Perioperative Glucose Management for Diabetic Patients Undergoing Orthopedic Surgery

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DNP Scholarly Project Proposal

With over 1.2 million procedures performed annually, orthopedic surgeries such as total hip arthroplasties (THA) and total knee arthroplasties (THA) are among the most popular and costly procedures in the United States (Kremers et al., 2015). Although these procedures are considered relatively safe and successful, studies show that patients with diabetes are at a significantly higher risk for adverse outcomes following orthopedic surgery than patients without diabetes (Duncan, 2012). The epidemic of diabetes mellitus in the United States affects 21.9 million adults (aged 18 and older) with 44.3 percent reporting a mobility limitation of stooping, bending, or kneeling (Centers for Disease Control and Prevention, 2015). Due to the degenerative nature of this disease and resultant functional limitations, diabetic patients are associated with an increased requirement for orthopedic surgery. Superimposing the risks of diabetes, patients presenting with hyperglycemia, or high blood glucose levels, are associated with increased negative outcomes such as surgical site infections, impaired wound healing, hardware/implant failures, and medical complications following orthopedic surgeries (Wukich, 2015).

There is growing evidence that improving blood glucose levels in the perioperative period leads to decreased postoperative complications such as mortality and stroke (Brooke et al., 2014). Evidence has shown that practicing "tight" glycemic control by implementing an insulin protocol can simplify the clinical management of perioperative hyperglycemia and reduce the risk of infections (Kwon et al., 2013). In a study by Schroeder et al., (2012), the number of hospital days were reduced by two days and the number of severe hyperglycemic events (BS >400) were significantly lower in patients who received care under the intensive subcutaneous insulin protocol (intervention).

Despite the research available on improving blood glucose levels in the perioperative period, a full-service teaching hospital recognized for its orthopedic achievements in total joint replacement surgeries, lacks a standardized clinical practice guideline (CPG) that facilitates providers in the recognition and treatment of hyperglycemia during the perioperative period. Currently, treatment and adjustments to high blood glucose levels are made at the discretion of the various multidisciplinary providers who are involved during the different points of care. While one provider may accept a blood glucose level of 300mg/dl for a non-urgent surgery, another may decide to cancel the surgery. The problem is that perioperative management of blood glucose levels in diabetic patients is not consistent. Treatment of hyperglycemia during the perioperative period is unequal between providers, which can result in a difference in postoperative outcomes. Therefore, there is a need for a standardized CPG at the institutional level regarding the management of hyperglycemia in diabetic patients presenting for orthopedic surgery. The CPG will provide evidence-based recommendations for the management of blood glucose levels in the preoperative, intraoperative and postoperative periods. It will include recommendations for an optimal blood glucose range and the associated guideline for perioperative insulin administration.

The purpose of this DNP scholarly project is to implement and evaluate a perioperative glucose management clinical practice guideline for diabetic patients undergoing orthopedic surgery. The anticipated outcomes of this project are to standardize glucose treatment amongst providers and maintain optimal glycemic control in patients throughout the perioperative period. By obtaining optimal glycemic control, the prevention of hyperglycemia and its associated outcomes such as surgical site infections, delayed wound healing, failed hardware, increased length of stay, morbidity, and mortality may be achieved.

Theoretical Framework

Rosswurm and Larrabee's (1999) *A Model for Change to Evidence-Based Practice* serves as the theoretical framework behind this DNP scholarly project. This model guides practitioners through the process of taking evidence-based research and integrating it into practice. This model takes a systematic approach by organizing the process into six steps: 1) assess need for change in practice, 2) link problem interventions and outcomes, 3) synthesize best evidence, 4) design practice change, 5) implement and evaluate change in practice, and 6) integrate and maintain change in practice.

This model is highly compatible with the designing and implementing of a perioperative glycemic CPG at an institution's surgical department. The first three steps of this model describe the sequence of steps that were taken prior to selecting a DNP scholarly project topic. These steps were used to identify the problem (hyperglycemia in diabetic patients undergoing orthopedic surgeries) and support the intervention (perioperative glycemic control CPG). This DNP scholarly project will primarily focus on step four of this model. A change in practice will be implemented in the form of a detailed perioperative glycemic control CPG. This framework provides guidance on increasing the chances of acceptance from key stakeholders such as hospital administrators and leaders from the department of anesthesiology, endocrinology, orthopedic surgery, and pharmacy. Authors of this framework describe that suitability of this CPG at the institution of interest will be necessary for successful implementation. The practicality of the implemented CPG will depend on the availability of necessary resources, predicted patient outcomes, and the associated financial expenses.

Literature Review

The management of blood glucose levels in diabetic patients during the postoperative period is the focus of the evidence in this literature review. The review will begin by discussing the evidence supporting the optimal blood glucose level to be maintained throughout the perioperative period (pre, intra, and post-op). This discussion will be followed by a review of evidence-based guidelines regarding the monitoring and treatment of postoperative blood glucose levels. The review will conclude with evidence supporting the significance of hypoglycemia in the postoperative period.

In a systematic review by Joshi et al. (2010), the literature regarding perioperative blood glucose control in patients undergoing ambulatory surgery was evaluated. Results of this research suggested that an insulin protocol be implemented during the perioperative period in order to maintain an optimal blood glucose level of less than 180mg/dL. Evidence-based clinical practice guidelines developed by Alexanian, McDonnell, & Akhtar (2011) were also reviewed. These guidelines were instituted at Boston Medical Center and Yale New-Haven and both recommended a target glucose range of 120-180mg/dL throughout the perioperative period. In another detailed clinical practice guideline designed by the Joslin Diabetes Center (2009), the proposed target blood glucose range for the perioperative management of adult diabetic patients undergoing surgery was 140-180mg/dL. All three reviewed studies indicated an optimal blood glucose level of no higher than 180mg/dL (Alexanian, McDonnell, & Akhtar, 2011; Joshi et al., 2010; Joslin Diabetes Center, 2009).

Monitoring of blood glucose levels in the postoperative period was reviewed. Both the Joslin Diabetes Center (2009) and Alexanian, McDonnell, & Akhtar (2011) present guidelines that recommend to institute blood glucose checks upon arrival to the post-anesthesia care unit

(PACU) and continue monitoring with hourly checks. According to Alexanian, McDonnell, and Akhtar (2011), an insulin infusion should either be continued if the presenting blood sugar level was out of range (greater than 180mg/dL) or transitioned to a subcutaneous sliding scale if within range. Comparably, clinical guidelines by the Joslin Diabetes Center (2009) suggest that if blood glucose levels are greater than 180mg/dL twice postoperatively, an insulin infusion may be initiated. Furthermore, recommendations from the Joslin Diabetes Center (2009) guideline state that if the blood glucose levels stay within the desirable range for four hours, the frequency of checks can be decreased to every 2 hours.

Vigilance in the postoperative period is necessary along with the application of preventative measures for hypoglycemic events. If insulin is administered during surgery, patients should be closely monitored for the possibility of hypoglycemia, or a blood glucose level of less than 70mg/dL (Joshi et al., 2010). The use of a perioperative insulin administration heightens the risk for hypoglycemic symptoms such as sweating, palpitations, confusion, and loss of consciousness. Following a subcutaneous dose of insulin, the risk of hypoglycemia can last from 1.5-4 hours (Joshi et al., 2010). Alexanian, McDonnell, and Akhtar (2011) also recommended that endocrinology residents be consulted with any untoward effects of insulin. In order to prevent hypoglycemia in patients requiring an insulin infusion, guidelines by the Joslin Diabetes Center (2009) recommend initiating a maintenance infusion containing 5% dextrose in water (D5W) at 40ml/hour or 10% dextrose in water (D10W) infusion at 20ml/hour. Once patients are tolerating oral intake, the risk of hypoglycemia can be counteracted and patients can resume their previous anti-diabetic medications (Alexanian, McDonnell, & Akhtar, 2011; Joshi et al., 2010; Joslin Diabetes Center, 2009). Stabilized blood glucose levels and tolerance of oral

intake mitigate the risks of hypoglycemia and permit the resumption of pre-hospital anti-diabetic therapy.

Methods

Design and Setting (need to change tense)

The design of this project will be a clinical practice guideline (CPG). The setting for this CPG is the perioperative area of a full-service community hospital in the mid-Atlantic region recognized for its orthopedic achievements in total joint replacement surgeries. The perioperative area includes the preoperative holding unit, intraoperative operating rooms, and the post-anesthesia care unit (PACU). The process and procedures for collecting data will be conducted across a period of three stages. Each stage of the process has a different sample. Identification of each sample will be covered under the procedures portion of this paper.

Sample and Procedures

Data will be collected throughout a process of three stages. Stage one will be held in the first month of the project and will include weekly meetings with the guideline development team. This team will include the three DNP student project leaders, one staff anesthesiologist, and DNP project chair. The meetings will be purposed to last one hour and will be held in person in a conference room that is typically used for staff meetings. Prior to each meeting, DNP student project leaders will be designated one of the following key roles: leader, facilitator, and recorder/timekeeper. The purpose of meeting one will be to present the evidence used to support the development of the CPG. A preliminary draft of the guideline will also be introduced. Feedback from the team will be obtained and revisions will be made as necessary by the next meeting. In meeting two, the revised guideline will be reviewed and the Appraisal of Guidelines for Research & Evaluation (AGREE) II Instrument (AGREE Next Steps Consortium, 2009) will

be introduced to the team as the selected instrument for assessing the quality of the clinical practice guideline. The team members including the project leaders will be requested to complete the AGREE II Instrument by the next meeting. In meeting three, results of the AGREE II Instrument will be discussed and areas for improvement will be considered. By meeting four, paper handouts of the revised version of the CPG will be passed out and a final discussion will be held with the team members.

Stage two of the data collection process includes two meetings in the second month of the project. Meetings will be held with the perioperative staff sample, which will include nurses, anesthesiologists, and certified registered nurse anesthetists (CRNA). The sample size (n) will be 20. During the meeting, an in-service will be conducted which will introduce the CPG, its purpose, components, and how to utilize it in clinical practice. The members of this sample will be requested to complete the Practitioners' Feedback Questionnaire (Brouwers, Graham, Hanna, Cameron, & Browman, 2004) as a tool to further assess the guideline. Paper handouts of the survey will be available as well as a locked box left in the anesthesia lounge for staff to fill out with a deadline of two weeks for completion.

Stage three will be held in the third month of the project and will include two meetings with the third sample: chief anesthesiologist. Meeting one will be held in the first week of the month and meeting two will be held in the fourth week of the month. The first meeting will be held in person and a brief but informative presentation will be held to review the CPG's process of development. Meeting two will be held two weeks later to allow time for feedback regarding concerns and or barriers from an administrative perspective. The final draft of the CPG will be handed out during meeting two as well as a final opportunity to discuss areas for improvement.

Timeline

Please refer to Appendix B for the Scholarly Project Timeline.

Data Collection

Data will be collected using the AGREE II Tool during stage one. The evaluation tool used in stage one of the data collection process will be the AGREE II Instrument (AGREE Next Steps Consortium, 2009). The purpose of the AGREE II instrument is to provide a framework for the student project leaders in the development of the clinical practice guideline as well as a tool for assessing the quality of the guideline. The AGREE II Instrument is a 23-item tool that addresses six quality domains: (1) scope and purpose, (2) stakeholder involvement, (3) rigour of development, (4) clarity of presentation, (5) applicability, and (6) editorial independence. All items are scored on a 7-point Likert-scale with 1= "strongly disagree" to 7= "strongly agree". As recommended by the user manual, the clinical practice guideline will be assessed by at least four appraisers in order to increase the reliability of the assessment. A group of 14 experts grouped by the name AGREE Steps Consortium conducted two studies to establish the reliability and validity of the instrument (National Collaborating Centre for Methods and Tools [NCCMT], 2011). Construct validity was established by conducting a study for systematic evaluation involving 30 participants (NCCMT, 2011). The reliability of the tool was reported using Cronbach's alpha and was calculated to range from 0.64 to 0.89 across the six domains (NCCMT, 2011).

In stage two, data will be collected using the Practitioners' Feedback Questionnaire (PFQ) (Brouwers, Graham, Hanna, Cameron, & Browman, 2004). This data will be obtained through anonymous paper and pencil surveys submitted to a secure and locked box left in the anesthesia lounge over a two week period. The purpose of this tool is to assess the guideline for

quality, applicability, and acceptability. The PFQ tool is a 23-item questionnaire with a 3-point Likert-scale for each item ranging from 3= "strongly agree", 2= "neither agree or disagree, and 1= "strongly disagree", with the exception of the negative items on this tool (#10, 13, 14 & 15), which are reverse scored. The researchers established content validity, and the reliability of the tool was reported using Cronbach's alpha coefficient factor ranging from 0.75-0.85 (Brouwers, Graham, Hanna, Cameron, & Browman, 2004).

Data Analysis

Data from the AGREE II Instrument will be analyzed by using the quality score calculations. Using Microsoft Excel, the sum of each individual domain score will be calculated and the total will be scaled as a percentage of the maximum possible score for that domain. The distribution of the data will be assessed for patterns and trends of scores across the domains. Qualitative data obtained from the comments section of each domain will be analyzed for common trends and patterns. Discrepancies in scores among team members will be discussed. Low scores will also be discussed and suggestions solicited from team members on how the item might be improved in the CPG.

Data from the PFQ translated into a univariate frequency table using Microsoft Excel. This will display the frequency of each score of three to a survey question. These frequency numbers will be divided by the total number of questions and converted into percentages for comparison.

Measures to Protect Human Rights

All participation involved with this project will be voluntary. Participation in the AGREE II tool and PFQ will be kept anonymous by not collecting any personal identifiers. The box used to collect the paper records of the PFQ's will be secure and similar to a voting box accessible

only to the student project leaders. When the paper records are retrieved from the box, they will be placed in a sealed envelope. All information from the assessment tools will be inputted into a computer system that is password protected. Once data is entered, documents will be destroyed in a shredder.

The project will be submitted to the hospital's Institutional Review Board (IRB) as well as the University of Maryland Baltimore IRB for a Non Human Subjects Research (NHSR) determination as a query.

Results

After a thorough systematic literature review on perioperative hyperglycemia management, a CPG was developed (Appendix D). A preliminary CPG was drafted by the three DNP project leaders and revised in collaboration with the DNP project chair and staff anesthesiologist at the hospital of interest. The team members were asked to evaluate the CPG by using the AGREE II tool. The domain scores were calculated using the formula described by the authors of the tool. AGREE II Appraisal Scoring (Appendix E) for each of the six domains were as follow: Editorial Independence (98%), Clarity of Presentation (97%), Scope and Practice (93%), Stakeholder Involvement (83%), Applicability (77%), and Rigour of Development (74%). Based on the results of the feedback, the CPG was made more applicable by designing an algorithm for the providers to use in order to apply the recommendations into practice.

An in-service presentation was held at the hospital of interest. The purpose of the presentation was to introduce the CPG, its purpose, components, and how to utilize it in clinical practice. Nineteen members of the anesthesia team attended the meeting, which included the chief anesthesiologist, staff anesthesiologists, nurse anesthetists, and the DNP chair. They were asked to evaluate the CPG using the Practitioner Feedback Questionnaire (PFQ). All surveys

were submitted voluntarily and collected anonymously. The responses from the 19 questionnaires were synthesized and recorded onto a spreadsheet in Microsoft Excel (Appendix F). The summary of the percentages of agreement (Appendix G) show that 100% of the group strongly agreed that there is a need for a guideline in this topic, agreed with the analysis and methodology used to support the guideline, and agreed that the recommendations are suitable for the intended patient population. The majority of the group (95%) strongly agreed that the CPG reflects an effective approach for improving patient outcomes than is current usual practice. The lowest scoring item (74%) stated that the expected effects on patient outcomes would be obvious. Nonetheless, 100% percent of participants strongly agreed that if the guideline gets approved, they would apply this guideline to their patients.

Discussion

Successful implementation of the CPG requires approval from the chief anesthesiologist, adherence to the CPG from anesthesia providers, and readily available hospital resources (glucometers, Insulin, etc.). Limitations include a small sample size and a continued need for education to the perioperative staff. One major limitation to the CPG is the risk of hypoglycemia and the clinical implications of insulin administration. Plans for translation include making sure that implementing the CPG is as easy as possible. Proper education of why the CPG is important will lead to changes in behavior and an increased likelihood for adhering to a new policy. Successful implementation will require readily available resources. This includes making sure that copies of the CPG are readily available and stocked in the pre-operative unit, in the operating rooms, and the post-operative unit. In addition, glucometers for checking blood glucose levels should be stocked and easy to access. Obtaining insulin from the pharmacy should

also be a hassle-free process. This plan for implementation will aim to eliminate barriers and facilitate a smooth transition in the management of diabetic patients undergoing surgery.

Conclusion

The data collected from the AGREE II Tool and the Practitioner Feedback Questionnaires reflected an overall acceptance for the CPG. The ultimate goal of this DNP project was to develop an evidence-based CPG that would assist in the management of perioperative hyperglycemia in diabetic patients undergoing orthopedic surgery. The implementation of this CPG will help standardize the way anesthesia providers treat high blood glucose levels and will help patients remain within a blood glucose range that has been shown to reduce adverse outcomes. It is hypothesized that the use of this CPG will potentially decrease the number of surgical site infections, improve wound healing, decrease length of stay, and reduce costs.

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Appendix A

Melnyk & Fineout-Overholt (2011) Evidence Rating Table- Perioperative Glucose Management

Author, year	Study objective/intervention or exposures compared	Design	Sample (N)	Outcomes studied (how measured)	Results	*Level and Quality Rating
Alexanian, McDonnell, & Akhtar, 2011	To provide standardized recommendations for identifying and treating hyperglycemia in patients with diabetes who present for surgery	Clinical Practice Guideline	N/A	-Optimal perioperative blood glucose levels -Postoperative blood glucose monitoring -Hypoglycemia significance in postoperative period	-Optimal blood glucose levels 120-180mg/dL -Check blood glucose level once the patient arrives in the PACU -Continue insulin infusion if BG >180mg/dL -If <180mg/dL, transition to a basal-bolus program. -Monitor potassium levels in patients on insulin drip - Resume previous insulin regimen or oral anti-diabetic medications when eating	IB
Joshi et al., 2010	To develop a consensus statement on perioperative glycemic management in patients undergoing ambulatory surgery	Systematic Review	1 Systematic Review and 9 trials, including 5 RCTs	-Optimal blood glucose level recommendation -Optimal blood glucose monitoring in perioperative period -Discharge considerations for diabetic outpatients -Management of	-Maintain blood glucose levels <180mg/dL -Observe patients post-op for possibility of hypoglycemia - The risk of hypoglycemia with subcutaneous rapid-acting insulin subsides within 1.5 hours - Risk of hypoglycemia regular insulin subsides in	IA

				hypoglycemia in the postoperative period -Post-discharge considerations for patients on glucose control	about 3-4 hours -Ensure discharge instructions on resuming pre-op anti-diabetic therapy are clear -Resume pre-hospital anti-diabetic meds once oral intake is resumed	
Joslin Diabetes Center, 2009	To help providers standardize the care for adult, non-pregnant patients with diabetes who are undergoing surgery	Clinical Practice Guideline	N/A	-Optimal perioperative blood glucose levels -Hypoglycemia prevention methods -Pre, intra, and postoperative Insulin Algorithm -Postoperative management guidelines including: frequency of blood sugar checks, and maintenance of IV fluid -Discontinuation of insulin infusion parameters	- Maintain target blood glucose levels 140-180mg/dl - Check blood glucose when patient returns to PACU - Administer insulin according to the subcutaneous algorithm or insulin infusion algorithm. - If insulin infusion is required, start D5W or D10W, receiving at least 50g glucose/24hours - If patient is able to tolerate at least 50% of prescribed diet, then resume previous oral anti-diabetic medications - Blood glucose levels >180mg/dl, start insulin infusion - If BG stays within the optimal range for 4 hours,	IA

					decrease BG checks to every 2 hours	

Appendix B

Scholarly Project Timeline

I. Submit Proposal to committee members by April 2016

II. Present Proposal to committee members in May 2016

III. Submit project proposal to UMB and hospital Institutional Review Boards (IRBs) by May 2016

III. Implement project from September, 2016 to December 2016

IV. Analyze, synthesize and evaluate data by March 2017

V. Submit final scholarly project manuscript to committee for review by March 2017

VI. Present final scholarly project report to Committee by April 2017

Appendix C

Practitioner Feedback Questionnaire

For each item, please check off the box that most adequately reflects your opinion.

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 ☐	Comments
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.

Appendix D

Clinical Practice Guideline for Perioperative Glucose Management for Diabetic Patients Undergoing Orthopedic Surgery

A. **Overview**: Diabetes Mellitus (DM) is diagnosed in 285 million adults worldwide. By 2030 this number is expected to increase to 439 million adults (Wukich, 2015). In the United States diabetes is diagnosed in 23.6 million people with 1.6 million new diagnoses every year (Moghissi et al., 2009). According to the American Diabetes Association (2014) 618,156 people in Maryland are diagnosed with diabetes. Diabetes results in many complications such as microvascular and macrovascular disease, hypertension, coronary artery disease, stroke, neuropathy, peripheral artery disease and end stage renal disease (Wukich, 2015).

B. **Background**: Hyperglycemic diabetic patients undergoing orthopedic surgery are at an increased risk for surgical site infections, prosthetic joint infections, longer inpatient length of stay, decreased likelihood of being discharged home and increased risk of morbidity and mortality (Thompson, Stearns, Apsey, Schlinkert & Cook, 2016). In patients undergoing orthopedic surgery, hyperglycemia from their diabetes can negatively impact bones, soft tissue, ligament and tendon healing, increase the risk for prosthetic joint infections and cause pulmonary embolism (Wukich, 2015).

C. **Objective**: The objective of this CPG is to standardize perioperative glucose treatment amongst providers and maintain optimal glycemic control in patients throughout the perioperative period. The CPG will provide evidence-based recommendations for the management of blood glucose levels in the preoperative, intraoperative and postoperative periods. It will include guidelines for perioperative insulin treatment, a threshold blood

glucose level for treatment with insulin, threshold blood glucose level for metabolic evaluation, and a recommended blood glucose level for cancellation of non-urgent surgery.

D. **Population**: Adult diabetic patients (Insulin and Non-Insulin Dependent) patients undergoing orthopedic Surgery
E. **Population Excluded**: Patients <18 years old, emergency surgery/trauma patients
F. **Health Care Setting**: Full-service community hospital in the mid-Atlantic region; perioperative area including pre-op/holding unit, intraoperative (operating rooms), and Postoperative Anesthesia Care Units (PACU)
G. **Target Users:** This CPG is intended for use of all anesthesia providers including anesthesiologists, CRNAs, and perioperative nurses
H. **Search Strategies**: A comprehensive search of the literature was conducted using CINAHL and PubMed. Search was limited to studies in English language and inclusion of human subjects. Two CPGs, one systematic review, two randomized controlled trials (RCTs) and one meta-analysis were used for the development of this CPG. The Melnyk Fineout-Overholt rating and evidence-grading tool was used for analysis of the studies.
I. **Inclusion Criteria for evidence**: Systematic reviews, Meta-analysis, RCTs, research within the past 5 years, diabetic patients, adult patients, patients undergoing orthopedic surgery. Presence of glycemic measurements and ranges, inclusion of two glucose range targets for comparison with statement of postoperative outcomes.
J. **Exclusion criteria for evidence**: Non-orthopedic surgical patients, Pediatric patients
K. **Strengths**: Two clinical practice guidelines, one systematic review, two RCTs, one meta-analysis. Testing among diabetic patients, random assignment in one study with variables

clearly stated and adequate sample size to detect statistical difference in serum glucose. Of the RCTs included both included pilot trials, one included a power analysis and one included a large sample size.

L. **Limitations**: Threat to external validity in one study because unable to generalize the protocol. In another study clinicians were not blinded to the treatment groups. Two of the studies included in the meta-analysis were retrospective.

M. **Consensus Techniques**: Group consensus will be used to finalize recommendations for the development of the CPG, agreed upon by including experts of the team.

N. **Procedure for updating the guideline**: Guideline will be updated every three years with the most recent literature.

O. **Facilitators and Barriers**: In order to identify facilitators and barriers to implementing the CPG, feedback from key stakeholders, perioperative staff, and administration will be sought throughout the three stages of data collection. Furthermore, a pilot program will be instituted for 3 months before widespread implementation to so that any unforeseen challenges or barriers that may arise during testing may be revealed. Strategies for facilitating implementation include making sure the CPG is well organized, easy to follow, and readily available. In-services will be conducted to ensure verbal understanding of the CPG from the staff. Anticipated barriers may include the risk of hypoglycemia and the skills/comfort of practitioners on recognizing and treating severe hypoglycemia. In order to prevent this barrier, the CPG will include hypoglycemic treatment strategies.

P. **How the Recommendations Can Be Put Into Practice**: The CPG will be in the form of a clinical algorithm. The instructions for recommendations will be clear and divided out

between preoperative, intraoperative, and postoperative recommendations. In-services will be provided where copies of the CPG will be disseminated. Once a pilot program will be implemented over a three-month period, results from a pilot test will be summarized and a paper handout will be passed out to the perioperative staff. Patient leaflets regarding education on controlling blood glucose levels in the perioperative period will be disseminated to patients during pre-op testing appointments.

Q. **Resource Implications**: The costs of implementing this CPG is expected to be minimal. The clinical skills required to implement the recommendations are within the standard practice of care provided by the perioperative staff. Consideration to the cost of equipment includes cost of supplying glucometers across the perioperative area and the pharmacological costs of subcutaneous insulin and intravenous insulin infusions. Other anticipated costs may include the costs of training/educating staff.

R. **Auditing Criteria**: In order to assess the adherence to the recommendations outlined in the clinical practice guideline, auditing criteria will include the following:

1. The perioperative blood glucose level should be maintained 120-180mg/dL
2. If the preoperative blood glucose level was >180mg/dL, an insulin infusion was initiated
3. Elective cases were cancelled if preoperative blood glucose levels were >400-500mg/dL
4. Intraoperative blood glucose levels were checked every hour
5. Blood sugars were checked upon arrival to PACU

S. This CPG was developed without funding.

T. The group members have declared they have no competing interests.

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Preoperative Recommendations:

- Schedule diabetic patients early in the day[3].
- Optimal Preoperative BG range: 120-180 mg/dL[3].
- Continue with surgery if BG level: 180 mg/dL or less[1].
- Initiate IV insulin infusion prior to the start of surgery if BG level: 181-300 mg/dL[1,3].
- If IV insulin infusion is initiated begin a 5% dextrose solution to avoid hypoglycemia [1,3].
- Notify the anesthesia providers regarding treatment in the preoperative area[1,3].
- Check BG levels every 2 hours for patients in optimal range[1,3].
- Elective cases should be postponed in patients with fasting BG>400-500mg/dL or in patients with significant complications of hyperglycemia such as severe dehydration, ketoacidosis, and hyperosmolar non-ketotic states [1,3]. Postponing elective cases is always up to the discretion of the provider taking into account the patient's stability, necessity of the procedure and acceptable risk [1,3].

Table 1
Pre-Operative Diabetic Medication Guidelines [1,2,3]

Type of Insulin	Day & Evening Before Surgery	Morning of Surgery
Oral Agents	Continue all oral agents. *If the patient has renal dysfunction or is likely to receive IV contrast, you may discontinue metformin 24-48 hours prior to surgery.	Hold.
Short-Acting Insulin (Aspart, Lispro, Apidra, Regular, Novolog, Humalog)	Continue.	Hold.
Intermediate-Acting Insulin (NPH)	Maintain usual meal plan & insulin dose. If taken in the evening, take 75% of dose.	Give 50% of the usual dose.
Long-Acting Insulin (Lantus, glargine, detemir)	Maintain usual meal plan and insulin dose. If taken at night and the patient has a history of nocturnal or morning hypoglycemia, reduce nighttime dose by 25%.	Take 75% of the usual dose.
Insulin Pump	Maintain usual meal plan & basal rate.	Maintain basal rate.

Intraoperative Recommendations:

1. Patient is optimal if blood glucose is maintained between 120-180 mg/dL do not need to initiate subcutaneous insulin or IV insulin [1,3,]
2. In patients with poorly controlled diabetes who will still undergo surgery blood glucose levels should be kept at preoperative levels and patients blood glucose should not be normalized[3]

Initiation of subcutaneous insulin

1. For patients already on subcutaneous insulin prior to day of surgery initiate subcutaneous insulin guideline intraoperatively for the following conditions
    a. Patient not critically ill (ASA 1 or 2) subcutaneous insulin is suggested for blood glucose >180mg/dL to maintain blood glucose level <180mg/dL [3]
    b. After initial dose of subcutaneous insulin do not administer additional dose until time to peak effect has passed[2]
    c. Check blood glucose every 2-4 hours if using rapid-acting insulin (aspart, glycine, lispro or inhaled insulin)[3]
    d. Check blood glucose every 4-6 hrs if using short-acting insulin (regular insulin)[3]

2. For insulin naïve patients (those taking oral glucose medications)
    a. Intraoperative insulin can be given if blood glucose levels are increased significantly and if patient can check sugar at home[2]

3. Refer to table 2 below for subcutaneous dosing of insulin[3]

Initiation of IV insulin

1. Patient is critically ill (ASA 3 or 4) with blood glucose >180mg/dL twice intraoperatively or undergoing major surgery (E.g. chest or abdominal cavity, LE bypass, transplant, spinal or brain surgery requiring general anesthesia total hip or knee replacement, surgery anticipated to be >4 hours)[3]
    a. Insulin infusion is a temporary intervention to attain metabolic control rapidly[1]
2. Intraop blood glucose is to be performed every 1-2 hrs[2]
3. Refer to table 3,4, and 5 below for initiation and continuation of IV insulin infusion

Management of Blood glucose <120mg/dL after initiation of subcutaneous insulin or IV insulin

1. If blood glucose <80mg/dL give 100mL D10W IV or 25-50mL (1/2-1 amp) D50
    a. Check blood glucose in 15-30min
2. Blood glucose 80-100mg/dL begin D5W at 40mL/hr or D10W at 20mL/hr
    a. Check blood glucose in 1 hour
3. If intraoperative blood glucose decreases < 120 mg/dL initiate D5W at 40mL/hr or D10W at 20mL/hr[3]
    a. Check blood glucose every hour[3]

Intraoperative Considerations

- Adequate intraop crystalloid 20-40mL/kg assuming no CI like CHF to prevent postop dehydration [2]
- Need aggressive PONV prophylaxis to allow for early resumption of oral intake[2]
- Patient should receive IV fluids without dextrose (e.g. LR rather than D5LR)[3]

Postoperative Recommendations:

- Maintain target perioperative glucose range 120-180mg/dL[1,2,3]
- Check BG once patient arrives in PACU.[1,3]
- Check BG every hour[3]
- If admission BG is >180mg/dL, maintain insulin gtt if already running or initiate an insulin infusion according to insulin algorithm[1]
- If admission BG is within 120-180mg/dL, transition patient to subcutaneous sliding scale[1]
- If BG remains within 120-180mg/dL for four hours, decrease frequency of checks to every 2 hours[3]
- If insulin is administered, a BG should be checked within 1 hour
- Maintain vigilance in the postoperative period for the risk of hypoglycemic symptoms such as sweating, palpitations, confusion, and loss of consciousness[2]
- Use maintenance IV fluids without dextrose unless the patient is on an insulin drip.[3]
- If on an insulin drip, provide a constant dextrose infusion (D5W @ 40 ml/hr or D10 W @20ml/hr)[3]
- Stabilized blood glucose levels and tolerance of oral intake permits the resumption of previous antidiabetic therapy[1,2,3]

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Table 2

Subcutaneous Insulin Sliding Scale[3]

Weight Class I (<175 lbs/80 kg)	Weight Class II (175-220 lbs/81-99 kg)		Weight Class III (>220 lbs/100 kg)
BG (mg/dl)	Insulin Units (subcut)	Insulin Units (subcut)	Insulin Units (subcut)
<150	0 unit	1 unit	2 units
150-180	1 unit	2 units	4 units
181-200	2 units	4 units	6 units
>200	Begin insulin infusion	Begin insulin infusion	Begin insulin infusion

Table 3

Calculation of Initial IV Insulin Dose[3]

Calculation of initial IV insulin dose[3]
If BG>180mg/dL give stat dose of IV insulin 0.1units/kg body weight
Patients who have never been on insulin, 0.02units/kg/hr
For acute surgical patients, e.g. cardiothoracic or transplant, higher starting doses may be necessary
For patients on total parenteral nutrition (TPN), insulin infusion is in addition to insulin currently administered in the TPN solution

Table 4

Alternative IV Insulin[3]

Alternative Initial Dose		
Blood glucose (mg/dL)	Regular Insulin (bolus)	Regular Insulin (infusion per hour)
151-200	No Bolus	2 units IV
201-250	3 units IV	2units IV
251-300	6 units IV	3 units IV
301-350	9 units IV	3 units IV
>350	10 units IV	4 units IV

Table 5

IV Insulin Sliding Scale[3]

Previous Blood Glucose (mg/dl)

Current Blood Glucose (mg/dl)	<60	60-80	81-100	101-150	151-200	201-250	251-300	301-400	>400
<60	Hold drip and give 1 amp 50% glucose and check BG every 30 minutes until >100 mg/dl and then re-initiate drip at 50% previous rate								
60-80	Hold drip and check BG every 30 minutes until >100 mg/dL and then re-initiate drip at 50% previous rate								
81-100	↓ _rate by 1unit/hr	No change	↓ _rate by 25% or 0.5 units/hr*		↓ _rate by 50% or 2 units/hr*			↓ _rate by 75% or 2 units/hr*	
101-150	No Change					↓ _rate by 50% or 2 units/hr*			
151-200	↑ _rate by 1 unit/hr		↑ _rate by 0.5 units/hr		↑ _rate by 25% or 1 unit/hr*	No Change	↓ _rate by 25% or 2 units/hr*		
201-250	↑ _rate by 25% or 2 units/hr*				↑ _rate by 25% or 1 unit/hr*			↑ _rate by 1 unit/hr	No Change
251-300	↑rate by 33% or 2.5 units/hr*			↑ _rate by 25% or 1.5 units/hr*	↑ _rate by 25% or 1 unit/hr*	↑ _rate by 1 unit/hr	↑ _rate by 1.5 units/hr	↑ _rate by 25% or 2 units/hr*	No Change
301-400	↑ _rate by 40% or 3 units/hr*								
>400	↑ _rate by 50% or 4 units/hr*								

Appendix E

AGREE II Tool Appraisal Scoring

Table 1

Domain 1: Scope & Practice

	Item 1	Item 2	Item 3	Total
Appraiser 4	7	7	7	21
Appraiser 3	7	6	7	20
Appraiser 2	6	5	7	18
Appraiser 1	7	6	7	20
Total	27	24	28	79

Maximum possible score= 7(strongly agree) x 3(items) x 4(appraisers)= 84
Minimum possible score= 1(strongly disagree) x 3(items) x 4 (appraisers)=12

The scaled domain score will be:
Obtained score-Minimum Possible score
Maximum possible score-Minimum possible score

79-12/84-12 x 100
(67/72) x 100
(0.93)x100= 93%

Table 2

Domain 2. Stakeholder Involvement

	Item 4	Item 5	Item 6	Total
Appraiser 4	6	6	7	19
Appraiser 3	7	7	7	21
Appraiser 2	7	2	7	16
Appraiser 1	7	2	7	16
Total	27	17	28	72

Maximum possible score= 7(strongly agree) x 3(items) x 4(appraisers)= 84
Minimum possible score= 1(strongly disagree) x 3(items) x 4 (appraisers)=12
(72-12)/(84-12)
(60/72) x100
(0.83) x100= 83%

Table 3

Domain 3. Rigour of Development

	Item 7	Item 8	Item 9	Item 10	Item 11	Item 12	Item 13	Item 14	Total
Appraiser 4	7	6	6	6	7	6	6	5	49
Appraiser 3	7	3	3	6	7	7	4	2	39
Appraiser 2	5	5	7	6	7	7	6	3	46
Appraiser 1	7	7	5	7	6	6	2	4	44
Total	26	21	21	25	27	26	18	14	178

Maximum possible score= 7(strongly agree) x 8(items) x 4(appraisers)= 224
Minimum possible score= 1(strongly disagree) x 8(items) x 4 (appraisers)=32

(178-32)/(224-32)
(146/192) x100
(0.76) x100= 76%

Table 4

Domain 4. Clarity of Presentation

	Item 15	Item 16	Item 17	Total
Appraiser 4	7	7	7	21
Appraiser 3	7	7	7	21
Appraiser 2	7	7	6	20
Appraiser 1	6	7	7	20
Total	27	28	27	82

Maximum possible score= 7(strongly agree) x 3(items) x 4(appraisers)= 84
Minimum possible score= 1(strongly disagree) x 3(items) x 4 (appraisers)=12

(82-12)/(84-12)
(70/72) x100
(0.97) x100= 97%

Table 5

Domain 5. Applicability

	Item 18	Item 19	Item 20	Item 21	Total
Appraiser 4	5	7	6	6	24
Appraiser 3	4	7	5	5	21
Appraiser 2	7	7	6	7	27
Appraiser 1	5	3	6	4	18
Total	21	24	23	22	90

Maximum possible score= 7(strongly agree) x 4(items) x 4(appraisers)= 112
Minimum possible score= 1(strongly disagree) x 4(items) x 4 (appraisers)=16

(90-16)/(112-16)
(74/96)x100
0.77x100=77%

Table 6

Domain 6: Editorial Independence

	Item 22	Item 23	Total
Appraiser 4	7	7	17
Appraiser 3	6	7	13
Appraiser 2	7	7	14
Appraiser 1	7	7	14
Total	27	28	58

Maximum possible score= 7(strongly agree) x 2(items) x 4(appraisers)= 56
Minimum possible score= 1(strongly disagree) x 2(items) x 4 (appraisers)=8

(55-8)/(56-8)
(47/48) x100
0.98x100= 98%

Table 7

Overall Assessment

	OA1
Appraiser 4	6
Appraiser 3	5
Appraiser 2	6
Appraiser 1	6
Total	23

Appendix F
Practitioner Feedback Survey Results

Table 1

Practitioner Feedback Survey

Item #	PFS 1	PFS 2	PFS 3	PFS 4	PFS 5	PFS 6	PFS 7	PFS 8	PFS 9	PFS 10	PFS 11	PFS 12	PFS 13	PFS 14	PFS 15	PFS 16	PFS 17	PFS 18	PFS 19	Mode
2	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	2	3	3
5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
7	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3
8	3	2	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
9	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
10	3	2	2	2	1	2	2	3	3	1	3	3	2	3	1	3	2	2	2	2
11	3	3	3	3	3	2	3	3	3	3	3	3	1	3	3	3	2	2	3	3
12	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
13	3	3	3	2	2	3	3	3	3	3	3	3	3	3	1	3	2	3	3	3
14	3	2	2	1	2	3	1	3	3	2	3	2	3	3	1	3	1	3	1	3
15	2	2	2	1	1	2	1	3	2	1	2	2	3	3	1	3	1	2	1	2
16	2	2	3	3	3	3	3	1	3	3	3	3	3	3	3	3	3	2	3	3
17	3	2	3	2	3	3	3	3	3	2	3	3	3	3	3	3	2	2	3	3
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3
19	3	3	3	2	3	2	3	3	3	3	3	3	3	3	3	3	2	3	3	3
20	3	3	3	3	3	2	3	3	3	3	3	3	1	3	3	3	3	3	3	3
21	3	2	3	2	3	3	2	3	3	3	3	3	3	3	3	3	3	3	2	3
22	3	3	3	2	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3
23	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

*PFS = Practitioner Feedback Survey
Strongly Agree = 3
Neither Agree or Disagree = 2
Strongly Disagree = 1

Appendix G
Percentage Response Per Survey

Table 2

Practitioner Feedback Questionnaire Percentage (%) Response Per Survey

Item #	Strongly Agree (%)	Neither Agree or Disagree (%)	Strongly Disagree (%)
2	89	11	0
3	100	0	0
4	89	11	0
5	100	0	0
6	100	0	0
7	95	5	0
8	89	11	0
9	100	0	0
10	37	47	16
11	79	16	5
12	100	0	0
13	79	16	5
14	47	26	26
15	21	42	37
16	79	16	5
17	74	26	0
18	95	5	0
19	84	16	0
20	89	5	5
21	79	21	0
22	89	11	0
23	100	0	0