

Association of Black Academic Surgeons

Tale of two sites: capillary versus arterial blood glucose testing in the operating room

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Abstract

INTRODUCTION: Pre- and intraoperative glycemic control has been identified as a putative target to improve outcomes of surgical patients. Glycemic control requires frequent monitoring of blood glucose levels with appropriate adjustments. However, monitoring standards have been called into question, especially in cases in which capillary samples are used. Point-of-care testing (POCT) using capillary samples and glucometers has been noted to give relatively accurate results for critically ill patients. However, the package inserts of most glucometers warn that they should not be used for patients in shock. This has led clinicians to doubt their accuracy in the operating room. The accuracy of capillary samples when tested in patients undergoing surgical procedures has not been proven. This study aims to determine the accuracy of intraoperative blood glucose values using capillary samples relative to arterial samples.

METHODS: A prospective study was conducted by collecting paired capillary and arterial samples of patients undergoing major operations at a tertiary medical center from August 2009 to May 2011. Subjects were a convenience sample of patients who had arterial lines and needed glucose testing while undergoing the procedure. Precision Xceed Pro (Abbott) handheld glucometers were used to obtain the blood glucose values. Our primary outcome of interest was the degree of correlation between capillary and arterial blood glucose values or the degree to which arterial glucose levels can be predicted by capillary glucose samples. We used linear regression and the Student *t* tests for statistical analyses.

RESULTS: Seventy-two-paired samples were collected. Of the cases, 54% were major abdominal operations, whereas 24% were vascular operations. The mean values \pm standard deviation for glucose levels were 146 ± 35 mg/dL (capillary) and 147 ± 36 mg/dL (arterial). The mean time \pm standard deviation between the collection of both samples was 3.5 ± 1.3 minutes. The regression coefficient showed a strong positive correlation of .91 between capillary glucose values and arterial values ($P < .001$) although correlation was less stringent at the hyperglycemic range of values. The R^2 statistic was 84%. Differences in values between capillary and arterial samples would not have altered the diagnosis of hypo- and hyperglycemia using typical thresholds.

CONCLUSIONS: Capillary samples collected intraoperatively are strongly correlated with arterial samples. Glucose monitoring in the operating room can be safely performed by collecting capillary samples for POCT. However, clinicians should still be cautious when interpreting glucose levels that are high, either by repeating the blood glucose test or by having samples sent to the laboratory.

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Point-of-care testing (POCT) of capillary samples for blood glucose levels is simple and convenient and can be performed repeatedly with minimal morbidity but has a relatively wide range of accuracy. Conversely, arterial samples may be considered more accurate and closer to a diagnostic standard, but the process of obtaining a sample is more difficult. The choice of one or the other site for blood glucose testing requires the consideration of risks and benefits of both sites.

The importance of monitoring is related to the burden of diabetes mellitus (DM) and hyperglycemia.^{1,2} In 2008, 25.8 million people were living with diabetes in the United States, which represents about 8% of the population.³⁻⁵ Elevated blood glucose has been found to be associated with attributable morbidity and mortality in patients undergoing surgical procedures.⁶⁻⁹ Diabetic patients have an increased hospital length of stay, use more hospital resources, and are more likely to experience adverse clinical outcomes and mortality.⁶⁻¹⁰ Adverse outcomes are not limited to only diabetic patients because those with preoperative and postoperative hyperglycemia are also more likely to develop postoperative complications. Recent randomized controlled trials have shown that inpatient control of hyperglycemia improves clinical outcomes in general surgical patients in the nonintensive care unit setting.¹¹ Identifying and treating hyperglycemia while a patient is still undergoing surgery may lead to more prompt glycemic control during subsequent hospitalization. To do this requires regular glucose monitoring in the operating room (OR).

Regular glucose monitoring in the OR can be performed with POCT of capillary samples using glucometers or by sending arterial or venous samples to the laboratory. Obtaining a laboratory sample requires phlebotomy or an arterial line in place. However, for most surgical patients, phlebotomy or arterial access is not routine. A patient who requires regular glucose levels is more likely to have a capillary glucose test performed (if a test is performed at all) because of the lack of easy access to phlebotomy and the requirement for rapid turnaround of results to influence treatment decisions.

Questions have been raised about the accuracy of glucometers compared with values from the laboratory in critically ill medical patients. Additional questions have been raised about the possible differences between capillary and arterial or venous samples. The package inserts of most glucometers warn that they should not be used on patients in shock. This concern in critically ill patients has led many clinicians to doubt the accuracy of glucometers in the operating room. Such concerns contribute to the underuse of POCT of glucose levels in intraoperative patients. To date, there are limited data regarding the accuracy of capillary sample testing in the OR. The primary aim of this study was to determine the accuracy of intraoperative capillary glucose values relative to arterial samples.

Methods

Study design

We performed a prospective observational study of 72 surgical patients who had paired capillary and arterial blood glucose values at the Brigham and Women's Hospital, a tertiary care hospital with 755 beds. We enrolled patients over a 22-month period with prior approval from the Human Subjects Office at our Institutional Review Board. We conducted this study by collecting blood glucose samples (capillary and arterial) on a convenience sample of patients who were undergoing major surgery at our tertiary medical center from August 2009 to May 2011. For inclusion in the study, patients had to be undergoing a major surgery, be older than 18 years of age, have an arterial line in place, and have fingers extended in such a way that they could be easily reached for capillary testing. Patients were not excluded based on dehydration, shock, or abnormal hematocrit levels.

Study protocol and analysis

After skin incision, capillary (finger stick) and arterial samples were obtained and tested using the Precision Xceed Pro point-of-care glucometers (Abbott, Abbott Park, IL).¹² Our primary outcome of interest was the degree of correlation between capillary and arterial blood glucose values using linear regression. We also examined the R^2 statistic, which describes the proportion of the variability among observed values of capillary samples that could be explained by arterial values. We used a Bland-Altman plot of the difference between capillary and arterial blood glucose levels against the mean blood glucose level of each patient. This shows the level of agreement between blood glucose levels of both sites. Most of the variation between patients is removed, thus leaving just the measurement error. Differences between the mean glucose values for the 2 samples were evaluated using the Student 2-sided t test. Descriptive statistics were used to estimate diagnostic accuracy using capillary test results and common clinical thresholds (glucose <70 mg/dL for hypoglycemia and glucose >180 mg/dL for hyperglycemia). Statistical analyses were performed using Stata statistical software (version 11; Stata-Corp, College Station, TX).

Results

Seventy-two paired samples were collected. The mean time \pm standard deviation between the collection of capillary and arterial samples was 3.5 ± 1.3 minutes. Demographically, 60% of subjects were men; the mean age was 62 years (range 18–88 years). Approximately 43% of patients had a prior history of diabetes mellitus (Table 1). Four fifths of the operations performed were either general or vascular procedures. The most common general surgical

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