PERIOPERATIVE GLYCEMIC CONTROL TO REDUCE SURGICAL SITE INFECTIONS: CLINICAL PRACTICE GUIDELINE

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Abstract

Background: Surgical site infections are a common postoperative complication that has been identified to be related to perioperative hyperglycemia. During times of stress, including surgical stress and anesthesia, the body responds by increasing levels of glucose to meet metabolic demands and reduces the production of insulin, leading to hyperglycemia. Intraoperative blood glucose monitoring and treatment has been demonstrated to reduce the incidence of hyperglycemic events and reducing the incidence of postoperative complications.

Local Problem: A tertiary medical center in Maryland requested an updated, evidence-based clinical practice guideline for perioperative glucose management. This clinical practice guideline will provide an evidence-based approach for the following: intraoperative glycemic control, blood glucose monitoring frequency, intraoperative insulin pump management and insulin administration.

Interventions: The purpose of this Doctorate of Nursing Practice project was to develop a clinical practice guideline for perioperative glycemic control to reduce surgical site infections in orthopedic surgical patients. This clinical practice guideline was designed for quality improvement purposes and conducted through a combined effort of three student registered nurse anesthetists as project leaders. Feedback and recommendations of the clinical practice guideline were received by key stakeholders through the utilization of the AGREE II tool. Implementation of the project was done via a PowerPoint presentation of the final clinical practice guideline to the end-users, the anesthesia staff, at the facility during the anesthesia staff meeting. End-users provided feedback of the clinical practice guideline via a Practitioner Feedback Questionnaire and demographic questionnaire to evaluate the clinical practice guideline. Data collected using The Agree II tool and Practitioner Feedback Questionnaire were analyzed using simple descriptive and correlative statistics.

Results: The mean overall guideline assessment score of the AGREE II tool results was 87%. Both stakeholders rated the overall quality of the guideline with high quality ratings and indicated "yes" to recommending this guideline for use. Descriptive statistics were calculated for the sample of anesthesia providers ($n = 23$) who completed a Practitioner Feedback Questionnaire. Demographic data revealed that of the 23 respondents, six were anesthesiologists (26%), 16 were certified registered nurse anesthetists (70%), and one student registered nurse anesthetist (4%). Analysis of the Practitioner Feedback Questionnaire results support this clinical practice guideline. The average total percentage of agreement was 80.5% ($SD=0.12$); indicating the acceptability and usability of this clinical practice guideline by the anesthesia providers at this institution.

Conclusions: Perioperative glycemic control has been shown to decrease surgical site infections rates. Recent evidence-based research demonstrates that a target glucose level of <180 mg/dL is effective in reducing surgical site infections, as well as reducing the risk of intraoperative hypoglycemic events. This clinical practice guideline was developed and successfully implemented specifically for this institution as requested to meet the needs of this anesthesia department. Sustainability and spread of the clinical practice guideline will be dependent on the institution.

Overview

Surgical site infections (SSI) are a common postoperative complication affecting approximately 2-5% of surgical patients (Anderson et al., 2014). In 2011, the Centers for Disease Control and Prevention reported 157,500 cases of SSIs in the United States (Centers for Disease Control and Prevention [CDC], Healthcare-associated Infections, 2018). Surgical site infections are defined as an infection, occurring after surgery, in the body where the surgery took place (CDC, Healthcare-associated Infections, 2012). Surgical site infections can be problematic and lead to prolonged postoperative hospital length of stay (7-11 additional days), increased risk of death (2-11 times higher), and increased healthcare costs ($3.5 billion to $10 billion annually) (Anderson et al., 2014).

Researchers have demonstrated a relationship between SSIs and perioperative hyperglycemia. Elevated blood glucose levels impair the body's immune system and its ability to fight infection. Diabetes mellitus (DM) is a chronic illness affecting approximately 30.3 million Americans (9.4% of the U.S. population) of all ages (American Diabetes Association, 2017). Approximately 25% of patients with DM will present for surgery and approximately 5-10% of these patients are undiagnosed or unaware of their DM status at the time of surgery (Setji et al., 2017). Hyperglycemia is an outcome of uncontrolled or undiagnosed DM. When the body undergoes acute periods of stress, such as surgical insult and anesthesia, increased levels of glucose are released to meet metabolic demands in patients with and without DM. During this stress response, pancreatic beta-cell function is reduced causing hypo-insulinemia and insulin tolerance, thereby worsening hyperglycemia (Takesue & Tsuchida, 2017). This increases the risk of SSIs in patients undergoing orthopedic surgery, especially total joint, spine, foot and ankle surgeries (Wukich, 2015).

In 2002, through the combined efforts of the Centers for Medicare and Medicaid (CMS) and the Joint Commission, the Surgical Care Improvement Project (SCIP) campaign was introduced to reduce postoperative surgical site infections and improve outcomes for surgical patients (Cataife, Weinberg, Wong, & Kahn, 2014). A quality performance measure guideline was developed for blood glucose management in cardiac surgery to keep 6 a.m. blood glucose (BG) levels <200 mg/dl (Takesue & Tsuchida, 2017). Current SCIP guideline recommendations for BG management goals in cardiac surgery patients include maintaining BG levels less than or equal to 180 mg/dl within 18 to 24 hours after "anesthesia end time" (CMS/The Joint Commission, 2014).

Purpose Statement and Outcomes

The purpose of this Quality Improvement project is to develop a clinical practice guideline (CPG) for perioperative glycemic control to reduce SSIs in orthopedic surgical patients. A tertiary medical center in Maryland requested an updated, evidence-based CPG for perioperative glucose management. This CPG will provide an evidence-based approach for the following: intraoperative glycemic control, BG monitoring frequency, intraoperative insulin pump management and insulin administration. The expected result of this project will be a standardized, evidence-based approach to glycemic management and a reduction in postoperative SSI's.

Literature Review

The development of an updated, evidence-based CPG for intraoperative glycemic control is the primary focus of this literature review (see Table 1). This review examines target BG levels, the efficacy of intraoperative BG management to reduce SSIs, and current intraoperative

BG management guidelines. The literature review will conclude with a summary of recommendations.

While the focus of this CPG is in orthopedic surgical patients, the majority of studies examining ideal target BG ranges were focused on cardiac surgeries. Desai et al (2012) conducted a randomized control trial (RCT) to compare liberal BG levels (121-180 mg/dL) to strict glucose levels (90-120 mg/dL) in patients that underwent first time cardiac surgery. In comparison to the Strict Group, the Liberal Group reached their target goal range 50% faster (83.5 ± 134.6 vs 173.3 ± 195.8 minutes) and required less total units of insulin (166.0 ± 156.7 vs 252.3 ± 193.4). Additionally, the Liberal Group experienced fewer hypoglycemic events (BG < 60 mg/dL) compared to the Strict Group (11 [11%] vs 30 [33%]). Based on the results of this study, the authors recommend target BG levels of 121 to 180 mg/dL.

A meta-analysis of 15 RCTs performed by de Vries et al (2017) examined the effect of intensive glucose control in comparison to conventional glucose control protocols on the risk of SSIs. The authors found that stricter BG target levels in comparison to conventional BG target levels significantly reduced the incidence SSIs ($P<0.001$). However, the risk for hypoglycemic events was higher in patients receiving stricter BG target levels versus patients receiving conventional BG target levels (OR 5.55, 95% CI 2.58 to 11.96). Among the 15 RCTs examined, four studies had no hypoglycemic events, five studies revealed significantly more asymptomatic hypoglycemic events with intensive protocols, three studies revealed no significant difference, and three studies did not report hypoglycemic events. Additionally, no significant difference was found between protocols in regards to postoperative death ($P=0{\cdot}484$) and stroke ($P=0{\cdot}511$) (OR 0.74 and OR 1.37) (de Vries et al., 2017).

Intraoperative BG management guidelines are designed to mitigate surgical complications related to intraoperative hyperglycemia. Two evidence based clinical guidelines recommended an intraoperative BG target level of less than 180 mg/dL for general surgical patients depending on their fasting status (Duggan et al., 2016; Joslin Diabetes Center, 2015). Additionally, recommendations for frequency of BG monitoring included known DM patients should have their BG checked prior to induction of anesthesia and then hourly for surgeries lasting more than 2 hours (Akiboye & Rayman, 2017). Other guideline recommendations for BG testing included checking BG levels every 2 hours throughout the perioperative period (Duggan et al., 2016; Joslin Diabetes Center, 2015). However, Duggan et al (2016) recommended BG monitoring is not required if fasting BG levels are less than or equal to 140 mg/dL.

Treatment and management of hyperglycemia in the non-critically ill surgical patient included the use of fast acting subcutaneous (SC) insulin for shorter procedures, less than 2 hours. Insulin dosing should be based on a patient stratification according to their response to insulin. Insulin administration is to be started at any time during the perioperative period if any BG reading is greater than or equal to 180 mg/dL (Duggan et al., 2016). However, critically ill surgical patients, patients undergoing surgeries greater than 3 hours, or who had a prolonged fasting status (>1 missed meal), an intravenous (IV) insulin infusion should be started and should be titrated every 1 to 2 hours based on BG readings (Akiboye & Rayman, 2017; Duggan et al., 2016). An IV infusion of dextrose 5% water (D5W) at 40 ml/hour or dextrose 10% water (D10W) at 20 ml/hour should be started with the insulin infusion to avoid hypoglycemia. Additionally, IV maintenance fluids without dextrose (Lactated Ringers solution or Normal Saline) should be used unless an insulin infusion is required (Joslin Diabetes Center, 2015).

Diabetic Type I patients have minimal or lack pancreatic beta cell function and need exogenous insulin administration to maintain balanced BG levels. Duggan et al (2016) provided specific recommendations for DM Type I surgical patients including: for surgeries lasting more than 2 hours, intraoperative IV insulin infusion with BG levels checked every 2 hours. For surgeries lasting less then 2 hours, DM Type I surgical patients should have BG levels checked every hour and treated with fast acting SC insulin for BG greater than or equal to 180 mg/dL (Duggan et al., 2016).

Insulin pumps are often utilized by DM Type I patients and an endocrinologist consult should be obtained for specific recommendations regarding the management of these surgical patients. If endocrinologist consults are not available, discontinuation of the insulin pump and conversion to SC insulin is recommended (Akigoye & Rayman, 2017; Duggan et al., 2016; Joslin Diabetes Center, 2015). If insulin pumps are discontinued recommendations include: SC basal insulin may be given at a dose equal to the amount of insulin a patient would receive over 24 hours via their pump (Akiboye & Rayman, 2017).

In summary, upon examination of the literature, a CPG for management of perioperative glycemic control was developed according to the following recommendations. The optimal range to maintain BG levels intraoperatively is 150 mg/dL to 180 mg/dL to avoid hypoglycemic events. Blood glucose monitoring of the known DM patients will be completed prior to induction of anesthesia and every 2 hours intraoperatively. If a regular insulin infusion is required, BG levels will be monitored hourly and adjusted according to the previous readings and current rate of infusion. Maintenance IV fluids will contain either D5W or D10W, infusing concurrently with the insulin infusion to prevent hypoglycemic events. For procedures lasting less than 2 hours, hyperglycemia treatment will be with SC regular insulin according to the institution's current insulin administration order sets. It is advised that for the DM Type I patient, a regular insulin infusion will be started intraoperatively. Additionally, DM Type I surgical patients with an insulin pump will remain on their insulin pump according to recommendations from an endocrinologist. If a preoperative endocrinologist consult is not available, discontinue the insulin pump and transition the patient to a continuous IV insulin infusion following the above recommendations for IV insulin infusion and titrate dosages according to the institution's current insulin infusion order sets.

Theoretical Framework

The quality improvement model selected to direct the implementation of this CPG is the Focus, Analyze, Develop, and Execute/Evaluate (FADE) quality improvement (QI) model. This model was developed by the Organizational Dynamics Institute to assist companies to improve customer satisfaction by enhancing quality and productivity (Wiseman & Kaprielian, 2005). The FADE QI model encompasses four comprehensive domains: 1) Focus, 2) Analyze, 3) Develop, and 4) Execute/Evaluate. The first domain is *Focus*, which involves the identification of the issue or practice of concern. The second domain is to *Analyze* where data is gathered and examined via a root cause analysis to establish baselines for the identified issues of practice concern in an effort to identify possible solutions (Wiseman & Kaprielian, 2005). The third domain of the FADE QI model is to *Develop* an action plan. This step includes development, implementation, communication and monitoring of practice changes. Progress reports throughout this step allow for modifications of the action plan. *Execution* and *Evaluation* is the final domain of the FADE QI model. Assessment of the practice change is necessary to determine the effectiveness of the interventions to produce the desired outcomes (Wiseman & Kaprielian, 2005).

The goal of this CPG is the development of a comprehensive perioperative glycemic control guideline to reduce SSIs. This is the practice problem identified under the *Focus* domain of the FADE QI model. The *Analyze* domain will investigate baseline data, including the incidence of perioperative hyperglycemia and SSIs at this tertiary medical center. Evidenced reviewed supports the effectiveness of established glycemic management protocols. An action plan will be designed in the *Develop* phase to address internal evidence from this facility, using evidence-based research supporting perioperative BG levels and glycemic control. The *Execution* phase will involve an educational presentation of the CPG to the anesthesia staff. Finally, *Evaluation* will be conducted via analysis of data collected from the Practitioner Feedback Questionnaire (PFQ) and demographic questionnaire (see Table 2) upon the completion of the educational presentation.

Implementation

Description, Sample, and Setting

The development of this CPG focuses on the perioperative management of the hyperglycemic surgical adult patient ≥ 18 years old without active infections undergoing elective orthopedic surgery (see Appendix A). This CPG is designed for quality improvement purposes, requested by a tertiary medical center in the state of Maryland. It is not meant to be generalizable to other organizations or settings.

Procedures and Timeline

After receiving an Institutional Review Board (IRB) determination of Not Human Subject Research for this project, the quality improvement project was completed in three phases. The first phase included three meetings with the key stakeholders: the Chairman of the Department of Anesthesiology and a Certified Registered Nurse Anesthetist (CRNA). A project proposal presentation of a draft CPG was presented to the key stakeholders by two student registered nurse anesthetist (SRNA) project leaders at the first meeting. Upon conclusion of the project proposal presentation, a draft CPG and the Appraisal of Guidelines for Research and Evaluation (AGREE) II tool was given to the stakeholders for their feedback and recommendations. A second meeting was held with the stakeholders to discuss their feedback and recommendations. Revisions of the CPG were done according to these recommendations. Additionally, a telephone conference call was conducted with the three SRNA project leaders and the Chairman of the Department of Anesthesiology to discuss further recommendations for added revisions of the CPG. Submission of the revised CPG was provided to the stakeholders at a third meeting. Upon conclusion of the third meeting, the stakeholders returned the completed AGREE II tools with final approval of the CPG.

A PowerPoint presentation of the final CPG to the anesthesia staff at the facility during the anesthesia staff meeting commenced phase two. Upon conclusion of the presentation, anesthesia staff members were asked to complete a Practitioner Feedback Questionnaire (PFQ) and demographic questionnaire to evaluate the CPG (see Table 2). Phase three began three weeks after the presentation to the anesthesia staff, when completed PFQs were collected and data analysis began.

Data Collection

Data collection was done in two parts. First, the validity and quality of guidelines developed was assessed using the Appraisal of Guidelines for Research and Evaluation II tool (AGREE II) (see Figure 1). The AGREE II tool is a valid and reliable instrument used to assess the validity and quality of CPGs. It consists of 23 items structured into the six quality domains: Scope and Purpose, Stakeholder Involvement, Rigor of Development, Clarity of Presentation, Applicability, and Editorial Independence. The 23 items focus on different aspects of practice guideline quality which are rated on a 7-point Likert scale (AGREE Next Steps Consortium, 2013).

The second part of data collection utilized The Provider Feedback Questionnaire (PFQ) that was distributed to anesthesia staff at a designated Friday morning anesthesia staff meeting. The PFQ is an appraisal tool that systematically quantify practitioner opinions of the recommendations of a CPG by clinician status and demographic data (Brouwers, Graham, Hanna, Cameron, & Browman, 2004). It comprises of 23 items which assess scientific quality, methodological rigor, implementability and applicability, and acceptability of the recommendations (see Figure 2). For the purposes of this project, the survey items were modified to include demographic questionnaire items and rated on a three-point Likert scale. The demographic questionnaire items included with the PFQ pertained to information regarding practice licensure (MD, CRNA, Resident/Fellow, or SRNA), and years of anesthesia provider experience.

Data Analysis

Data analysis from the AGREE II tool was based on the scores calculated for each domain. A total domain score was obtained by summing the scores of specific items of that domain. The total score was calculated as a percentage of the maximum score possible for that domain based on the number of appraisers (AGREE Next Steps Consortium, 2013). The scores of the AGREE II tool determine whether guidelines are recommended for use. Guidelines with higher total scores are highly recommended for use. Revisions of the CPG were made according to the results and recommendation of the AGREE II provided by the key stakeholders.

Data collected using The Agree II tool and PFQ were analyzed using simple descriptive and correlative statistics. The information obtained was delivered to the institution's Department of Anesthesia Chairman, stakeholders, and University of Maryland-Baltimore School of Nursing faculty.

Protection of Human Subjects

In order to protect the rights of human subjects, a project proposal for this CPG was submitted to the University of Maryland, Baltimore (UMB) Institutional Review Board (IRB) and received a Non-Human Subjects Research Determination. Information obtained from the PFQ and demographic questionnaire were gathered anonymously on paper, secured in a locked box, and data was transferred into a secure data analysis computer program. At the conclusion of the project, all paper documentation and computer data obtained from the PFQ and demographic questionnaires was securely destroyed.

Sustainability and Generalizability

The practices defined by the CPG will be sustained through on-going endeavors by the institution's anesthesia department. Electronic health records and order sets will be audited quarterly to evaluate continued compliance with the recommendations of the CPG. Additionally, patient outcomes and satisfaction ratings as they relate to the CPG will be assessed on regular basis according to institutional review policies.

Hospital administration recognize the necessity of an evidence-based perioperative CPG. Thus, this CPG is intended exclusively to fulfill the needs of this institution (see Appendix A). This CPG is designed for quality improvement purposes at this specific institution. It is not meant to be generalizable to other organizations or settings.

Results

The calculated domain scores of the AGREE II tool provides a framework to evaluate the quality, strengths, and limitations of a CPG (AGREE Next Steps Consortium, 2013). The results from the two key stakeholders were used to revise the CPG to fulfill the needs of the anesthesia department at a tertiary medical center in Maryland. The calculated scores of the six domains are (see Table 2): Scope and Purpose (92%), Stakeholder Involvement (86%), Rigor of Development (90%), Clarity of Presentation (83%), Applicability (90%), and Editorial Independence (83%). The mean overall guideline assessment score is 87%. Both stakeholders rated the overall quality of the guideline with high quality ratings and indicated “yes” to recommending this guideline for use.

The Department of Anesthesia at this tertiary medical center in Maryland consists of 33 anesthesiologists and 24 CRNAs; a total of 57 anesthesia providers. The anticipated sample size was 20-30 providers due to the timing of the scheduled presentation during the Christmas holiday period. However, only 16 individuals were in attendance for the formal PowerPoint presentation of the CPG at the designated anesthesia staff meeting. Completed PFQs were collected at the conclusion of the presentation, of the 16 distributed questionnaires, 10 completed PFQs were returned. Anesthesia providers not present for the formal presentation were provided paper copies of the CPG and an opportunity to complete a PFQ. An additional 13 completed questionnaires were collected, for a total of 23 completed PFQs available for analysis. Descriptive statistics were calculated for the sample of anesthesia providers (n = 23) who completed a PFQ (see Table 3). Demographic data revealed that of the 23 respondents, six were anesthesiologists (26%), 16 were CRNAs (70%), and one was a SRNA (4%). Additionally, anesthesia provider years of experience are as follows: 0-5 years n=6 (26%), 6-10 years n=9 (39%), and >10 years n=8 (35%).

Analysis of the PFQ results support this CPG. The average total percentage of agreement was 80.5% (SD=0.12); indicating the acceptability and usability of this CPG by the anesthesia providers. The PFQ results were further divided into five subscales of interest: Quality (items 2-7), Acceptance of Recommendations (items 8, 9, 11, 12,16, 17), Applicability of Recommendations (reverse scored items: 10, 13, 14, 15), Comparative Value (items 18, 19), and Outcome Variables (items 21, 23). The average total percentages of "strongly agree" responses were calculated for each subscale (see Figure 3): Quality (96%), Acceptance of Recommendations (83%), Applicability of Recommendations (38%), Comparative Value (83%), and Outcome Variables (93%).

Results Analysis

Discussions with the key stakeholders and the results of the AGREE II tool assisted in guiding revisions of the CPG to its current, final product. For example, current recommendations for the type II diabetic (DM type II) surgical patient on an oral metformin regimen is to withhold metformin on the day of surgery to prevent metabolic acidosis due to increased lactic acid production (DeFronzo, Fleming, Chen, & Bicsak, 2016). Verbal feedback from the key stakeholders of the intraoperative phase portion of the CPG included adding recommendations of fluid management to prevent metabolic acidosis in the DM type II surgical patient that may have taken their metformin on the day of surgery. Furthermore, feedback from the stakeholders and anesthesia providers requested that intraoperative hyperglycemia treatment should be with the administration of IV bolus doses of insulin rather than SC insulin as recommended through the literature review. The stakeholders and anesthesia providers reasoned that the administration of IV bolus doses of insulin to correct intraoperative hyperglycemia is more feasible and has a greater bioavailability than with SC insulin.

The descriptive and statistical analysis of the PFQ results were done utilizing Microsoft Excel. The total percentage of agreement, "strongly agree" responses, and the standard deviation were calculated to obtain an average percentage of agreement of all respondents. As previously discussed, items 2-23 of the PFQ were divided into five subscales of interest. Of the five areas examined, the subscale Applicability of Recommendations scored the lowest percentage of agreement (38%). This subscale identifies provider's opinions regarding ease or rigidness of applicability of recommendations, willingness to change current practice, and costs. Items within the Applicability of Recommendations subscale were reversed scored due to its negative wording, which may have contributed to negative scoring by respondents. However, despite the low percentage of agreement for Applicability of Recommendations, verbal feedback from providers in attendance of the PowerPoint presentation revealed a strong support of recommendations of the CPG.

The development and implementation of this CPG is a quality improvement project. The interventions outlined in the CPG has not yet resulted in changes in practice at the time of writing this manuscript. Additionally, it is undetermined whether any unexpected benefits, barriers, or costs were encountered and associated with the intervention.

Discussion

The development of this CPG was to standardize the management and treatment of perioperative glycemic control. As a quality improvement project, the association between the recommendations and outcomes are yet to be determined upon institutional implementation and review. Key stakeholders identified the need for a specific guideline for perioperative management and expressed strong support of project leaders in the development and implementation process of this updated evidence-based CPG. The short-term objectives of this project were met with the development of this CPG and anesthesia staff education on these recommendations. However, long-term objectives to assess the efficacy and cost-effectiveness of perioperative glycemic control to reduce SSI's is yet to be determined through an institutional quality improvement review of patient outcomes and data. Project leaders anticipate 100% provider compliance with the CPG recommendations, and improved patient outcomes with better perioperative glycemic control and a reduction in SSI rates.

The greatest strength of this project was the support demonstrated by the stakeholders. Project leaders obtained buy-in from the stakeholders early on, as well as valuable feedback throughout the project. Current institutional glycemic control order sets enabled project leaders to create an updated CPG specifically for this organization at no additional costs. However, a barrier encountered was a delay in communication with one of the stakeholders due to personal circumstances. Despite this barrier, there were no significant repercussions to the development of the CPG. Open communication with the second stakeholder, acting as a liaison for the first stakeholder, allowed the project leaders to move forward with the project in a timely manner.

A limitation of this project is the generalizability of the work. This CPG was developed specifically for this institution to meet the needs of this organization. As a result, the sample size is small. Additionally, not all anesthesia providers of this institution were surveyed. However, project leaders received valuable feedback of the CPG from the stakeholders and end-users. The limited generalizability and small sample size may also have limited internal validity such as bias. Another limiting factor is the lack of input from ancillary sources within the institution including endocrinologist and surgeons. Future updates of this CPG should include input and recommendations from these specialty consultants to increase internal validity and decrease bias.

Conclusion

Perioperative glycemic control has been shown to decrease SSI rates. Recent evidence-based research demonstrates that a target glucose level of <180 mg/dL is effective in reducing SSIs, as well as reducing the risk of intraoperative hypoglycemic events. This CPG was developed and successfully implemented specifically for this institution as requested to meet the needs of the anesthesia department. Sustainability and spread of the CPG will be dependent on the institution. Next steps include institutional approval of the CPG for utilization in daily practice and continued provider education of the CPG in practice. Additionally, future updates of this CPG should include input and recommendations from endocrinologist and surgical specialty providers.

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Table 1. Evidence Review Table

Table 1. Evidence Review Table

Author, year	Study objective/intervention or exposures compared	Design	Sample (N)	Outcomes studied (how measured)	Results	*Level and Quality Rating
Akiboye, F., & Rayman, G. (2017)	Clinical recommendations for management of perioperative hyperclycemia in orthopedic surgical patients with diabetes.	Clinical practice guideline	N/A	• Intraoperative management including:		1 A
				- Blood glucose (BG) test timing	• BG testing prior to anesthetic induction - Then hourly for surgeries > 2hours	
				- Insulin infusion	• Surgeries > 3hours or prolonged NPO status (>1 missed meal), start insulin infusion of either: - Intravenous (IV) infusion of glucose, insulin and potassium (GIK) mixed in one bag - Separate IV infusions of glucose, potassium (+ or – depending on institution), and insulin at variable infusion rate ▪ Insulin infusion rate titrated every 1 to 2 hours	
				- Patients on long acting basal insulin	• Continue basal insulin with variable insulin infusion rate - If basal insulin is discontinued before surgery: ▪ Give basal insulin 30 to 60 minutes before starting IV insulin to reduce the risk of diabetic ketoacidosis (DKA)	
				- Subcutaneous (SC) insulin pump	• Considerations for continuation of SC insulin pump intraoperatively: - Obtain endocrinologist consult	

Table 1. Evidence Review Table (con't)

Akiboye, F., & Rayman, G. (2017) [con't]					- May safely continue SC insulin pump intraoperatively up to 3 hours - Or SC basal insulin may be given at an equivalent dose of insulin given over 24 hours via patient's pump - Type of surgery and necessity for imaging, i.e. MRI, X-ray, or CT - Use of intraoperative electro-cautery	
de Vries, F. E. E., Gans, S. L., Solomkin, J. S., Allegranzi, B., Egger, M., Dellinger, E. P., & Boermeester, M. A. (2017)	To examine the effect of intensive glucose control in comparison to conventional glucose control protocols on the risk of surgical site infection (SSI)	Meta-analysis of RCTs	N=15 RCTs • Intensive protocol group (n=1442) - Studies with very strict BG targel level, < 110 mg/dL - Studies with moderately strict BG target levels 110-150 mg/dL - Studies with stricter and lower BG levels ≤ 150 mg/dL	• Surgical site infections • Hypoglycemic events • Postoperative death and stroke	• Significant benefit of intensive protocol in comparison to conventional protocol to reduce SSI (*p*<0.001) • Higher risk for hypoglycemic events with intensive versus conventional protocols (OR 5.55, 95% CI 2.58 to 11.96) - 4 studies had no hypoglycemic events - 5 studies showed significantly more asymptomatic hypoglycemic events with intensive protocols - 3 studies found no significant difference - 3 studies did not report hypoglycemic events • No significant difference between protocols in regards to postoperative death and stroke (OR 0.74 and OR 1.37)	1A

Table 1. Evidence Review Table (con't)

de Vries et al (2017) [cont]			• Control protocol group (n=1394) ○ Conventional protocol- more liberal and higher BG target levels, ≤ 220 mg/dL	**Hyperglycemia=BG >180 to 220 mg/dL; Hypoglycemia=BG <40-80 mg/dL		
Desai et al (2012)	To compare liberal blood glucose group (121-180 mg/dl) to strict glucose group (90-120) in patients that underwent first time isolated coronary artery bypass graft (CABG).	Randomized control study (RCT)	N=189 patients Strict Glucose Group (n=91) Liberal Glucose Group (n=98)	Primary outcomes assessed: • Time to target glucose range • Total insulin administered • Number of hypoglycemic events Secondary outcomes assessed: • Perioperative renal failure • Pneumonia	• Time to target glucose range: Liberal Group reached target goal range (121-180 mg/dL) 50% faster than Strict Group (90-120 mg/dL) (83.5 ± 134.6 vs 173.3 ± 195.8 minutes). • Total insulin administration: Liberal Group needed less insulin compared to the Strict Group (166.0 ± 156.7 vs 252.3 ± 193.4). • Hypoglycemic events: Liberal Group < Strict Group (BG < 60 mg/dL) (11 [11%] vs 30 [33%]). • Perioperative renal failure (Strict Group=2.2%, Liberal Group=0) • Pneumonia (Strict Group=2.2%, Liberal Group=0)	2 B

Table 1. Evidence Review Table (con't)

Desai et al (2012) [cont]				• Deep sternal wound infection • Hospital length of stay • 30-day mortality	• Deep sternal wound infection (Strict Group=1.1%, Liberal Group=0) • Length of stay >10 days (Strict Group=3.3%, Liberal Group=2.0%) • Operative mortality (Strict Group=1.1%, Liberal Group=1.0%)	
Duggan, E. W., Klopman, M. A., Berry, A. J., & Umpierrez, G. (2016)	A clinical guideline to help health care practitioners diagnose, manage and care for the surgical patient with diabetes and hyperglycemia perioperatively undergoing non-cardiac surgeries.	Clinical practice guideline	N/A	• Target BG levels	• BG levels < 180 mg/dL for general surgical patients depending on fasting status	1 A
				• BG monitoring intraoperatively	• Intraoperative BG monitoring: - Fasting BG levels ≤ 140 mg/dL—monitoring not required - Patients with known history of diabetes: ▪ BG monitoring pre-operatively, every 2 hours intraoperatively, and immediately postoperatively	
				• Management of hyperglycemia in critically ill surgical patient	• IV insulin is the favored to maintain glycemic control in the critically ill surgical patient - Short half life (35 minutes) of regular insulin enables easy titration - Start insulin infusion intraoperatively for BG ≥ 180 mg/dL	
				• Elements of a successful insulin infusion protocol	• Insulin infusion rate adjustments based on: - Trends of current and previous BG level	

Table 1. Evidence Review Table (con't)

Duggan, E. W., Klopman, M. A., Berry, A. J., & Umpierrez, G. (2016) [con't]	• Management of hyperglycemia in non-critically ill surgical patient (con't)	- Current rate of insulin infusion - Changes from previous BG results - Frequency of BG levels within target range • Fast acting SC insulin preferred for surgeries < 2 hours -May only necessitate one dose of SC insulin -Onset is 15-30 min; Peak time 1-1.5 hours Advantages include: easy administration, lower incidence of hypoglycemia, and effectively corrects hyperglycemia - Insulin dosing is based on patient stratification according to their response to insulin ▪ BG levels checked every 2 hours throughout the perioperative period ▪ Insulin administration started at any time during the perioperative period if any BG reading is ≥ 180 mg/dL • Intraoperative management of Type I diabetic surgical patients: - Intraoperative IV infusion with BG levels checked every 2 hours for surgeries > 2 hours - Surgeries < 2 hours, BG levels are checked every hour and treated with fast acting SC insulin for BG ≥ 180 mg/dL

Table 1. Evidence Review Table (con't)

Duggan, E. W., Klopman, M. A., Berry, A. J., & Umpierrez, G. (2016) [con't]				• Management of hyperglycemia in non-critically ill surgical patient (con't)	-Type I diabetic surgical patients with insulin pumps: • May continue insulin pump perioperatively in facilities with established policy and procedures to standardize care and management of insulin pumps ○ Consult inpatient diabetes experts ▪ If inpatient diabetes experts are not accessible, discontinuation of insulin pump and conversion to SC insulin is advisable	
Joslin Diabetes Center (2015)	A clinical guideline to help health care providers tailor patient care for the adult, non-pregnant diabetic patient undergoing surgery. The purpose of these guidelines is to support evidence based clinical practice to improve patient outcomes and satisfaction.	Clinical practice guideline	N/A	• Intraoperative glycemic and fluid management	• Intraoperative management -BG monitoring every 2 hours -Patients on insulin pump may continue basal rate throughout surgery or convert to IV insulin -No IV fluids with dextrose -Start D5W @ 40 ml/hr or D10W @ 20 ml/hr if insulin infusion required	1 A

***Rating System for Hierarchy of Evidence**

Level of the Evidence	Type of the Evidence
I (1)	Evidence from systematic review, meta-analysis of randomized controlled trials (RCTs), or practice-guidelines based on systematic review of RCTs.
II (2)	Evidence obtained from well-designed RCT
III (3)	Evidence obtained from well-designed controlled trials without randomization
IV (4)	Evidence from well-designed case-control and cohort studies
V (5)	Evidence from systematic reviews of descriptive and qualitative studies
VI (6)	Evidence from a single descriptive or qualitative study
VII (7)	Evidence from the opinion of authorities and/or reports of expert committees

Melnyk, B.M. & Fineout-Overholt, E. (2014). *Evidence-based practice in nursing & healthcare: A guide to best practice* (3rd ed.). New York: Lippincott, Williams & Wilkins.

Rating Scale for Quality of Evidence

A: High – consistent results with sufficient sample, adequate control, and definitive conclusions; consistent recommendations based on extensive literature review that includes thoughtful reference to scientific literature

B: Good – reasonably consistent results; sufficient sample, some control, with fairly definitive conclusions; reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence

C: Low/major flaw – Little evidence with inconsistent results; insufficient sample size; conclusions cannot be drawn

Newhouse, R.P. (2006). Examining the support for evidence-based nursing practice. *Journal of Nursing Administration, 36*(7-8), 337-40.

Table 2. ***Calculated AGREE II Tool Domain Scores***

		Appraiser 1	Appraiser 2	**Total**
Domain 1	Item 1	7	6	13
	Item 2	7	6	13
	Item 3	7	6	13
	Obtained Scores	-	-	39
	Domain Scores	-	-	**92%**
Domain 2	Item 4	5	6	11
	Item 5	7	6	13
	Item 6	7	6	13
	Obtained Scores	-	-	37
	Domain Scores	-	-	**86%**
Domain 3	Item 7	6	6	12
	Item 8	7	6	13
	Item 9	6	6	12
	Item 10	7	6	13
	Item 11	7	6	13
	Item 12	7	6	13
	Item 13	7	6	13
	Item 14	7	6	13
	Obtained Scores	-	-	102
	Domain Scores	-	-	**90%**
Domain 4	Item 15	6	6	12
	Item 16	6	6	12
	Item 17	6	6	12
	Obtained Scores	-	-	36
	Domain Scores	-	-	**83%**
Domain 5	Item 18	7	6	13
	Item 19	7	6	13
	Item 20	6	6	12
	Item 21	7	6	13
	Obtained Scores	-	-	51
	Domain Scores	-	-	**90%**
Domain 6	Item 22	5	6	11
	Item 23	7	6	13
	Obtained Scores	-	-	**24**
	Domain Scores	-	-	**83%**
Overall guideline assessment		7	7	14
Calculated Domain Scores		-	-	**87%**

Table 3. ***Demographic Data of Total PFQ Respondents***

Title	n	Percentages
Anesthesiologist	6	26%
CRNA	16	70%
SRNA	1	4%
Total Providers	23	

Years of Experience	n	Percentages
0-5 years	6	26%
6-10 years	9	39%
>10 years	8	35%

Figure 1. ***AGREE II Tool***

Domain 1: Scope and Purpose (1-3) (For each question below, please circle your choice).

1. The overall objective(s) of the CPG is specifically described.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
2. The health question(s) covered by the CPG is specifically described.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
3. The population to whom the CPG is meant to apply is specifically described.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:

Domain 2: Stakeholder Involvement (4-6)

4. The guideline development group includes individuals from all relevant professional groups.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
5. The views and preferences of the target population and stakeholders have been sought.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
6. The target users of the guideline are clearly defined.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:

Domain 3: Rigor of Development (7-14)

7. Systematic methods were used to search for evidence.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
8. The criteria for selecting the evidence are clearly described.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
9. The strengths and limitations of the body of evidence are clearly described.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
10. The methods for formulating the recommendations are clearly described.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
11. The health benefits, side effects, and risks have been considered in formulating the recommendations.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
12. There is an explicit link between the recommendations and the supporting evidence.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
13. The guideline has been externally reviewed by experts prior to its publication
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
14. A procedure for updating the guideline is provided.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:

Domain 4: Clarity of Presentation (15-17)

15. The recommendations are specific and unambiguous.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
16. The different options for management of the condition or health issue are clearly presented.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
17. Key recommendations are easily identifiable.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:

Domain 5: Applicability (18-21)

18. The guideline describes facilitators and barriers to its application.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
19. The guideline provides advice and/or tools on how the recommendations can be put into practice.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
20. The potential resource implications of applying the recommendations have been considered.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
21. The guideline presents monitoring and/or auditing criteria.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:

Domain 6: Editorial Independence (22-23)

22. The views of the funding body have not influenced the content of the guideline.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:
23. Competing interests of guideline development group members have been recorded and addressed.
Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree
Comments:

Overall Assessment

For each question, please choose the response which best characterizes the guideline addressed:

1. Rate the overall quality of this guideline.

Lowest possible quality 1 2 3 4 5 6 7 Highest possible quality

2. I would recommend this guideline for use:

Yes Yes with modifications No

Notes:

Adapted from: AGREE Next Steps Consortium. (2013). AGREE II: Advancing guideline development, reporting and evaluation in healthcare. Retrieved from http://www.agreetrust.org/wp-content/uploads/2013/10/AGREE-II-Users-Manual-and-23-item-Instrument_2009_UPDATE_2013.pdf

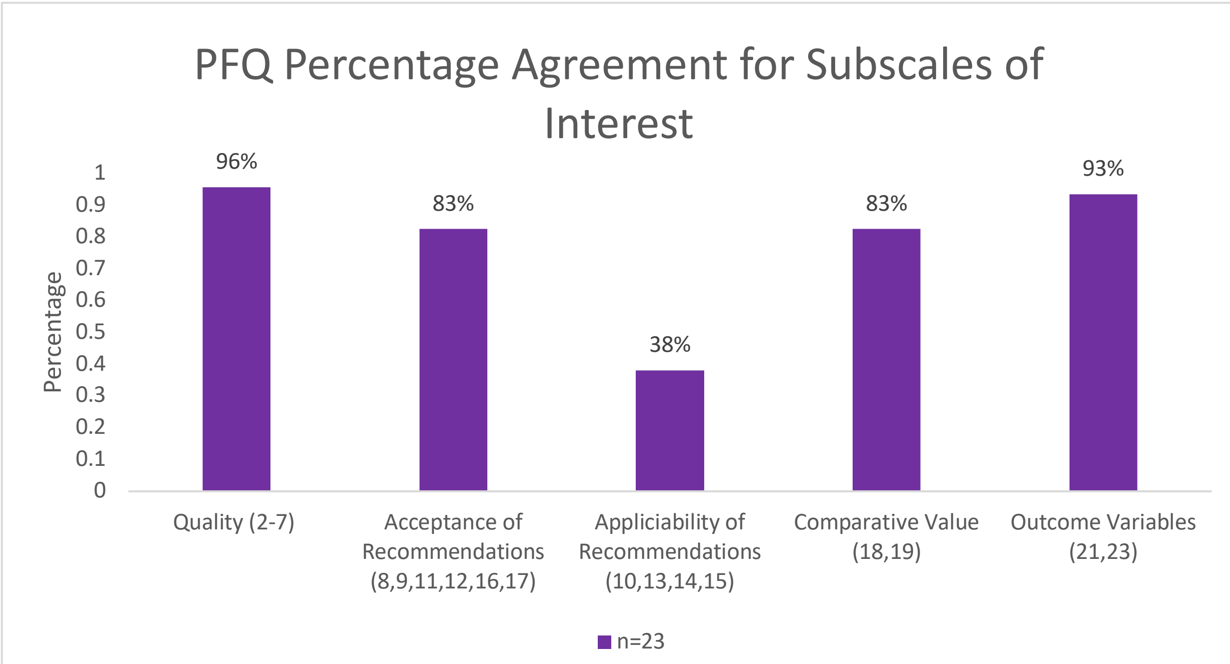
Figure 2. ***Modified Practitioner's Feedback Questionnaire (PFQ)***

Please select the appropriate demographic category that most accurately describes you. Title: ☐ MD Anesthesiologist ☐ CRNA ☐ Resident/Fellow ☐ SRNA Years of Experience: ☐ 0-5 years ☐ 6-10 years ☐ >10 years			
1. Are you responsible for the care of patients for whom this draft guideline report is relevant? This may include the referral, diagnosis, treatment, or follow-up of patients.	Yes ☐	No ☐	Unsure ☐
If you answered "*No*" or "*Unsure*", there is no need to answer or return this questionnaire. If you answered "*Yes,*" please answer the questions below and return to **[enter expected destination of surveys]**.			
	Strongly agree	Neither agree or disagree	Strongly disagree
2. The rationale for developing a guideline is clear.	☐	☐	☐
3. There is a need for a guideline on this topic.	☐	☐	☐
4. The literature search is relevant and complete (e.g., no key evidence was missed nor any included that should not have been) in this draft guideline.	☐	☐	☐
5. I agree with the methodology used to summarize the evidence included in this draft guideline.	☐	☐	☐
6. The results of the evidence described in this draft guideline are interpreted according to my understanding of the evidence.	☐	☐	☐
7. The draft recommendations in this report are clear.	☐	☐	☐
8. I agree with the draft recommendations as stated.	☐	☐	☐
9. The draft recommendations are suitable for the patients for whom they are intended.	☐	☐	☐
10. The draft recommendations are too rigid to apply to individual patients.	☐	☐	☐
11. When applied, the draft recommendations will produce more benefits for patients than harms.	☐	☐	☐
12. The draft guideline presents options that will be acceptable to patients.	☐	☐	☐
13. To apply the draft recommendations will require reorganization of services/care in my practice setting.	☐	☐	☐
14. To apply the draft guideline recommendations will be technically challenging.	☐	☐	☐
15. The draft guideline recommendations are too expensive to apply.	☐	☐	☐
16. The draft guideline recommendations are likely to be supported by a majority of my colleagues.	☐	☐	☐
17. If I follow the draft guideline recommendations, the expected effects on patient outcomes will be obvious.	☐	☐	☐
18. The draft guideline recommendations reflect a more effective approach for improving patient outcomes than is current usual practice. (If they are the same as current practice, please tick NA). *NA* ☐	☐	☐	☐

19. When applied, the draft guideline recommendations will result in better use of resources than current usual practice. (If they are the same as current practice, please tick NA). *NA* ☐	☐	☐	☐
20. I would feel comfortable if my patients received the care recommended in the draft guideline.	☐	☐	☐
21. This draft guideline should be approved as a practice guideline.	☐	☐	☐
22. If this draft guideline were to be approved as a practice guideline, I would use it in my own practice.	☐	☐	☐
23. If this draft guideline were to be approved as a practice guideline, I would apply the recommendations to my patients.	☐	☐	☐

Adapted from: Brouwers, M.C., Graham, I.D., Hanna, S.E., Cameron, D.A., & Browman, G.P. (2004). Clinicians' assessments of practice guidelines in oncology: The CAPGO survey**.** *International Journal of Technology Assessment in Health Care, 20*(4), 421-6.

Figure 3. ***PFQ Percentage Agreement for Subscales of Interest***



Appendix A
Clinical Practice Guideline for Perioperative Glucose Management

Purpose: The purpose of this guideline is to provide an evidence-based approach to perioperative glycemic control. This guideline provides information for perioperative management of the hyperglycemic surgical adult patient ≥ 18 years old without active infections undergoing elective orthopedic surgery.

Background: Diabetes mellitus (DM) is a chronic illness affecting approximately 30.3 million Americans (9.4% of the U.S. population) of all ages (American Diabetes Association, 2017). Approximately 25% of patients with DM will present for surgery and 5-10% of these patients have undiagnosed DM (Setji et al., 2017). The end result of uncontrolled or undiagnosed DM is hyperglycemia. This increases the risk of SSIs in patients undergoing orthopedic surgery, especially total joint, spine, foot and ankle surgeries (Wukich, 2015).

Implementation:

Target blood glucose (BG) level ≤ 180 mg/dL.

A. **Preoperative BG monitoring**: Patients will be contacted 24 hours prior to day of surgery by the preoperative nurse to verify preoperative orders and provide instructions on diabetic medication usage based on the following:

DM Type I:			
Day before surgery (DBS):	• 80% subcutaneous basal insulin ○ Hold prandial insulin dose when fasting		
Day of surgery (DOS):	• 80% subcutaneous basal insulin		
DM Type II:			
Oral medication	**Day Before Surgery**	**Day of Surgery: if normal PO intake same day/minimally invasive surgery**	**Day of Surgery: if reduced PO intake, extensive surgery, major hemodynamic changes, or fluid shifts**
Metformin	Hold	Hold	Hold
Sodium glucose cotransporter-2 inhibitors (canagliflozin, dapagliflozin, and empagliflozin)	Hold	Hold	Hold
Secretagogues *Sulfonylureas*: glimepiride (Amaryl), glipizide (Glucotrol), and glyburide (Diabeta) *Glinides*: repaglinide (Prandin) and nateglinide (Starlix)	Take	Hold	Hold
Thiazolidinediones pioglitazone (Actos) and rosiglitazone (Avandia)	Take	Take	Hold
DPP-4 inhibitors Januvia (Sitagliptin), Galvus (Vildagliptin), Onglyza (Saxagliptin), and Tradjenta (Linagliptin)	Take	Take	Take

Adapted from Duggan, Carlson, & Umpierrez (2017) and Dungan et al. (2016).

B. Intraoperative BG monitoring:

<table>
<tr><td>Intraoperative BG Goals:
DM Type I and Type II Surgical Patients</td><td>Check BG level prior to induction of anesthesia.
Fasting BG levels ≤ 140 mg/dL: treatment not required.
All procedures regardless of duration: monitor BG hourly.</td></tr>
<tr><td>Intraoperative Insulin Administration:
DM Type I and Type II Surgical Patients</td><td>Administer insulin at any time during the intraoperative period if any BG reading is >180 mg/dL.
Maintenance IV fluid: normal saline, plasmalyte or lactated ringers solution, unless insulin infusion started.
If patient took Metformin on DOS use normal saline solution to prevent lactic acidosis.
All procedures regardless of duration:
Administer IV bolus of fast acting insulin following current institution order set: “Perioperative Hyperglycemia Management Orders” and according to patient’s insulin sensitivity.
For surgeries > 2 hours: consider insulin infusion according to current institution order set: “Perioperative Hyperglycemia Management Orders.”
Titrate according to insulin sliding scale.
Check BG hourly.
Administer with separate infusion of D5W at 40 ml/hr or D10W at 20 ml/hr.</td></tr>
<tr><td>DM Type I surgical patient with insulin pump:</td><td>Refer to endocrinologist recommendations.
Consider continuation of insulin pump intraoperatively.
Continue basal rate.
Monitor BG hourly.
BG >180: treat with IV bolus of fast acting insulin following current institution policy.
If intraoperative continuation is contraindicated or not advised per endocrinologist consult, convert to insulin infusion and monitor BG hourly.</td></tr>
<tr><td>Intraoperative Hypoglcemia:
BG <60 mg/dL</td><td>BG <60 mg/dL give 25 grams of D50 IV bolus according to current institution order set: “Perioperative Hyperglycemia Management Orders.”
Recheck BG 15 minutes after administration of D50 IV bolus.
Continue hourly BG checks.</td></tr>
</table>

Adapted from Duggan, Carlson, & Umpierrez (2017) and Dungan et al. (2016).

C. Postoperative BG Management:

Postoperative BG Management: **PACU**	• Manage non-cardiac, elective surgery patients with IV insulin postoperatively.

	• Check BG on patient arrival to PACU.
	  o If initial PACU BG is <140 or >180mg/dL, initiate q1hr POC checks.
	  o If BG is within 140-180mg/dL for 4 hours, decrease frequency of checks from q1hr to q2hrs.
	  o If initial PACU BG is 140-180 mg/dL, initiate q2hr POC BG checks.
	  o If BG is within 140-180mg/dL for 4 hours, decrease frequency of checks from q2hr to q4hrs.
	  o For BG >180mg/dL follow the IV insulin sliding scale for correctional dose or continue insulin infusion.

	• Monitor for signs and symptoms of hypoglycemic symptom such as sweating, palpitations, confusion, and loss of consciousness. Treat hypoglycemia according to protocol.
	• Use maintenance IV fluids without dextrose unless the patient is on an insulin drip.
	• Manage blood glucose levels and tolerance. If oral intake permits, resume previous anti-diabetic therapy.
	• If patient is on an insulin pump, assess patient's ability to use insulin pump before discharge home.

	• If patient has an insulin pump;
	  o Assess patient's ability to use insulin pump before discharge home.
	  o Admission to inpatient unit: consult endocrinologist or hospitalist for postoperative parameters and continue follow-up with assigned nursing unit that will manage insulin pump.

Critically Ill or Acutely Injured Patients*:*	• **"**Patients with an impairment of one or more vital organ systems such that there is a high probability of imminent or life-threatening deterioration in the patient's condition" **(**CMS, 2018).
	• For NPO patients, start insulin infusion with a starting treatment threshold no higher than 180 mg/dL. Target range for patients on an insulin infusion is 140–180 mg/dL. • If patient is on an insulin pump, consult endocrinology or hospitalist for postoperative parameters and continue follow-up with assigned nursing unit that will manage insulin pump.
Non-critically ill patients:	• IV insulin can be used to achieve glycemic control in the operating room for both diabetic patients and those with stress hyperglycemia. • Transitioning to basal-bolus subQ regimen is appropriate for the surgical floor and has been shown to improve glycemic control and reduce perioperative complications in surgical patients.

DM Type I:	• 80% of the patient's daily basal dose (TDD) is administered as basal insulin. • When eating, the patient's home dose of prandial insulin should be initiated. • Blood glucose is checked 4x daily and correctional insulin is provided for BG ≥140 mg/dL.
Transitioning from a continuous insulin infusion (CII) to subcutaneous insulin:	• For patients treated with intraoperative IV insulin, it may be easiest to continue IV insulin alongside a dextrose infusion until the patient can tolerate food without difficulty.
NPO patients with history of DM or those requiring insulin infusion ≥ 3 units/hour:	• Determine average hourly rate of CII and multiply by 24 to obtain the average insulin requirement for the past 24 hours. • Consider starting a 10% dextrose infusion to maintain euglycemia.
Hypoglycemic Recommendations:	• If blood glucose < 80mg/dL give 100mL D10W IV or 25-50mL (1/2-1 amp) D50 and Check blood glucose in 15-30min. • Blood glucose 80-100mg/dL—begin D5W at 40mL/hr or D10W at 20mL/hr and Check blood glucose in 1 hour.

Adapted from Duggan, Carlson, & Umpierrez (2017) and Dungan et al. (2016).

References:

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