whole blood and venous Whole blood were 19.17 % and 21.51% respectively when compared with the control value( plasma blood glucose). Conclusion: Capillary blood glucose estimation by glucometer is a faster method for glucose estimation , provided that the device used for the measurement is calibrated according to the manufacturer's conditions, but the main controversial issue is the reliability of glucometers, as they may show large deviations. However, a degree of caution should be exercised in the interpretation of bedside glucometer measurements as they may not be sufficiently accurate to replace laboratory blood glucose results.As the study includes 60 sampl only, a larger study is necessary for authentication of the findings. Although, many studies also show the same results. Future research with a larger sample size should be done.

# مقارنه بين قياس تركيز الجلوكوز في الدم الشعيري و الدم الوريدي باستخدام جهاز الجلوكوميتر، وقياس تركيز الجلوكوز في بلازما الدم الوريدي باستخدام التحليل الآلي

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**الكلمات المفتاحية:**
الدم الكامل الشعري
جلوكوز الدم
جلوكوز الدم الوريدي
غلوكمتر
بلازما

**الملخص**

توجد طرق معملية عديدة لقياس نسبة الجلوكوز في الدم. والجدير بالذكر ان تحديد معدل الجلوكوز في الدم يلعب دورا حيويًا في التشخيص للمرضى الذين يعانون من اضطرابات في التمثيل الغذائي للكربوهيدرات . والهدف من هذه الدراسة هو المقارنة بين قياس تركيز الجلوكوز في الدم بالطرق المختلفة وهي استخدام مقياس الجلوكوز( جلوكوميتر) لتحديد تركيز الجلوكوز في كلا من الدم الوريدي الكامل ، والدم االشعيري الكامل ، وكذلك استخدام جهاز المحلل الآلي لتقدير تركيز الجلوكوز في بلازما الدم وتم اعتبار قيم الجلوكوز المقاسة في بلازما الدم الوريدي

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في المختبر بواسطة جهاز التحليل الالي هي قيم السيطرة (التحكم) لأنها هي تعتبر القيم الحقيقة أو المرجعية ، وبالتالي في هذه الدراسة تم مقارنتها بقياسات جلوكوز الدم الوريدي الكامل ، والدم االشعيري الكامل المقاسة بالجلوكوميتر لتقييم دقة تقنيات وطرق قياس الجلوكوز. تم اختيار 60 شخص بالغ بشكل عشوائي( منهم مرضى سكري ومنهم غير مصابين بالسكري) 34 اناث و 26 ذكور وأعمارهم من 18-72 سنة تم إدراجهم في هذه الدراسة ، لقياس نسبة السكر في الدم، حيث جمعت عينات الدم من جميع الاشخاص بعد صيام 10-12 ساعة. وتم قياس نسبة الجلوكوز في الدم عن طريق جهاز قياس السكر( جلوكوميتر) في كلا من الدم الوريدي الكامل (سحب من الوريد) ، والدم الكامل للشعيرات الدموية (جمع بوخز الإصبع)، وكذلك تم تقدير تركيز الجلوكوز في بلازما الدم بواسطة المحلل الآلي في المختبر. وكانت النتائج المتحصل عليها من هذه الدراسة انه لا توجد فروق معنوية هامة بين متوسطات تركيزات جلوكوز الدم التي قيست بالطرق المختلفة ، حيث ان متوسطات قيم تركيز الجلوكوز في الدم الوريدي الكامل و في الدم الشعيري كانت هي الاعلى ، 146.63 ± 10.16 ملجم / ديسيلتر و 143.80 ± 9.73 مجم / ديسيلتر على التوالي (المتوسط ± الخطأ القياسي) ، عند مقارنتها مع متوسطات قيم تركيز الجلوكوز في بلازما الدم.67 ± 8.88 مجم / ديسيلتر ، ولكن هذا الارتفاع كان غير هام من الناحية الإحصائية رغم ان متوسطات قيم تركيز الجلوكوز في الدم الوريدي الكامل و الدم الشعيري كانت غير طبيعية بينما متوسطات قيم الجلوكوز لبلازما الدم قريبة جدا من الطبيعي لان هذه طبعا عبارة متوسطات قيم 60 عينة دم وواضح معها الخطأ القياسي جمعت من اشخاص مصابين بالسكري وغير مصابين بالسكري ، حيث كان هدف الدراسة هو المقارنه بين طريقة قياس تركيز الجلوكوز في الدم الوريدي الكامل والدم الشعيري الكامل بواسطة جهاز الجلوكوميتر وبين طريقة قياس تركيز الجلوكوز في بلازما الدم الوريدي المقاسة بواسطة التحليل الالي المختبر. وباعتبار انه لا توجد فروق معنوية هامه بين تركيزات الجلوكوز بالطرق المختلفة والمستخدمة في هذه الدراسة نستنج ان تقدير نسبة الجلوكوز في الدم الشعري بواسطة مقياس الجلوكوز( الجلوكوميتر) يعتبر أسرع من تقدير تركيز الجلوكوز في البلازما بواسطة المحلل ألآلي بشرط أن يكون الجهاز المستخدم للقياس معايرًا وفقًا لظروف الشركة المصنعة ، ولكن القضية الرئيسية المثيرة للجدل هي موثوقية أجهزة قياس السكر ، حيث انها قد تظهر انحرافات كبيرة في القراءات لذلك ، يجب توخي درجة من الحذر عند تفسير قياسات جلوكوز الدم المقاسة بواسطة الجلوكوميتر لأنها قد لا تكون دقيقة بما يكفي لتحل محل نتائج جلوكوز الدم المختبرية. ونظرًا لأن الدراسة شملت 60 عينة ، فمن الضروري إجراء دراسة أكبر للتحقق من النتائج. على الرغم من أن العديد من الدراسات تظهر أيضًا نفس نتائج التقييم ، ولإثبات ذلك يجب إجراء بحث مستقبلي بحجم عينة أكبر.

**Introduction**

The detection, identification and quantification of glucose in blood has played a vital role in the diagnosis and management of patients suffering from disorders of carbohydrate metabolism and is one of the most frequently performed determinations in clinical chemistry. Glucose is the main energy source for tissues, as it is abundantly present in the circulatory system of mammals, except when fasting for long hours [(1)].

Thus maintenance of the blood glucose concentration is closely controlled and affected by many factors. Glucose levels in the blood may be transiently increased as a result of the absorption of ingested glucose from the gut. Glucokinase enzyme in the liver removing high amounts of glucose after a meal, and this prevents exceeding the renal threshold for glucose (approximately 10 mmol/L), which causes glucosuria. The liver is the main organ that supplies the blood with glucose during fasting periods by decomposing stored glycogen or by synthesising glucose from its precursors such as lactate, pyruvate, glycerol and amino attacks. In addition to these metabolic processes, many hormones affect glucose homeostasis. It has long been appreciated that insulin is the glucose regulatory hormone; It suppresses glucose production, accelerates glucose utilization and thus lowers the plasma glucose concentration[(2)].

At present, blood glucose level may be measured by several portable devices, photometric, oxidation reduction reaction and measuring electrode techniques [(3,4)]. The Portable blood glucose meters (PBGMs)used to measure blood glucose are simple of cost and effort, and also very fast to measure the level of glucose in the blood [(5)] and very useful in veterinary practice[(6,7)], easy to use and only needs a small amount of blood (1–5 µl) [(8)]. The chromatography/spectrophotometry of plasma glucose using the glucose oxidase method is the gold standard for glucose determination [(9)], but has the drawback of presenting late analysis results. Hence, resorting to remote laboratories is not appropriate for emergency situations [(10)].

WHO has specified the criteria for diagnosis of DM and impaired glucose tolerance for only venous plasma sample[(11)]. Blood glucose estimation is the main stay of management and diagnostics of DM. Blood glucose monitering is also recommonded in emergency complications of DM; even one hourly, in management of diabetic ketoacidosis, hyperosmolar state and hypoglycemia. In such cases, glucometer monitoring is most convenient, cheaper and a quicker method than laboratory analysis. So, it is essential to compare and find out variations in results of different methods of blood collection and methods of estimation. There is a marked variation in glucose level, when estimated from whole blood and plasma, venous blood or capillary blood. It also varies with glucometer method and Auto analyzer method. [(12)]

Accordingly, the aim of the present study was to compare the results of blood glucose estimation in venous whole blood, capillary whole blood by glucometer, and plasma glucose estimation by Auto analyser.

**Materials and Methods :**

Sixty adult persons were randomly selected to participate in this study and they were 34 females and 26 males, with age range from 18 to 72 years. They asked to attend to Outpatient Department (OPD)

in Sirt, which advised for blood glucose estimation by their consultant. Blood samples were collected from all patients (fasting 10/12-hour overnight), whether a known case of diabetes or not. After informed consent and registration, the venous blood samples were collected from antecubital vein which sent for plasma glucose estimation by auto analyzer in Approved Center for Medical Analysis and the whole blood remaining in syringe was used to estimate blood glucose by bedside glucometer. At the same time, Samples from the finger-capillary were taken preferably from the patient's non-dominant hand from the soft tissue surface of the index finger. The finger was sterilized with a sterilizer, then after the sterilizer was evaporated, the finger was pricked with a sterile needle to obtain a drop of blood[13]. The first drop of blood is neglected, and the second drop of blood is taken and placed on the edge of the test strip by touching the strip with a finger, and when a sound is issued from the glucometer, the measurement result appears on the screen in mg/dl., using the same bedside glucometer[14]. Venous blood glucose VBG and Capillary whole blood glucose CBG were measured in each patient using a glucometer device, and in this study, the values of blood plasma glucose concentrations measured by the auto analyzer were considered as the **control** values because they are considered the true or reference values, its comparison with measurements of venous blood and capillary blood. Blood sample types and different methods of estimation are shown in Table 1.

**Table1: Types of blood sample and methods for their determination**

| Blood Sample | Method of blood glucose determination |
|---|---|
| Venous blood plasma glucose (VBPG) **(control)** | GOD-POD Method by Auto analyser |
| Capillary whole blood glucose (CBG) | blood glucose strip and glucometer |
| Venous blood glucose (VBG) | blood glucose strip and glucometer |

***Test strip(Test Principle):***

The ***Test strip*** is a plastic strip containing chemicals and electrodes. When inserted into a TRUE result or TRUE result twist Meter, glucose is measured using amperometric technology employing a glucose dehydrogenase-FAD reaction. Glucose in the blood sample in to tip of the strip reacts with chemicals and as a result of this reaction an electric current occurs, and then the device measures this current and calculates the glucose concentration in the blood sample.

**Chemical Composition:** Glucose dehydrogenase-FAD (Aspergillus sp.), mediators, buffers and stabilizers.

***GOD-POD method*** **For the determination of glucose in plasma** [9] :

The GOD-POD method is linear (up to 500 mg/dl), sensitive (detection limit 0.3 mg/dl), simple (requires 10 microlitre of sample to be incubated for 30 minutes with single reagent at room temperature) and requires simple instrumentation (the absorbance to be read between 505 nm to 550 nm).

***Principle of the method:***

Glucose oxidase (GOD) catalyses the oxidation of glucose to gluconate. The formed hydrogen peroxide ($H_2O_2$) (POD) is detected by a chromogenic oxygen acceptor, phenol, 4-Aminophenazone (4-AP) in the presence of peroxidase .

β-D-Glucose + $O_2$ + $H_2O$ GOD Gluconate + $H_2O_2$

$H_2O_2$ + Phenol + (4-AP) POD Red Quinone dye + $H_2O$

The intensity of the color formed is proportional to glucose concentration in plasma.

**Equipments needed :**

- Spectrophotometer or colorimeter measuring at 505nm.
- Matched cuvettes 1.0 cm light path.
- General laboratory equipment.

**Statistical Analysis:**

The results were analyzed using SPSS. All values were recorded as Mean+ standards error of the mean ,whereas, the statistical differences between the means were determined by ANOVA,(one way ANOVA) and the P< 0.05 was accepted as significant level [15].

**Results :**

Table **2** shows concentrations of glucose which are measurements by different methods used for the present study. Mean levels of blood glucose in capillary whole blood and venous Whole blood **143.80±9.73 mg/dL** and **146.63±10.16 mg/dL** respectively were observed more highest than those of plasma blood glucose **120.67±8.88 mg/dL** but this rise was statistically insignificant (P< 0.05 **).** The percentage statistically insignificant elevations of blood glucose concentrations in capillary whole blood and venous Whole blood were 19.17 % and 21.51% respectively when compared with the control value( plasma blood glucose).

**Table 2: Values of glucose concentrations (Means ± SE) for all measurement methods.**

| Method | Sample type | Glucose concentration (mg/dL) | P value |
|---|---|---|---|
| GOD-POD Method by Auto analyser | Blood plasma | 120.67±8.88 | - |
| blood glucose strip and glucometer | Capillary whole blood | 143.80±9.73 | 0.09 |
| | % of Change from G1 | 19.17% | |
| blood glucose strip and glucometer | Venous Whole blood | 146.63±10.16 | |
| | % of Change from G1 | 21.51% | 0.058 |
| | % of Change from G2 | 1.93% | 0.83 |

**Discussion:**

Blood glucose concentration estimation was based on three types of samplings. Venous blood plasma sampling estimated by laboratory auto analyzer method (control), Venous blood sample measured by a glucometer and, Capillary blood sample measured by glucometer. In this study, mean of blood glucose concentrations for Venous Whole blood and capillary blood measurements by glucometer are higher than glucose concentration of blood plasma measuring done in laboratory method (**146.63**mg/dL, **143.80** mg/dL, and**120.67** mg/dL) respectively, the percentage of change was **21.51%** for Venous Whole blood and **19.17%** for capillary blood when compared with the blood plasma samples(control), these changes were statistically insignificant (P< 0.05 ). These results agree with the findings recorded by **Patel and Patel** [16], **Chopra and Kumar**[17], **Kaur *et al.***[18] **, Yang *et al.*** [19] and multi previous studies **Biag *et al.*** [20] and **Colagiuri *et al.*** [21] reported that The capillary blood glucose concentration is comparable to the concentration of arterial blood glucose while the concentration of venous plasma glucose is the estimation of glucose after tissue utilization of glucose. So on lower side, change in concentration depends on tissue extraction of glucose, and depends on acts of cortisone, growth hormone, insulin, and glucagon and also on-demand of tissues and postprandial and preprandial status as well as the concentration of blood glucose. Furthermore, our finger-prick blood samplings are to collect

peripheral capillary blood in which blood glucose concentrations approximate to arterial blood glucose concentrations [12] because glucose assimilated by the human body is sequentially conveyed into arteries and tissue cells via diffusion in peripheral capillaries and some remaining glucose returns to veins. American Diabetes Association[22] suggests that capillary blood glucose estimation may not be as reproducible as plasma glucose estimation. Accordingly, both arterial blood glucose concentrations and postprandial capillary blood glucose concentrations are higher than venous blood glucose concentrations in virtue of capillaries close to an artery [23].

In this regard, the glucose regulation mechanism which is naturally developed in the human body having experienced fast overnight causes arterial blood glucose, venous blood glucose and capillary blood glucose levels almost the same due to blood glucose levels regulated by insulin and glucagon: (1) Insulin secreted by pancreatic β-cells with blood glucose levels ascending facilitates blood glucose absorbed by liver, muscles and adipose tissues but reduces blood glucose concentrations; (2) Glucagon with features opposite to insulin facilitates glycogenolysis, decomposition of triglycerides, and gluconeogenesis (a process of amino acid synthesized to carbohydrate) and promotes lowered blood glucose concentrations and glucose balance [24]. Thus, there is no significant difference between fasting venous blood glucose and fasting capillary blood glucose.

Funk *et al.*, [25] reported that the correlation between venous blood glucose and capillary blood glucose estimations using glucometer was poor in healthy volunteers. Sylvian *et al* ., and Thomas *et al.*, [26,27]found that the venous-derived bedside glucose estimations were more accurate than capillary-derived samples of critically ill patients. Boyd *et al.*, [28] reported that statistically, the significant difference did occur between the capillary and venous bedside blood glucose estimates, but such a difference (0.33 mmol/l) may not be clinically significant in routine practice. This supports the view that venous blood glucose measured by glucometer may be used in place of capillary blood in the management of non-critically ill patients. However, a degree of caution should be exercised in the interpretation of bedside glucometer measurements as they may not be sufficiently accurate to replace laboratory blood glucose results.

As the study includes 60 subjects only, a larger study is necessary for authentication of the findings. Although, many studies also show the same evaluation results[29].·

**Conclusion :**

Capillary blood glucose estimation by glucometer is a faster method for glucose estimation , provided that the device used for the measurement is calibrated according to the manufacturer's conditions, but the main controversial issue is the reliability of glucometers, as they may show large deviations. However, a degree of caution should be exercised in the interpretation of bedside glucometer measurements as they may not be sufficiently accurate to replace laboratory blood glucose results.As the study includes 60 sampl only, a larger study is necessary for authentication of the findings. Although, many studies also show the same results. Future research with a larger sample size should be done.

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