

ORIGINAL ARTICLE

Capillary versus venous bedside blood glucose estimations

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Objectives: To determine the mean difference and correlation between capillary and venous bedside glucose estimation in comparison to laboratory blood glucose analysis in emergency department (ED) patients.

Methods: Blood glucose levels were synchronously analysed using a bedside blood glucometer on capillary and venous derived samples from consenting ED patients aged >12 years. The venous sample was sent for comparative testing using a laboratory based multichannel analyser. Mean difference and correlation coefficients were determined.

Results: A total of 20 subjects (aged 13–88 years) were enrolled, with 100% data capture. The mean laboratory glucose was 7.075 mmol/l. The mean capillary blood glucose was 7.66 mmol/l (mean difference compared with mean laboratory glucose 0.58 mmol/l; 95% confidence interval 0.3 to 0.9). The mean venous derived blood glucometer glucose was 7.99 mmol/l (mean difference compared with mean laboratory glucose 0.91 mmol/l; 95% CI 0.6 to 1.2). The correlation coefficient for the laboratory blood glucose versus the capillary blood glucometer glucose was 0.97 mmol/l ($p < 0.001$). The correlation coefficient for the laboratory blood glucose and the venous blood glucometer glucose was 0.96 ($p < 0.001$). Variation occurred between the glucometer and the laboratory blood glucose results.

Conclusions: There is a small but significant difference in the blood glucose results analysed on a bedside glucometer when the samples are taken from capillary or venous sources. 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.

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Blood sugar estimation is a commonly performed practice in the reception phase of emergency department (ED) care. It is used to gain information on patients with symptoms suspected to be caused by hypoglycaemic or hyperglycaemic conditions, facilitating management decisions in acutely ill patients.

Testing has traditionally been performed using capillary blood samples taken by finger prick testing. With the implementation of advanced paramedic training and the widespread use of extended nursing practice, patients often undergo early intravenous cannula insertion. This has enabled venous samples to be more readily available for bedside blood glucose testing during the immediate reception phase of care, removing the need for finger prick sampling.

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 in ED patients.

METHODS

Approval was gained from the relevant hospital medical ethics committee. Patients aged >12 years attending the emergency department, who were triaged using the National Triage Guidelines³ to categories 2–4 and required the insertion of an intravenous (IV) cannula, were eligible for inclusion in the study. All subjects were required to give written consent. Category 1 patients were excluded, as the consent procedure could have led to a clinically significant delay in their medical care. Patients were approached for inclusion using a random pattern sample. This sampling

method used sequential patients presenting to the ED over a random pattern of shifts in order to allow a complete spectrum of patient presentations to be included.

After written consent was obtained, a peripheral IV cannula was inserted, through which 10 ml of venous blood were withdrawn and two samples taken from this. A bedside glucometer analysis was performed on one sample, and the second sample was sent to the clinical biochemistry laboratory in a lithium heparin tube for whole blood glucose estimation using a Dade-Behring Multichannel Analyzer (Dade-Behring, USA). A simultaneous capillary finger prick was performed, which was also analysed using the bedside glucometer. The bedside blood glucose estimation was performed with a Medisense Precision Plus Glucometer (Abbott Laboratories) by an accredited registered nurse. A single glucometer calibrated and validated following the manufacturer's guidelines was used for all subjects enrolled in the study.⁴ All capillary, bedside venous, and laboratory glucose estimations were recorded on a standardised data sheet.

Statistical analysis

Statistical analysis was performed using Stata statistical software (version 6.0, 1999; StataCorp, College Station, TX, USA). The mean value for the three 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. A Bland and Altman plot was used to plot the mean difference between venous derived glucometer tested and laboratory blood glucose against the mean blood glucose level. This plot provides a graphical

Abbreviations: ED, emergency department; IV, intravenous

comparison of the level of agreement between two methods of assessment, by plotting the difference between the two measurements versus the mean for each subject. 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. This calculation used an α of 0.05 and a β of 0.1, and suggested that 16 patients would be required to detect a 1 mmol/l difference in means between the formal laboratory analysed blood glucose and the glucometer tested capillary blood glucose.

RESULTS

There were 20 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 11:9, and the mean age of the subjects was 56.9 years (range 13–88 years). Five (25%) subjects were triaged to category 2, 11 (55%) subjects to category 3, and four (20%) to category 4.

The mean laboratory blood glucose was 7.075 mmol/l, and the mean capillary blood glucose was 7.66 mmol/l, giving a statistically significant difference ($p < 0.001$) between the mean values for the laboratory and capillary glucose samples (0.58 mmol/l; 95% confidence interval (CI) 0.3 to 0.9).

The mean venous derived glucometer blood glucose was 7.99 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 (0.91 mmol/l; 95% CI 0.6 to 1.2).

There was a 0.33 mmol/l difference (95% CI 0.0004 to 0.6) between the capillary and venous derived glucometer tested samples. This was again statistically significant ($p < 0.05$).

Fig 1 shows a scatter graph detailing the correlation between (A) laboratory and bedside capillary derived blood glucometer samples ($r = 0.97$; $p < 0.001$), and (B) laboratory and venous derived blood glucometer measurements ($r = 0.96$; $p < 0.001$).

Fig 2 shows a Bland and Altman plot demonstrating the differences in blood glucose between venous and laboratory blood glucose samples versus mean blood glucose level. The mean difference shown is 1 mmol (95% CI 0.62 to 1.39). This suggests that appreciable differences do occur between the venous glucometer and laboratory blood sugar levels despite good correlation.

DISCUSSION

Use of venous derived blood glucose estimation using glucometers designed for capillary blood samples enables rapid treatment decisions during the reception phase of ED treatment. The procedure has the advantages of: not requiring a capillary specimen, thereby minimising patient discomfort; decreasing the risks to staff from additional needlestick exposures; and reducing the risk of factitious hyperglycaemia from finger pulp glucose contamination.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 tested on blood glucometers 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}

The aim of the present study was to test the accuracy of bedside venous derived blood glucometer results using glucometers designed for capillary samples in the broad spectrum of non-critical illness that represents the majority of ED patients.

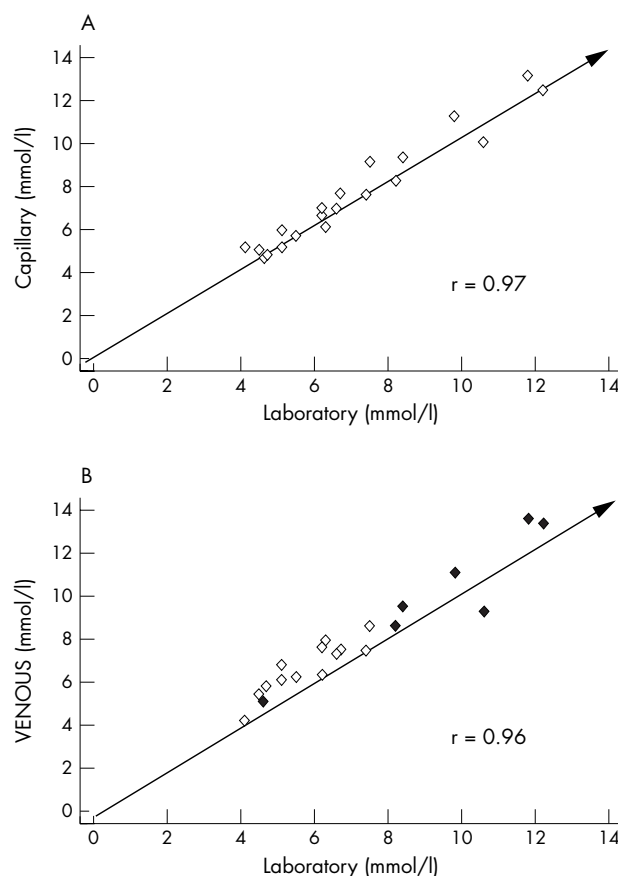


Figure 1 Correlation: laboratory and capillary blood glucose values (A) and laboratory and venous blood glucose values (B).

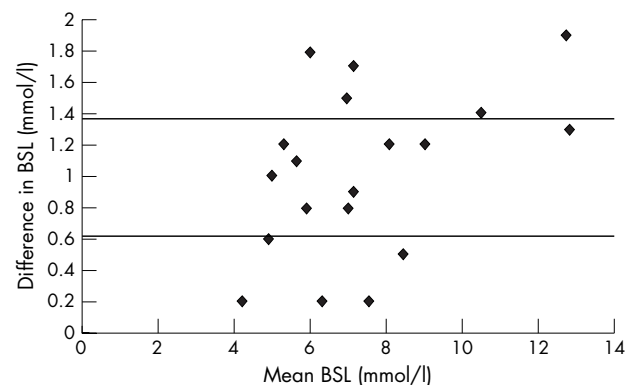


Figure 2 Bland and Altman plot: venous and laboratory BSL. Mean and 95% CI of the difference.

A statistically 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 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. In our study, 10 of the mean differences in blood sugar levels on the Bland Altman plot (fig 2) were outside the 95% confidence intervals. As significant outliers are not infrequent, it is advisable that where the blood glucometer result is borderline or likely to significantly alter clinical management, a laboratory blood glucose measurement is required.

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. In this study, no patient had an abnormal capillary glucometer result with a normal range laboratory glucose result. The study was not engineered to have sufficient power to determine this, but rather, was designed to detect a 1 mmol/l difference, which may or may not be clinically truly relevant. The study was limited to non-critically ill patients and included no hypoglycaemic patients. Only three mild 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 bedside 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 and do occur, although their true clinical relevance is as yet undetermined. It is recommended that a 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.

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