

ORIGINAL ARTICLE

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A comparative study between capillary and venous blood glucose levels of type 2 diabetes mellitus patients in intensive care units

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Abstract

Blood glucose estimation is required to be done rapidly or even on hourly basis for effective dosing of insulin in diabetic patients admitted in intensive care units (ICUs). Glucose test strip precision is usually considered clinically acceptable if the difference from the reference value (lab method) does not exceed 15%. With an aim to determine the correlation of capillary blood glucose versus venous blood glucose in hyperglycemic type 2 diabetes mellitus patients admitted in ICU, a study was conducted in a large tertiary care hospital. This study was a cross sectional, descriptive study which was carried out in a large tertiary care teaching hospital in Pune, from 01 Nov 2015 to 31 Oct 2016. After excluding all the confounding factors, 65 patients were included in this study. The laboratory results and glucose strip results were tabulated in a master chart as sample 1 (capillary/venous- time of admission), sample 2 (capillary /venous – 24 hrs), sample 3 (capillary /venous – 48 hrs) and also segregated into less than 250 mg/dl and more than 250 mg/dl for determining the correlation and agreement between the capillary and venous blood glucose levels. A good correlation existed between the CBG and VBG of sample 1 ($R^2 = 0.995$, $p < 0.05$), sample 2 ($R^2 = 0.986$, $p < 0.05$) and sample 3 ($R^2 = 0.988$, $p < 0.05$). Similarly a good correlation also existed between CBG and VBG at < 250 mg /dl and > 250 mg/dl which was ($R^2 = 0.943$, $p < 0.05$) and ($R^2 = 0.989$, $p < 0.05$) respectively. The capillary blood glucose values were always higher than the venous values and was within 10 -11%. The CBG and VBG levels agreed more than 95% times in all the samples. The capillary blood glucose estimation using a glucometer is a prudent alternative in ICU setting to venous blood glucose estimation by laboratory methods keeping in view that a 8-11% higher capillary blood glucose value exists. This should be taken into consideration while deciding on the insulin dosage for T2DM patients admitted in ICU who are on insulin infusion.

Keywords: Type 2 Diabetes mellitus, intensive care unit, capillary blood glucose, venous blood glucose, glucometer, correlation

Introduction

Increased mortality is observed in patients admitted in intensive care units (ICU's) with hyperglycemia [1,2]. Intensive insulin therapy, with strict glucose monitoring has shown to reduce mortality in Surgical Intensive Care Units (ICU's) [3]. In the recently concluded "The Normoglycemia in Intensive Care Evaluation and Surviving using Glucose Algorithm Regulation" (NICE-SUGAR) study it was shown that strict blood sugar levels were associated with hypoglycemia and levels between 140-180 mg/dl were feasible. Rapid and even one hourly blood glucose estimation is required to prescribe treatments and to make insulin dose adjustments in diabetic patients admitted with emergency complications like hyperosmolar state, diabetic ketoacidosis and hypoglycemia in the ICU. Measuring plasma glucose levels is time consuming and therefore, the use of glucometers is quicker, cheaper, and convenient [4,5].

Glucose measurement can be performed in arterial, capillary or venous blood samples. Laboratory assay on venous blood samples for measuring blood glucose levels is the reference method, regular monitoring is usually performed using reagent strips on capillary blood at the bedside, even during intensive insulin therapy [5]. Glucose test strip precision is usually considered clinically acceptable if the difference from the reference value (lab method) does not exceed 15% [6,7].

In certain situations, such as shock with peripheral hypoperfusion, hypotension, certain drugs (Acetaminophen, Ascorbic acid, Dopamine, Mannitol) and Low/High Haematocrit, values obtained may not accurately reflect serum glucose levels [4]. Average inaccuracies of only 5-6% are common in the best glucometers [8,9].

It is essential to compare the blood glucose levels obtained by capillary finger prick using a glucometer with the blood glucose levels obtained by a venous blood sample sent to the laboratory. Various studies have been conducted to estimate the correlation between capillary blood measurement by a finger prick method with a glucometer in comparison with measurement of venous

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blood sample with a standard laboratory method [4,7]. Although very few studies exist which compare the capillary blood glucose levels with venous blood glucose levels at different levels of blood glucose [5], no literature exists about the correlation between the two values at different levels of blood glucose in T2DM patients admitted in an ICU. If the capillary blood glucose overestimates the given values in the lower ranges it would lead to unnecessary increase in doses of insulin leading to hypoglycemia, therefore correlation at various levels of blood glucose may help in better management of patients.

This study aims at determining the correlation between capillary blood glucose (CBG) and venous blood glucose (VBG) at various levels of blood glucose, and also to find the agreement between the two, so that we can use of capillary blood glucose to manage Type 2 Diabetes Mellitus (T2DM) patients admitted in ICU with a more accurate range of Insulin dosing and prevent them from going into hypoglycemia. The data from this study will help in planning and formulating the management algorithms of glucose control with insulin.

Material and methods

This study was a cross sectional, descriptive study carried out in a large tertiary care teaching hospital, Pune, from 01 Nov 2015 to 31 Oct 2016. The hospital ethical committee approval was obtained prior to the initiation of study.

In our study only T2DM patients admitted in the ICU and whose stay was more than 48 hours were included. The patients who had these confounding factors i.e. hypotension, low perfusion index, coma, low/high haematocrit, anemia (males -Hb <13gm/dl, females-Hb<12gm/dl) and patients with prior medication with Acetaminophen, Ascorbic acid, Mannitol and Dopamine were excluded from the study.

During our study period a total 142 T2DM patients were admitted in the ICU. Out of these 82 patients were included in the study after excluding the confounding factors. Capillary and venous samples were drawn at admission for all these 82 patients. However 17 patients were shifted to general ward within 48 hours, hence were excluded from the study and we proceeded with the samples of the remaining 65 patients. Capillary blood sample from right ring finger and venous blood sample from right antecubital vein were taken simultaneously at the time of admission, 24 hours and 48 hours later. The capillary blood glucose levels were measured using One Touch Horizon Glucometer (Life Scan – Johnsons and Johnsons Co.) using strips by Glucose Oxidase Method.

The Venous blood samples were sent to Pathology lab for determination of blood glucose levels by fully automated analyzer (XL- 300) by Glucose Oxidase – Peroxidase method (GOD –POD) - Transasia – Erba. The laboratory results and glucose strip results were tabulated in a master chart as sample 1 (capillary/venous-time of admission), sample 2 (capillary /venous – 24 hrs), sample 3 (capillary/venous – 48 hrs) and also segregated into values less than 250 mg/dl and more than 250 mg/dl for determining the correlation and agreement between the two.

Statistical analysis

The results of all the patients were collected, documented and maintained. The data was compiled for analysis. Correlation between the capillary and venous blood glucose levels were drawn by Pearson's correlation analysis and agreement between the two blood glucose values were ascertained using Bland Altman's plot. Statistical Package for Social Sciences version 21 was used for data analysis (SPSS 21)

Results

In our study, table 1 represents the various demographic factors of the patients.

Table 1. Demographic Distribution

SEX	Number	Percentage
Male	44	68%
Female	21	32%
Total	65	
Age Wise Distribution Of Patients		
Age	Number	Percentage
≤60 yrs	42	65%
≥61 yrs	23	35%
Distribution According To Duration Of Dm-Type-II		
Duration	Number	Percentage
≤15 yrs	28	47%
≥16 yrs	37	53%
DDistribution According To Micro/Macro Vascular Complications		
Complication (Micro/Macro vascular)	Number	Percentage
Present	36	55%
Absent	29	45%
Distribution Of Patients According To Prior Medication		
Medication	Number	Percentage
Insulin	14	22%
OHAs	37	57%
Ayurvedic medicines	04	06%
No medication	10	15%

Around 68 percent patients were male, who were less than 60 years and 53 percent of patients were diabetic for more than 16 years. Micro/macrovacular complications were present in 58 percent, and only 22 percent patients were on prior insulin therapy. 57 percent patients were on oral antidiabetic medication and 15 percent of the patients were not on any medications. Table 2 represented the correlation between CBG and VBG at different time intervals and at different levels.

Figure 1, 2 and 3 represented correlation between CBG and VBG in sample 1, 2 and 3 drawn at the time of admission, 24 hours and 48 hours respectively.

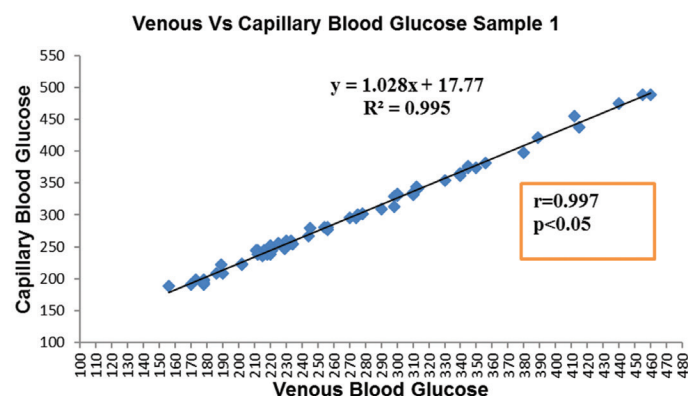


Figure 1. The Correlation Coefficient between Venous & Capillary Blood glucose (Sample 1) was $r=0.997, p<0.05$

All the three graphs showed a good correlation and a significant p value (< 0.05). Figure 4 and 5 represented correlation between CBG and VBG at < 250 mg /dl and > 250 mg /dl. These two graphs also showed a good correlation and a significant p value (< 0.50). Figure 6 and 7 depicted the agreement between the CBG and VBG at < 250 mg /dl and > 250 mg /dl.

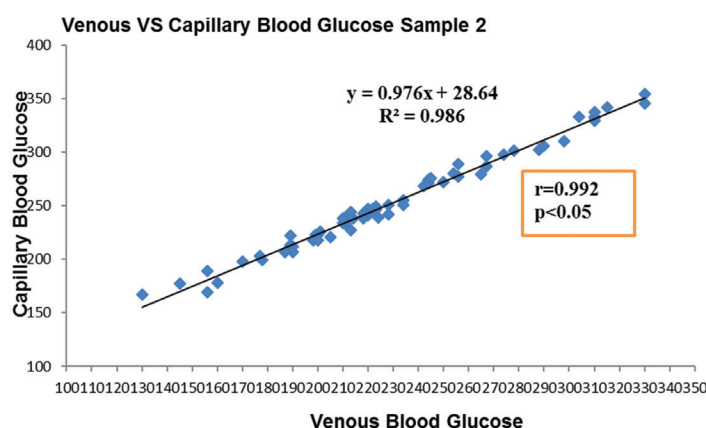


Figure 2. The Correlation Coefficient between Venous and Capillary Blood glucose(Sample 2) was $r=0.992, p<0.05$

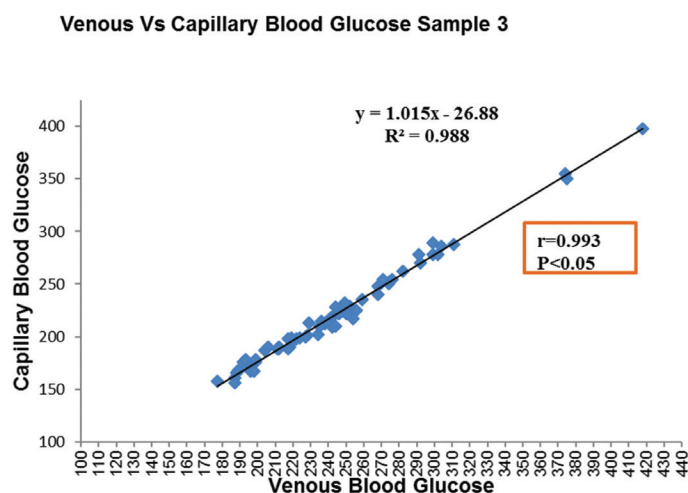


Figure 3. The Correlation Coefficient between Venous & Capillary Blood glucose (Sample 3) was $r=0.993, p<0.05$

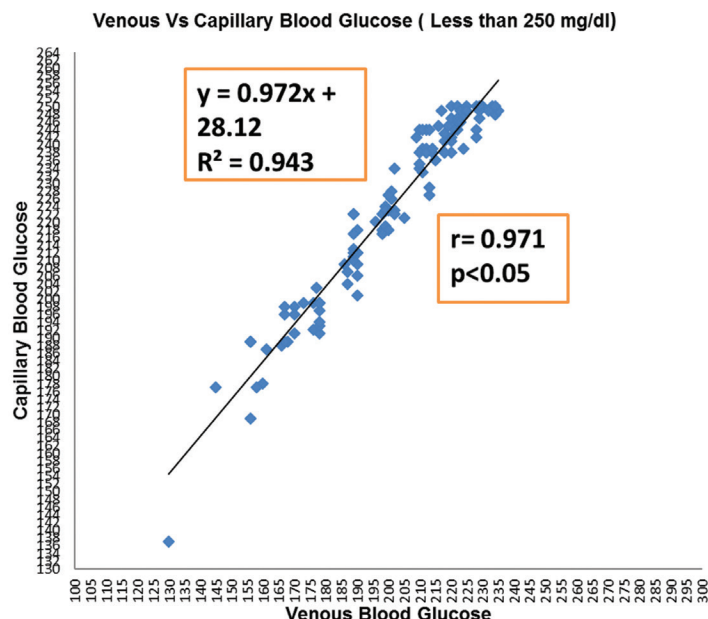


Figure4. The Correlation coefficient between Venous and Capillary blood glucose (< 250 mg /dl) was found to be $r=0.943, p<0.05$

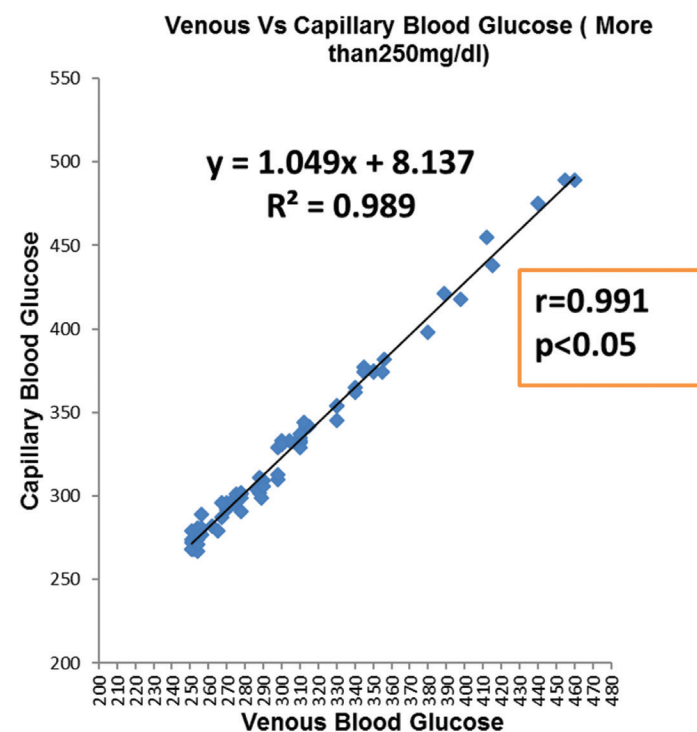


Figure 5. The Correlation Coefficient between Venous and Capillary Blood glucose (more than 250mg/dl) was $r=0.991, p<0.05$

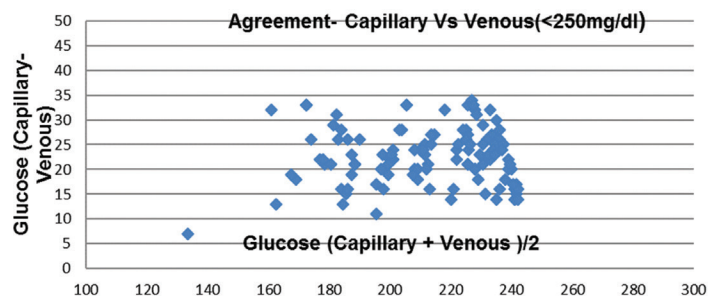


Figure 6. How often did the two tests agree with each other:
 • 98% times, it was within 35 mg of the Venous glucose (117) • Only 02 times of 100 capillary glucose was beyond clinically acceptable range of agreement.

Table 2. Correlation Between Capillary And Venous Blood Glucose Levels

Corelation Between Capillary And Venous Blood Glucose Level											
	MEAN		MD	PV	SD		95% CI		SE	R2/r/p value	95%CI between MD
	Capillary	Venous			Capillary	Venous	Capillary	Venous			
SAMPLE 1	294.23 mg/dl	268.91 mg/dl	25.32 mg/dl	9.91 %	76.24	73.99	294.23±18.53	268.91±17.99	13.17	0.995/0.997/<0.05	25.32±25.82(0.5-51.14)
SAMPLE 2	253.18 mg/dl	230.02 mg/dl	23.1 mg/dl	10.63%	45.00	46.77	253.18±10.94	230.02±11.73	9.33	0.986/0.992/<0.05	27.13±18.28(4.89– 41.45)
SAMPLE 3	243.7 mg/dl	220.66 mg/dl	23.06 mg/dl	10.97%	46.56	47.56	243.72±11.32	220.66±11.55	8.254	0.988/0.993/<0.05	23.06±16.17 (6.89-39.23)

Corelation Between Capillary And Venous Glucose At Different Levels											
Blood Glucose levels	MEAN		MD	PV	SD		95% CI		SE	R2/r/p value	95%CI between MD
	Capillary	Venous			Capillary	Venous	Capillary	Venous			
≤250 mg/dl	223.6 mg/dl	201.03 mg/dl	22.64 mg/dl	11.45%	23.51	23.48	223.67±4.22	201.03±4.22	3.04	0.943/0.971/<0.05	22.64±5.96(16.68-28.61)
≥ 251 mg/dl	324.79 mg/dl	301.61 mg/dl	23.18 mg/dl	8%	53.68	50.86	324.79±12.07	301.61±11.43	8.48	0.989/0.991/<0.05	23.18±16.62(6.56-39.8)

MD- Mean deviation, PV- Percentage Variation, SD- Standard Deviation, CI- Confidence Interval, p- Pearson's Correlation Coefficient in population, r- Pearson's Correlation Coefficient in sample, R2- Squared Pearson's Correlation Coefficient in sample

Discussion

As T2DM in ICU settings can lead to increased morbidity and mortality, it is prudent to maintain the blood sugar levels between 140 – 180 mg/dl according to the NICE- SUGAR study [10]. Due to the frequent requirement of assessing the blood glucose levels to initiate correct and judicious insulin therapy, the capillary finger prick method using a glucometer is essential in managing T2DM patients in the Medical/Surgical ICU. Therefore this study was focused in establishing a correlation between CBG and VBG and also establishing an agreement between the two. In our study, statistically significant ($p < 0.05$) difference was found between the capillary and venous blood glucose levels at the time of admission (sample 1), samples taken at 24 hrs (sample 2) and also at 48 hrs (sample 3) with a mean difference of 25.32 mg/ dl, 23.1 mg/ dl and 23.06 mg/ dl respectively. The correlation between the capillary and venous blood glucose of sample 1, 2 and 3 were corroborated with another study conducted under similar circumstances [7-9].

In this study, the capillary values were always higher than the venous values and was within 10 -11% of the venous values. A similar study conducted in Taiwan by Chiaohsin Yang et al revealed a variation of capillary and venous blood glucose of 4.8 % at admission to a maximum of 49.5% at 90 minutes .There was also a variation of 35% between capillary and venous blood glucose levels [11]. These results however did not collaborate with our results and also with most of the studies [1, 4]. Capillary and venous blood glucose levels were also segregated into less than 250 mg /dl and more than 250 mg /dl. 119 capillary and venous samples had blood sugar levels less than 250 mg/ dl and 76 samples had more than 250 mg /dl. The samples with blood sugar levels less than 250 mg/dl had a mean difference of 22.64 mg/dl , percentage variation of 11.45 percent , standard error of 3.04, $R^2 = 0.943$, $p < 0.05$. The samples with more than 250 mg/dl

had a mean difference of 23.18 mg/dl , percentage variation of 8% , standard error 8.48, $R^2 = 0.989$, $p < 0.05$. Both the levels showed a significant p value (< 0.05). A study by Patel N et al compared capillary and venous blood glucose levels taken from patients on outpatient department basis irrespective of their diabetic or nondiabetic status and compared their values at less than 100 mg/dl, between 100 – 200mg/dl and greater than 200 mg/dl. The capillary blood glucose levels by glucometer were 7% to 15% higher than the venous blood glucose levels by lab and also agreed more than 95 % times [5]. These findings corroborated with our study. Previous studies have studied the correlation between CBG and VBG, but none have studied the correlation between the two at various levels of blood glucose in T2DM patients admitted in ICU. ISO guideline 15197 suggests that for glucose levels below 75 mg/dl, a meter should read within 15 mg/dl of the reference sample, and for levels above 75 mg/dl, the reading should be within 20% [12,13]. It is extremely confusing that for different levels of blood glucose whether we should take 20% variation as an excepted value, for eg. for blood glucose levels < 100 mg/dl , a reading of 80 mg /dl can be taken into consideration , but for a blood glucose level > 500 mg/dl a value of 400mg/dl or 600 mg/dl, as an acceptable value is really debatable. Our study demonstrated that a good correlation exist between the two, at < 250 mg /dl ($R^2 = 0.943$, $p < 0.05$) and at > 250 mg /dl ($R^2 = 0.989$, $p < 0.05$). In our study on an average the capillary blood glucose level was 11% higher than venous blood sugar levels in samples < 250 mg / dl and 8 % higher in samples > 250 mg /dl.

It was also shown that 95% of all measured values should fall within 20% of glucose values above 75 mg/dl and within 15 mg of glucose values below 75 mg/dl according to the ISO guidelines. [8, 13] Keeping this as the baseline we aimed to find the agreement between the CBG and VBG of sample 1, 2 and 3 and to also at different levels of blood glucose i.e. < 250 mg/ dl and > 250 mg/

dl. In our study, the CBG and VBG of sample 1, 2 and 3 agreed more than 95% times within 11% of the venous blood glucose level. On an average the capillary blood glucose level was 9.91% higher than venous blood sugar levels in sample 1, 10.63% in sample 2 and 10.97% in sample 3. Agreement between CBG and VBG at different levels of blood glucose was also found to be 95% times within 11% of venous blood glucose. Good correlation exists in the blood glucose results analyzed between capillary and venous blood glucose in the setting of ICU, provided patient related factors e.g. hypotension, haematocrit are normal. This correlation extends across various levels of blood glucose. Capillary blood glucose, measured with a glucometer which is much easier and quicker, can be used to manage Type 2 DM patients admitted in ICU with a more accurate range of insulin dosing (considering a 8 - 11% higher value than venous samples measured by lab method) and prevent them from going into hypoglycemia. In this study the exclusion criteria limited the study to only those patients admitted to ICU in whom other patient related factors were controlled. The strength of correlation of blood glucose at various levels can be determined only when one does a multiple-regression on patients without controlling other patient related factors. Small sample size of this study is a great limiting factor. Any delay in processing or transportation of venous samples can decrease glucose levels by 5 -7% / h [5]. Venous Blood Sample were immediately sent to the lab, but exact time from collection of the sample to processing was not ascertained due to the heavy workload of the hospital laboratory. A particular brand of glucometer was used which was calibrated, calibration of glucometer is vital before results can be generalized.

Conclusion

Our study strongly support that in T2DM patients admitted in ICU we should use finger prick method using glucometer to measure blood glucose levels, if all the confounding factors which impede with the measurement of blood glucose are taken into consideration. A 8 -11% higher value exist between the capillary prick method and the venous blood glucose measured in the laboratory, which should be taken into consideration while deciding on the insulin dosage for patients who are on insulin infusion, so that the patients does not go into hypoglycemia.

Competing interests

The authors declare that they have no competing interest.

Financial Disclosure

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