A Comparative Study of Venous and Capillary Blood Glucose Levels by Different Methods

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Abstract :

Introduction : Diabetes Mellitus (DM) is the most common metabolic disorder in nearly 5-10 % of western population aged more than 40 years. Blood glucose estimation is the main stay of diagnosis and management of DM. **Aim :** To compare the blood glucose estimation methods from capillary blood and venous blood by glucometer and also with venous plasma glucose estimation by auto analyzer and to find out variation percentages in results. **Material & Methods :** 60 patients attending Outpatient department of a tertiary care level hospital who were advised blood glucose estimation were selected. Finger prick (capillary) blood glucose & venous blood glucose estimation was done by glucometer; and venous plasma glucose estimation was done by auto analyzer in laboratory. **Result & Conclusion :** Capillary blood glucose estimation by glucometer is a better alternative to venous plasma glucose estimation for diagnosis; follow up and in emergency conditions in diabetic as well as non diabetic patients. Venous blood glucose estimation by glucometer is not advisable as a routine method, but it is advocated when patient refuses for a second pin prick of finger.

Key Words : Auto analyzer estimation, Blood glucose, Finger prick capillary, Glucometer, Plasma.

Introduction :

Diabetes Mellitus is the most common metabolic disorder in nearly 5-10 % of western population aged more than 40 years.[1] In developing country like India, its prevalence is rapidly increasing since last few decades. India would be the largest host of diabetes mellitus by 2020.[2] Every 4th person above the age of 40 years may have impaired glucose tolerance or avert diabetes mellitus. WHO has specified the criteria for diagnosis of DM and impaired glucose tolerance for only venous plasma sample.[3] Blood glucose estimation is the main stay of diagnosis and management 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. In our study, we have tried to compare the results of blood glucose estimation in capillary whole blood by glucometer, venous whole blood by glucometer and plasma glucose estimation by Auto analyser. Estimation of blood glucose level was done in all patients irrespective of their diabetic or non diabetic status. Capillary blood sample's blood glucose is comparable to the level of arterial blood glucose. There are a few differences between fasting capillaries glucose and fasting venous glucose, while postprandial venous blood glucose level is lower than postprandial capillaries blood glucose by 7%, as glucose is absorbed by the tissue cells via diffusion in peripheral capillaries, and some remaining glucose return to veins.[4]

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Materials and Methods :

The subjects selected in the study were all adults, aged 18 -70 years, attending Out Patient Department (OPD) of a tertiary care level hospital, and advised to get blood glucose estimation done by their consultant. Blood sugar samples were collected from all subjects, whether a known case of diabetes or not. After informed consent and registration, venous blood sample collection from antecubital vein of the subject was done. The collected sample was sent for plasma glucose estimation by auto analyzer in central laboratory. Whole blood remaining in syringe was used to estimate blood glucose by glucometer. At the same time, capillary sample was collected by finger prick method and blood glucose estimation was done by the same glucometer.[5] All three results were recorded in a master chart. Blood sample types & different methods of estimation are shown in Table 1.

Table1: Blood samples type & Methods of estimation:

Blood Sample types	Method of blood glucose estimation
Capillary whole blood glucose(C)	TRUE result blood glucose strip* and glucometer
Venous whole blood glucose(V)	TRUE result blood glucose strip* and glucometer
Venous plasma glucose(P)	GOD-POD Method by Auto analyser**

Note: "TRUE result test strip" measures whole blood glucose by glucose dehydrogenase-FAD reaction, in which glucose in the sample reacts with the chemicals and produces an electric current. The meter measures the current and calculates the amount of glucose.[6] GOD-POD method:-Trinder's methodology (α D glucose is converted to red dye by enzymatic reaction with use of glucose) GOD-POD reagent auto-analyzer system is used to estimate plasma glucose of venous sample in central laboratory.

Results :

Table 2 : Distribution of study subjects according to blood glucose level.

Established status of Diabetes mellitus	Blood glucose ≤ 100mg/dl Group A	Blood glucose between 101 to 200mg/dl Group B	Blood glucose >200mg/dl Group C	TOTAL (%) n = 60
DM	00	04	10	14 (23%)
Non-DM	30	16	00	46 (77%)
Total	30	20	10	60 (100%)

All 60 subjects were classified into **Group A, B** and **C** as per their plasma glucose levels done by auto analyser as shown in the above table. Plasma glucose (P), less than or equivalent to 100mg/dl is **Group A,** between 101 -200mg/dl is **Group B** & more than 200mg/dl is **Group C.**

Table 3 : Average Blood glucose level and standard deviation in Groups A, B and C.

Groups	Average Standard Deviation	Capillary Blood Glucose (C) mg/dl (Glucometer)	Venous Blood Glucose (V) mg/dl (Glucometer)	Auto Analyser Plasma (P) mg/dl
Total Blood glucose level mg/dl	Mean ± 1 SD	151.38 ± 106.35	157.71 ±100.11	141.75 ± 97.58
Less than or 100mg/dl **Group A**	Mean ± 1SD	97.5 ±17.85	105.13 ±18.77	86.96 ± 7.12
101 to 200mg/dl **Group B**	Mean ± 1 SD	133.6 ± 39.33	142.3± 37.34	131.3 ± 33.17
More than 200mg/dl **Group C**	Mean ± 1SD	317.5 ±144.82	316.8 ± 97.78	299.4 ± 97.3

In the above table, average blood glucose value in all 60 subjects shown as (C), (V) &(P), 151.38 mg/dl, 157.7 mg/dl & 141 mg/dl respectively, suggests highest value in venous sample (V) and lowest in Plasma sample (P). The average and standard deviation of blood glucose levels in all the three groups suggest highest values in venous sample (V) and lowest in capillary sample (C). It is interesting to note that the level increases in the groups from A to B to C, as blood glucose level increases. Venous blood glucose (V) estimation by glucometer has a higher total and mean value than capillary blood glucose(C) and it is the lowest in plasma glucose value (P).

Table 4 : Difference in Blood glucose level by different methods

Difference in blood glucose level mg/dl	(X) mg/dl	(Y) mg/dl	(Z) mg/dl
Total	6.43	15.96	9.63
Group (A)	7.67	18.17	10.54
Group (B)	9.7	11	2.3
Group (C)	0.07	17.4	18.1

Note: (X) = V- C VALUE, (Y) = V- P VALUE, (Z) =C- P VALUE.

The table 4 shows that the difference between venous sample **(V)** & capillary sample **(C)** is **(X)** = 6.43 mg/dl, Venous sample **(V)** & plasma sample **(P)** is **(Y)**= 15.96 mg/dl and capillary sample **(C)** & plasma sample **(P)** is **(Z)** = 9.63 mg/dl. Range of differences between different methods is between 6.43 to 15.96 mg/dl. Highest values are in **(Y)** and lowest in **(X),** 15.96 mg/dl & 6.3 mg/dl, respectively. The different blood glucose level values (X),(Y) & (Z) shown in each group A, B, & C do not show any specific correlation.

Variation %	C-V (X)	P-V (Y)	C-P (Z)
< 15%			
<5%	23	14	28
5-10%	15	13	12
10-15%	9	9	14
Subject no. up	47/60	36/60	54/60
to15%/Total (%)	(78.30)	(60%)	(90%)
15%	13	24	6

The variation percentage shown in **Table 5** abovesuggests less than 15 % variation in value, in nearly 90% cases between capillary(C) versus plasma (P) samples, 60% cases in plasma(P) versus venous (V), while 78% in Capillary(C) versus venous(V) samples. All calculations were done with standard statistical computerised methods. In short, all the above results show following:

1. As blood glucose level rises in Group A, B & C; mean glucose level and standard deviation also rise.
2. The difference value trend in all groups doesn't follow any increasing or decreasing pattern.
3. The percentage variation value (X), (Y) & (Z) are compared. 78.3%, 60%, & 90% of subjects, respectively, are showing less than 15% variation difference in blood glucose value.

Discussion :

Blood glucose concentration estimation is based on three types of samplings. 1. Venous blood sampling estimated by laboratory autonalyser method. 2. Capillary blood glucose estimated by glucometer and 3. Venous sample estimated by glucometer. In this study, finger prick capillary mean blood glucose by glucometer is higher than venous plasma glucose estimation done in laboratory method by 9.63 mg/dL and variation percentage less than 15% between two samples is in 90% subjects. [5] It suggests that capillary blood glucose estimation may not be as reproducible as plasma glucose estimation.[6] As blood glucose level difference percentage rises with increase in value in glucose level, in more than 200mg/dl group, it leads to less accurate correlation at higher than 200mg/dl level. But even at higher level, 15% or less variation percentage was noted in 60 % subjects. So utilisation of finger prick method with glucometer estimation is a better alternative in cases with glucose levels up to 200mg/dl or less level of blood glucose and an acceptable alternative to venous blood glucose estimation above 200mg/dl glucose levels. Similar observations were noted in other studies also. [7, 8] The level of capillary blood glucose is comparable to arterial blood glucose level while venous plasma glucose level is the estimate glucose after utilization of glucose by tissues. The remaining amount returns to the venous side. So on lower side, change in concentration depends on tissue extraction of glucose. It is also depends on effects of insulin, glucagon, growth hormone and cortisone and also on demand of tissues and postprandial and pre-prandial status as well as the level of blood glucose.

The variation percentage increases as blood glucose level increases. The percentage change is explained by all these factors, but change is insignificant in clinical practice as blood glucose for diagnostic as well as monitering criteria is well under 200 mg/dl, i.e., Fasting Blood glucose is 126 mg/dL, while post- prandial blood glucose is 200mg/dl or more in the WHO

recommendations for the diagnosis of diabetes mellitus. The disadvantages of venous blood glucose estimation are many. 1. More painful than finger prick, 2. Expert phlebotomist required. 3. More punctures. 4. Counter puncture of vein and hematoma. 5. Long time consumed in laboratory process, nearly 3 hours. Finger prick estimation on the contrary has all the advantage 1. Spot result 2. Convenience and also acceptability for patient. 3. No loss of precious time in emergency management. Results of venous plasma glucose estimation by laboratory analyser and venous whole blood analysed by glucometer method showed marked variation in blood glucose levels with no definite pattern in the variation of results. Also to be noted, only 60% samples had less than 15% variation, because glucometer is calibrated for estimation of pinprick capillary blood glucose which shows digitalised display and it is equivalent to plasma glucose estimation. So venous blood or blood from other part of body may give irrelevant & wide variations by glucometer, when compared with venous plasma glucose. So in clinical practice, it is a significant variation in value of blood glucose from venous blood glucose estimated by glucometer. Hence, using present glucometer for venous blood glucose estimation is not recommonded. The same time estimation of capillary blood glucose from pinprick and venous blood glucose estimated by glucometer show less than 15% variation in readings in 78.3%. This suggests a good correlation in levels. So ante cubital vein sample can be significantly matched with the pinprick capillary samples, but results do not correspond with plasma glucose as the variation becomes wider and without any specific trend. This method is not recommended, except when the patient refuses for a second prick of finger pulp. [9]

Limitation of study: As the study includes 60 subjects only, a larger study is necessary for authentication of the findings. Although, larger studies also show same evaluation results. [10]

Conclusion :

Capillary blood glucose estimation by glucometer is a better alternative to venous plasma glucose estimation for diagnosis; follow up and in emergency conditions in diabetic and non diabetic patients. Venous blood glucose estimation by glucometer is not advisable as a routine method, but it is advocated when patient refuses for a second pin prick of finger pulp.

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