Title: Accuracy of the Dexcom G6 continuous glucose monitoring system following cardiac surgery

Investigators

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Background

Maintaining tight blood glucose control following surgery is imperative to reducing infections and neurologic dysfunction. This requires frequent blood sampling while in the intensive care unit, leading to increased waste of blood and utilizing time and resources to collect samples and wait for results. Additionally, when on the regular floors, frequent point of care fingersticks for glucose levels are needed for therapeutic intervention.

Continuous glucose monitoring systems (CGMS) are now available for ambulatory use in patients with diabetes. The potential of using such a system in the hospital, including during the postoperative critical care setting and upon transfer to the regular floor, may reduce personnel burden, produce rapid results, and decrease blood waste.

However, these systems have not yet been validated for hospital use.

Objectives

To assess the accuracy of the continuous glucose monitor Dexcom G6 (or similar device) on patients with hyperglycemia, with or without known diagnosis of diabetes, after cardiovascular surgery.

To calculate potential cost savings, time savings, and blood waste compared to current care (point of care glucose through blood gas)

Methods
All patients following cardio-thoracic surgery are required to have tight control of blood glucose, thus requiring multiple blood draws as part of the Surgical Care Improvement Project (SCIP).
Patients
Patients will be identified and consented preoperatively

Inclusion criteria for consenting patients:
Age 18 years old and above
Planned Cardiovascular surgery
Planned admission to Cleveland Clinic Main Campus J5 or J6 or Q5 cardiovascular ICU (CVICU) post-operatively
With or without known diabetes (as 75% of patients entering the CVICU have hyperglycemia requiring intravenous insulin infusion)
If with known diagnosis of diabetes, diabetes can be type 1, type 2, or secondary (such as due to glucocorticoids or pancreatitis

Exclusion criteria:
Allergy to the material of the CGMS or the adhesive to be used
Skin conditions precluding the use of the CGMS
Pregnancy
Other conditions that the investigators deem inappropriate for the study

Consent:
Consent will be performed pre-operatively at the TCI (To Come In) unit.

Procedure:
Dexcom G6 has a sensor (see photo below) that goes underneath the skin to sense interstitial glucose.
It is attached to a transmitter.
The third component is a receiver. The receiver has to be within 10-15 feet from the patient. We will place this in a well-marked pouch/bag.
In the photo below, the purple is the sensor and the gray oval on top of it is the transmitter. The sensor is inserted first, then the transmitter is attached to it.

The sensor/transmitter will be applied pre-operatively in the preop holding area or in the operating room (before anesthesia induction) to the upper outer arm by a physician, nurse, nurse practitioner or physician's assistant. The insertion area can be cleaned with alcohol of betadine.

The glucose readings on the device will not be visible to the ICU/regular floor staff nor the patients.
At the end of 10 days or upon discharge from the hospital, which ever comes first, the sensor/transmitter will be removed.

Time-stamped data from the CGMS software will be compared with the correlated ABG or venous of Accu-check Inform II glucose reading

The data transmission occurs via Blue-Tooth from sensor to the receiver.

The data have do be downloaded within 2 weeks.

The sensor has an adhesive so that it can stick to the skin. Skin Tac can be used to increase the adhesion to the skin. An adhesive overpatch specifically coming from/approved by Dexcom can be used over the sensor as needed to increase adhesion. NOTE: OpSite or Tegaderm CANNOT be used over the sensor as this will decrease reliability.

Sanitation
We requested for enough sensors and transmitters for 30 patients.
Should the transmitters fall short for some reason, they can be cleansed with bleach or alcohol

The sensors can only be used for one person each.
The receivers will come with sterile shields which wil be changed in-between patients.

Safety:
The CGMS will be inserted on the outer arm after the site is cleaned. The insertion site will be inspected daily for signs of infection, or of allergy from the sensor, adhesive, or overpatch.

Study Design
This is a prospective longitudinal study to study the agreement between a novel continuous glucose monitoring system (CGMS) versus current blood glucose monitoring.
Subjects in this study will have their blood glucose measured regularly every 1-3 hours with current methods in the CVICU, and by point of care glucose using the Accuchek Inform II on the regular floors, and the CGMS at the same time will be captured. Subjects will have measurements taken throughout their stay in the CVICU and on the regular floors. Agreement and correlation between systems will be calculated, and error will be classified using the Surveillance Error grid. The proportion of errors of at least moderate risk will be calculated.

Subject compensation
There is no subject compensation for this study.

Statistical Methods
Subject characteristics including demographics, comorbidities and baseline disease severity will be summarized using means and standard deviations for continuous measures and frequencies and percentages for categorical factors. To evaluate agreement between methods, concordance correlation coefficients will be calculated, using the method that adjusts for repeated measures as described by King et al. (2007) and implemented in software by Carrasco et al. (2013). Analysis will be performed overall, and then stratifying by type of current measure, if the type of measurement varies across settings. Correlations will be calculated using the methods described by Bland and Altman (1995) and implemented by Bakdash and Marusich (2017). Differences will also be evaluated for errors according to the Surveillance Error Grid (Klonoff et al, 2014). Rates of moderate or more severe errors will be calculated. For each measure above, 95% confidence intervals will be calculated, accounting for the clustering within subject.. Analyses will be performed using SAS software (version 9.4; Cary, NC) and R software (version 3.5; Vienna Austria).

Sample Size
Sample size calculations were performed based on the precision of the moderate error rate as based on the surveillance error grid calculations. Given the goal to estimate the error rate to within 5% based on 95% confidence intervals, assuming 10 samples per patient and a moderate intraclass correlation coefficient (ICC) of 0.3, if the observed error rate is 5%, then 28 subjects (at least 271 paired samples) will be required to achieve this level of precision. Note that if you wish to estimate these levels with this precision for subgroups of your population, each subgroup will need to have this many subjects. Table 1 shows the number of samples required for different levels of precision and error rates under similar assumptions. Sample size calculations were performed using the online calculator by Dhand, N. K., & Khatkar, M. S. (2014).

Table 1. Samples required to achieve precision as described assuming 95% confidence, an ICC of 0.3, and 10 paired samples per subject. Number is subjects would be the number below divided by 10.

	Absolute precision							
Error Rate	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**	**0.10**
20%	2527	1422	910	632	465	356	281	228
15%	2014	1133	725	504	370	284	224	182
10%	1422	800	512	356	262	200	158	128
5%	751	422	**271**	188	138	106	84	68

Primary outcome:
To address accuracy, glucose readings obtained from the CGMS will be compared with

1) blood glucose from the arterial blood gas (ABG) or peripheral/central venous catheter if arterial catheter not in use (standard of care in CVICU) while patients are in the CVICU
2) fingerstick point of care (POC) glucose when patients are on the regular floors

Other outcomes:
The following can be derived based on the average length of stay (LOS) of the study patients in the CVICU and the regular floors (current average of 24-36 hours, and a total hospital LOS of 4-5 days)

Cost savings: cost of CGMS device including sensor, transmitter versus cost of doing an ABG to obtain glucose levels (CVICU stay), and versus the cost of Accu-chek Inform II meter, test strips, and lancets

Time savings: time it takes to perform and time it takes to have results based on an ABG or fingerstick POC on Accu-check Inform II

Blood waste: blood sample amount for an ABG or fingerstick POC on Accu-chek Inform II

Variables:
Age
Gender
Race
Weight
Height
BMI
Systolic blood pressures
Diastolic blood pressures
Temperatures
Diabetes status (no known diagnosis, known diagnosis)
Type of diabetes
Type of cardiothoracic surgery
Presence of peripheral vascular disease

Presence of peripheral edema
Presence of medications/substances that might interfere with the CGMS
Glucose readings (lab, point of care, CGMS)
Serume creatinine
Intravenous insulin infusion rate
Subcutaneous insulin doses
Use of pressors/vascoconstrictors/vasodilators
Intravenous fluids
Medications administered in the hospital

Data

Because the data are blinded to the nurses and ICU staff, we need to use the web-based Clarity program to be able to download data.
The endocrine department already has an existing Clarity account for clinic patients. Dexcom has given us instructions since they have studies with other institutions. For our study, there will be an account in Clarity. Subject ID can be entered. Clarity can then export data as an Excel file to be imported into RedCap.
The Dexcom G6 gives glucose readings every 5 minutes. The closest glucose reading to the time and date of the blood gas or point of care blood glucose will be matched.

Other info

CDA already executed with Dr Lansang, Dr. Insler and Dexcom