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Level of Accuracy of Capillary Blood Glucose by Glucometer in Comparison to Standard Venous Blood Glucose by Analyzer.

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Abstract

The accuracy of blood glucose estimation using capillary blood with glucometers has been questioned. This study was done to determine the mean difference and correlation between capillary blood glucose estimation with glucometer in comparison to laboratory blood glucose analysis by analyzer in outdoor patients. Blood glucose levels were synchronously analyzed using a glucometer on capillary blood and in venous sample using a laboratory based multichannel analyzer. Mean difference and correlation coefficients were determined. A total of 126 subjects (aged 13-88 years) were enrolled, with 100% data capture. The mean laboratory glucose was 7.8 mmol/l. The mean capillary blood glucose was 8.54 mmol/l (mean difference compared with mean laboratory glucose 0.7 mmol/l; 95% confidence interval 0.3 to 0.9). The mean venous derived blood glucometer glucose was 7.14 mmol/l (mean difference compared with mean laboratory glucose 0.66 mmol/l; 95% CI 0.6 to 1.2). The correlation coefficient for the laboratory blood glucose versus the capillary blood glucometer glucose was 0.99 mmol/l ($p<0.001$). The correlation coefficient for the laboratory blood glucose and the venous blood glucometer glucose was 0.97 ($p<0.001$). Variation occurred between the glucometer and the laboratory blood glucose results. So it was concluded that there is a significant difference in the blood glucose results analyzed on a bedside glucometer when the samples are taken from capillary blood and laboratory analyzer when samples are taken from venous blood. Although good correlation is the norm between venous and capillary derived samples, caution must be exercised in accepting the results as equivalent or using either as substitutes for a laboratory blood glucose result.

Key words: Capillary blood glucose, venous blood glucose.

Introduction

Blood sugar estimation is a commonly performed practice in the diabetic as well as non-diabetic patients. Handheld blood glucose meters are easily available, simple & cost effective way to check blood sugar in general population. It is commonly used for home monitoring of blood glucose in diabetic patients as well as to screen diabetes in people not known to be diabetic. But the accuracy of blood glucose estimation using venous derived blood with glucometers designed for capillary sample testing has been questioned.[1] In addition, concern has also been raised about the accuracy of capillary blood glucose estimation in the face of systemic illness, and it has been suggested that in such patients, venous sampling may be more accurate.[2] The aim of this study was to determine the mean differences and correlation of capillary and venous bedside glucose estimation in comparison with laboratory blood glucose analysis.

Materials and Methods

Approval was gained from the relevant hospital medical ethics committee. Patients aged >13 years attending the outpatient department, were eligible for inclusion in the study. All subjects were required to give written consent. Patients were approached for inclusion using a random pattern sample. This sampling method used sequential patients presenting to OPD.

After written consent was obtained, 5 ml of venous blood were withdrawn & sample was sent to the clinical biochemistry laboratory in a lithium heparin tube for whole blood glucose estimation

using a Multichannel Analyzer (Spectra 400, Anatron, Germany). A bedside glucometer analysis was performed simultaneously by capillary finger prick. The bedside blood glucose estimation was performed with a Glucometer (Glucolab, infopia, Korea) by an accredited registered laboratory technician. A single glucometer calibrated and validated following the manufacturer's guidelines was used for all subjects enrolled in the study.[4] All capillary & venous glucose estimations were recorded on a standardized data sheet.

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software (version 20.0). The mean value for the two groups, the mean difference between groups, and the 95% confidence intervals were determined. Student's t test was used to measure the statistical significance of the mean differences, and Pearson's correlation coefficient was used to determine the degree of correlation of the capillary glucose and venous glucose with the laboratory glucose result. As the procedure removes most of the variation between subjects and leaves the measurement error, it is expected that the differences will be normally distributed. When there is a high level of agreement, the mean difference will be close to zero, and the confidence intervals for the difference will be narrow.[5] A power calculation was performed to estimate the required sample size.

Results

There were 126 patients enrolled in the study. No patient declined to participate in the study, and there was complete data capture. There was a male: female ratio of 2:3, and the mean age (+SD) of the subjects was 40.4 (+16.8) years. The mean laboratory blood glucose (+SD) was 7.8 (+3.1) mmol/l, and the mean capillary blood glucose (+SD) was 8.54 (+3.9) mmol/l, giving a statistically significant difference ($p<0.001$) between the mean values for the laboratory and capillary glucose samples (0.6 mmol/l; 95% confidence interval (CI) 0.3 to 0.9). The mean venous derived blood glucose (+SD) was 7.14 (+3.5) mmol/l. There was a statistically significant difference ($p<0.001$) between the mean values for the laboratory and venous derived glucometer tested blood glucose (0.66 mmol/l; 95% CI 0.6 to 1.2). The mean differences (+SD) between capillary blood glucose (by glucometer) & venous blood glucose (by multichannel analyzer) was 1.39 (+1.2) mmol/l.

Table I: Age distribution of the study patients (n=126)

Age in years	Number of patients	Percentage
≤20	10	7.9
21-40	40	31.6
41-60	67	53.1
>60	9	7.1

Table II: Sex distribution of the study patients (n=126)

Sex	Number of patients	Percentage
Male	52	41.2
Female	76	60.3

Table III: Capillary vs Venous glucose comparison (n=126)

Patients	Venous blood glucose (Mean ± SD)	Capillary blood glucose (Mean ± SD)	Average difference
Non-diabetic	5.85 ± 1.08	7.08 ± 1.44	1.29 ± 1.06
Diabetic	13.39 ±4.5	14.16 ± 4.67	1.91 ± 1.69
All (Diabetic+ Nondiabetic)	7.14 ±3.55	8.54 ± 3.9	1.39 ± 1.20

Discussion

Use of blood glucose estimation using glucometer designed for capillary blood samples enables rapid treatment decisions during emergency treatment. The procedure has the advantages of: not requiring a venepuncture, thereby minimizing patient discomfort; decreasing the risks to staff from additional needlestick exposures.[6] It is important, however, that the venous blood glucose measurement is accurate to avoid failure to treat underlying hypoglycaemia or placing the patient at risk for potential neurological complications from the administration of 50% dextrose for erroneous hypoglycaemia in the presence of cerebral ischaemia and cardiac arrest.[7]

There is confusing evidence in the current literature as to whether capillary or venous blood glucose measurements are more accurate. In one study of healthy volunteers, it was concluded that there was a poor correlation between capillary and venous blood glucose estimations using glucometers designed for capillary samples.1 However, the study did not use a laboratory blood glucose measurement or consider the potential interaction of acute illness on blood sugar estimation. Two studies of critically ill patients found that the venous derived bedside glucose estimations were more accurate than capillary derived samples.[8,9]

A statistically significant difference did occur between the capillary and venous bedside blood glucose estimates but such a difference (1.1 mmol/l) may not be clinically significant in routine practice. This supports the view that venous derived bedside glucometer blood glucose measurements may be used in place of capillary derived specimens 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.

There are a number of limitations to the study. The number of patients included in the study was comparatively small, but was guided by a power study. The study was limited to non-critically ill patients and included no hypoglycaemic patients. Only twelve cases of hyperglycaemia were included. The narrow range of blood glucose levels present in the subjects enrolled in the study and the wide range of presenting conditions meant that subgroup analysis could not be performed meaningfully. It is therefore not possible to make conclusions about the accuracy of venous derived blood glucometer estimates in the presence of severe illness or blood glucose levels outside the normal range. Further study will be required to determine the accuracy of blood glucometer analysis in these situations.

Conclusion

Venous glucose estimation can be used with some degree of confidence in the mid ranges of blood glucose measurements as it correlates well with both capillary derived blood glucometer estimations and laboratory blood glucose estimations. However, significant outlying results can do occur, although their true clinical relevance is as yet undetermined. It is recommended that laboratory blood glucose should still be performed if the venous bedside estimation is at the extremes of the glucose range or the results are likely to significantly influence clinical management.

Competing interests

None declared.

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