Optimization of Perioperative Blood Glucose Levels in Patients with Diabetes

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Abstract

Problem: Perioperative hyperglycemia places surgical patients with diabetes at higher risk for developing surgical site infections and poor surgical outcomes. Anesthesia and perioperative nursing leadership at a Mid-Atlantic hospital identified concern regarding blood glucose monitoring practice and optimization during the perioperative period, with only 26.6% glucose evaluation during the intra-operative period, and 40% remained hyperglycemic in the post-operative period. **Purpose**: The purpose of this quality improvement project was to implement an evidence-based Perioperative Blood Glucose Management guideline over a 15-week period at a Mid-Atlantic hospital to improve blood glucose practices during the intra and post-operative period among adult patients with diabetes undergoing outpatient surgery. **Methods:** A practice guideline was approved by anesthesia leadership and formal education sessions were then provided to anesthesia and nursing staff. The guideline was placed in each operating room and at nursing stations for reference. Implementation barriers were tracked weekly and addressed by the Project Lead. Re-education, presence and facilitation, feedback, and incentives increased staff adherence and project sustainability. Data was collected weekly via chart audits to determine guideline adherence rates and post- operative blood glucose optimization, defined as 70mg/dL to 180mg/dL. **Results:** A total of 238/ 238 eligible adult patients with diabetes undergoing outpatient surgery were included. The average intra and post-operative guideline adherence rate was 79.1% and 47%, respectively. The average post-operative glucose optimization rate was 90%. **Conclusions:** This practice change is a feasible, practical, evidence-based solution to improve quality, safety, and outcomes. Overall findings suggest that instituting a guideline can increase perioperative glucose monitoring, allow for earlier recognition of hyperglycemic or hypoglycemic episodes, and increase post-op blood glucose optimization rates.

Keywords: perioperative hyperglycemia, diabetes mellitus, glucose monitoring, glycemic control, guidelines, outpatient surgery, anesthesia.

Optimization of Perioperative Blood Glucose Levels in Patients with Diabetes

With the prevalence of diabetes in Maryland (MD) reaching approximately 10.5%, it is common to encounter patients with diabetes presenting for surgery (MD Department of Health, 2019). During surgery patients diagnosed with diabetes can encounter many fluctuations in their blood glucose leading to sub-optimal blood glucose levels (Leung & Ragbir-Toolsie, 2017). Sub-optimal glucose, defined as a blood glucose greater than180mg/dL, results in decreased blood flow, decreased tissue oxygenation, impaired neutrophil phagocytic function, and impaired leukocyte function (Leung & Ragbir-Toolsie, 2017). Additionally, during surgery a neuroendocrine stress response causes insulin resistance, which can further increase glucose levels (Leung & Ragbir-Toolsie, 2017). Hyperglycemia alone puts all surgical patients at risk for developing surgical site infections (SSI) and experiencing delayed wound healing, but in diabetics this risk is greater (Martin et al, 2016). Risk reduction and improvement in patient outcomes would be expected by increasing glucose monitoring and glucose optimization during the intraoperative (intra-op) and post-operative (post-op) period.

Internal data collected during the month of October 2021 from an outpatient surgical center in a MD hospital demonstrated that, of the patients with diabetes who entered the intra-op period with a blood glucose of greater than 180 mg/dL, only 26.6% had their glucose re-evaluated during the intra-op period and 40% remained hyperglycemic in the post-op period. Root cause analysis indicates that factors most likely contributing to the issue were provider unawareness of the problem, high production pressures to start/end surgery on-time while safely executing care, and lack of a standardized blood glucose management practices, leading to variability in blood glucose monitoring and treatment by anesthesia providers (Figure 1).

The purpose of this quality improvement (QI) project was to implement a new perioperative blood glucose management (p-BGM) guideline at a MD hospital to improve blood glucose optimization and monitoring during the intra-op and post-op period among patients with diabetes undergoing outpatient surgery (Appendix A). Guideline driven care such as this reduces variability in practice for this patient population and improves outcomes by establishing a structured process for providers to follow (Murad, 2017).

When analyzing the evidence to support this intervention, research indicates that implementing p-BGM guidelines can increase blood glucose monitoring rates during the intra-op and post-op periods, improve blood glucose optimization, and reduce the likelihood of the patient entering the post-op period remaining hyperglycemic (Table 1 and Table 2).The p-BGM guidelines presented in the evidence describes glucose testing and insulin administration thresholds to achieve blood glucose optimization during surgery. Nair et al. (2016) , Colibaseanu et al. (2018), and Shah et al. (2014) treated blood glucose levels when greater than 140mg/dL, while Vongsumran et al. (2020) and Duggan et al. (2019) treated when greater than 180mg/dL, and DiNardo et al. (2011) treated when greater than 200mg/dL. While insulin administration during the perioperative period can put the patient at risk for hypoglycemia, the evidence shows that the risk is low when combined with frequent blood glucose monitoring (every 1 to 2 hours) and administering subcutaneous (SQ) rapid acting insulin (such as insulin Aspart) in short ambulatory procedures (less than 4 hours) versus regular intravenous (IV) insulin (DiNardo et al., 2011; Duggan et al., 2019; Vongsumran et al., 2020).

The overall strength of the empirical research synthesized is low, however, the quality of the evidence combined with organizational priority for the delivery of safe and uncomplicated quality of care supports a practice change that is expected to yield high benefit with manageable

risk. The process goals for this initiative are to have 100% provider adherence to the intra-op and post-op blood glucose guidelines in patients with diabetes undergoing outpatient surgery. The outcome goal for this initiative is to have 100% of patients with diabetes optimized during the post-op period (mean blood glucose level between 70mg/dL to 180mg/dL).

The Framework of Complex Innovation Implementation by Helfrich et al. (2007) was utilized to underpin this initiative. The framework identifies six contributing elements to successful implementation change as management support, available resources, innovation values, use of unit champions, implementation of policies and procedures, and innovation perceived as a priority (Figure 2). To leverage these elements, the Project Lead conveyed to stakeholders how the proposed practice change is consistent with the organization's value for safe and effective care. Support was secured from anesthesia leadership to advance the initiative, with a commitment to (a) champion the effort among staff , (b) secure needed resources, and (c) advocate for the establishment of a standardized procedure. The framework elements were further operationalized by mobilizing and involving a team of stakeholders including a Chief Certified Registered Nurse Anesthetist (CRNA) and a Chief Anesthesiologist, providing education to staff (anesthesia providers, anesthesia technicians, and nurses), awarding incentives (free breakfast), mitigating barriers as identified, and providing ongoing monitoring and feedback on progress to goal.

Methods

Approximately 30 anesthesia providers, six anesthesia technicians, and 50 post-op nurses employed by the project site work within the organization's 20 operating rooms (OR) and 16-bed post-op anesthesia care unit (PACU). The environment within the OR and PACU is fast paced and rapid surgery turnover is critical to prevent future surgery cancellations or delays. Anesthesia

leadership stresses the importance of improving patient outcomes and they value QI. The current practice when managing perioperative blood glucose levels in diabetics undergoing outpatient surgery includes nursing identifying that the patient is diabetic on arrival, obtaining a pre-op blood glucose, and administering SQ insulin (per anesthesia provider order) when the blood glucose is "elevated" (no definition provided), a blood glucose is then re-checked within 15 minutes (Figure 3). Further intra-op blood glucose checks and insulin treatment is based on anesthesia provider judgment. Once surgery is completed, the anesthesia provider decides whether or not to place an order for a post-op blood glucose check. Two Accu-Chek glucometers are available in both the intra-op and post-op areas for testing.

The desired process for this project included implementing a new p-BGM guideline (Figure 4 & Appendix A). The p-BGM guideline includes identification of eligible patients, parameters regarding the frequency of glucose monitoring, and the appropriate care management in response. Patient's eligible to be included in this guideline were identified by nursing and anesthesia by reviewing the patient's past medical history in the electronic healthcare record (EHR) and identifying that the patient was diabetic and receiving outpatient surgery. The Project Lead (PL) conducted weekly EHR reviews of all surgical patients at the site to determine if all eligible patients were included as evidenced by documented glucose management data.

The evidence-based p-BGM guideline QI project was implemented over a 15-week period from August 2022 through December 2022 at the practice site with the goal of improving post-op blood glucose optimization rates and monitoring during the intra-op and post-op period among adult patients with diabetes undergoing outpatient surgery. Infrequent perioperative blood glucose monitoring and optimization was recognized as a major problem by anesthesia leadership, which prompted early leadership buy-in. To introduce the practice change, a team of key stakeholders

including Chief CRNA, Chief Anesthesiologist, Clinical Site Representative (CSR), site Sponsor, project champion, Perioperative Nurse Manager, and faculty advisor was assembled.

Specific structure, process, and outcome goals were established to monitor project progress and impact. The first structure goal involved creation of a new organizational p-BGM guideline and obtaining guideline approval by anesthesia leadership. The p-BGM guideline was developed based on a review of the current evidence. While the actions included in the guideline are evidence-based, this p-BGM guideline has not been tested and was designed specifically for this project site. The insulin sliding scale utilized within the p-BGM guideline is the project site's current hospital approved insulin sliding scale order set that is also conveniently located in the EHR as well. Anesthesia approval of the p-BGM guideline was obtained in July 2022.

The second structure goal was to educate 100% of staff on the p-BGM guideline. The PL conducted education sessions with staff (anesthesia, pre-op nurses, post-op nurses) to review the p-BGM guideline and ensure educational objectives were met (Appendix B). A PowerPoint was presented to anesthesia staff to discuss current problem, the guideline, benefits, and the desired process. Unfortunately, many anesthesia staff could not attend the in-person session; therefore, the presentation was recorded and sent via email. Handouts detailing the guideline were distributed to staff via email and also laminated and placed at each pre-op and post-op nurse's station and in every OR. Evaluation of knowledge gain was determined by staff participation in case scenarios and providing feedback during the educational sessions. Staff education rates were measured by tallying the number of anesthesia staff and pre-op/post-op nurses who attended education sessions and tracking them using the Education Data Collection Tool (Appendix C).

The process goal included achieving 100% adherence to the intra-op and post-op blood glucose guidelines. Strategies and tactics used to achieve this goal involved the PL completing

weekly EHR data audits to analyze adherence rates. Data elements collected from each participant included blood glucose levels, insulin administration, and glucose monitoring rates, which were transferred into a Project Audit Tool (Appendix D). Blood glucose values were measured using an Accu- Chek glucometer. The Accu-Chek glucometer is a reliable and valid tool approved by the Food and Drug Administration to monitor point of care blood glucose levels (Accu-Chek, n.d.). The hospital quality control tests are performed daily on the Accu-Chek monitors to ensure that the blood glucose measurements are accurate and consistent. These data elements were then compared to the p-BGM guideline to analyze guideline adherence. Adherence rates were calculated as percentages and presented in run charts at weekly intervals over the 15- week implementation period to monitor for change (Figure 5 & 6). When weekly improvements were detected, staff were updated and incentivized (free breakfast) to continue adherence. When degradation of project aims was observed within the run chart data patterns, associated factors such as provider resistance to change were discussed with CSR, anesthesia leadership, and nursing leadership. Anesthesia and nursing leadership continued to promote the utilization of the p-BGM guideline at staff meetings to increase staff buy-in and decrease resistance. The PL continued to re-educate staff as needed.

The outcome goal for this initiative was for 100% of eligible patients to have their post-op blood glucose optimized (mean blood glucose 70mg/dL to 180mg/dL). To attain this goal the PL completed weekly EHR data audits to analyze eligible patient's post-op blood glucose levels and transferred data into a Project Audit Tool (Appendix D). Post-op glucose optimization rates were calculated as percentages and presented in run charts at weekly intervals over the 15- week implementation period to monitor for change (Figure 7). Strategies and tactics employed to sustain outcome goals included incentivizing staff when weekly improvements in post-op blood

glucose levels were observed. When decrease optimization rates were detected the PL rounded with nursing and anesthesia staff to assess barriers and then address these barriers with CSR, anesthesia leadership, and nursing leadership.

To promote accuracy and minimize sources of data collection errors, the PL was the sole data collector throughout the entirety of the project. The PL used the same systematic approach when collecting data to ensure no participant was missed. This systematic approach involved reviewing data on all surgical cases at the project site to determine which cases were inpatient versus outpatient. Once outpatient cases were identified, the PL evaluated each outpatient's past medical history and if they were diagnosed with diabetes, they were considered an eligible participant. Once deemed eligible the PL reviewed the patient's EHR to analyze blood glucose levels, surgical timelines (surgery start time, surgery stop time, discharge time), and insulin administration to collect the required data to assess the project's process goals and outcome goals. Baseline post-op blood glucose optimization rates were compared to intervention data to detect if change had occurred after the implementation of the guideline.

Prior to the implementation of the QI project, Non-Human Subject's Research Determination from the Human Research Protections Office of the University of MD School of Medicine Institutional Review Board was obtained. Education sessions and EHR chart reviews were conducted in a secure and private area located within the project site. The Education Data Collection Tool and Project Audit Tool used to extract data from EHR reviews was stored in REDCap, a password protected, HIPAA compliant, encrypted software only available to authorized users to protect data confidentiality (Appendix C & D). In REDCap each participant received a non-identifiable auto-generated Record ID to protect confidentiality. Healthcare providers were collecting blood glucose levels following HIPAA policy as a condition to their

employment. The QI project poses no harm to staff, but participants could experience hypoglycemia, which was monitored.

Results

Approximately 87% (80/97) of nursing and anesthesia staff were educated on the practice change by week 7. Over the 15-week implementation period, a total of 238/ 238 eligible adult patients with diabetes undergoing outpatient surgery were included in the initiative (Table 3). The average intra-op and post-op guideline adherence rate was 79.1% and 47%, respectively. Overall, intra-op guideline adherence rates ranged from 65% in week 1 to 94% in week 9. Overall post op guideline adherence rates ranged from 17% in week 9 to 62.5% in week 8.

When observing staff adherence rates to the intra-op guidelines and post-op guidelines the first data point of each run chart is at 0% adherence in order to demonstrate the project site's absence of a p-BGM guideline prior to implementation (Figure 5 & 6). In the intra-op guideline adherence rates run chart, no shifts, trends or astronomical data points were observed, and only 5 runs exist, meaning that special-cause determination cannot be established (Figure 5). From week 3 to week 9, there was a steady increase in intra-op adherence rates, which is likely due to anesthesia leadership maintaining continuous support throughout the duration of the QI project and the PL sending out weekly guideline reminder emails. At week 10 there was a slight drop in intra-op adherence rates from 94% to 76.9%. The PL attempted to increase adherence rates in the following weeks by providing re-education and food incentives to the nursing and anesthesia staff. By week 15 intra-op guideline adherence rates were at 82.3%.

When observing the post-op guideline adherence rates run chart, no shifts or trends were observed and only 5 runs exist, meaning that special-cause determination cannot be established (Figure 6). From week 2 to week 8, post-op adherence rates steadily increased. One astronomical

data point is noted in week 9 when adherence rates drop to 17% from previously 62.5%. Upon this finding, the PL rounded with post-op nursing staff to assess project barriers. Nurses indicated that anesthesia providers were not always placing post-op blood glucose monitoring orders, which was causing the nursing staff to not be able to monitor the patient's blood glucose post-op. The PL immediately communicated this information to anesthesia leadership and the following week at a staff meeting the Chief CRNA reminded and encouraged anesthesia providers to continue to engage in the QI project and place post-op blood glucose monitoring orders. Having this leadership support likely influenced adherence rates from week 9 to week 12. By week 15 post-op guideline adherence rates were at 47.5%.

Post-op blood glucose optimization rates at baseline averaged to 60% over the month of October in 2021. During implementation blood glucose optimization rates ranged from 77.7% to 100%. Post-op blood glucose optimization rates reached the project's goal of 100% in weeks 3, 5, 7, 8, 9, 11 and 15. On average, post-op optimization rates were approximately 90%. The run chart depicting post-op optimization rates had no shifts, trends, or astronomical data points and only 9 runs exist, meaning that special-cause determination cannot be established (Figure 7). Two hypoglycemic events were noted during the post-op period and neither of these patients' received insulin during their hospital stay. This is clinically significant because utilizing the p-BGM guideline likely allowed for earlier detection and treatment of these hypoglycemic events.

Barriers were encountered during the implementation of the p-BGM guideline including not being able to educate 100% of the staff nurses and anesthesia providers on how to utilize the guideline due to staff turnover and frequent new hires. Additionally, staff resistance was a barrier to the QI project that was counteracted by continued re-education, anesthesia leadership promoting the practice change at staff meetings, providing food incentives, and sending out

weekly reminders. Another barrier to the project was the lack of direct access to glucometers in every OR, which likely led to lower intra-op guideline adherence rates.

Discussion

The final project results indicate that the proposed goal of maintaining 100% adherence to the intra-op and post-op guidelines was under-achieved. However, implementing the p-BGM guideline did increase provider awareness of the local problem and the importance of perioperative glucose monitoring in the diabetic patient. Furthermore, implementation of the p-BGM guideline improved care delivery by providing a structured process for providers to follow.

On average, 90% of patients achieved an optimized post-op blood glucose, which was an improvement from previous baseline data where 60% of patients on average were being optimized. The improvement in post-op blood glucose levels seen within this project compares with the results from other studies that have implemented perioperative glycemic management guidelines/protocols with similar results (Vongsumran et al., 2020; Shah et al., 2014; Colibaseanu et al., 2018; DiNardo et al., 2011) . While the QI initiative generated additional upfront hospital costs associated with increased glucose monitoring, the benefit of optimizing perioperative blood glucose levels is worth the extra cost and has the potential to save the hospital money by potentially decreasing risk of developing a surgical site infection.

Differences were noted between observed and anticipated project outcomes. It was anticipated that all anesthesia and nursing staff would receive education on the p-BGM guideline and participate in the QI initiative. However, the PL was unable to educate 100% of staff due to staff turnover and frequent new hires occurring throughout the implementation period, which likely affected adherence rates to the intra-op and post-op guidelines.

One limitation of this project is that this QI initiative only focused on patients with diabetes having outpatient surgery. However, implementing the p-BGM guideline did increased provider awareness and improved a structured process, which has the potential to transform the future care of all patients with diabetes who undergo surgery within this facility. Another limitation of this project is that a post-op blood glucose monitoring standardized order-set was not incorporated into the EHR system, which could have reduced provider variation in post-op blood glucose monitoring orders and increased post-op guideline adherence rates. Finally, the main outcome goal of this project focused on increasing post-op blood glucose optimization rates utilizing the p-BGM guideline. Although improvements in glucose optimization were observed in this QI project, their direct impact on outcomes such as post-op surgical site infection rates and hospital length of stay are unknown at this specific organization and further research is needed.

Conclusion

The p-BGM guideline practice change is an evidence-based practice, feasible, and practical solution to improve quality and safety outcomes. Overall, implementation of the p-BGM guideline at this Mid-Atlantic hospital was relatively successful. Utilizing the p-BGM guideline in patients with diabetes receiving outpatient surgery did increase perioperative blood glucose monitoring, allow for earlier recognition of hyperglycemic or hypoglycemic episodes, and increase post-op blood glucose optimization rates.

Strategies to promote sustainability and spread of the p-BGM guideline practice change include continued anesthesia leadership support and promoting the guideline during staff meetings. This will help to remind staff to continue to participate in the intervention long after the implementation period. Additionally, the p-BGM guideline was presented by the

perioperative nursing staff at the hospital's local diabetes fair to spread knowledge of the p-BGM guideline to patients and other healthcare providers. The PL also presented the QI project results at state conferences to ensure dissemination and spread of the p-BGM guideline initiative.

Future QI projects should focus on diabetics receiving inpatient surgery and ways to incorporate a perioperative glycemic management guideline for this specific patient population. These patients often require urgent or emergent surgery and experience frequent fluctuations in their blood glucose levels making it difficult for anesthesia providers alone to manage their blood glucose levels effectively. It would be beneficial to involve endocrinology and pharmacy when making these specific inpatient guidelines due to the complexity of this patient population.

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Shah, M., Apsey, H. A., Stearns, J. D., Schlinket, R. T., Seifert, K. M., & Cook, C. B. (2014). Guidelines to improve perioperative management of diabetes mellitus: An example of a successful quality initiative. *Diabetes Management, 4(4)*, 327–337. DOI:10.2217/dmt.14.26

Vongsumran, N., Buranapin, S., & Mansoroi, W. (2020). Standardized glycemic management versus conventional glycemic management and postoperative outcomes in type 2 diabetes patients undergoing elective surgery. *Diabetes, Metabolic Syndrome, and Obesity Dovepress Journal, 13,* 2593- 2601. https://doi.org/10.2147/DMSO.S262444

Table 1:

Evidence Review

Citation: Colibaseanu, D. T., Osagiede, O., McCoy, R. G., Spaulding, A. C., Habermann, E. B., Naessens, J. M., Perry, M. F., White, L. J., & Cima, R. R. (2018). Proactive protocol-based management of hyperglycemia and diabetes in colorectal surgery patients. *Endocrine Practice, 24(12)*, 1073–1085. https://doi.org/10.4158/EP-2018-0379					**Level and Quality (Dang et al., 2022).** Level V Quality B
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/ Measures**	**Results/Conclusions**
Purpose was to "examine the efficacy of a perioperative diabetes optimization protocol implemented at a single institution in improving perioperative glycemic control with a target blood glucose of 80 to 180 mg/dL (p. 1073)."	Quality Improvement Study	**Sampling Technique**: N/A **Population**: Diabetic patients undergoing who elective colorectal surgery **Setting**: Surgical center in a Mayo Clinic located in Jacksonville, Florida **# eligible**: Not stated **# accepted**: 199 subjects **# in control:** 103 subjects **intervention:** 96 subjects **Power analysis**: N/A **Group Homogeneity**: No significant differences were found between the two groups with respect to age, sex, American Society of Anesthesiologists score, body mass index, baseline HbA1c, and surgical type.	**Control**: Pre-intervention phase before the diabetic optimization protocol was implemented **Intervention**: Implementing the diabetic optimization protocol **Intervention fidelity** Summary of protocol includes: obtaining a pre-anesthesia medical exam and Hemoglobin A1c (HbA1c). Referring the patient to an endocrinologist to be optimized if HbA1c >8.0%. On the day of surgery blood glucose (BG) is monitored every hour (q1h) while NPO. If BG is greater than 140 treat per institution protocol. If BG less than 70, use hypoglycemia protocol. Intraoperative: monitor BG q1h. Treat BG per institution protocols. If the patient is stable and the procedure is less than 2 hours, administer subcutaneous (SQ) insulin. On arrival to the postoperative anesthesia care unit (PACU) check BG and monitor q1h. If blood glucose is greater than 140 use a corrective SQ insulin sliding scale or continue insulin drip (according to institution protocol).	**DV/ outcome measure**: Preoperative, intraoperative and postoperative BG levels. **State the instrument, reliability, and measurement procedure**: The instrument used to check BG was not reported. Categorical variables (hyperglycemia and hypoglycemia) were compared using the Chi squared test and continuous variables were compared using the Wilcoxon rank sum.	**Statistical Results:** Intervention group had significantly lower BG levels intraoperatively (P = .03) and postoperatively (P = .005) compared to control. A larger proportion of patients received insulin in the intervention group versus the control group (P = .01). **Clinical Significance**: Adherence to a standardized diabetic perioperative BG optimization protocol resulted in improved BG monitoring and management of BG during the intraoperative and postoperative period. **Conclusions**: BG control during the perioperative period was improved after the institution implemented a standardized protocol for managing BG levels in diabetics during elective colorectal surgery.

Citation: DiNardo, M., Donihi, A. C., Forte, P., Gieraltowski, L., & Korytkowski, M. (2011). Standardized glycemic management and perioperative glycemic outcomes in patients with diabetes mellitus who undergo same-day surgery. *Endocrine Practice, 17(3),* 404–411. https://doi-org.proxy-hs.researchport.umd.edu/10.4158/EP10316.OR					**Level and Quality (Dang et al., 2022).** Level V, Quality C
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedure**	**Primary Outcome/ Measures**	**Results/Conclusions**
Purpose was "to assess the safety and effectiveness of a standardized glycemic management protocol in patients with diabetes mellitus who undergo same-day surgery (p. 404)."	Quality Improvement Study	**Sampling Technique**: N/A **Population**: Diabetic patients undergoing same-day surgery. **Setting**: Surgical center at the University of Pittsburgh Medical Center. **# eligible**: Not stated **# accepted**: 115subjects **# in control:** 55 subjects **intervention:** 60 subjects **Power analysis**: N/A **Group Homogeneity**: Not reported.	**Control**: Pre-intervention phase before the perioperative glycemic management protocol was implemented **Intervention**: Implementing the perioperative glycemic management protocol **Intervention fidelity** Summary of protocol includes: identifying patient as diabetic, pre-operative blood glucose taken, if blood glucose >200mg/dL anesthesia notified and perioperative order set was initiated with insulin sliding scales. Monitor blood glucose every two hours during the intraoperative and postoperative phases.	**DV/ outcome measure**: Preoperative, intraoperative and postoperative BG levels (continuous variables). Compliance of perioperative glycemic order sets (categorical variables). **State the instrument, reliability, and measurement procedure**: The instrument used to check BG was not reported. Categorical variables (was perioperative glycemic order-set being initiated yes or no) were compared using the Chi squared test and continuous variables were compared by t test or Mann Whitney U test. Logistic regression analysis was used to determine if the perioperative management protocol predicted blood glucose reduction to acceptable range (70mg/dL to 200mg/dL) by the time of discharge from the PACU.	**Statistical Results:** Intervention group had significantly lower BG reductions intraoperatively ($P < 0.001$) and postoperatively ($P < 0.05$) compared to control. There were no incidences of hypoglycemia in the intraoperative or postoperative phases in either the control or intervention group. **Clinical Significance**: Adherence to a standardized perioperative glycemic protocol resulted in improved BG management during the intraoperative and postoperative period. **Conclusions**: Utilizing a perioperative glycemic management protocol is safe and can be a more effective approach when managing BG levels for ambulatory surgery patients with diabetes during the perioperative period.

Citation: Duggan E. & Chen, Y. (2019). Glycemic management in the operating room: Screening, monitoring, oral hypoglycemics, and insulin therapy. *Current Diabetes Reports, 19(11),* 134. https://doi.org/10.1007/s11892-019-1277-4					**Level and Quality (Dang et al., 2022).** Level V, Quality B
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedure**	**Primary Outcome/ Measures**	**Results/Conclusions**
The purpose of "this review provides a literature update and practical outline for the management of diabetes and stress hyperglycemia for adult surgical patients in the pre- and intraoperative settings (p. 134)."	Expert opinion based on evidence	**Sampling Technique**: N/A **# eligible**: N/A **# accepted**: N/A **# in control**: N/A **# in intervention**: N/A **Power analysis**: N/A **Group Homogeneity**: N/A	**Control**: N/A **Intervention**: N/A **Intervention fidelity (describe the protocol)**: N/A	**DV**: N/A **State the instrument, reliability, and measurement procedure**: N/A	**Statistical Results**: N/A **Clinical Significance**: Expert review provides a detailed algorithm and recommendations, that can be used to help guide providers in managing BG in diabetic surgical patients during the perioperative period. Review states that during the intraoperative period maintaining a BG of less than 180 mg/dL is recommended by multiple creditable committees. In patients that are not critically ill, intraoperative BG levels greater than 180 mg/dL should be treated with SQ insulin (rapid acting) over IV regular insulin infusions. BG shouldn't be corrected more frequently than every 2 hours (q2h) because it creates a "stacking effect" that can lead to hypoglycemia When administering SQ insulin, intraoperative BG checks should be completed q2h. **Conclusions**: Elevated BG has been associated with increased postoperative complications in diabetic and non-diabetic patients. The day of surgery BG testing is recommended and administration of insulin (SQ and/or IV), is based on the patient's condition (critically ill or non-critically ill). BG checks should be maintained throughout the perioperative period for continual monitoring of hyperglycemia and potential hypoglycemia events.

Citation: Nair, B. G., Horibe, M., Neradilek, M. B., Newman, S.-F., & Peterson, G. N. (2016). The effect of intraoperative blood glucose management on postoperative blood glucose levels in noncardiac surgery patients. *Anesthesia and Analgesia, 122(3)*, 893–902. https://doi.org/10.1213/ANE.0000000000001100					**Level and Quality (Dang et al., 2022).** Level III Quality B
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/ Measures**	**Results/Conclusions**
The purpose of this study was to "explore the association between intraoperative glycemic levels and corresponding postoperative glycemic levels. The study also explored whether better intraoperative glycemic control leads to better postoperative glycemic levels (p. 894)."	Observational retrospective study	**Sampling Technique**: N/A **Setting**: Surgical area at academic medical center. **Population**: Non-diabetic and diabetic surgical patients undergoing non-cardiac surgery. **# eligible**: 2,440 subjects **# accepted**: 2,383 subjects **# in control:** N/A # **intervention**: N/A **Power analysis**: N/A **Group Homogeneity**: not reported.	**Control**: N/A **Intervention**: N/A **Intervention fidelity**: N/A **Procedure**: Researchers collected intraoperative and postoperative glucose management data (glucose levels and insulin administration) , patient characteristic data, and surgery-specific data from the anesthesia management system database and electronic healthcare records (EHR).	**DV/ outcome measure**: Intraoperative BG measurements. Postoperative BG measurements within 60 minutes of arriving to PACU and mean BG levels within the first 12 hours and 24 hours of the postoperative period. Other measures analyzed included whether insulin administration was initiated for a hyperglycemic threshold of 140 or 180 mg/dL during the intraoperative period. **State the instrument, reliability, and measurement procedure**: The instrument used to measure BG levels was not mentioned. Data was collected through EHR database and multivariate logistic/linear regression models and Chi squared test was used to analyze if there was an association between intraoperative BG management and postoperative BG levels.	**Statistical Results:** Increase in mean intraoperative BG levels by 10 mg/dL was associated with increases in postoperative BG levels ($P < 0.001$). A 10mg/dL increase in intraoperative blood glucose increased mean BG levels by 4.7mg/dL ($P<0.001$) in the first 60 mins on arrival to PACU, increased mean BG in first 12 hours post-op by 2.6 mg/dL ($P < 0.001$), and increased mean BG in first 24 hours post-op by 2.4 mg/dL ($P < 0.001$). When comparing administration of insulin at intraoperative BG threshold levels of 140 mg/dL versus 180 mg/dL treating BG levels at a threshold of 180mg/dL was associated with an increase in postoperative BG levels ($P < 0.001$) and continued PACU hyperglycemia ($P = 0.01$). **Clinical Significance**: Frequent intraoperative BG checks and insulin administration for intraoperative hyperglycemia results in better BG management as well as reducing hyperglycemia in the postoperative period. **Conclusions**: Elevated intraoperative BG levels are associated with future increases in postoperative BG levels. Initiating insulin administration when intraoperative glucose level is greater than 140 mg/dL to prevent hyperglycemia is associated with lower postoperative glucose levels.

Citation: Shah, M., Apsey, H. A., Stearns, J. D., Schlinket, R. T., Seifert, K. M., & Cook, C. B. (2014). Guidelines to improve perioperative management of diabetes mellitus: An example of a successful quality initiative. *Diabetes Management, 4(4)*, 327–337. DOI:10.2217/dmt.14.26					**Level and Quality (Dang et al., 2022).** Level V Quality B
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/ Measures**	**Results/Conclusions**
To "assess the impact of perioperative care glucose management guidelines for patients with diabetes mellitus undergoing elective surgical procedures (p. 327)."	Quality Improvement project	**Sampling Technique**: N/A **Population**: patients with diabetes undergoing elective surgery **Setting**: Surgical area in tertiary care academic hospital located in Phoenix, Arizona. **# eligible**: not stated **# accepted**: 580 subjects **# in control/ pre-QI project**: 254 subjects **# in intervention/ post-QI project**: 326 subjects **Power analysis**: N/A **Group Homogeneity**: no difference in baseline characteristics such as age, sex, race, duration of diabetes, and pharmological management between control group and intervention group. Differences were identified in the type of surgical procedures the participants underwent between the control and intervention group.	**Control**: Pre- intervention group before perioperative BG guidelines were initiated. **Intervention**: Implementation of perioperative BG management guidelines. **Intervention fidelity:** Summary of Protocol: During the pre-perioperative period: conduct preoperative medical examination (POME) and obtain HbA1c level. In the pre-operative period: measure BG on arrival, then q1h and treat glucose if greater than 140 mg/dl with insulin. In the intraoperative: measure BG q1h and treat glucose if greater than 140 mg/dl with insulin. In the PACU measure BG on arrival, then q1h . Treat glucose greater than 140 mg/dl with insulin.	**DV/ outcome measure**: Was preoperative HbA1c measurement obtained, the frequency of perioperative BG monitoring and perioperative insulin use. **State the instrument, reliability, and measurement procedure**: Glucose levels were checked with point of care Accu-Chek machines. Reliability of Accu-Chek was not reported.. Data was reported as mean or percentage. Categorical variables were analyzed using the chi- squared test ($\chi 2$ test). Continuous variables were analyzed using t-tests.	**Statistical Results:** HgbA1c was measured 80% of the time in the intervention group versus 47% in the pre-intervention group ($p < 0.01$). Preoperative BG monitoring was 95% (intervention group) versus 88% (pre-intervention group) ($p < 0.01$). Intraoperative BG monitoring was 67% (intervention group) versus 29% (pre-intervention group) ($p < 0.01$). PACU BG data was unchanged ($p = 0.11$). The administration of insulin increased during the perioperative period ($p \leq 0.04$). Average preoperative BG levels were 130mg/dl (intervention group) versus 141 mg/dl (pre-intervention group) ($p < 0.01$) and post anesthesia care BG levels were 152 (intervention group) versus 162 mg/dl (pre-intervention group) ($p = 0.01$). **Clinical Significance**: Utilization and adherence to a standardized set of perioperative BG management guidelines resulted in increased preoperative HbA1c monitoring, increased preoperative and intraoperative BG monitoring (q1h), and increased administration of insulin when indicated (hyperglycemia). **Conclusions**: A perioperative glucose management guideline can improve perioperative BG monitoring, insulin use, and BG control in diabetic patients undergoing elective surgery.

Citation: Vongsumran, N., Buranapin, S., & Mansoroi, W. (2020). Standardized glycemic management versus conventional glycemic management and postoperative outcomes in type 2 diabetes patients undergoing elective surgery. *Diabetes, Metabolic Syndrome, and Obesity Dovepress Journal. 13,* 2593- 2601. https://doi.org/10.2147/DMSO.S262444					**Level and Quality (Dang et al., 2022).** Level III Quality A
Purpose/ Hypothesis	**Type of Evidence Research Design**	**Sample – Population, Size, Setting**	**Intervention/Procedures**	**Primary Outcome/ Measures**	**Results/Conclusions**
Purpose was to "compare the efficacy of postoperative glycemic control and complications with the two protocols, conventional perioperative glycemic protocol and standardized glycemic control protocol (p. 2593)."	Ambispective study (retrospective and prospective components)	**Sampling Technique**: Convenience sampling. **Population**: Type 2 diabetics undergoing elective surgery **Setting**: Surgical center in tertiary medical care center. **# eligible**: not stated **# accepted**: 380 subjects **# in control:** 182 subjects **intervention:** 198 **Power analysis**: A sample size of at least 360 participants was needed (at least 180 in control and intervention group) to give 80% power at the 5% significance level. **Group Homogeneity**: No significant difference in baseline characteristics between control and intervention groups.	**Control**: Conventional perioperative glycemic protocol (pre-intervention group). No specific guidelines on how to manage perioperative hyperglycemia and insulin administration was based on provider expertise/ judgment. **Intervention**: Implementing a standardized perioperative glycemic protocol. **Intervention fidelity (describe the protocol)**: Standardized glycemic protocol was created by multiple committees, endocrinologists, and nurses. The protocol consists of perioperative SQ and IV insulin administration based on elevated perioperative BG levels greater than 180mg/dL and provides guidelines on the frequency of BG checks throughout the perioperative period. If receiving an insulin infusion, q1h BG checks. If receiving SQ insulin, BG check q4h.	**DV/ outcome measure**: Blood glucose levels. **State the instrument, reliability, and measurement procedure**: Point-of-care devices were used to measure capillary blood glucose levels, but the device was not named and therefore reliability of the instrument cannot be confirmed. Statistical analysis was performed using STATA version 16.0 statistical program. Continuous data (mean and standard deviation) was analyzed using independent t-tests. Categorical data (counts and percentages) was analyzed using Fisher exact test.	**Statistical Results:** Patients in the intervention group had significantly lower mean BG levels 24 hours postoperative compared to the control group (p=0.42). There was no statistically significant difference in postoperative hypoglycemia between the two groups. **Clinical Significance**: Adherence to a standardized perioperative glycemic management protocol resulted in improved BG monitoring and management throughout the entire perioperative period **Conclusions**: In type 2 diabetics undergoing elective surgery implementing a standardized protocol to manage BG is more effective than the conventional protocol previously implemented at this institution with no increased risk in hypoglycemic events.

Table 2

Evidence Synthesis

Category (Level Type)	Total Number of Sources/ Level	Overall Quality Rating	Synthesis of Findings
Level 1 - Experimental study · Randomized Controlled Trial (RCT) · Systematic review of RCTs with or without meta-analysis	0		
Level II · Quasi-experimental studies · Systematic review of a combination of RCTs and quasi-experimental studies, or quasi-experimental studies only, with or without meta-analysis	0		
Level III · Non-experimental study · Systematic review of a combination of RCTs, quasi-experimental, and non-experimental studies, or non-experimental studies only, with or without meta-analysis · Qualitative study or systematic review of qualitative studies with or without meta-synthesis	2	B	The two studies discuss how frequent perioperative BG checks can improve glycemic management of diabetic patients during the perioperative period (Vongsumran et al., 2020; Nair et al., 2016). In diabetic patients undergoing elective surgery or non-cardiac surgery, utilizing and adhering to a standardized institutional perioperative BG management protocol can result in improved hyperglycemic management with insulin administration when perioperative BG levels are elevated. Insulin administration thresholds varied throughout the studies. Nair et al. (2016) administered insulin when BG was greater than 140 mg/dL, while Vongsumran et al. (2020) administered insulin when BG was greater than 180 mg/dL. Overall, studies found that treating elevated intraoperative BG levels reduces the incidence of hyperglycemia in the postoperative period (Vongsumran et al., 2020; Nair et al., 2016).
Level IV · Opinion of respected authorities and/or reports of nationally recognized expert committees/consensus panels based on scientific evidence	0		
Level V · Evidence obtained from literature reviews, quality improvement, program evaluation, financial evaluation, or case reports · Opinion of nationally recognized expert(s) based on experiential evidence	4	B	Duggan et al. (2019) discusses how establishing a standardized algorithm for perioperative BG management in diabetic surgical patients is recommended by anesthesia experts and credible national committees. Colibaseanu et al. (2018), DiNardo et al. (2011), and Shah et al. (2014) implemented a standardized perioperative BG guideline/protocol at their local hospital and found it was successful in controlling BG throughout the perioperative period in diabetic surgical patients. Anesthesia experts further explain that on the day of surgery BG should be checked and treated with insulin if greater than 180mg/dL (Duggan et al, 2019). SQ rapid acting insulin is recommended for non–critically ill patients, while IV insulin is recommended for critically ill patients (Duggan et al, 2019). Colibaseanu et al. (2018) and Shah et al .

			(2014) administered insulin when BG was greater than 140 mg/dL, while DiNardo et al. (2011) administered insulin when BG was greater than 200mg/dL. Frequent intraoperative BG monitoring should occur either every hour or every two hours to monitor for hyperglycemic or hypoglycemia events (Duggan et al, 2019; DiNardo et al., 2011, Shah et al., 2014).
Recommendations Based on Evidence Synthesis Overall, low levels of evidence exist to support frequent intraoperative BG monitoring of at least every hour or every two hours during the perioperative period in diabetic surgical patients. However, when looking at the research results, quality improvement studies, and expert opinions there appears to be consistent recommendations indicating that implementing a standardized glycemic perioperative guideline/protocol can improve BG optimization, increase BG monitoring rates, and reduce the likelihood of the patient entering the postoperative period continuing to remain hyperglycemic. When treating the patient's elevated BG (greater than 180mg/dL) during the perioperative period with insulin there is always the risk that this could lead to hypoglycemia, but the risk is low when combined with frequent BG monitoring (every hour or two hours) and utilizing SQ rapid acting insulin in short ambulatory procedures (less than 4 hours) versus regular IV insulin. Patients will also likely be in support and prefer to have their BG monitored frequently and optimized throughout their surgical procedure to prevent any future postoperative complications that are frequently associated with hyperglycemia during surgery.			

Table 3

Number of Eligible Patient's Included Each Week During quality Improvement Project 15- week Implementation Period

Week #	**% Eligible Patients Included/ # of Eligible Patients Included**
1	100 (n=18)
2	100 (n=20)
3	100 (n=15)
4	100 (n=19)
5	100 (n=21)
6	100 (n=21)
7	100 (n=12)
8	100 (n= 9)
9	100 (n=17)
10	100 (n=13)
11	100 (n=16)
12	100.0 (n=15)
13	100.0 (n=11)
14	100 (n=18)
15	100.0 (n=17)
Total: 15 weeks	*Total: 100% (n=238)*

Figure 1
Root Cause Analysis Fishbone

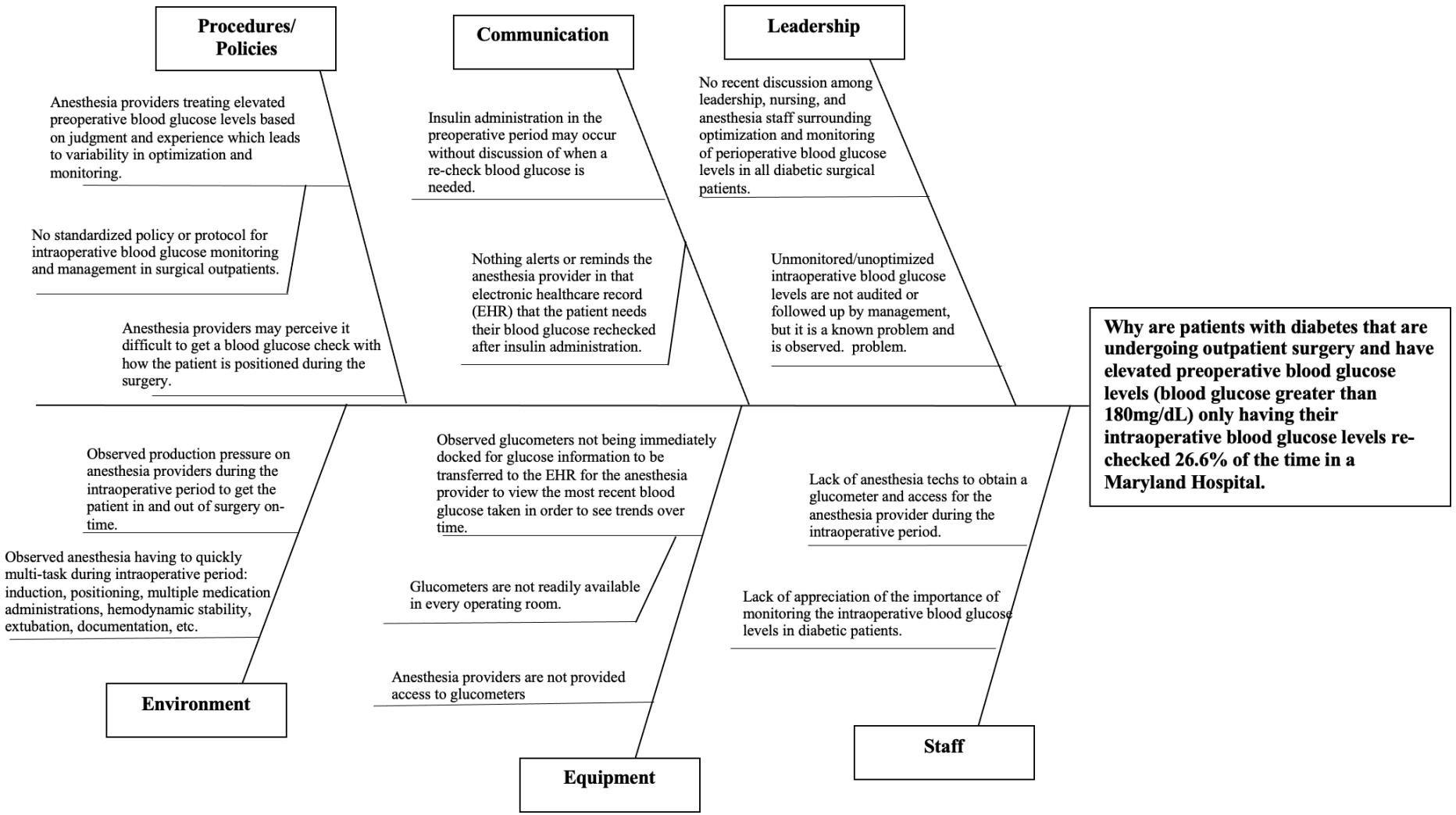
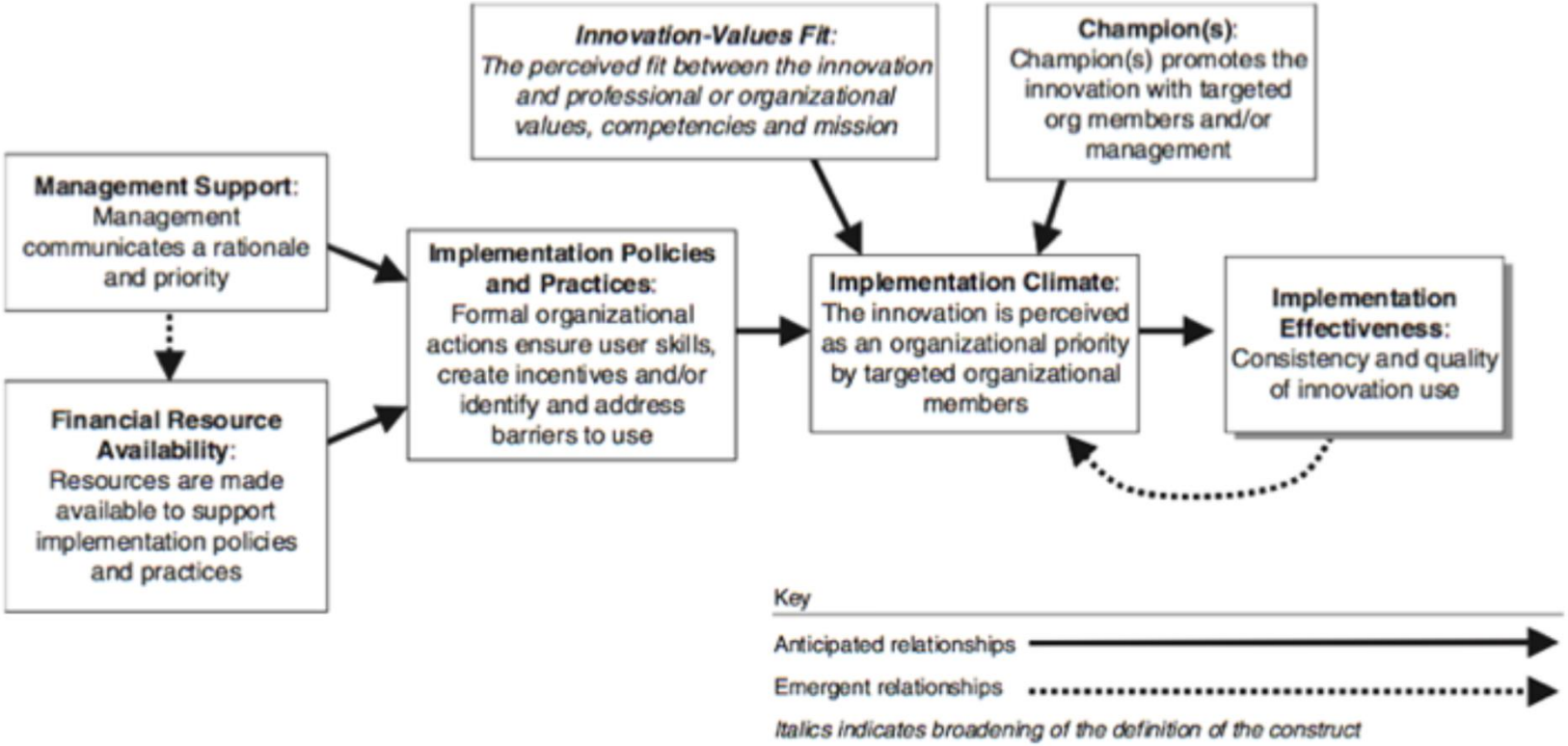


Figure 2

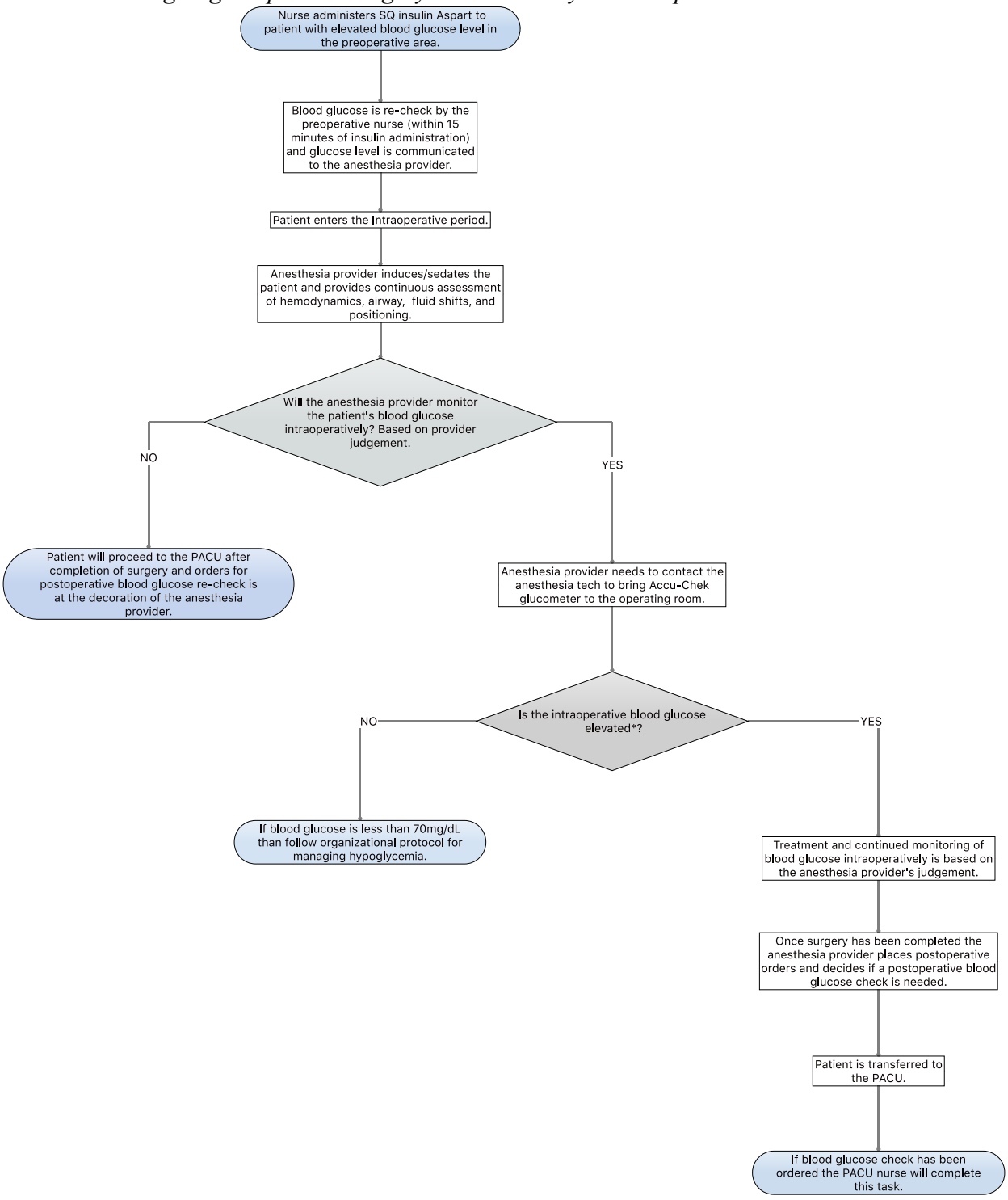
Framework of Complex Innovation Implementation



Notes: Image from Helfrich, C.D., Weiner, B.J., McKinney, M.M. & Minasian. L. (2007). Determinants of implementation effectiveness adapting a framework for complex innovations. *Medical Care Research and Review, 64*(3), 279-303 doi: 10.1177/107755870729

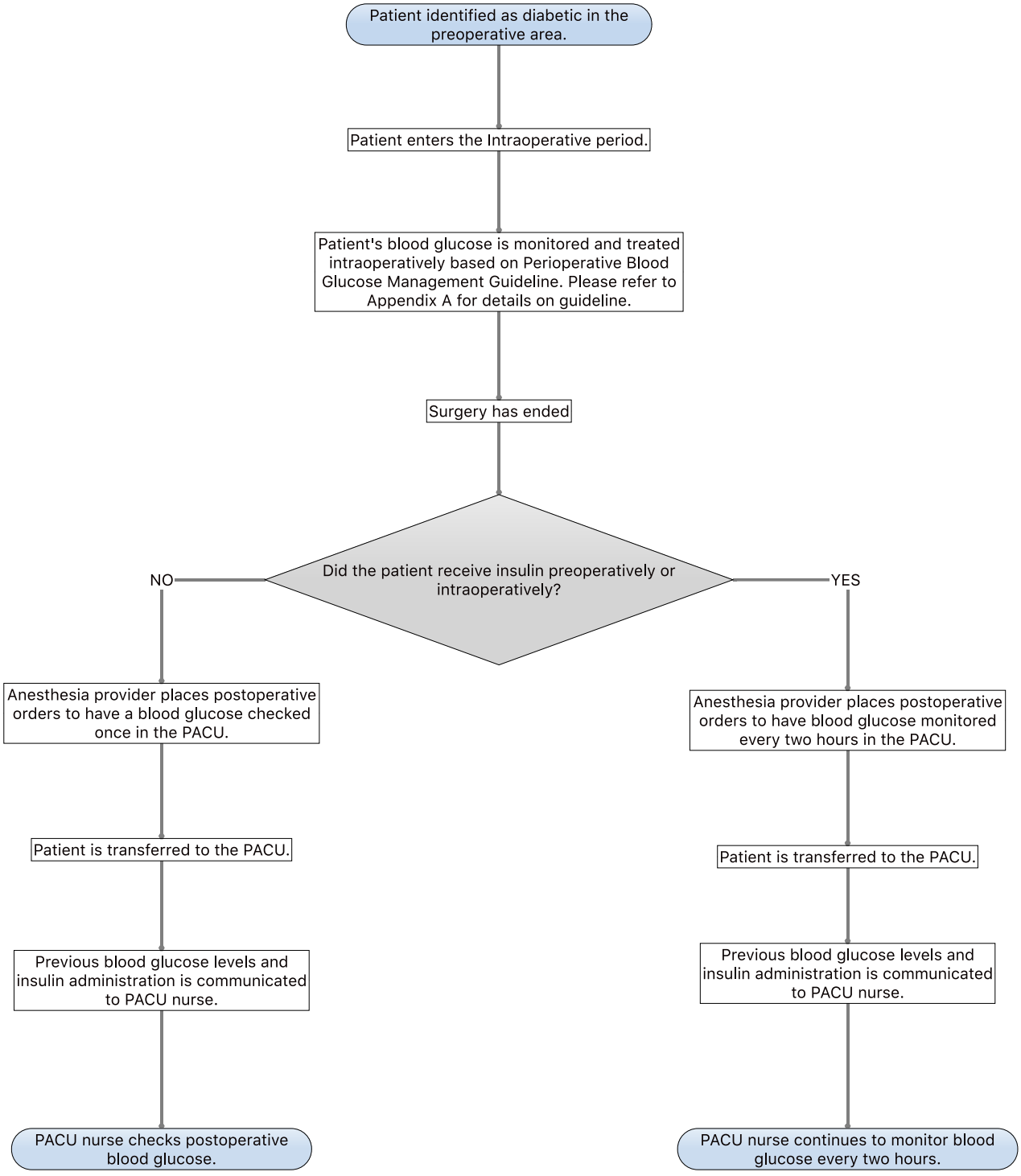
Figure 3

Flowchart of the Current Process of Perioperative Blood Glucose Management in Patients with Diabetes Undergoing Outpatient Surgery within a Maryland Hospital.



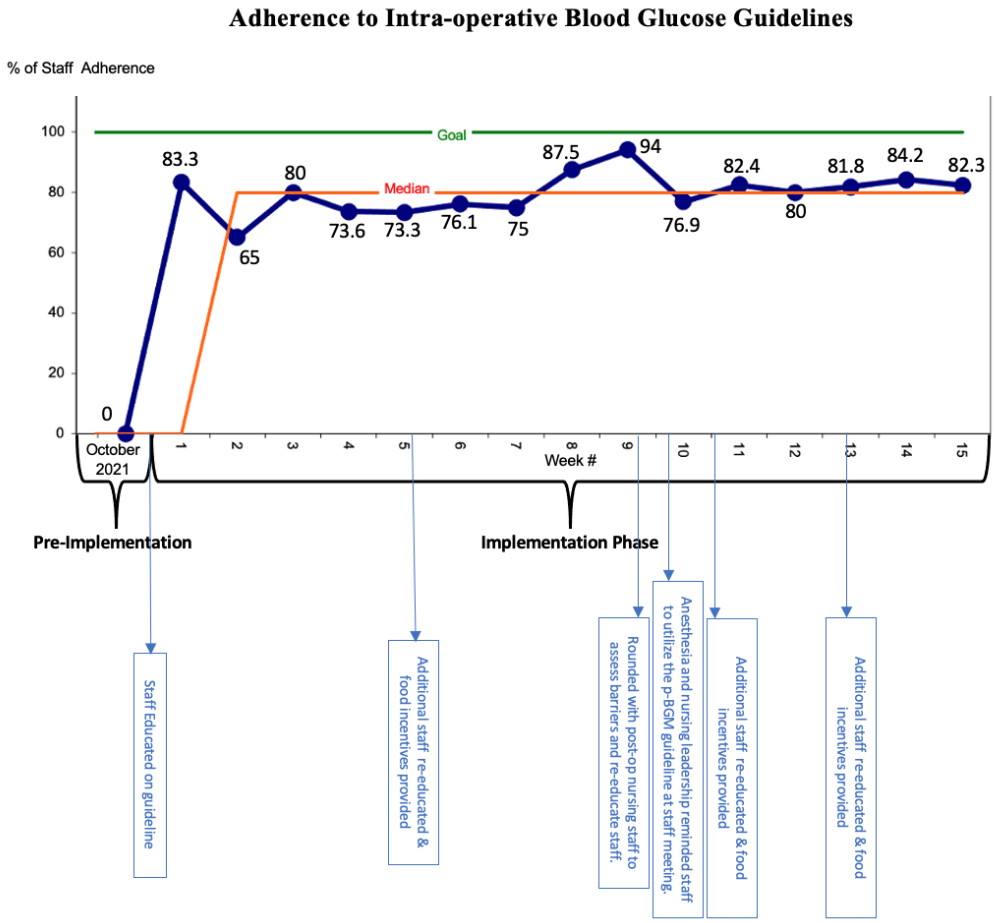
Notes: Oval- start or end of process; Rectangle- step in process; Diamond- decision in process; PACU- post anesthesia care unit; SQ- subcutaneous; no definition provided as to what is considered and elevated blood glucose

Figure 4:
Flowchart of the Desired Process of Perioperative Blood Glucose Management in Patients with Diabetes Undergoing Outpatient Surgery within a Maryland Hospital.



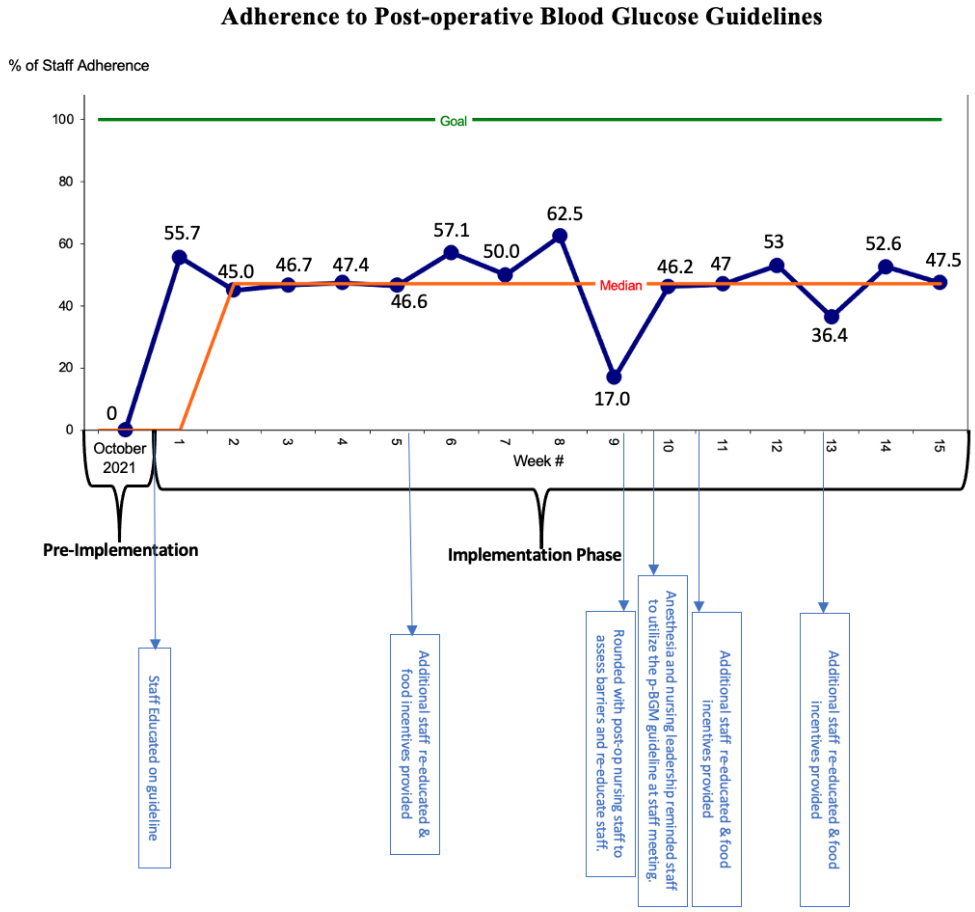
Notes: Oval- start or end of process; Rectangle- step in process; Diamond- decision in process; PACU- post anesthesia care unit

Figure 5: *Process Measure Run Chart: Adherence to Intra-Operative Blood Glucose Management Guidelines.*



Note: Pre-implementation baseline data was collected over the month of October in 2021. The pre-implementation data point is at 0% adherence in order to demonstrate the hospital's absence of a Perioperative Blood Glucose Management Guideline during this time.

Figure 6: *Process Measure Run Chart: Adherence to Post-Operative Blood Glucose Management Guidelines.*



Note: Pre-implementation baseline data was collected over the month of October in 2021. The pre-implementation data point is at 0% adherence in order to demonstrate the hospital's absence of a Perioperative Blood Glucose Management Guideline during this time.

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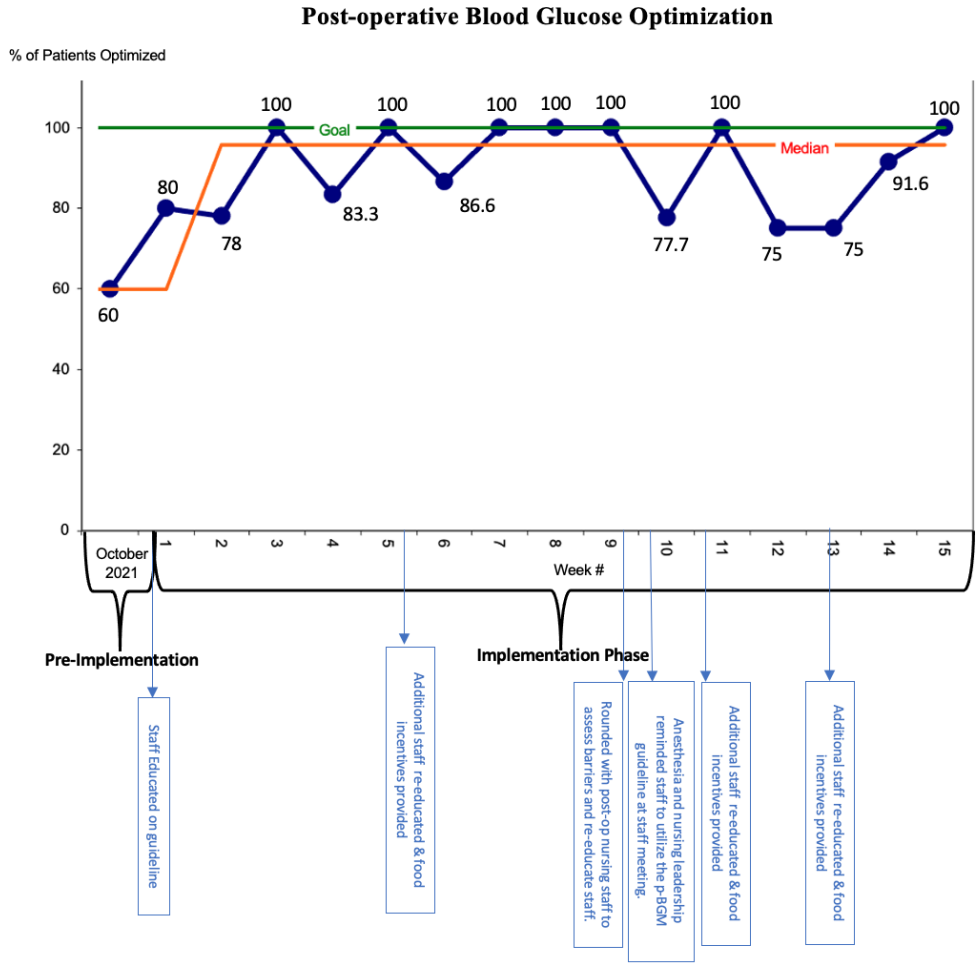
Figure 7: *Outcome Measure Run Chart: Post-Operative Blood Glucose Optimization (mean post-op blood glucose between 70mg/dL to 180mg/dL).*



Note: This data set only includes patients that had a post-op blood glucose evaluated. Pre-implementation baseline data was collected over the month of October in 2021.

Appendix A

Perioperative Blood Glucose Management Guideline for Adult Surgical Outpatients with Diabetes

This guideline is intended for:

- Non- critical diabetic patients scheduled for outpatient surgery

This guideline is not intended for:

- Critically ill patients
- Emergency surgery
- Inpatient surgery
- Patients with subcutaneous insulin pumps
- Surgeries with anticipated hemodynamic instability or large fluid shifts
- Prolonged surgeries (greater than 4 hours)

Preoperative period:

1. Check preoperative blood glucose on diabetic patients.
2. If blood glucose is >180 mg/dL use Subcutaneous (SQ) Insulin Aspart (NovoLog) sliding scale below to treat hyperglycemia

Blood glucose level (mg/dL)	**Low Dose Scale (units)** *Use with patients with insulin sensitivity, weight <70kg, or renal insufficiency*	**Medium Dose Scale (units)** *Use for patients 71-100kg*	**High Dose Scale (units)** *Use for patients with insulin resistance, weight >100kg, or concurrent steroid therapy*
181-200	1	1	2
201-220	1	2	3
221-240	2	2	4
241-260	2	3	5
261-280	2	3	6
281-300	3	4	7
301-320	3	4	8
321-340	3	5	9
341-360	4	5	10
361-380	4	6	11
381-400	4	6	12
>400*	5	7	13

3. If blood glucose < 70mg/dL or > 400mg/dL, notify anesthesia provider.
4. Recheck blood glucose in 1 hour, ideally before leaving preoperative area.

Intraoperative period:

1. Verify pre-op blood glucose check and if insulin was administered/ time.
2. Monitor blood glucose intra-op every 2 hours in diabetic patients.
3. If intra-op blood glucose is > 180mg/dL than treat with SQ Insulin Aspart (NovoLog) sliding scale. Continue to monitor blood glucose every 2 hours.

   Please Note: *SQ insulin is recommended over IV insulin infusion for treatment of hyperglycemia in non-critically ill, stable patients undergoing surgeries without anticipated large fluid shifts, or in short outpatient procedures (less than 4 h). "**Rapid-acting SQ insulin should not be dosed more frequently than every 2 hours to minimize the risk of insulin stacking. No more than 2 doses should be provided to an anesthetized patient to limit the risk of hypoglycemia**" (Duggan, et al., 2019, p. 134).*
4. Place post-op anesthesia care unit (PACU) orders to monitor blood glucose Q2H.

Postoperative period:

1. On PACU arrival communicate last blood glucose and insulin administration/time.
2. Monitor blood glucose every 2 hours while the patient is in the PACU.
3. Notify anesthesia if blood glucose is < 70 mg/dL or > 180 mg/dL

References: Duggan E. & Chen, Y. (2019). Glycemic management in the operating room: Screening, monitoring, oral hypoglycemics, and insulin therapy. *Current Diabetes Reports, 19(11),* 134. https://doi.org/10.1007/s11892-019-1277-4

Appendix B

Educational Sessions Lesson Plan

Learning Objectives: By then end of the presentation learner will be able to:	**Content Outline**	**Method of Instruction**	**Method of Evaluation**
1. Describe the background and significance of perioperative blood glucose monitoring	• Internal data surrounding blood glucose monitoring rates in patients with diabetes receiving outpatient surgery o Enter the intra-op period with an elevated blood glucose greater than 180 mg/dL and experience a re-evaluation rate of only 26.6% during the intra-op period o 40% of patients remaining hyperglycemic in the post-operative (post-op) period. • Negative effects related to hyperglycemia o Delayed wound healing o Surgical site infection rates higher • Benefits of using a p-BGM guideline that is supported by the literature o Improves blood glucose monitoring rates during intra-op/post-op periods o Improves blood glucose optimization o Reduces likelihood of patient entering post-op period hyperglycemic	In- person PowerPoint presentation/ Group discussion	Verbal feedback during presentation
2. Compare the current blood glucose management process to the newest EBP approach.	• Describes current blood glucose management process of patients with diabetes receiving outpatient surgery o No guideline or protocol currently exists o Much unit and provider variability in monitoring and treatment • Describes newest EBP approach in managing blood glucose in diabetic patients receiving outpatient surgery o Presents a photo of the new p-BGM guideline and goes through guideline in step by step o Provides staff with a copy of this new guideline initiative for reference during the presentation/discussion	In- person PowerPoint presentation/ Group discussion	Verbal feedback during presentation
3. Describes the new p-BGM guideline, their role during implementation, and start date of QI project.	• Identifies start date of the QI project • Identifies the role of staff during implementation o Pre-op nurses: checking blood glucose on all diabetics scheduled for outpatient surgery and notifying provider if pre-op blood glucose is >180mg/dL o Anesthesia: Follow-up with pre-op nurse about blood glucose level, treat blood glucose if >180mg/dL, continue to monitor and/or treat blood glucose intra-op, place PACU orders for continued blood glucose monitoring per p- BGM guideline o PACU nurses: check post-op blood glucose on all diabetic outpatients per p-BGM protocol o Anesthesia technicians help obtain glucometer during the intra-op period • Discusses how weekly audits will be completed on diabetic outpatients in order to monitor for adherence and effectiveness of the p-BGM guideline intervention.	In- person PowerPoint presentation/ Group discussion	Verbal feedback during presentation & example case scenario

Appendix C

Education Data Collection Tool

Learning Activity: Blood Glucose Perioperative Management Guideline

Education Data Collection Tool

Record ID	_____
Date of Education?	_____
Role of staff member?	◯ Pre-op Nurse ◯ Operating Room nurse ◯ Post-op Nurse ◯ CRNA ◯ Anesthesiologist ◯ Anesthesia Technician

Appendix D

Project Audit Tool

Project Audit Tool

Record ID	_____
Data collection week	◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ 10 ◯ 11 ◯ 12 ◯ 13 ◯ 14 ◯ 15
Pre-op blood glucose assessed	◯ Yes ◯ No
Time of last pre-op blood glucose assessment	_____
Pre-op blood glucose level (mg/dL)	_____
Insulin administered	◯ Yes ◯ No
Patient's pre-op blood glucose greater than 180mg/dL	◯ Yes ◯ No
Blood glucose assessed during the intra-op period	◯ Yes ◯ No ◯ N/A
Time of the 1st intra-op blood glucose measurement	_____
1st intra-op blood glucose level (mg/dL)	_____
Insulin administered	◯ Yes ◯ No
Time of insulin administration	_____
Units of insulin administered	_____

2nd blood glucose assessed intra-op	◯ Yes ◯ No ◯ N/A
Time of 2nd intra-op blood glucose	_____
2nd intra-op blood glucose level (mg/dL)	_____
Insulin administered	◯ Yes ◯ No
Time of insulin administration	_____
Units of insulin administered	_____
3rd blood glucose assessed intra-op	◯ Yes ◯ No ◯ N/A
Time of 3rd blood glucose intra-op	_____
3rd intra-op blood glucose level (mg/dL)	_____
Insulin administered	◯ Yes ◯ No
Time of insulin administration	_____
Units of insulin administered	_____
4th blood glucose assessed intra-op	◯ Yes ◯ No ◯ N/A
Time of 4th intra-op blood glucose	_____
4th intra-op blood glucose level (mg/dL)	_____
Insulin administered	◯ Yes ◯ No
Time of insulin administration	_____
Units of insulin administered	_____

5th blood glucose assessed intra-op	◯ Yes ◯ No ◯ N/A
Time of 5th intra-op blood glucose check	_____
5th intra-op blood glucose level (mg/dL)	_____
Insulin administered	◯ Yes ◯ No
Time of insulin administration	_____
Units of insulin administered	_____
Intra-op blood glucose monitoring was at the appropriate interval (every 4 hours) in patients that did not receive pre-op insulin per the Perioperative Blood Glucose Guideline?	◯ Yes ◯ No ◯ N/A
Intra-op blood glucose monitoring was at the appropriate interval (every 2 hours) in patients that did receive pre-op insulin per the Perioperative Blood Glucose Guideline	◯ Yes ◯ No ◯ N/A
Intra-op mean blood glucose less than 180	◯ Yes ◯ No ◯ N/A
Immediate post-op blood glucose measured	◯ Yes ◯ No
Time of first post-op blood glucose	_____
1st post-op blood glucose level (mg/dL)	_____
2nd post-op blood glucose measured	◯ Yes ◯ No ◯ N/A
Time of 2nd post-op blood glucose	_____
2nd post-op blood glucose level (mg/dL)	_____
3rd blood glucose level measured	◯ Yes ◯ No ◯ N/A

Time of 3rd blood glucose measure	_____
3rd post-op blood glucose level (mg/dL)	_____
Post-op mean blood glucose less than 180	◯ Yes ◯ No ◯ N/A
Post-op blood glucose monitoring was followed per the Perioperative Blood Glucose Management Guideline	◯ Yes ◯ No
Hypoglycemic events	◯ Intra-op ◯ Post-op ◯ Intra-op and Post-op ◯ None