PERIOPERATIVE GLUCOSE MANAGEMENT TO REDUCE SURGICAL SITE INFECTIONS: CLINICAL PRACTICE GUIDELINE

by

Sheilla S. Joseph

Under Supervision of

Michelle LR Gonzalez, PhD, CRNA

And

Veronica Y. Amos, PhD, CRNA, PHCNS-BC

Second Reader

Margaret Hammersla, PhD, CRNP-A

A DNP Project Manuscript
Submitted in Partial Fulfillment of the Requirements for the
Doctor of Nursing Practice Degree

University of Maryland School of Nursing
May 2019

Abstract

Background: The association of hyperglycemia during and after surgery has been shown to increase the risk of Surgical Site Infections in multiple surgical specialties. Surgical site infections are a complication that has an annual financial impact of over $3 billion dollars nationally. Patients with poorly controlled glycemic levels are at higher risk for surgical site infections and are commonly predisposed to post-op soft tissue and bone healing complications.
Local Problem: A large tertiary medical facility in Maryland requested an updated evidence-based guideline to manage perioperative hyperglycemia to reduce surgical site infections in their adult patient population undergoing elective orthopedic surgeries. A review of the literature revealed current standard of practice recommendations of maintaining glycemic values </= 180 mg/dL demonstrated a stronger link to reducing rates of surgical site infections and other post-op complications. The purpose of this Doctorate of Nursing Practice project was to develop a clinical practice guideline that provided best practice strategies for the management of postoperative hyperglycemia in adult patients undergoing elective orthopedic surgery.
Intervention: A clinical practice guideline was developed for this quality improvement project. The project included three Student Nurse Anesthetists as project leaders, and three stakeholders. Stakeholders reviewed and graded the guideline draft using the Appraisal of Guidelines for Research & Evaluation Tool. This tool is an open source appraisal instrument used worldwide to evaluate structure, content and the quality of guidelines. Revisions made to the guideline were based on stakeholder recommendations and the appraisal tool results. Implementation of the project was in the form of a brief formal PowerPoint presentation to the anesthesia department and providers were asked to rate the guideline using the Provider Feedback Questionnaire. The data collected from this questionnaire and the appraisal tool were examined using simple descriptive and correlative statistics. Results were acquired to make final modifications to the guidelines.
Results: The overall response to the guideline was favorable. The average percentage scores of the guideline appraisal tool were calculated by domain and showed an overall guideline assessment score of 87%. A total of 23 provider feedback questionnaires were collected; and the most common response was a 3 (Strongly Agree), appearing on 18 out of the 23 survey responses. The overall percentage of respondents' agreement for the guideline was 79% with a standard deviation of 10%. In total, these results are very promising for continuing to explore the implementation of the guidelines.
Conclusion: Perioperative glycemic control of </= 180mg/dL has been demonstrated to reduce the incidence of surgical site infections in adult patients undergoing orthopedic surgery. This clinical practice guideline was developed and implemented specifically for this institution. The guideline found strong support among the end users/stakeholders and both doctors and nurses strongly approved of the guidelines. The results of the provider feedback questionnaire indicated effective and internal reliability in which implementing the Guidelines would result in decreasing the rate of perioperative hyperglycemia and the rates of surgical site infections. Further evaluation of patient outcomes after implementation of the guidelines is recommended to measure continued guideline efficacy.

Keywords: Perioperative Blood Glucose Management, Postoperative Blood Glucose Management, Perioperative Glycemic Control, Clinical Practice Guideline, Surgical Site Infection, Orthopedic Surgery, Stress-induced Hyperglycemia.

Overview & Problem Statement

Surgical site infection (SSI) is a complication that can occur after orthopedic procedures. SSI is defined as an infection(s) occurring 30-days after surgery with no implant, or within 1-year if an implant is placed and infection appears to be related to surgery (Darouiche, 2013). Occurrence of SSI is estimated to increase hospital stay by 7-to-10 days and have an annual financial impact of over $3 billion dollars nationwide (Darouiche, 2013; Martin et al., 2016). In 2002, an estimated 1.7 million healthcare-associated infections (HAIs) occurred in the United States, with 22% reported as SSIs that led to 8,205 deaths (Jeon, Furuya, Berman, & Larson, 2012). The most recent National Nosocomial Infections Surveillance System (NNISS) studies have demonstrated that the infection rate is 2.49% after open reduction and internal fixation (ORIF) of fractures, 1.67% after hip arthroplasty, and 1.47% after knee arthroplasty (Fisichella, Fenga, & Rosa, 2014).

Hyperglycemia is often synonymous with Diabetes Mellitus (DM), however, not all patients with hyperglycemia are diabetics. Stress-Induced Hyperglycemia (SIH) is a form of hyperglycemia seen secondary to surgical stress and anesthesia (Goyal, Kaur, Sud, Ghorpade, & Gupta, 2014). Hyperglycemia is defined as an unusual rise in blood glucose (BG) levels >140 mg/dL in non-diabetics or those with glycated hemoglobin (HgA1C) levels of < 5.7; an indicator of how well a person's BG is controlled over time (Domingos, Iida, & Poveda 2016; Richards, Kauffmann, Zuckerman, Obremskey, & May 2012). The association of hyperglycemia during and after surgery has been shown to cause increased risk of SSIs in multiple surgical specialties (Jupiter, Humphers, & Shibuya, 2014; Sadoskas, Suder, & Wukich, 2015). One of the reasons that poor glycemic control is believed to contribute to worsened outcomes is due to

hyperglycemia causing white blood cell dysfunction, thus increasing the risk of infection (Shaw, Saleem, & Gahtan, 2014).

The Centers for Disease Control and Prevention (CDC) estimated over 30 million Americans suffer from DM, with 1.6 million new cases of DM each year (CDC, 2018). DM is defined as a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both (American Diabetes Association [ADA], 2018). It is estimated that more than eight percent of patients with DM undergo primary or revision total hip or knee arthroplasty in the United States each year (Mraovic, Suh, Jacovides & Parvizi, 2011). Surgical stress and anesthesia influence pancreatic β cell function, resulting in lower plasma insulin levels, which may result in significant hyperglycemia (Vries et al., 2016). Patients with poorly controlled BG levels are commonly predisposed to postoperative soft tissue and bone healing complications resulting in longer hospital stays (Jupiter, Humphers, & Shibuya, 2014; Sadoskas, Suder, & Wukich, 2015).

There currently exists no uniform guidelines defining a desired target range for optimal postoperative BG control for adult patients undergoing elective orthopedic surgery (Jeon, Furuya, Berman, & Larson 2012). Studies varied on recommended targets for optimal glucose control for the preventions of SSIs, and death. However, the Surgical Care Improvement Project (SCIP), in partnership with the Centers for Medicare and Medicaid (CMS), and other healthcare organizations have developed a core measure to maintain BG at a level of </=180 mg/dL. This core target was based on evidence of decreased SSIs in the postoperative period (Boreland, Scott-Hudson, Hetherington, Frussinetty, & Slyer, 2015).

Purpose Statement and Goals

The purpose and short-term goal of this Quality Improvement (QI) project was to develop an evidence-based clinical practice guideline (CPG) that constituted best practice strategies for a tertiary medical facility in Maryland to manage perioperative hyperglycemia. The long-term goal is to reduce SSIs in adult patients undergoing elective orthopedic surgical procedures. This CPG will provide an evidence-based approach for the following: Postoperative BG management, BG monitoring frequency, postoperative insulin management and insulin administration. The implementation of this CPG is expected to provide clear directions and standardize practices for managing hyperglycemia in the postoperative period. Additionally, execution of this CPG is also projected to reduce the incidence of postoperative hyperglycemia, prevent hypoglycemia; reduce the rates of SSIs, hospital length of stay and total hospitalization costs.

Theoretical Framework

The *FADE Quality Improvement (QI) Model* was selected as the theoretical framework to guide this DNP project. The model provided and supported the organization and structure of the design methods used in developing the project, and implementing a plan for change (Wiseman & Kaprielian, 2005). The *FADE Model* is a cyclical tool consisting of four steps. The four steps according to Wiseman & Kaprielian (2005) are: 1) *Focus,* 2) *Analyze,* 3) *Develop and* 4) *Execute & Evaluate*. The *Focus* step focused on defining the problem to be improved. The *Analyze* step consisted of collecting and analyzing data that established baselines, identified root causes, and indicated possible solutions. The *Develop* step focused on designing an action plan based on needs of the facility and data gathered to support improvement. The final step, *Execute & Evaluate* included implementing the action plan, measuring and monitoring the system to promote successful improvement (Wiseman & Kaprielian, 2005).

In the *Focus* step, a lack of updated evidence-based protocol on the management of perioperative hyperglycemia to reduce SSIs was identified as a problem at this organization. In the *Analyze* step, external and internal evidence analysis through a preliminary literature review, indicated that implementation of a postoperative glycemic management guideline may be effective to obtain and maintain postoperative glycemic results between 140-180mg/dL (Marik & Bellomo, 2013). In the *Develop* step, proposed interventions to effect change of existing practices were constructed based on evidence supporting postoperative hyperglycemic management. The *Execute* step facilitated implementation and included an educational PowerPoint presentation to the anesthesia department. *Evaluation* involved analysis of data collected from the Practitioner Feedback Questionnaire (PFQ) and demographic questionnaire (Appendix E) upon the completion of the educational presentation. Staff and stakeholders were asked to support and promote the application of the CPG for patient care and data on patient outcomes will be gathered and assessed after guideline implementation. Lastly, the CPG was finalized and incorporated specifically for the target facility.

Literature Review

The main emphasis of this literature review is the development of an updated, evidence-based CPG for postoperative glucose management to reduce the rates of SSIs (Table 1). A literature review was performed to gain a greater understanding and knowledge of the risk factors for postoperative hyperglycemia and best practice strategies and recommendations to manage and treat hyperglycemia. Each of the six studies used was reviewed independently to include strengths and limitations. The Six articles examined met the proposed criteria (adults 18 years and older, DM & non-diabetic patients undergoing any orthopedic surgery, no pre-existing SSIs) for this evidence review and synthesis. Please refer to Table 1 at the end of this report for

a detailed account of each article. The review begins with evidence from two studies on the association of hyperglycemia and patient risk factors related to outcomes of postoperative SSI in DM and non-DM patients undergoing surgical procedures. Following, three studies examined related impacts of postoperative glycemic control, effective strategies and "strict versus conventional" glucose target levels for reducing rates of SSIs. Additionally, a currently existing BG control guideline was also evaluated.

In the first study reviewed, Martin et al. (2014) performed a systematic review and meta-analysis of risk factors for SSIs among DM and non-DM adult patients undergoing surgical procedures of any type in the U.S. The purpose of this study was to determine the association between DM and SSIs across multiple surgical procedures. The most common types of surgeries were cardiac and spine. Half of the studies assessed post-op BG thresholds of >/= 200 mg/dL for defining hyperglycemia with the remaining half using 125mg/dL to 180mg/dL. The authors found increased SSIs among patients with DM was consistent across surgery types. Combined SSI was higher for cardiac surgery ($p= 0.001$) than any other type of surgery. While there were increases of SSIs across all surgery times, increased SSIs were statistically significant ($p < 0.001$) for Arthroplasty, breast, cardiac and spine surgeries. The strengths of this study included the design, (systematic review and meta-analysis), a large and varied sample size comprised from 94 studies and 866K procedures; hyperglycemia was well defined with thresholds, and SSI was defined using criteria specified by the CDC for the purposes of surveillance and reporting. Findings were statistically significant with definitive results allowing for generalization to the general population and minimizing threats to validity. Limitations included all studies reviewed were observational except for three RCTs; none of the studies differentiated between Type 1 and Type 2 DM, and no results were reported on non-DM patients.

Presently, there is a scarcity of literature on hyperglycemia in non-DM patients following orthopedic surgery. Richards et al. (2012) conducted a retrospective investigational study of patients with isolated orthopedic injuries requiring acute operative interventions. The purpose of the study was to evaluate the relationship of hyperglycemia with 30-day SSI incidence in a population of orthopedic trauma patients without a history of DM at the time of admission. Hyperglycemia was defined in two ways: two or more random glucose values of (>/= 200 mg/dL) and hyperglycemic index (HI) of 1.76 (equivalent to >/= 140 mg/dL). The researchers found SSIs were significantly more common in patients with a HI of >/= 1.76 ($p < 0.001$) and concluded that HI of >/= 1.76 was an independent risk factor for SSI. The strengths of this study included a large sample size of patients (N=976); hyperglycemia was well defined with two definitions; postoperative SSI was identified using the International Classification of Diseases (ICD), and findings were statistically significant with definitive results. Limitations of this study included its design as a retrospective investigational study; such a design may contain inherent bias and pose threats to internal validity.

Another study reviewed was a retrospective cohort study completed by Jeon, Furuya, Berman, & Larson (2012) that examined how pre- and post-operative glucose levels and their variability are associated with the risk of SSI and deaths in hospitalized patients. Data was extracted from hospitalized in-patients (N= 13,800). Documented patient pre-operative BG levels (n=5,618); post-operative BG levels (n=13,166), and 21.2% had diabetes (n=2,927). Gastrointestinal (GI) and heart surgeries made up 50% of the types of surgeries performed. Maximum glucose levels were recorded for 72-hours pre-and-post surgery and BG variability was expressed as the coefficient of variation of the glucose measurements. Results showed BG levels after surgery were higher than levels taken before the operation, with > 65% of patients

having BG levels of >/= 140 mg/dL post procedure. Patients with SSIs and those who died had higher maximum pre-op and post-op glucose levels compared to others (SSI: $p = 0.04$ for pre-operative and $p < 0.0001$ for post-operative; death: $p < 0.0001$ for pre-operative, $p < 0.0001$ for post-operative). The strengths of this study included a large sample size (N= 13,800), maximum BG levels before and after surgery were measured showing baseline and correlation of impact of surgical stress on BG levels postoperatively. Limitations of this study included study design- a retrospective cohort study, (which may contain inherent bias and poses threat to internal validity), and all study patients were hospitalized, limiting generalizability.

Some authors have expressed concern regarding the risk of hypoglycemia involving intensive glucose control which may result in potentially severe complications. Vries et al. (2016) carried out a systematic review and meta-analysis of Randomized Control Trial (RCTs), (N=15) to evaluate the impact of intensive BG control protocols (n=1442) versus conventional BG control protocols (n=1394) on the risk of SSI and other complications including hypoglycemia, mortality, and stroke. Glycemic definitions were defined as follows; hyperglycemia: BG > 180 mg/dl to >/= 220 mg/dl; hypoglycemia was a BG of < 40 mg/dl to < 80 mg/dl; more liberal glucose target levels: 220 mg/dl or less, and stricter glucose target levels: 150 mg/dl or less. All studies in the intensive group used intravenous (IV) insulin administration, whereas other studies used subcutaneous (SC) insulin in the conventional group. A significantly higher risk of hypoglycemic events was revealed in the intensive group as compared to the conventional group ($p < 0.001$), with no increased risk of death ($p < 0.484$) or stroke ($p < 0.511$). Overall, significant benefits were revealed for intensive compared with a conventional glucose control protocol in reducing SSI ($P < 0.001$). The strengths of this study included the design, (a systematic review and meta-analysis), a large sample size from RCTs, (N

= 15) and presence of control groups. Additional strengths were, "strict versus conventional" protocols were well defined; findings were statistically significant with definitive results which increases generalizability and minimizes threats to validity. Limitations included study was restricted to patients undergoing major cardiac or GI surgery, with a substantial proportion of the study population having a postoperative ICU stay.

Domingos, Iida, & Poveda (2016) performed a systematic review examining existing data on the correlation between glycemic control approaches implemented and the incidence of SSI in adult patients undergoing surgical procedures. This study defined hyperglycemia as an abnormal elevation in glucose levels >140 mg/dL in non-diabetic patients or those with HgA1C levels < 5.7. The outcomes of this review revealed that keeping glucose levels between 80 and 120 mg/dL is associated with decreased complications in the post-op phase, and therefore, reduces cost of hospitalization. The strengths of this study included the design (systematic review) with a large total sample size from eight RCTs (N=447) and the study groups consisted of diabetic and non-diabetic patients. Limitation of the study included none of the studies involved orthopedic surgery patients.

The CPG by Duggan, Klopman, Berry, & Umpierrez (2016) was developed by a multidisciplinary team of physicians used to comprehensively manage perioperative hyperglycemia across diabetic and non-diabetic patients undergoing non-cardiac elective surgery at Emory University. This CPG contains insulin algorithms that addresses all phases of the perioperative surgical processes, evaluation of diabetic and non-diabetic patients, a postop glycemic monitoring and treatment plan for DM Type I & II, and stress-induced hyperglycemia (SIH). For the management of post-op hyperglycemia in non-critically ill patients undergoing general surgery, this CPG recommended patients be managed with SC insulin, however IV

insulin may also be used with provider discretion. The strengths of this protocol included it's evidenced-based practice recommendations from subject matter experts and organizations on diabetic management. This protocol is designed to manage all types of glycemic variability and patient populations. Limitations of this CPG included the lack of specialty surgical patient groups, such as orthopedic patients.

Evidence Synthesis

As several studies in patients with and without DM have shown, hyperglycemia is associated with poorer postoperative outcomes. Two of the six studies agreed that hyperglycemia was an independent risk factor for SSIs in surgical patients (Martin et al., 2014; Richards et al., 2012). These two studies differed in target population and surgical procedures done in the studies. Two other studies supported intensive protocol which had significant benefits in reducing SSIs compared to conventional glycemic protocols (Domingos, Iida, and Poveda, 2016; Vries et al., 2016). However, they differed on the glucose target range used. Domingos, Iida, and Poveda, (2016) found that maintaining BG between 80 and 120 mg/dL was associated with lower rates of complications in the postoperative period and hence decreased SSIs and cost of hospitalization. Vries et al., also found significantly higher risk of hypoglycemic events for the intensive group compared with the conventional group but with no increased risk of death, while Domingos, Iida, and Poveda, (2016) made no mention of hypoglycemic related events. One study supported less aggressive therapy for critically ill patients (target 140–180 mg/dL) than previously recommended based on the Society of Critical Care Medicine recommendations (Duggan, Klopman, Berry, & Umpierrez, 2016). However, this same study supported BG trigger (150-180 mg/dL) for treatment in all non-cardiac patients. Domingos, Iida, and Poveda (2016)

& Vries et al (2016) also supported treatment for BG values of <180 mg/dL in non-critically ill general surgery patients based on evidence of decreased SSIs.

Two additional studies differed on the types of insulin to be used at the different phases of the perioperative period (Duggan, Klopman, Berry, & Umpierrez 2016; Domingos, Iida, and Poveda, 2016). Domingos, Iida, and Poveda, (2016) investigators found continuous infusion of insulin paralleled with different methods of glycemic control in regards to maintaining BG levels below 150-200 mg/dL, demonstrated a stronger link to reducing rates of SSI and other postoperative outcomes. Duggan, Klopman, Berry, & Umpierrez (2016), recommended single doses of SC insulin injections for short procedures. Their CPG recommended the use of SC insulin over IV insulin for correction of post-op hyperglycemia in non-critically ill general surgery patients. Benefits of SC rapid-acting insulin analogs include ease of administration, low rate of hypoglycemia, and efficacy in correcting hyperglycemia.

Project Methods: (Design, Setting & Sample)

This evidence-based quality improvement project was implemented to provide clear directions and best practice strategies for the management of hyperglycemia throughout the postoperative period of diabetic and non-diabetic adult patients undergoing orthopedic surgery to decrease the incidence of SSIs. This project took place in the perioperative unit of a full-service tertiary medical facility in Maryland. This CPG was created for use by all anesthesia providers and perioperative staff, to include Anesthesiologists (MDAs), Certified Registered Nurse Anesthetists (CRNAs), and Post Anesthesia Care Unit (PACU) nurses.

Project Procedures and Timeline

This project took place in three phases. *Phase I* of the project began the first week of June 2018, where three Student Registered Nurse Anesthetists (SRNAs) project leaders recruited

an expert panel or stakeholders to assist with the development of the CPG, without any conflict of interest. This expert panel consisted of an MDA-Chairman of the Anesthesia Department, a CRNA-Clinical Coordinator and a PhD, CRNA/UMSON-Anesthesia faculty advisor. An initial meeting was held in June 2018 with the expert panel for formal agreement of project participation. In this meeting, roles and responsibilities of the project participants were discussed; evidence-based research was presented and project goals, outcomes and tools were reviewed and explained. Furthermore, at least one site champion was identified at this meeting. Once the stakeholders agreed to participate, a draft of the CPG, to include the Appraisal of Guidelines for Research and Evaluation (AGREE) II tool (Appendix D) was presented mid-July 2018. The expert panel reviewed, modified and rated the CPG draft using the AGREE II tool based on the needs of the facility. The panel had a week after the initial meeting to rate the CPG using the AGREE II tool. A second meeting with the panel was held the first-week of August 2018 to review the results of the AGREE II tool and recommendations for revisions of the CPG. Project leaders had a week to revise the CPG based on the AGREE II tool results. Once updated, the CPG was resubmitted to the expert panel during the third-week of August 2018. Some additional changes were made during the second meeting, revisions were emailed to the expert panel until full support of the final CPG draft was obtained. Moreover, during *phase I,* at the end of July 2018, Institutional Review Board (IRB) permission was requested and a project proposal was submitted to the University of Maryland Baltimore (UMB). The project was determined to be Non-Human Subjects Research (NHSR) by the IRB committee. A proposal was also submitted to the IRB of the organization where the project was implemented and was also deemed NHSR.

In *phase II,* a meeting was held during the first-week of September 2018 with key administrators such as the Head of the Anesthesia Department (MDA) for feedback, approval and support to present the finalized CPG to the anesthesia department. A date was selected to present the CPG to the anesthesia staff at the facility during a Friday morning staff meeting. In *phase III*, mid-December 2018, a brief 30-minute formal presentation was given to an anticipated sample of 20-30 anesthesia providers, including the chief MDA. However, only 16 individuals were in attendance for the formal PowerPoint presentation of the CPG. Providers were given a Provider Feedback Questionnaire (PFQ) (Appendix E) to evaluate the CPG and presentation. Completed PFQs were collected at the conclusion of the presentation. Out of the 16 distributed questionnaires, 10 completed PFQs were returned. Providers not in attendance were given a paper copy of the CPG and a PFQ to evaluate it at a later date. Providers had three-weeks to complete the PFQ following the presentation. After all the PFQ data was collected, synthesized and analyzed, there was a final meeting the first week of February 2019 with the expert panel and chief MDA to discuss the data obtained from a total 23 PFQ surveys collected. Final revisions were made to the CPG based on these results. The final CPG was submitted to the Project Committee for review in mid-February 2019. The final QI project report was presented to the Committee in April 2019.

Data Collection Plan

The AGREE II Tool was used for data collection throughout the different phases of CPG development. The purpose of the AGREE II, was to provide a framework to evaluate the quality of guidelines; provide a methodological strategy for the development of guidelines; and inform what and how information should be reported in the guidelines. The AGREE II National Collaboration defined quality of the guidelines as the confidence that potential biases of

guideline development have been addressed adequately and that the recommendations are both internally and externally valid and are feasible for practice (AGREE Next Steps Consortium, 2010). According to the National Collaborating Centre for Methods and Tools [NCCMT] (2011), construct validity, and reliability of the tool was reported with a Cronbach alpha score ranging from 0.64 to 0.89, as a measure of internal consistency (NCCMT, 2011). This tool was obtained through an open source and the original author encouraged use of the tool with appropriate citation. User feedback and suggestions were welcomed by the original author for continued improvement and possible revision of the Tool. The AGREE II contains 6 domains with a total of 23 questions and was employed using a 7-point Likert scale ranging from strongly disagree [rated 1] to strongly agree [rated 7], (AGREE Next Steps Consortium, 2010). The data for this tool was collected by paper and pencil (Appendix D).

The PFQ was a tool utilized to collect data from the anesthesia providers during the last phase of the project. The PFQ was used to collect information from providers about their sentiments towards the CPG. The PFQ has a total of 23 questions and graded using a 3-point Likert Scale that ranges from strongly agree [rated 3] to neither agree nor disagree [rated 2] to strongly disagree [rated 1]. Questions in favor of the CPG were regarded as positive entries and were graded according to the scoring system. Questions not in favor of the CPG or negative entries [#10, 13, 14 & 15] were reversely scored and the CPG was revised accordingly. Reverse scoring means the numerical scoring scale runs in the opposite direction. So, strongly agree [rated 1] to neither agree nor disagree [rated 2] to strongly disagree [rated 3]. Content validity & reliability measures showing internal consistency was reported with Cronbach alpha coefficients for the factors ranging from 0.75 to 0.85. (Brouwers, Graham, Hanna, Cameron & Browman, 2004). Demographics data such as the number of CRNAs, MDA's, and number of years

practicing anesthesia were also collected with the questionnaire. The data for the PFQ was gathered using paper and pencil. (Appendix E).

Data Analysis

Data collected from the AGREE II tool and PFQ were analyzed using descriptive and correlative statistics to evaluate the project. Each domain of the AGREE II (Appendix D) was independently graded with the corresponding scores being representative of the quality of the data in that domain (AGREE Next Steps Consortium, 2010). Each item in the domain was entered in excel for data analysis and computed. From these calculations, a percentage value was obtained and utilized to determine whether the CPG was of poor or high quality. The results were presented to the expert panel and poor-quality data domains were discussed and utilized to determine areas of improvement and revisions made within the CPG. The demographics data collected from the PFQ surveys containing the number of CRNAs, MDA's, and number of years practicing anesthesia were computed and results were used to evaluate the CPG.

The overall mean score, Standard Deviation (SD) and mode (the most recurring response) were calculated for questions # 2-23 in the survey. Additionally, the average score, was also calculated for each item. To evaluate independence between survey responses and professional certifications and independence between survey responses and number of years of practicing anesthesia, two different Chi-squared tests were conducted. For all statistical analyses involving scores, survey responses were changed to scores as delineated in the data collection plan.

Human Subject Protection

Measures to safeguard human subjects' rights involved de-identification of all information obtained through data collection using the AGREE II tool and the PFQ, with the intention of protecting subject anonymity. All subject participation was on a voluntary basis. To

guard and protect confidentiality, participants were instructed to put completed PFQ surveys in a protected locked box, which was stowed in a safe office area. This data was then stored on a password protected computer and locked in a secured office space with access only granted to members assigned to the project. Moreover, the demographics collected from the PFQ surveys were scanned and electronically stored using a password protected computer and paper copies of all PFQs were subsequently shredded.

Results and Analysis

Two AGREE II questionnaires were completed by stakeholders. Because the number of questionnaires were low, limited analysis was performed based on domain scores. The domain scores (Table 2) indicated favorable responses to the guidelines. The overall domain score from the AGREE II was 87%. In total, these results were very promising for continuing to explore the implementation of the guidelines.

A total of 57 anesthesia providers are in the Department of Anesthesia at this tertiary medical center in Maryland; 33 anesthesiologists and 24 CRNAs. A total of 23 provider feedback questionnaires were received. The reason the sample size of providers who were in attendance for the presentation of the CPG was so small may have been due to the fact that the CPG presentation was given in December, close to Christmas holiday and many providers were on vacation at this time. In general, respondents reacted favorably to the guidelines. The most common response was a 3 (Strongly Agree), appearing on 18 out of the 23 total survey responses (Figure 1). The overall percentage of respondents' agreement for the guideline was 79% with a standard deviation (SD) of 10% (Table 3).

The percentage of respondents' agreement on individual questions ranged from 13% to 100% (Table 4). Particularly positive were questions 2, 5, 6, 20, 22 and 23 which had exclusively

"Strongly Agree" responses, indicating that every respondent would feel comfortable if their patients were cared for in a manner consistent with these guidelines. Generally, the questions with the lowest averages appeared to be due to the reversed scoring on negatively worded items (questions 10, 13, 14, 15). These negatively worded questions pertained to whether the CPG was too rigid to apply (10), would require reorganization of services (13), too challenging (14) and too expensive to apply (15). The negative wording in these questions may have confused respondents into thinking they were responding favorably toward the guidelines. If the responses to these negatively worded questions are taken as favorable responses, then the average percentage of agreement would be 90%.

In total, 17 CRNAs and 6 MDs responded to the PFQ survey. A Chi-squared test for independence was performed to assess if CRNAs responded differently from MDAs, however, no significant differences were found (*p*- 0.68), (Table 5). Moreover, a second Chi-squared test of independence was performed to assess whether responses were independent of years of experience. Six respondents had 0-5 years of experience, nine respondents had 5-10 years of experience, and eight respondents had more than 10 years of experience. The result of the test (Table 6), suggested that responses did depend significantly on years of experience (*p*- 0.014). Respondents with 0-5 years of experience were less likely to view the guidelines favorably.

Lastly, PFQ survey results were also broken into five subscales, measuring various aspects of the guidelines, such as, Acceptance of Recommendations (82.6%), Applicability of Recommendations (30.4%), Comparative Value (82.6%), Outcome Variables (93.5%), and Quality (95.7%), (Table 7). Items in this subscale were reverse scored as well, so participants confusion may have contributed to the low Applicability of Recommendations score.

Discussion

In general, respondents reacted extremely positive towards the guidelines. Doctors and CRNAs both provided very positive feedback, suggesting that both groups strongly approved of the guidelines. Further evaluation may be necessary on questions 10, 13, 14, and 15 to determine if the low ratings on those questions is simply due to the reverse wording or if it is indicative of genuine negative sentiment relevant to those items. Additional studies may also be warranted on individuals with less experience, who generally scored the guidelines less favorably. It will be important to determine the reason for this, for example, whether the guidelines are too complicated for inexperienced practitioners to follow.

Modifications made to the planned interventions for the postoperative phase of this project included utilizing IV insulin in the postoperative period based on providers discretion in-lieu of subcutaneous insulin coverage. Facility stakeholders preferred management of their PACU patients with fast-acting IV insulin to ensure expeditiously safe stabilization of patients' BG levels before discharge home. Additionally, a specific glycemic target of </= 140mg/dL was recommended by stakeholders for healthy non-diabetic patients throughout the three phases of the perioperative period. This was not a problem, as this target was still a safe target recommended by the literature and is within the core target of </= 180mg/dL. Furthermore, it was recommended by stakeholders to include an Endocrinologist consult for patients with insulin pumps, especially concerning the intra-op and post-op period. However, this may not be feasible for smaller rural facilities with fewer resources.

Some noted barriers included minimal and delayed communication or input from stakeholders using the AGREE II tool during the first round of revisions of the CPG. Initial revisions were strictly based on verbal recommendations without the use of the AGREE II Tool to rate the CPG by one of the primary stakeholders. Facilitators included the need and request

for the CPG by the chief of the anesthesia department. The proposed changes and revisions of the CPG were clearly verbalized and written out for each section of the CPG draft by one of the primary stakeholders. Furthermore, all verbal and written proposed changes recommended by the stakeholders were addressed without any contradictions made on the final AGREE II tool assessment by either of the stakeholders.

Strengths of this project included integration of the highest quality evidence available in managing postoperative hyperglycemia in elective orthopedic surgical procedures. Additional strengths included incorporating a table with bullet point format into the CPG as well as separating the three phases of the perioperative period into different sections, which allows for ease of read, understandability, and flow. A limitation of this project is that this CPG is not generalizable. This project was developed specifically to meet the needs of this institution and cannot be generalized to any other institution. Other limitations noted during the initial review of literature included: research published greater than five years and a limited number of practice guidelines based on randomized controlled trials (RCTs), systematic review, and meta-analysis.

Conclusion

This quality improvement project utilized the latest and best evidence in developing a CPG that facilitated the reduction of SSIs in adult patients undergoing elective orthopedic procedures. This CPG provided best practice strategies for the management of hyperglycemia throughout the postoperative period for all adult patients undergoing orthopedic procedures. Despite some barriers, responses to the guidelines provided sufficient evidence that are very promising for continuing to explore the implementation of the guidelines.

The CPG will be sustained through the continuous collaboration between the anesthesia department and orthopedic surgeons at the facility. In order to translate the guideline into

practice, training and education will need to be provided to anesthesia providers, perioperative nurses and staff as well as new incoming providers. Education and training of anesthesia providers and staff nurses is essential as they are part of the process in helping to transition the patient through each stage of the operative phase. Pharmacy will be a great asset to have during implementation of the guideline as they play an important role in supplying the insulin and providing anesthesia providers with education on the different insulin regimens. Biomedical engineering will also play a vital role in providing ample working glucometers.

Quarterly Electronic Health Record (EHR)/charts or Electronic Medication Administration Record (eMAR) audits will be completed by designated department champions to assess compliance of guideline utilization. The guideline will be updated every three-years based-on facility needs and new evidence. Strict implementation of this CPG is expected to reduce the incidence of perioperative hyperglycemia, prevent hypoglycemia; reduce the rates of SSIs, hospital length of stay and total hospitalization costs. Further evaluation of patient outcomes after initiation of the CPG is highly recommended. Future guidelines should expand to specialized surgeries with input and recommendations from endocrinologists and surgeons.

References

AGREE Next Steps Consortium (2009). The AGREE II Instrument [Electronic version]. Retrieved from http://www.agreetrust.org

American Diabetes Association. (2009). *Diagnosis and Classification of Diabetes Mellitus*. Retrieved from http://care.diabetesjournals.org/content/27/suppl_1/s5

Boreland, L., Scott-Hudson, M., Hetherington, K., Frussinetty, A., & Slyer, J. T. (2015). The effectiveness of tight glycemic control on decreasing surgical site infections and readmission rates in adult patients with diabetes undergoing cardiac surgery: A systematic review. *Heart and Lung, 44,* 430- 440. http://dx.doi.org/10.1016/j.hrtlng.2015.06.004

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(04), 421-426.

Centers for Disease Control and Prevention. (2016). *Working to reverse the US epidemic at a glance.* Retrieved from https://www.cdc.gov/chronicdisease/resources/publications/aag/diabetes.htm

Darouiche, R. (2013). Hospital infection control: Surgical site infections. Retrieved from https:/www.infectiousdiseaseadvisor.com/hospital-infection-control/surgical-site-infections/article/598857

Domingos, C.M.H, Iida, L.I.S., & Poveda, V.B (2016). Glycemic control strategies and the occurrence of surgical site infection: A systematic review. *Journal of School of Nursing, 50*(5), 868-874. DOI: http://dx.doi.org/10.1590/S0080-623420160000600022

Duggan, E.W., Klopman, M.A., Berry, A.J., & Umpierrez, G. (2016). The Emory University perioperative algorithm for the management of hyperglycemia and diabetes in non-cardiac surgery patients. *Current Diabetes Reports,* 16, 34-46. DOI 10.1007/s11892-016-0720-z

Fisichella, L., Fenga, D., & Rosa, M. A. (2014). Surgical site infection in orthopedic surgery: Correlation between age, diabetes, smoke and surgical risk. *Folia Medica, 56*(4), 259-263. doi:10.1515/folmed-2015-0005

Goyal, N., Kaur, R., Sud, A., Ghorpade, N., & Gupta, M. (2014). Non-diabetic and stress induced hyperglycemia (SIH) in orthopedic practice: What do we know so far? *Journal of Clinical Diagnostic Research, 8*(10), 1-3. doi: 10.7860/JCDR/2014/10027.5022

Guidry, M., Vischi, T., Han, R., & Passons, O. *Map-It: A guide to using healthy people 2020 in your community*. Retrieved from https://www.healthypeople.gov/2020/toolsand-resources/Program-Planning

Jeon, C.Y., Furuya, E.Y., Berman, M.F., & Larson, E.L. (2012). The role of pre-operative and post-operative glucose control in surgical-site infections and mortality. *Plos One, 7*(9),1-7. doi:10.1371/journal.pone.0045616

Jupiter, D.C., Humphers, J.M., & Shibuya, N. (2014). Trends in postoperative infections rates and their relationship to glycosylated hemoglobin levels in diabetic patients undergoing foot and ankle surgery. *The Journal of Foot & Ankle Surgery*, 53, 307-311. http://dx.doi.org/10.1053/j.jfas.2013.10.003

Marik, P. E., & Bellomo, R. (2013). Stress hyperglycemia: An essential survival response. *Journal of Critical Care, 17*(2), 305-311. doi:10.1186/cc12514

Martin, E.T., Kaye, K.S., Knott, C., Nguyen, H., Santarossa, M., Evans, R., Bertran, E., . . . & Jaber, L. (2016). Diabetes and risk of surgical site infection: A systematic review and meta-analysis. *Infection Control Hospital Epidemiology, 37*(1), 88-99. doi:10.1017/ice.2015.249.

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.

Mraovic, B., Suh, D., Jacovides, C., & Parvizi, J. (2011). Perioperative hyperglycemia and postoperative infection after lower limb arthroplasty. *Journal of Diabetes Science and Technology, 5*(2), 412-418. Retrieved from http://journals.sagepub.com/doi/pdf/10.1177/193229681100500231

National Collaborating Centre for Methods and Tools [NCCMT] (2011). Critically appraising practice guidelines: The AGREE II instrument. Hamilton, ON: McMaster University. Retrieved from http://www.nccmt.ca/resources/search/100.

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

Richards, J.E., Kauffmann, R.M., Zuckerman, S.L., Obremskey, W.T., & May, A.K. (2012). Relationship of hyperglycemia and surgical-site infection in orthopedic surgery. *The Journal of Bone and Joint Surgery, 94*, 1181-1186. http://dx.doi.org/10.2106/JBJS.K.00193

Sadoskas, D., Suder, N.C., and Wukich, D.K. (2016). Perioperative glycemic control and the effect on surgical site infections in diabetic patients undergoing foot and ankle surgery. *The Journal of Foot and Ankle Specialist, 9*(1), 24-30. DOI:10.1177/1938640015593077.

Shaw, P., Saleem, T., & Gahtan, V. (2014). Correlation of hemoglobin A1C level with surgical outcomes: Can tight perioperative glucose control reduce infection and cardiac events? *Seminars in Vascular Surgery 27*, 156–161. http://dx.doi.org/10.1053/j.semvascsurg.2015.03.002

Vries, F.D., Gans, S.L., Solomkin, J.S., Allegranzi, B., Egger, M., Dellinger, E.P., & Boermeester, M.A. (2016). Meta-analysis of lower perioperative blood glucose target levels for reduction of surgical-site infection. *British Journal of Surgery, 104*, 97-105. DOI: 10.1002/bjs.10424

Wiseman, B. & Kaprielian, V. (2005). Patient safety-quality improvement: What is quality improvement? Department of community and family medicine, Duke University Medical Center. Retrieved from http://patientsafetyed.duhs.duke.edu/module_a/methods/methods.html

Table 1.

Evidence Review and Rating Table

Author, year	Study objective	Design	Sample (N)	Outcomes studied	Results	*Level and Quality Rating
Domingos, Iada, & Poveda (2016).	To analyze available evidence on the relationship between glycemic control strategies performed and the occurrence of SSI.	Systematic review	N= 8) RCTs Samples ranged between (n= 41 to n= 447) patients n= diabetic & nondiabetic patients 18-years old and older undergoing different types of surgeries. Procedures: (General, gastrointestinal (GI), vascular and heart surgeries).	Hyperglycemia was defined as the abnormal increase in blood glucose levels, greater than 140 mg/dL in patients with no history of diabetes or absence of changes in glycated hemoglobin levels (HbA1c).	(N=7) studies that used continuous infusion of insulin, compared to different forms of glycemic control focused on maintaining the blood glucose below 200 mg/dL, preferably with values below 150 mg/dL, showed higher association with reduced rates of SSI. (N= 2) studies showed no statistically significant associations between continuous infusion of insulin and the occurrence of SSI. Continuous Insulin infusion during surgery was the most tested and seems to get better results in reducing surgical site infection rates and success in glycemic control compared to other strategies.	1 B
Duggan, Klopman, Berry, & Umpierrrez (2016).	To present a universal insulin algorithm for the perioperative management of. hyperglycemia and diabetes implemented	CPG derived from several RCTs, Systematic reviews and Meta-analyses.	Hyperglycemic and diabetic patient population undergoing general surgery at Emory University Hospital.	DM and hyperglycemia risk evaluated prior to elective surgery in Preoperative Clinic. Nondiabetic patients aged 45 years or older, or with a BMI ≥25 undergo HgA1C testing if not done within the last 3	Glucose control in general surgery non-ICU patients should be managed with subcutaneous insulin. Scheduled SC basal insulin with glargine or detemir given once daily, in	1 A

	at Emory University Hospital.			months to rule out undiagnosed DM. Point of care (POC) testing is completed using a monitoring device with demonstrated accuracy in the hospital setting.	combination with short (regular) or rapid acting insulin (lispro, aspart, glulisine) prior to meals, is effective and safe for the management of post-op patients with diabetes.	
Jeon, Furuya, Berman, & Larson (2012).	To examine how pre- and post-op glucose levels and their variability are associated with the risk of SSI and in-patient deaths.	Retrospective cohort study	(N= 13,800) hospitalized patients who underwent a surgical procedure at a large hospital in NY between 2006-2008. Patients with Pre-op BG measurements: (n=5618). Patients with Post-op BG measurements: (n=13,166). BG measurements of those who had DM: (n=2,927). Procedures performed: 50% of surgeries were abdominal and cardiac surgeries.	Max pre-and post-op BG levels were determined for 72 hours before and after the operation and glucose variability was defined as the coefficient of variation of the glucose measurements. In-hospital death was defined as death due to any cause during hospital stay. SSIs were identified as occurring in patients who underwent an operative procedure and subsequently had a positive wound culture within 30 days of procedure.	Post-operative glucose levels were higher than pre-op glucose levels, with over 65% of patients had BG levels of 140 mg/ld after surgery. Results showed that SSI risk did not vary significantly with glucose levels. On the other hand, in-hospital deaths were associated with pre-op hypoglycemia (OR = 5.09, 95% CI (1.80, 14.4)) and glucose variability (OR = 1.14, 95% CI (1.03, 1.27) for 10% increase in coefficient of variation).	3 B
Martin, Kaye, Knott, Nguyen, Santarossa, Evans,	To determine the independent association between DM and SSI across multiple surgical procedures.	Systematic Review and meta-analysis.	(N= 94) studies included adult diabetic and non-diabetic patients undergoing	Measures for the association between pre-existing diabetes and SSI were collected from studies that ascertained the presence of diabetes prior to	(N=90) studies provided estimates for the association between diabetes and SSI.	1 B

Bertran & Jaber (2016).			surgical procedures of any type. Studies comprised a total of (n= 866,427) procedures with (n=32,067) of which had SSIs. Surgical categories included obstetrical and gynecological, colorectal, arthroplasty, breast, cardiac, spinal, or other. Most common categories: cardiac (15 studies) & spinal (14 studies)	the time of surgery either through the patient's medical record or testing HbA1c. A wide range in the threshold for defining hyperglycemia was observed. (N= 11) studies used threshold ranged from 100-200 mg/dL, to assess pre-op BG. (N= 11) studies used threshold ranged from 125-200 mg/dL, to assess post-op BG.	(N=16) studies assess the association between hyperglycemia and SSI No studies differentiated between Type 1 and Type 2 diabetes. Estimates by surgery type for the association between diabetes and SSI ranged from 1.16 (95% Predictive Interval 0.93, 1.44) for colorectal surgeries to 2.03 (95% Predictive Interval 1.13, 4.05) for cardiac surgeries The overall estimate for the association between elevated blood glucose in the post-operative period and SSI was 1.45 (95% Predictive Interval 0.77, 3.04).	
Richards, Kauffman, Zuckerman, Obremskey, & May (2012).	To evaluate the relationship of hyperglycemia with thirty-day SSI in a population of orthopedic trauma patients without a history of diabetes at time of admission.	Retrospective investigational study.	(N= 976) patients 18-years and older with isolated orthopedic injuries requiring acute operative interventions at a university-based level-I trauma center. (n= 268): open fractures (fx)s. Orthopedic Injuries: (n=147): upper-extremity, (n=144):	BG- values were obtained, and hyperglycemia was defined in two ways: First: two or more BG levels of >=200 mg/dL were identified. Second: Hyperglycemia Index (HI), a validated measure of overall glucose control during hospitalization, was calculated for each patient. A HI of >=1.76 (equivalent to >=140	(n= 790) patients had two or > 200mg/dl BG values. (n= 21 [2.7%]) 30-day SSI. n=294 (37.2%) had more than one BG value of >=200 mg/dL. This factor was associated with a 30-day SSI, with n=13 (4.4%) of the 294 patients with that indication of hyperglycemia having a SSI vs. n= 8 (1.6%) of the 496 patients without more	3 A

			pelvic or acetabular fxs, (n=281): femoral fxs, (n=167): tibial fxs & (n=51): foot injuries.	mg/dL) was considered to indicate hyperglycemia. All blood glucose values, including both finger-stick and serum levels, were prospectively recorded in the patient's electronic medical record.	than one BG value of >=200 mg/dL (p = 0.02). n=134 (17.0%) of the 790 patients had a HI of >=1.76, and this was also associated with a 30-day SSI (n=10) [7.5%] of 134 vs. n=11 [1.7%] of 656; p < 0.001). No patient with a surgical-site infection had had a prior infection during the index hospitalization. The unadjusted odds ratio for an SSI following an open fx was nearly three times greater than that following a closed fracture (OR: 3.3, 95% CI: 1.6 to 10.1). No significant association was noted between the presence of an SSI and age, number of comorbidities, ASA class, race, tobacco use, Injury Severity Score (ISS), or blood transfusion.	
	.					
Vries, Gans, Solomkin, Allegranzi, Egger, Dellinger, & Boermeester (2016).	To evaluate the impact of intensive versus conventional patient glucose protocol on the risk of SSI. This review also aimed to define optimal perioperative blood glucose target	Systematic review and meta-analysis.	(N= 15) RCTs comparing a perioperative *intensive glucose protocol* with a *conventional glucose protocol* in adult diabetic and nondiabetic patients.	The primary outcome was SSI (or wound infection). Secondary outcomes were hypoglycemic events (both laboratory results or clinically relevant), stroke and mortality. The definition of 'postoperative' varied from	Significant benefit in the *intensive protocol* compared with the *conventional protocol* was observed in reducing SSI (odds ratio (OR) 0·43, 95 per cent CI.0·29 to 0·64; $P < 0·001$).	I B

levels in surgical patients with or without diabetes to prevent SSI.		(n= 1442) patients in the Intensive group: (all studies) used intravenous insulin administration. (n= 1394) Conventional group: (3) studies used SC administration. Some studies used continuous insulin administration, whereas others used intermittent administration. Procedures included: Cardiac, abdominal, neuro surgery.	18h, 'until enteral nutrition' to a maximum of 14 days. The definition of SSI/wound infection also differed between studies. (4) studies mentioned only deep/organ space wound infections, (1) study reported only superficial wound infections, and the other studies either reported on both, or did not clearly describe their definition criteria. (n=2) studies compared only intra-op BG, (n=8) studies assessed intra-op and post-op BG control, and (n=5) studies examined postoperative BG control. Definitions: *Hyperglycemia*: BG; (>180 mg/dl to >= 220 mg/dl). *Hypoglycemia*: BG (< than 40 mg/dl to < than 80 mg/dl). *More liberal*: BG target levels; (220 mg/dl or less). *Stricter*: *BG target levels*; (150 mg/dl or less). *Very strict*: BG target levels (< than 110 mg/dl). *Moderately strict*: BG target level (110–150mg/dl).	There was no evidence that the effect of intensive blood glucose control differed between studies including patients with or without diabetes ($P = 0{\cdot}590$). Meta-analysis of adverse events showed a higher risk of hypoglycemic events in intensive *versus* conventional protocols (OR 5·55, 95 per cent CI: 2·58 to 11·96). Meta-analyses of postoperative death and stroke showed no significant differences between intensive and conventional protocols (OR 0·74 (0·45 to 1·23) and OR 1·37 (0·26 to 7·20) respectively).

Table 2.

AGREE II Domain Score Table

	Domain 1	**Domain 2**	**Domain 3**	**Domain 4**	**Domain 5**	**Domain 6**	**Overall Guideline Assessment Score**
Domain Score	91.70%	86.00%	89.60%	83.00%	89.50%	83.00%	87.13%

Table 3.

Respondent Agreement Score Table

Respondent	**Percentage Strongly Agree**
# 1	86.36%
# 2	68.18%
# 3	81.82%
# 4	86.36%
#5	59.09%
#6	72.73%
# 7	77.27%
# 8	86.36%
#9	63.64%
#10	86.36%
#11	72.73%
#12	81.82%
#13	86.36%
#14	81.82%
#15	86.36%
#16	86.36%
#17	81.82%
#18	77.27%
#19	81.82%
#20	95.45%
#21	59.09%
#22	72.73%
#23	90.91%

Table 4.

Descriptive Statistics Summary Table

Item Number	Percentage of Agreement	Mean Response	Standard Deviation of Responses	Mode
2	100.00%	3.00	0.00	3.00
3	82.61%	2.78	0.52	3.00
4	95.65%	2.96	0.21	3.00
5	100.00%	3.00	0.00	3.00
6	100.00%	3.00	0.00	3.00
7	95.65%	2.96	0.21	3.00
8	82.61%	2.83	0.39	3.00
9	95.65%	2.96	0.21	3.00
10*	47.83%	2.26	0.81	3.00
11	91.30%	2.91	0.29	3.00
12	91.30%	2.91	0.29	3.00
13*	43.48%	2.22	0.80	3.00
14*	17.39%	1.87	0.69	2.00
15*	13.04%	1.61	0.72	1.00
16	60.87%	2.61	0.50	3.00
17	73.91%	2.74	0.45	3.00
18	78.26%	2.70	0.70	3.00
19	86.96%	2.87	0.34	3.00
20	100.00%	3.00	0.00	3.00
21	86.96%	2.87	0.34	3.00
22	100.00%	3.00	0.00	3.00
23	100.00%	3.00	0.00	3.00

**Reverse scored items*

Table 5.

Response Level and Certification Score Table

	Strongly Agree	Neither Agree Nor Disagree	Strongly Disagree	Total
CRNA	296	24	53	373
MD	105	6	21	132
Total	**401**	**30**	**74**	**505**
	The chi-square statistic is 0.7783. The *p*-value is .677644. The result is *not* significant at $p < .05$.			

Table 6.

Response Level and Years of Experience Score Table

	Strongly Disagree	Neither Agree Nor Disagree	Strongly Agree	Total
0-5 Years	13	18	145	176
6-10 Years	9	14	108	131
>10 Years	8	42	148	198
Total	**30**	**74**	**401**	**505**
The chi-square statistic is 12.475. The *p*-value is .014145. The result is significant at $p < .05$.				

Table 7.

Subscale Score Table

Subscale	**Percentage of Agreement**
Acceptance of Recommendations	82.61%
Applicability of Recommendations	30.43%
Comparative Value	82.61%
Outcome Variables	93.48%
Quality	95.65%

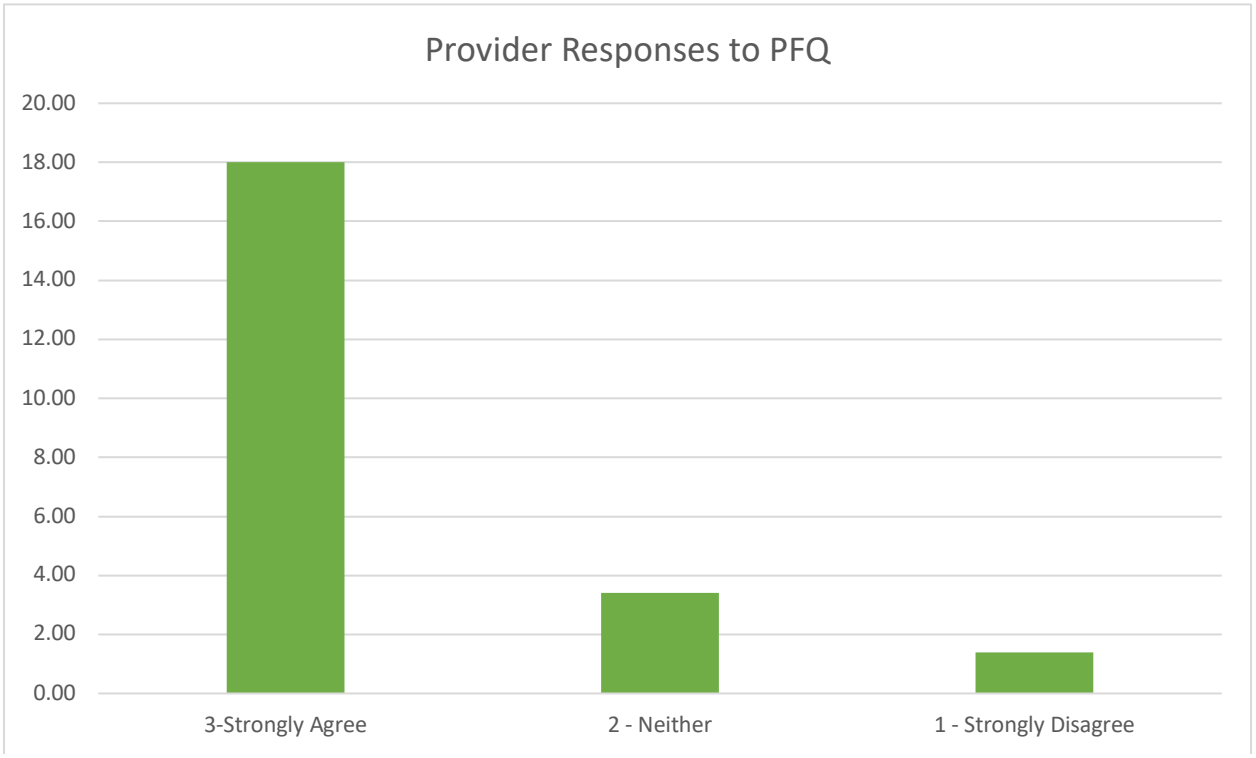

Figure 1: Provider Responses to PFQ

Note: *Provider Feedback Questionnaire (PFQ)

Appendix 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 trails (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.

Appendix B

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.

Appendix C

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)	Take	Hold	Hold

Glinides: repaglinide (Prandin) and nateglinide (Starlix)			
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:

Intraoperative BG Goals: **DM Type I and Type II Surgical Patients**	• 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.

Intraoperative Insulin Administration:
DM Type I and Type II Surgical Patients
	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.
	  o If patient took Metformin on DOS use normal saline solution to prevent lactic acidosis.
	• All procedures regardless of duration:
	  o 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."
	  o Titrate according to insulin sliding scale.
	  o Check BG hourly.
	  o Administer with separate infusion of D5W at 40 ml/hr or D10W at 20 ml/hr.

DM Type I surgical patient with insulin pump:	• Refer to endocrinologist recommendations.
	• Consider continuation of insulin pump intraoperatively.
	  o Continue basal rate.
	  o Monitor BG hourly.
	  o 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.

Intraoperative Hypoglcemia: BG <60 mg/dL	• 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.

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 SC insulin postoperatively. May also use IV insulin based on provider discretion.

	• 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.

	○ If BG is within 140-180mg/dL for 4 hours, decrease frequency of checks from q2hr to q4hrs. ○ 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; ○ Assess patient's ability to use insulin pump before discharge home. ○ 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:

American Diabetes Association (July, 2017). Statistics about diabetes. Retrieved from http://www.diabetes.org/diabetes-basics/statistics/

Duggan, E. W., Klopman, M. A., Berry, A. J., & Umpierrez, G. (2016). The Emory University perioperative algorithm for the management of hyperglycemia and diabetes in non-cardiac surgery patients. *Current Diabetes Reports, 16*(3), 34-34. doi:10.1007/s11892-016-0720-z

Duggan, E., Carlson, K., & Umpierrez. E. (2017). Perioperative hyperglycemia management. Anesthesiology 126(3). doi:10.1097/ALN.0000000000001515

Setji, T., Hopkins, T. J., Jimenez, M., Manning, E., Shaughnessy, M., Schroeder, R., . . . Aronson, S. (2017). Rationalization, development, and implementation of a preoperative diabetes optimization program designed to improve perioperative outcomes and reduce cost. *Diabetes Spectrum, 30*(3), 217-223. doi:10.2337/ds16-0066

Wukich, D. K. (2015). Diabetes and its negative impact on outcomes in orthopaedic surgery. *World Journal of Orthopedics, 6*(3), 331-339. doi:10.5312/wjo.v6.i3.331

Contributors: Sheilla Joseph, Tara Labang and Frances Santiago, University of Maryland School of Nursing, Doctor of Nursing Practice-Nurse Anesthesia

Appendix D

AGREE II Tool

Domain 1. Scope and Purpose (Items 1-3)						
1. The overall objectives of the guideline are specifically described.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
2. The health question covered by the guideline is specifically described.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
3. The population to whom the guideline is meant to apply is specifically described.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
Domain 2. Stakeholder Involvement (Items 4-6)						
4. The guideline development group includes individuals from all relevant professional groups.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
5. The views and preferences of the target population have been sought.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
6. The target users of the guideline are clearly defined.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
Domain 3. Rigour of Development (Items 7-14)						
7. Systematic methods were used to search for evidence.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
8. The criteria for selecting the evidence are clearly described.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
9. The strength and limitations of the body of evidence are clearly described.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
10. The methods for formulating the recommendations are clearly described.						
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

Strongly Disagree						Strongly Agree
Comments:						

11. The health benefits, side effects, and risks have been considered in formulating the recommendations.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
12. There is an explicit link between the recommendations and the supporting evidence.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
13. The guideline has been externally reviewed by experts prior to its publication.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
14. A procedure for updating the guideline is provided.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
Domain 4. Clarity of Presentation (Items 15-17)						
15. The recommendations are specific and unambiguous.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						

16. The different options for management of the condition or health issue are clearly presented.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
17. Key recommendations are easily identifiable.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
Domain 5. Applicability (Items 18-21)						
18. The guideline describes facilitators and barriers to its application.						
1 ☐ Strongly Disagree	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.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
20. The potential resource implications of applying the recommendations have been considered.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						

21. The guideline presents monitoring and/or auditing criteria.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
Domain 6. Editorial Independence (Items 22-23)						
22. The views of the funding body have no influenced the content of the guideline.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
23. Competing interests of guideline development group members have been recorded and addressed.						
1 ☐ Strongly Disagree	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Strongly Agree
Comments:						
Overall Guideline Assessment For each question, please choose the response which best characterizes the guideline assessed:						
1. Rate the overall quality of this guideline						
1 ☐ Lowest possible quality	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐ Highest Possible quality
2. I would recommend this guideline for use.						
☐ Yes		☐ Yes, with modifications			☐ No	
Notes:						

AGREE Next Steps Consortium (2009). The AGREE II Instrument [Electonic version]. Retrieved from http://www.agreetrust.org

Appendix E

Modified Practitioner Feedback Questionnaire

Please select the appropriate demographic category that most accurately describes you.

Type of anesthesia provider:			Years practiced in current role:					
CRNA	Anesthesiologist	SRNA	<5	5-10	10-15	15-20	20-25	>25
☐	☐	☐	☐	☐	☐	☐	☐	☐

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 ☐
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 **Chief CRNA**			
	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(04), 421-426.

Appendix F

Project Time Line

Project Timeline	Description
June 2018	Initial Meeting with stakeholders to confirm willingness to participate as expert panel along with project goals and objections.
June 2018	Literature Review performed with initial findings translate to expert panel.
July 2018	Presentation of project proposal to stakeholders along with updates of CPG to expert panel
August 2018	Submission of initial CPG to expert panel for first round of revision utilizing the AGREE II tool.
End of August 2018	CPG (with suggested revisions/recommendations) sent back to students
End of September 2018	Submit Revised CPG to expert panel for final approval or final revisions to be made to CPG prior to submission to the Chief of Anesthesiology
End of October 2018	Final approval from stakeholders and expert panel permitting submission of revised CPG to Chief of Anesthesiology.
November 2018	Project submission to the Chief of Anesthesiology pending approval.
End of November 2018	Recommendations/revisions Received from Chief of Anesthesiology
End of December 2018	CPG revised per recommendations from chief of Anesthesiology.
End of December 2018	CPG Presentation during Thursday morning grand rounds to Anesthesia Department.
End of January 2019	Analysis, synthesis and evaluation of completed PFQ forms from anesthesia department members in attendance.
March 2019	Begin process for policy formation via submission to committee.
April 2019	Presentation of findings of scholarly project to committee at UMSON and UMSON NAP faculty.