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Does Continuous Glucose Monitoring Reduce Complications for Diabetic Surgical Patients?

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Degree Master of Science

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Abstract

Optimal glycemic control is paramount to decreasing surgical complications. Continuous glucose monitoring plays a key role in glycemic control. Continuous glucose monitoring in the perioperative setting is not currently recommended by American Diabetes Association (Umpierrez & Klonoff, 2018). Current literature identifies the importance of glycemic control in the perioperative period to decrease risk of surgical complications. Since continuous glucose monitoring improves glycemic control, it would be reasonable to think that it would improve glycemic control during the perioperative period as well. However, the benefits in the outpatient setting do not translate to benefits in the perioperative period. Continuous glucose monitor accuracy is affected by surgical stress, medications, and tissue perfusion, all things common in surgery. Research is lacking regarding the use of continuous glucose monitoring during the perioperative period. Continuous glucose monitoring needs to be further studied to help provide clinical recommendations about its potential risks versus benefits in reducing complications of surgery

Keywords: continuous glucose monitoring, glycemic control, diabetes, surgical complications.

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Background

The case report follows Mrs. S, who presented for a preoperative evaluation for her upcoming surgery. She has type II diabetes, obesity, hypertension, and is a pack per day smoker for the past twenty years. Each one of these are well known detriments to health. Diabetes causes increased risk of surgical complications as well. These complications include but are not limited to surgical site infections, hypoglycemia, hyperglycemia, increased hospital stay, and increased mortality (Sreedharan & Abdelmalak, 2018). Optimal glycemic control is necessary to reduce surgical complications. Preoperative diabetes control improves glycemic targets, decreasing hypoglycemia, and has implications for reducing adverse effects post-surgery (Garg et al., 2018).

Continuous glucose monitoring is a technology that is becoming more frequently used to obtain optimal glucose control. Perioperative blood glucose monitoring is necessary to evaluate for hyperglycemia and hypoglycemia. Hypoglycemia is easily disguised during surgery. Hypoglycemia can result in irreversible neurologic damage, among other adverse perioperative consequences (Sreedharan & Abdelmalak, 2018). The Center for Disease Control and Prevention (CDC) currently does not recommend a specific blood glucose target for the perioperative period. The CDC did state that blood glucose levels above 200mg/dL within 48 hours of surgery were associated with an increased risk of surgical site infections (Berrios-Torres et al., 2017).

Currently, the American Diabetes Association recommends starting insulin therapy when blood glucose is persistently above 180 mg/dL for hospitalized patients (American Diabetes Association [ADA], 2019). The use of continuous glucose monitors has the potential to alert the provider to blood glucose trends above 180 mg/dL and initiate insulin therapy for postoperative

inpatients. There are limitations to the usefulness of continuous glucose monitors in the surgical setting, including the cost of operation, usability, and current guidelines related to the use of continuous glucose monitors in inpatient settings, perioperative settings, and use as the sole determination of insulin dosing.

Case Report

Mrs. S

Chief Complaint. Preoperative evaluation

HPI. Mrs. Smith is a 46-year-old woman presenting for a preoperative evaluation prior to a right knee arthroscopy due to a meniscal tear. The meniscal tear occurred approximately six months ago. She is currently taking ibuprofen six hundred milligrams of ibuprofen three times a day and acetaminophen one thousand milligrams three times a day for pain. Her daughter is her support person and can help her when she is recovering.

Past Medical History. Hypertension, obesity, type two diabetes, hypothyroidism, squamous cell skin carcinoma.

Allergies. Amoxicillin, Morphine.

Past Surgical History. Hysterectomy, skin biopsy, cesarean section twice.

Medications. Lisinopril 10 mg daily, Metformin 1000 mg twice daily, Rybelsus 7 mg daily, Synthroid 125 mcg daily, Aspirin 81 mg daily, Tylenol 1,000 mg three times a day, Ibuprofen 600 mg three times a day.

Substance Use. One pack per day tobacco smoker for the last twenty years. Rare alcohol use and no illicit drug use.

Family History. Father had coronary artery disease with stenting times three at age fifty-five, prostate cancer, hypertension, and hyperlipidemia. Mother had breast cancer at age sixty,

hypertension, and obesity. Maternal grandmother had hypertension and breast cancer. Maternal grandfather, none. Paternal grandfather had hypertension and melanoma. Paternal grandmother had cerebral vascular accident at age eighty. Sister is age thirty-three and alive and well. Brother is twenty-eight and alive and well.

Review of Systems. Pre-operative risk assessment is as follows. No significant history of transfusion reactions. Positive for history of diabetes but negative for insulin use. Her functional health status is independent. She has not had any fevers in the last month. She has not had any steroid use in the last six months. She does not have any actively managed cancers. Her cardiac history includes hypertension, medication controlled. Her functional capacity assessment is greater than four METS. She briskly walks her hallway more than four times without getting short of breath. Pulmonary history is negative. She does not suffer from any dyspnea. She has no infections or open wounds. No history of bleeding disorders in herself or family. She also has no history of renal disease. Central nervous system history is negative, no history of cardiovascular accident, or neurologic deficits. No history of anesthesia complications in herself or family. In a general review of systems, she denied unexplained weight loss, fatigue, fever, or chills. Ear, nose and throat review was negative for hearing changes, vision changes, and headaches. Cardiovascular review was negative for chest pain, heart palpations, and edema. No history of heart murmurs. She denied any dyspnea, wheezing, cough, and shortness of breath. Denied abdominal pain, nausea, and vomiting. She denied any genitourinary symptoms including any urinary frequency, urgency, pain/burning with urination, and hematuria. Musculoskeletal review was positive for limited range of motion in right leg due to meniscal tear but otherwise reported normal range of motion. Denied and endocrine dysfunction such as polydipsia and polyuria. Neurological review was negative for dizziness, fainting, seizures, and numbness/tingling.

Physical Examination. Vital Signs were as follows blood pressure 136/88, pulse 78, temperature 98.5 degrees Fahrenheit, oxygen saturation 95 percent, height 5 feet 6 inches, weight 211 pounds, body mass index 34. General examination revealed pleasant person, alert and orientated to person, place, and time. In no distress and cooperative. Her skin was normal color with no apparent rashes. Eyes are normal and pupils equally round, reactive to light and accommodation. Ears revealed normal bilateral tympanic membranes and external ear canals Throat had normal appearing mucosa. Lungs revealed normal respiratory effort, no wheezing, and normal breath sounds. Heart had a regular rhythm, normal heart sounds, and no murmur noted. Abdomen had normal bowel sounds, no hepatosplenomegaly, nontender, no masses or distention. Extremities had no edema and normal pulses.

Laboratory and Diagnostic Tests. Due to her history of hypothyroidism, a TSH was ordered and came back normal. A complete blood count was also ordered for a baseline hemoglobin and hematocrit. Due to her history of hypertension, a complete metabolic panel was drawn to evaluate her electrolyte status, liver function, and kidney function. All lab results were unremarkable. An EKG was ordered due to her hypertension and diabetes, which was also unremarkable. A hemoglobin A1C was not completed but should be ordered.

Diagnosis/Plan. RCRI risk estimate was very low and the thirty-day risk of cardiac event is 0.4 percent. She was recommended to avoid all non-steroidal anti-inflammatory medications for seven days prior to surgery. She was also instructed to hold her metformin for 48 hours prior to surgery. She should hold her Ryselbus and lisinopril the day of surgery. She was counselled on the effects of smoking related to surgical outcomes and it was recommended to cut down or stop smoking. She declined at this time. She was also instructed to call her surgical team if there are any changes in her medical history prior to surgery.

Literature Review

It is well documented in the literature that perioperative hyperglycemia is correlated with an increased risk of postoperative infection. As the severity of hyperglycemia increases, so does the increased risk of complications even when adjustments have been made for the complexity of surgery and comorbidities (Shanks et al., 2018). The correction of hyperglycemia reduces cardiac and general surgical patients' risk of complications and lowers mortality rate (Duggan et al., 2017). Glycemic control is difficult in the perioperative period because of hormones counter regulating, immune suppression, insulin resistance, proinflammatory responses, and intravenous fluids contains dextrose (Evans et al., 2015).

The CDC recognizes that complications occur when blood glucose is not managed below 200 mg/dL in the perioperative window and recommends treatment if frequently above that threshold (Berrios-Torres et al., 2017). It is more difficult to achieve normoglycemia during surgery if the blood glucose is above 300 mg/dL prior to surgery. In contrast to hyperglycemia, the effects of hypoglycemia need to also be seriously considered. Intensive insulin therapy targeting blood glucose in the range of 80 to 110 mg/dL increases the serious risk of hypoglycemia and has shown no additional benefits in surgical patients (Evans et al., 2015). In pediatrics and traumatic brain injury patients, it has been found just as essential to prevent hypoglycemia as it is to prevent hyperglycemia when considering risk reduction (Evans et al., 2015). Tight glycemic control has value but is not appropriate for all.

To accurately identify hyperglycemia and hypoglycemia in the surgical setting monitoring blood glucose is necessary. Currently, the gold standard of blood glucose monitoring is venous blood sampling via evaluation from a laboratory (Evans et al., 2015, p. 1). Continuous glucose monitoring allows for more frequent monitoring of blood glucose and would allow for

recognition of hyperglycemia to be corrected in a timely manner. It is also a valuable tool in monitoring glycemic trends to help target insulin needs.

Effectiveness of Continuous Glucose Monitoring

Technology regarding continuous glucose monitoring is rapidly evolving. Literature is limited by the constant changes in continuous glucose technology. There are two crucial factors in the successful use of continuous glucose monitoring. The success of the device is highly dependent on the education and ability to use the monitor correctly and near constant use of the device (Peters et al., 2018). Without frequent use of the continuous glucose monitor, benefits are limited. It is currently recommended by the Endocrine Society to use continuous glucose monitoring in those with type 1 diabetes and a hemoglobin A1C above target. As it was associated with decreased hemoglobin A1C in adults with type 1 diabetes that had hemoglobin A1C's above target range (Peters et al., 2016). The hemoglobin A1C was lowered without increasing the rate of hypoglycemia by using continuous glucose monitoring (Peters et al., 2018). It is recommended by the Endocrine Society to use continuous glucose monitoring intermittently in people with type 2 diabetes if their hemoglobin A1C is above target to look for trends in hyperglycemia and monitor for hypoglycemia unawareness (Peters et al., 2016). There is not currently enough research to recommend the use of continuous glucose monitoring daily in people with type 2 diabetes (Peters et al., 2016). The Endocrine Society also reported on replacing daily finger sticks with continuous glucose monitoring. There was no statistical difference in time in range of glucose targets or hypoglycemia when patients used the continuous glucose monitor versus finger sticks to dose insulin (Peters et al., 2018).

Forty-two percent of surgeries are done in an inpatient setting (Healthcare Cost and Utilization Project et al., 2017). For this reason, the use of inpatient glucose monitoring must be

addressed. In the ICU setting, a study of mechanically ventilated patients using continuous glucose monitoring was shown to decrease severe hypoglycemic episodes by 9.9 percent (Wallia et al., 2017, p. 1038). Currently, the American Diabetes Association recommends against utilizing continuous glucose monitoring in the hospitalized patient until more data is available, and accuracy is addressed. Studies showed an increase in hypoglycemia detection but did not improve glycemic control (ADA, 2019).

Use of Continuous Glucose Monitoring Perioperatively

Evans et al. (2015) discussed the accuracy of continuous glucose monitoring in postcardiac surgical patients. There were similar results between continuous glucose monitors and traditional testing of blood glucose readings. The major downfall is the need for these devices to be calibrated multiple times a day.

In a study of perioperative neurosurgical and cardiac surgical patients, the accuracy of continuous glucose monitoring was found to be clinically acceptable. The neurosurgical cases showed more consistent results and were more accurate at 82 to 86 percent. The accuracy during cardiopulmonary bypass was decreased, registering a lower glucose than actual result but otherwise had similar results (Sugiyama et al., 2018). The reduced accuracy during cardiopulmonary bypass limits the effectiveness of the study because cardiopulmonary bypass is a large part of the surgery. If it is not generalizable to the whole operation, it loses some of its credibility. Utilizing a continuous glucose monitor for only part of a surgical procedure negates the benefits of its utility.

Outcomes monitored in a randomized control trial of major abdominal, and cardiothoracic patients included differences in median blood glucose one-hour post-operation and percentage of glucose readings in target range. The study found that the accuracy of

continuous glucose monitoring was in the acceptable range. The study was limited by a small sample size and high rates of continuous glucose monitor failure which was approximately twenty-four percent. The monitor was considered failed if there was a large difference in continuous glucose monitor results and point of care results (Polderman et al., 2017). Considering it a glucose monitor failure when out of range for a significant portion is questionable. The threshold for considering it a failure versus continuous glucose monitor inaccuracy needs to be clearly stated.

Barriers to Continuous glucose monitoring

Lack of standardized care for diabetics in the perioperative period is a significant barrier to utilizing continuous glucose monitors to decrease surgical complications. Continuous glucose monitors are of limited value if diabetes care isn't routinely and performed and standardized. According to Jackson, et al. (2016), an audit of perioperative diabetic management revealed only approximately seventy-one percent of two-hundred and forty-seven patients had a hemoglobin A1C checked prior to operation. Nationally, the perioperative guidelines were not followed in a significant portion of patients having elective surgery.

A barrier to continuous glucose monitoring in the surgical setting is the lack of studies in the inpatient and surgical settings. The information obtained in outpatient studies is not as easily generalizable to the inpatient and surgical settings. There are multiple factors that affect glucose sensor monitors that are different in the surgical and inpatient settings, such as accuracy of devices when there is a lack of tissue perfusion (Wallia et al., 2017). Accuracy is also affected by severe hypoglycemia. In hypoglycemia, the tissue sensor accuracy breaks down (Wallia et al., 2017). If it is not accurate when it is most dangerous, it limits its effectiveness.

Another barrier in the surgical setting is medication use and interference with accuracy of continuous glucose monitors. It is known that certain medications may interfere with the accuracy of a continuous glucose sensor. Some of these medications include acetaminophen, maltose, ascorbic acid, dopamine, mannitol, heparin, uric acid, and salicylic acid (Umpierrez & Klonoff, 2018). Acetaminophen and heparin are frequently used medications in surgical settings and therefore affecting the accuracy of continuous glucose monitoring may be affected.

The cost of use is a barrier for many considering continuous glucose monitoring. The financial burden of diabetes is high, so the cost of additional technology needs to be considered when implementing it. The American Diabetes Association evaluated the cost of continuous glucose monitoring and found that the average cost of continuous glucose monitoring was approximately 11,032 dollars for the first six months of use. This is compared to the 7,236-dollar cost of use associated with traditional supplies for blood glucose testing in the first six months. (Wan et al., 2018). However, when the cost was analyzed based on increased quality of life (quality-adjusted life year) and risk reduction, continuous glucose monitors increased by 0.54. The coverage of continuous glucose monitors by insurance companies varies and will likely be a major determining factor in its utility.

Conclusion

The importance of glycemic control is well established in the literature. Glycemic control likely reduces the risk of complications in patients undergoing surgery. Literature shows it reduces mortality and there are significant reductions in surgical complications for general surgical patients (Duggan et al., 2017). Literature shows that glycemic control is important during the surgical period but adherence to surgical glycemic control guidelines are lacking (Jackson et al., 2016).

The use of continuous glucose monitoring is helpful in the early detection of hyperglycemia and hypoglycemia. This has implications for reducing complications in the perioperative time frame. Studies are lacking in the accuracy and feasibility of its use in the perioperative setting. It is recommended that additional studies during the perioperative period be completed to understand the utility in the perioperative setting better.

The barriers to use of continuous glucose monitoring include cost, medication interference, and accuracy in the surgical setting need to be addressed before continuous glucose monitors can appropriately be used in the perioperative setting. The implications for use are plenty, and with technology improving on a constant basis, their utility will likely prove even more beneficial. Currently, further research is needed to determine if continuous glucose monitoring reduces complications in patients undergoing surgery.

Learning Points

- Glycemic control is imperative to the reduction of surgical complications in patients with diabetes.
- Continuous glucose monitor technology is a great way to improve glycemic control in patients with diabetes.
- There is not enough research to currently support the use of continuous glucose monitoring in the surgical setting to reduce surgical complications.
- More research is needed to compare cost versus benefit of continuous glucose monitoring in patients undergoing surgery.

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