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An Evidence-Based Teaching Plan for Anesthesia Providers on Intraoperative Blood Glucose Monitoring in Diabetic Patients Undergoing Noncardiac Surgery

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AN EVIDENCE-BASED TEACHING PLAN FOR ANESTHESIA PROVIDERS ON INTRAOPERATIVE BLOOD GLUCOSE MONITORING IN THE DIABETIC PATIENT UNDERGOING NONCARDIAC SURGERY

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By

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Abstract

As the incidence of diabetes continues to rise both locally and nationally, anesthesia providers must be prepared to manage diabetic patients intraoperatively during the administration of anesthesia. Literature suggests that blood glucose levels are not adequately monitored in the operating room, potentially contributing to many postoperative complications. Therefore, this doctoral project aims to develop an evidence-based teaching plan for monitoring intraoperative glucose levels in the diabetic patient population to enhance anesthesia provider knowledge.

Keywords: intraoperative, glucose, teaching plan, anesthesia management

AN EVIDENCE-BASED TEACHING PLAN FOR ANESTHESIA PROVIDERS ON INTRAOPERATIVE BLOOD GLUCOSE MONITORING IN THE DIABETIC PATIENT UNDERGOING NONCARDIAC SURGERY

Diabetes is classified as a group of metabolic diseases in which insulin secretion/action is impaired, leading to episodes of hyperglycemia (Sudhakaran & Surani, 2015). Diabetes affects approximately 34.2 million Americans, or 10.5% of the United States population, with the incidence of diabetes projected to reach 39.7 million in 2030 and 60.6 million in 2060 (Lin et al., 2018). According to experts, nearly 15% to 20% of all surgical patients in the U.S. carry a diagnosis of diabetes (Morrison et al., 2014).

Locally, the population in Philadelphia and the surrounding area is experiencing an increased incidence of diabetes every year. According to the Philadelphia Department of Public Health (2019), 11.4% of the Philadelphia population was affected by diabetes in 2017, demonstrating a 50% increase from 2002. In 2016, the hospital admission rate of people with diabetes in Philadelphia was 75% higher than the entire state of Pennsylvania as a whole (Philadelphia Department of Public Health, 2019). With 61 hospital/ medical centers in the Tri-state area alone, local anesthesia providers will be tasked with managing a growing population of diabetic patients.

Although professional organizations, including the Society for Ambulatory Anesthesia (SAMBA), American Diabetes Association (ADA), and Society of Thoracic Surgeons (STS), recommend targeted blood glucose between 140 to 180 mg/dL intraoperatively, diabetic patients continue to experience inadequate management of glucose levels during surgery (Duggan et al., 2018). Some experts believe this may be attributed to a lack of accessibility to glucometers in the operating room, while others

believe that anesthesia providers are often unaware of when to recheck glucose levels (Morrison et al., 2014). Ehrenfeld et al. (2017) found that only 19.8% of diabetic patients had blood glucose measured when in the operating room, and only 57% of 2,224 diabetic patients had their blood glucose rechecked after receiving insulin intraoperatively.

According to Dogra & Jialal (2021), hyperglycemia is documented in 20% to 30% of general surgery cases and 80% to 90% of cardiac surgery cases. Surgical stress-induced hyperglycemia places the patient at an increased risk of developing a multitude of postoperative complications, including sepsis, impaired wound healing, poor circulation, acidosis, prolonged ICU/ hospital stays, and increased healthcare costs (Sudhakaran & Surani, 2015). Surgical stress-induced hyperglycemia can also contribute to the development of serious diabetic pathologies, including diabetic ketoacidosis (DKA) or hyperglycemic hyperosmolar syndrome (HHS) in the postoperative setting. Kaur and Joyner (2021) also found that morbidity and mortality rates were 50% higher in diabetic patients compared to non-diabetic patients when intraoperative hyperglycemia was poorly controlled.

Along with hyperglycemia, hypoglycemia may also adversely affect the diabetic patient undergoing surgical intervention. According to Sudhakaran & Surani (2015), uncontrolled hypoglycemia may result in a wide range of neurological complications, including somnolence, unconsciousness, seizures, and even irreversible cerebral ischemia or death when appropriate treatment is delayed. Close monitoring of blood glucose levels during the intraoperative phase is crucial as signs and symptoms of hypoglycemia may be challenging to recognize during the administration of anesthesia.

With surgical cases happening more frequently, paired with the rise of diabetes cases, many people with diabetes are in operating rooms daily. Improving the management of diabetes in the surgical setting is essential to minimize adverse outcomes related to hyperglycemia and hypoglycemia. Compared to their non-diabetic counterparts, people with diabetes often require more frequent surgical interventions and experience a greater risk of developing acute hyperglycemia associated with surgical stress (Apostilidou & Prielipp, 2006). Nurse anesthetists and anesthesiologists have opportunities during surgery and interventional procedures to minimize the risk of complications by adequately monitoring blood glucose levels and providing appropriate interventions.

Problem Statement

The incidence of diabetes is on a steady incline both locally and nationally, with the disease potentially contributing to many post-operative complications when not adequately managed perioperatively. Research demonstrates that anesthesia providers are not sufficiently monitoring blood glucose levels intraoperatively due to a lack of resources or confusion about when to check them. Consequently, diabetic patients are being placed at a disadvantage (Ehrenfeld et al., 2017). The lack of blood glucose checks can result in either a hyperglycemic or hypoglycemic episode, each with its own set of negative consequences.

Purpose Statement

The purpose of this doctoral project is to develop an evidence-based teaching plan to structure an educational intervention for novice anesthesia providers on the topic of intraoperative blood glucose monitoring of diabetic patients. The goal of this educational

intervention is to improve provider knowledge regarding targeted glucose levels and potential complications associated with hyper/hypoglycemia.

Project Question

The project question is: What are the elements of an evidence-based teaching plan for intraoperative glucose monitoring of diabetic patients for anesthesia providers, including instruction on targeted glucose levels and potential postoperative complications with improper management?

Conceptual Definitions

Anesthesia providers are responsible for all "non-cutting" aspects of patient medical care in the immediate perioperative period, as well as monitoring, sedating, and providing general or regional anesthesia in numerous areas outside the operating room (Butterworth et al., 2018). They include certified registered nurse anesthetists (CRNAs) and anesthesiologists.

Glucose is a simple sugar used for energy by many organs in the body. Blood glucose is a tightly controlled concentration of glucose in the blood, regulated by the liver and pancreas (Hall & Hall, 2021). This tight index is needed because specific organs, such as the brain, can only utilize glucose for energy (Hall & Hall, 2021). Blood glucose can be checked in numerous ways. The primary source of checking blood glucose levels in the operating room is point-of-care glucometers.

Hypoglycemia is defined as a decrease in normal blood glucose levels. The Mayo Clinic defines this as a blood glucose level 70 mg/dL, or 3.9 mmol/L and below (Mayo Clinic, 2022). A moderate reduction in glucose levels can cause central nervous system excitability due to sensitized neuronal activity, leading to nervousness, trembling, and

sweating (Hall & Hall, 2021). Severe decreases in glucose levels can cause seizures or loss of consciousness (Hall & Hall, 2021). Hypoglycemia is often associated with long fasting periods before surgery or aggressive treatment of hyperglycemia by the anesthesia provider.

Hyperglycemia is defined as an increase in normal blood glucose levels, which can be due to many diseases, including diabetes mellitus, medications, etc. The Mayo Clinic defines this as blood glucose levels usually above 180-200 mg/dL or 10-11.1 mmol/L (Mayo Clinic, 2022). Damage to beta cells in the pancreas causes a lack of insulin secretion and decreased sensitivity of insulin's effect on target tissues in the body, causing glucose levels to rise in the blood (Hall & Hall, 2021). This elevation in blood glucose can lead to dehydration, fat metabolism causing metabolic acidosis, and structural changes in blood vessels, which can impair their function (Hall & Hall, 2021).

A teaching plan is defined as a blueprint to achieve goals and objectives while indicating the purpose, content, methods, tools, timing, and evaluation of the instruction (Bastable, 2021). They should incorporate eight basic concepts; purpose, statement of the goal, list of objectives, an outline of the content to be covered in the plan, teaching methods, time allotted for each objective, teaching resources, and evaluation methods (Bastable, 2021).

Review of Literature

Search Methods

This project team completed a comprehensive search that included the terms ‘intraoperative’ and ‘glucose’ from several databases. This team then expanded the search to be more inclusive, containing terms: *anesthesia, anesthesia provider,*

perioperative, blood glucose, blood glucose monitoring, postoperative complications, hyperglycemia, hypoglycemia, surgery, surgical complications, post-surgical outcomes, and glycemic control.

The databases searched included CINAHL, PubMed, and Medline.

The years searched for the literature review were 2012-2022.

Narrative Summary of Appraised Studies

Lai et al. (2022) performed a meta-analysis of randomized control trials to determine if intensive blood-glucose-lowering regimens are beneficial in reducing surgical site infections (SSIs) compared to more conventional regimens. Lai et al. (2022) conducted the systematic literature review in November of 2021 using MEDLINE (PubMed) and Cochrane Register of Controlled Trials (CENTRAL) databases identifying 29 RCTs that fit inclusion criteria, most of which observed patients undergoing cardiac surgery (n=15), abdominal surgery (n=4), or neurosurgery (n=3). A total of 14,126 participants were included in the 29 RCTs, with 7,351 labeled as the intensive intervention group and the other 6,775 as the control group. Meta-analyses were performed using the Mantel-Haenszel method, and forest plots were constructed with statistical significance determined by a p-value less than 0.05. Through their review of the literature, Lai et al. (2022) found that diabetic patients in the intensive treatment group undergoing cardiac and abdominal procedures demonstrated a significantly lower incidence of SSIs ($P<0.00001$) when compared to diabetic patients in the control group. One downside to this review is that the intensive group also experienced a statistically higher incidence of hypoglycemia and mortality ($p=0.0006$).

Long et al. (2022) evaluated whether perioperative glucose variability was a significant predictor of outcomes for diabetic patients following hip fracture. One thousand ninety-nine patients were included in this retrospective observational study from September 2008 to December 2012. Two hundred thirty-nine were diabetics, and 860 were nondiabetic. Patients with diabetes were more likely to develop infectious complications following hip surgery (P=.045) and experience mortality at the one-month mark (P=.052) and the twelve-month mark following surgery (P=.006). The postoperative mortality rate was also increased when glucose variability was increased for this patient population. Limitations to this study were the ability to differentiate between Type 1 and Type 2 diabetes because that information was not collected at the time of patient admission. Second, due to the retrospective nature of the data collection, HbA1C was not obtained. In conclusion, it is stated that diabetic patients who undergo hip fracture surgery are at an increased risk for postoperative infectious complications and postoperative mortality.

Kim et al. (2021) also conducted a retrospective observational study to identify if there is a relationship between intraoperative blood glucose levels in diabetic patients and the incidence of myocardial injury after noncardiac surgery (MINS). The study included 11,302 adult diabetic patients (> 18 years) with intraoperative blood glucose measurements and a cardiac troponin level measured postoperatively. The sample population was also subdivided into two groups, the blood sugar glucose (BST) < 180 mg/dL group, which consisted of 8337 patients, and the BST > 180 mg/ dL group, which included 2965 patients. The primary outcome studied was MINS, with in-hospital and 30-day mortalities secondary. Differences between the BST groups were determined

using the Mann-Whitney test or Student's t-test for continuous data. Through analysis, Kim et al. (2021) were able to statistically conclude that the incidence of MINS was significantly higher in the BST > 180 group when compared to the BST<180 group (P<0.001). They also concluded that in-hospital and 30-day mortalities were significantly higher in the BST>180 group (P=0.001, P<0.001, respectively) and that the threshold of glucose level associated with MINS in 149 mg/dL.

Shah et al. (2020) conducted a retrospective cohort study that collected data on noncardiac surgical patients from 2013-2015. Over 92,000 patients were reviewed, but only 5014 had glucose testing intraoperatively. Of the 5014 patients, 32.9% experienced the primary outcome (combined 30-day morbidity/mortality including infectious, cardiovascular, thrombotic, neuro adverse events), and 18.1% experienced the secondary outcome (30-day infectious complications). There was no statistically significant difference in patients with a recorded blood glucose greater than 180mg/dL versus less than 180mg/dL at the primary and secondary outcomes. The only statistically significant value was that a rise of 20mg/dL in blood glucose levels greater than 180mg/dL increased the risk of the primary outcome but not the secondary outcome. This does show that poorly controlled blood glucose levels may be harmful. It was noted that the limitations of this study included cofounders, the inability to assert causality and selection bias. It was concluded in this study that a targeted blood glucose level of approximately <180mg/dL was not associated with poor outcomes.

Peacock (2019) conducted a literature review that included 16 studies that compared glucose control in adult surgical patients with surgical complications. The studies reviewed showed a direct correlation between adverse surgical outcomes when

perioperative hyperglycemia was noted and that a random elevated glucose check resulted in post-surgical complications. The literature review also noted that the level of compliance among anesthesia providers is poor, as there is a fear of hypoglycemia from treatment, and that tight glycemic control is recommended in diabetic and nondiabetic surgical patient populations. The literature review suggests that perioperative hyperglycemia is a risk for all surgical patients, and glucose levels should be monitored to prevent postoperative complications.

Shanks et al. (2018) completed a single-center retrospective observational study to determine the relationship between intraoperative glucose levels and postoperative outcomes in the noncardiac surgery population. The primary outcome of postoperative infectious complications included surgical site infection (SSI), urinary tract infection (UTI), pneumonia, and/or sepsis within thirty days of the procedure. The patient population studied included 3150 adults (age > 18 years), diabetic or non-diabetic, undergoing elective or emergency general, vascular, or urologic surgery (Shanks et al., 2018). Pregnant, currently infectious, and individuals with an American Society of Anesthesiologists Physical Status Classification (ASA) of 5 or 6 were excluded from the study. Data was collected from the National Surgical Quality Improvement Program (NSQIP) with intraoperative glucose measurements obtained through the electronic health record.

Statistical analysis was performed using SPSS Version 20 along with a multivariable logistic regression model to adjust for other patient or surgical variables that could contribute to postoperative infectious complications. Through their analysis, Shanks et al. (2018) found that 49% of the patient population experienced hyperglycemia

intraoperatively, and another 15% experienced an infectious complication. They also concluded that intraoperatively, mild (8.3-11.0 mmol/L) ($p=0.04$) and moderate (11.1-16.6 mmol/L) ($p=0.02$) hyperglycemia led to a statistically significant increase in postoperative infections.

Gruenbaum et al. (2017) performed a multicenter and prospective single cohort observational study to determine if severe intraoperative hyperglycemia (SIH), considered a blood glucose level > 180 mg/dL, was independently associated with post-craniotomy infection. Infections examined in the study included pulmonary, urinary, blood, and wound. The study observed 224 diabetic/nondiabetic patients>18 years of age that underwent an elective or emergency craniotomy between May 2013 and January 2016 at two medical centers. Blood glucose levels were measured twice during each case using an intra-arterial catheter, once immediately after induction and once before tracheal extubation at the end of surgery (Gruenbaum, 2017). A multiple logistic regression analysis was performed after adjusting for other significant factors that could contribute to postoperative infection to determine the independent effect of SIH. Through their analysis, Gruenbaum et al. (2017) found that 10 of 30 (26.3%) patients that experienced SIH developed infection compared to 12 of 186 (6.5%) that were normoglycemic throughout surgery ($P<0.001$). After adjusting for multiple factors, including length of surgery, patient age >65 years of age, and emergent nature of the surgery, SIH was determined to be independently associated with the development of postoperative infection ($P=0.006$).

Frisch et al. (2010) also conducted a single-center observational study to identify if there is a relationship between perioperative blood glucose levels and length of stay

(LOS) complications and mortality in noncardiac surgery patients. The sample included 3,184 adult patients with a mean standard deviation age of 56.5 $\pm$ 16 that underwent various noncardiac procedures, including general, neurosurgical, orthopedic, oncology, thoracic, vascular, urology, gynecology, and otolaryngology procedures at Emory University Hospital between January 2007 and June 2007. The sample population included diabetic (643 patients) and nondiabetic patients (2,541 patients), at least 60 years of age, that sustained a femoral neck or intertrochanteric fracture. Glucose variability was obtained by nursing staff checking blood glucose levels. Blood glucose levels and other pertinent information were collected from the patient medical record. Data analysis was performed by nonparametric Wilcoxon tests for continuous variables, x2 tests for categorical variables, and multivariate linear regression to determine the effects of covariates (Frisch et al., 2010). Through this analysis, Frisch et al., 2010) were able to conclude that perioperative hyperglycemia in both nondiabetic and diabetic patients was associated with an increased risk of developing acute renal failure (ARF) ($P=0.005$), an acute myocardial infarction ($P=0.005$), and prolonged LOS in the ICU ($P<0.001$). Perioperative hyperglycemia also contributed to a higher incidence of postoperative infections, including pneumonia ($P<0.001$), urinary tract infection ($P<0.001$), and systemic blood infection ($P<0.001$). Another interesting finding is that compared to their nondiabetic counterparts, patients with a pre-existing diagnosis of diabetes experienced a higher rate of complications previously mentioned, including pneumonia ($P<0.001$), systemic blood infection ($P<0.001$), urinary tract infection ($P<0.001$), skin and wound infection ($P<0.001$), acute myocardial infarction ($P=0.008$), ARF ($P<0.001$), and higher ICU LOS ($P<0.001$) (Frisch et al., 2010). Lastly, Frisch et al.

(2010) also found that the risk of death increased in relation to increasing perioperative glucose levels in nondiabetic patients compared to diabetic patients (P=0.008).

Jackson et al. (2016) conducted a prospective observational study auditing the adherence to national guidance on managing adults with diabetes undergoing surgery, published in 2011. The study included 247 participants with diabetes undergoing elective surgery at participating hospitals during the week from October 7th to October 18th, 2013. The research group reviewed the 22 principal recommendations in the national guidelines and chose eight based on measurable data related to individual patient care during the immediate perioperative period. Additionally, sub-recommendation categories were chosen. Participants that included trauma, obstetrics, and pediatrics were excluded from the group. A data collection sheet was utilized by the anesthetist involved with the case and then completed in the recovery area. The data form included patient demographics, anesthesia used, and assessment of the implementations chosen based on the national guidelines. It was demonstrated that the national guidelines for treating diabetic patients during elective surgery were poorly implemented. These results concluded that the characterization of current practice is similar in nature and that diabetic patients undergoing elective surgery are not being cared for as the national guidelines suggest.

Related Literature

In their most recent *Standards of Medical Care in Diabetes 2022* publication, the American Diabetes Association (2021) recommends that diabetic patients have their blood sugar measured at least every 2-4 hours in the perioperative setting while NPO, receive short or rapid-acting subcutaneous insulin for hyperglycemia, and have blood

glucose levels maintained between 80-180mg/dL throughout the perioperative period. This targeted blood glucose range is based on multiple clinical trials that compared intensive intravenous insulin regimens with a target glycemic range of 80-110 mg/ dL to more moderate approaches with targeted glucose levels between 180-215 mg/dL or 140-180mg/dL. Although Van Den Berghe et al. (2001) found that blood glucose levels maintained between 80-110 mg/dL reduced mortality by 40% compared to a range of 180-215mg/dL in patients undergoing both cardiac and noncardiac surgery, follow-up studies found that this tight glycemic window was not favorable in the critically ill patient population. The Normoglycemia Intensive Care Evaluation and Survival Using Glucose Algorithm Regulation Trial (NICE-SUGAR) (2009), supported by multiple meta-analyses, found that intensive glycemic targets (80-110mg/dL) in critically ill patients are associated with significantly higher mortality rates and ten to fifteen-fold higher rates of hypoglycemia when compared to patients with blood sugars maintained between 140-180mg/dL (ADA, 2021). The culmination of these studies led to the formation of the ADA's targeted glucose range of 80-180mg/dL, which includes making adjustments on an individual basis. In their *Standards of Medical Care in Diabetes 2022*, the ADA (2021) also explains that "best practice" protocols and evidence-based guidelines are often inconsistently implemented within healthcare institutions, negatively affecting the quality of care afforded to diabetic patients.

The American Society of Anesthesiologists (ASA) discusses the idea that targeted perioperative blood glucose levels should take into consideration the duration of surgery, type of anesthetic technique used, invasiveness of the surgical procedure, and expected time until the patient can resume oral intake and diabetes medications (Duggan et al.,

2017) Like the ADA, the Society of Ambulatory Anesthesia (SAMBA), and the Endocrine Society, the ASA recommends that blood glucose levels be maintained less than 180 mg/dL intraoperatively (Duggan et al., 2017). The ASA also recommends that blood glucose levels be monitored at least every 2 hours in the perioperative period when rapid-acting subcutaneous insulin is administered for the treatment of hyperglycemia (Duggan et al., 2017) If an insulin infusion is determined to be the best management strategy, as is often the case with the critically ill and patients undergoing cardiac surgery, they recommend those blood glucose measurements occur hourly. According to Duggan et al. (2017), perioperative hyperglycemia affects approximately 20 to 40% of patients that undergo general surgery and nearly 80% of patients in cardiac surgery, the majority of which are patients with a known diagnosis of diabetes. As previously mentioned, it is also important to consider the type of anesthesia used for the surgical procedure as general anesthesia is linked to increased levels of catecholamines, glucagon, and cortisol levels in comparison to local or epidural anesthesia (Duggan et al., 2017). The volatile agents that are commonly used for general anesthesia also contribute to increased hepatic glucose production and inhibition of insulin secretion (Duggan et al., 2017).

Critical Summary

Through this literature review, many consistencies were identified among the studies observed. For instance, multiple studies demonstrated that perioperative hyperglycemia is associated with a wide range of postoperative complications, which inherently places diabetic patients at greater risk. Frisch et al. (2010) concluded that perioperative hyperglycemia in the diabetic patient population undergoing noncardiac

surgery was associated with higher rates of pneumonia, wound/skin infections, UTIs, systemic blood infections, acute myocardial infarction, and ARF compared to nondiabetic patients. They also found that people with diabetes experienced higher 30-day mortality and had increased LOS in the ICU (Frisch, 2010). Kim et al. (2021) also found that diabetic patients with a peak intraoperative glucose level >180mg/dL are at a significantly higher risk for myocardial injury after noncardiac surgery (MINS) and experience increased in-hospital and 30-day mortality. A blood glucose level of 149mg/dL was identified as the threshold for MINS development (Kim et al., 2021). Another retrospective observational study performed by Shanks et al. (2018) also concluded that intraoperative hyperglycemia, considered a blood glucose level above 8.3mmol/L (150mg/dL), was linked to a significantly increased risk of postoperative infections in both non-diabetic and diabetic patients undergoing major noncardiac surgery. Postoperative infections measured included superficial SSI, deep incisional SSI, organ space SSI, wound disruption, UTI, sepsis, and pneumonia (Shanks et al., 2018).

Another recurring theme identified in the literature is that despite significant evidence that perioperative hyperglycemia contributes to postoperative complications, perioperative glucose levels are often poorly monitored and inadequately managed. In a recent literature review examining the effects of stress-induced hyperglycemia on patient outcomes during the perioperative period, Peacock (2019) discusses the need for increased compliance among anesthesia providers in the monitoring of blood glucose levels perioperatively along with proper treatment of hyperglycemia based on evidence-based practices without fear of causing a hypoglycemic event. Peacock (2019) claims that many of the studies included in the literature review echoed this sentiment and that it

remains an ongoing struggle. Similarly, in a prospective observational study performed by Jackson et al. (2016), the researchers found that national perioperative recommendations for managing adult diabetic patients undergoing elective surgery, established by the National Health Society of England and the Joint British Diabetes Societies Inpatient Group, were poorly followed. Jackson et al. (2016) discovered that only 43% of the diabetic patients studied had an intraoperative blood glucose measurement documented, and only 73% of the patients had blood glucose recorded in the recovery area. In their discussion, the authors urge providers to adhere to these evidence-based guidelines as the incidence of type 2 diabetes continues to rise worldwide, along with the fact that diabetic patients are more likely to require surgical intervention compared to non-diabetics.

By performing this literature review, it is also evident that many studies on this subject primarily focus on diabetic patients undergoing cardiac surgery. Many researchers in this review agree that further inquiry is needed regarding the diabetic noncardiac surgery population. One of the goals of this project is to bring attention to this specific group through an evidence-based teaching plan. By establishing an evidence-based teaching plan, anesthesia providers will better understand the potential postoperative complications associated with perioperative hyper/hypoglycemia in diabetic patients undergoing noncardiac surgery. Based on guidelines established by the ADA, recommendations will also be provided on the frequency in which intraoperative blood glucose should be measured and targeted blood glucose ranges. Through this process, anesthesia providers will gain increased awareness about the importance of

maintaining normoglycemia, increasing adherence to evidence-based guidelines, and improving patient outcomes.

Theoretical Framework

Ronald Havelock's six-step Theory of Change provides the framework for this project as it looks at changing current practices. Currently, there are no guidelines for when to check and treat blood sugars in the operating room. There have been protocols for certain specialties, but none have defined the evaluation and treatment for diabetic patients across the entire perioperative timeframe. Havelock's change theory provides six steps that address changing current practice, evaluating the change, and continuing the new practice (Wagner, 2018). Adhering to these steps is essential as establishing change to current practices is often met with resistance.

The six steps highlighted in Havelock's change theory are: building a relationship, diagnosing the problem, acquiring resources for change, selecting a pathway for the solution, establishing and accepting change, and maintaining and separating (Wagner, 2018). The project team has identified and diagnosed the problem; blood glucose levels and interventions are not initiated as often as needed to prevent postoperative complications in diabetic patients undergoing noncardiac surgery. Building a relationship is an ongoing process that this team continues to pursue as it works to incorporate itself into the anesthesia workforce. The resources necessary for this change would best be gathered through a literature review. Educating the anesthesia professional about postoperative complications related to hyper/hypoglycemia is essential to implementing the change. In order to find a path to the solution, this team must provide clear instructions on the frequency of when to check blood glucose levels in diabetic

patients. Establishing and maintaining change is what this team hopes to accomplish through this DNP project. This change theory not only provides the framework but also highlights the goals for this DNP as it seeks to improve the management of diabetic patients intraoperatively, minimizing unfavorable outcomes.

Method

Design

The design of this project is an evidence-based teaching plan that can be used as a quality improvement project centered on anesthesia provider education. This evidence-based teaching plan was developed through a systematized literature review, expert validation of content, and directed content analysis.

Sample

The sample of this project consisted of expert anesthesia providers, including anesthesiologists and CRNAs, that participated in the content validity process. The expert panel consisted of seven anesthesiologists and fourteen CRNAs with experience ranging from less than five years to greater than twenty years of clinical experience.

Ethical Considerations

This project was submitted and reviewed by the Einstein Healthcare Network IRB and determined "not to meet the definition of human subject research" and is considered exempt. Data resources also remain anonymous, with no identifiable risks to participants. The results of the content validity survey are also password protected and secured via Qualtrics software.

Instrumentation

The program planning matrix form (Table 3) provides information regarding the development of the teaching plan, including overall project goals, objectives, timelines, resources, responsible personnel, and outcomes. Upon performing a needs assessment, data was gathered using a systematized literature review that included multiple databases, including CINAHL, PubMed, and Medline, among other reputable sources. The studies obtained from this review were then appraised using the John Hopkins Nursing Evidence-Based Practice: Research Evidence Appraisal Tool and assigned a level representing each study's quality of evidence. Pertinent information about the studies identified through the literature review and the quality of each study can be viewed in Table 2.

Data was also collected by distributing a content validity tool to expert anesthesia providers. The content validity tool consisted of an eleven-question survey which included demographic information and qualitative and quantitative questions regarding key topics identified within the literature review. Qualtrics software was used for survey creation, distribution, and data analysis. The expert panel was asked to provide feedback and was provided the opportunity to comment on survey questions. Lastly, directed content analysis was performed to identify recurring themes throughout the literature and provide structure for developing the teaching plan.

Procedures for Data Collection

Data related to the content validity of the proposed evidence-based teaching plan was collected through the use of Qualtrics software in the form of a survey. The survey was distributed to a total of twenty-five expert anesthesia providers, including anesthesiologists and CRNAs, via email, with the survey open to response for a one-week period. Of the twenty-five anesthesia providers polled, twenty-one of them responded to

the survey within the appropriate time frame, with responses and comments saved in Qualtrics. The responses from the survey were then discussed with all members of the project team, with revisions made to the teaching plan as deemed necessary.

Upon completion of the evidence-based teaching plan with the approval of both FJTSA and La Salle faculty, project members plan to have future DNP cohorts adopt this educational intervention for implementation in the hospital setting as part of anesthesia provider training. The success of the educational tool can then be assessed through analysis of pre and post-test scores of participating anesthesia providers with feedback taken into consideration related to effectiveness. A sample pre/post-test was developed for later use and can be found in Appendix D.

Data Analysis

After the expiration of the predetermined content validity survey allowable response time, the survey responses and comments were discussed among team members. Item-level content validity index (I-CVI) was then calculated to evaluate the relevance of the teaching plan content and determine expert opinion. CVI values range from 0 to 1, with a value of > 0.78 representing item relevance, 0.70 to 0.77 demonstrating the possible need for revision, and values <.70 deemed nonrelevant/eliminated (Yusoff, 2019). Qualitative data was also obtained by analyzing the expert panel's comments and identifying common themes. The content of the teaching plan was again discussed with project team members once the analysis was complete, with revisions made as deemed necessary.

Results

Findings

Through analysis and interpretation of expert responses to the content validity survey, the results demonstrate a need for our proposed teaching intervention. The expert panel, consisting of currently practicing anesthesiologists and CRNAs with varying years of experience ranging from less than five years to over twenty years, agreed that the teaching tool would benefit patient care. Survey question #11, which asked if the providers believed an educational intervention regarding intraoperative blood glucose monitoring in diabetic patients undergoing noncardiac surgery would improve the quality of patient care, resulted in 20/20 respondents answering yes. The unanimous answer resulted in an I-CVI score of 1.0, signifying relevance. Survey question #3 assessed anesthesia providers' knowledge of complications associated with perioperative hypoglycemia, with only 11/18 respondents answering correctly. Although these findings may demonstrate a misunderstanding of the question, they may also highlight a knowledge gap.

Survey questions #4 and #5 assessed whether providers are aware of any protocols within their facility on intraoperative blood glucose monitoring on diabetic patients undergoing noncardiac surgery and, if so, how often they follow the protocol. Responses showed that only 9/20 anesthesia providers were aware of a current hospital policy and that most providers do not follow these policies 100% of the time as recommended. Question #6 addressed the frequency with which anesthesia providers monitored intraoperative blood glucose levels in this specific patient population. Responses demonstrate that only 3/20 providers are checking blood sugars according to the recommendations set forth by the ASA and ADA. Although this may signify differences among institutional policies, it can also signify the need for provider

education regarding up-to-date professional society recommendations and revision of current policy.

Other items in the content validity survey, including questions #7 and #8, show that anesthesia providers may not have adequate access to the equipment necessary to promptly monitor and manage intraoperative glucose levels. The answers and comments provided by the respondents show that the quantity of blood glucose monitors may be insufficient and/or access to the available monitors is challenging. Some providers stated that they have to share glucose monitors with the PACU and often have issues with passwords/logins for the equipment. Other providers commented that they have to call the anesthesia technician to retrieve the equipment, which can lead to delays in care. Lastly, questions #9 and #10 were used to identify anesthesia providers' awareness of current ASA and ADA recommendations regarding targeted intraoperative blood glucose levels and ERAS protocol. Responses demonstrate that although most providers answered the questions correctly, less than 100% agreement reflects a lack of knowledge validating the content of the teaching plan and future implementation.

Limitations

Limitations of this project include a lack of responses from an equal number of participants from each group; anesthesiologists and CRNAs. This does not invalidate the answers to the survey. However, it may be assumed that the different professions may have responded differently. This is also true for the length of time each participant has been practicing. There was not an even number of participants from each timeframe of experience, thus possibly weighing on the answers provided.

Lastly, the anesthesia providers that participated in the survey only practice in the Philadelphia region at a select number of hospitals in the area. This shows a small sample from a small area compared to the rest of the country, potentially limiting generalizability. Treatment plans, policies, and protocols may also be different in other areas of the United States and may influence the answers to the questions on the survey.

Implications

The need for further education of anesthesia providers on intraoperative blood glucose monitoring is imperative to improve patient safety and postoperative outcomes in diabetic patients undergoing general surgery. National and global statistics indicate that the diabetic patient population is steadily growing, necessitating highly trained healthcare providers to care for them. With diabetes linked to multiple comorbidities, diabetic patients present a unique challenge in the perioperative setting. Intraoperative hypoglycemia and stress-induced hyperglycemia are associated with various symptoms and complications that may be difficult to recognize under general anesthesia requiring vigilant monitoring by anesthesia providers for prompt management. Although the ADA and other professional societies provide recommendations, our survey of expert anesthesia providers demonstrates a knowledge gap and reinforces the need for our proposed evidence-based teaching plan.

The educational opportunity provided by the project will hopefully enhance anesthesia provider knowledge of how to monitor blood glucose levels perioperative in this unique patient population appropriately and, in turn, improve patient outcomes. The teaching plan can potentially be implemented as part of anesthesia provider orientation,

annual training, or other educational seminars in a variety of healthcare settings, with effectiveness evaluated through pre and post-test results.

Future Projects and Plans

The hope of this project is that it may be built upon in the future. Our project has laid the groundwork for future DNP cohorts and demonstrated the need for our proposed teaching intervention. The content validity survey showed a disconnect among expert anesthesia providers regarding intraoperative blood glucose monitoring of diabetic patients undergoing noncardiac surgery. Perhaps future DNP cohorts may use our project as a springboard to bring change to hospital policies and protocols and enhance provider knowledge and patient outcomes.

Future projects may also be able to examine equipment-related issues and the barriers that lack of equipment causes in the operating room concerning blood glucose monitoring and management. The institutions in which the writers of this project have been a part show a small number of glucometers in each perioperative setting. Comments obtained from the survey voiced a lack of glucose monitors as the reason for not checking as often as required. Future projects may look to prove that a specific ratio of glucometers to operating rooms may be a necessity to increase compliance and timely management of intraoperative blood glucose levels.

Conclusion

With the number of individuals diagnosed with diabetes increasing locally, nationally, and worldwide each year, anesthesia providers must know how to care for these patients in the perioperative setting. As demonstrated by the literature, hypoglycemia and stressed induced hyperglycemia are associated with many potential

complications requiring vigilante monitoring of blood glucose levels intraoperatively so that timely treatment can be initiated. Despite evidence-based recommendations from professional societies, including the ADA and ASA, the responses to our expert panel survey demonstrate a knowledge gap and a need for the proposed educational intervention. All anesthesia providers unanimously agreed that an educational intervention would help improve the quality of care for diabetic patients undergoing noncardiac surgery. With the help of future DNP students, this evidence-based teaching plan can be disseminated and implemented within healthcare settings to close the knowledge gap and protect this unique population of patients from unnecessary complications.

Project Committee

Chair: Dr. Robert Simon DNP, CRNA, CHSE, CNE

First Reader: Joan Frizzell Ph.D. CRNP ANP-BC

Mentor: Dr. Michael Kost DNP, CRNA, CHSE, FAANA, FAAN

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Table 1

Search Process Review of Literature

Database	Total Articles	Articles Remaining After Title Review	Articles Remaining After Abstract Review	Articles Retrieved and Examined	Articles that Fit Inclusion Criteria
CINAHL	**215**	**29**	**11**	**6**	**3**
Pubmed	**676**	**36**	**25**	**10**	**4**
Medline	**422**	**18**	**4**	**3**	**2**

Table 2

Review of the Literature Matrix

Database # Article **First Author, Year (full citation in references)**	**Purpose of the Study** **Major Variables (IV, DV) or Phenomenon**	**Theory or Conceptual Framework**	**Design**	**Measurement Major Variables (instrument**	**Data Analysis (Name of Statistics, descriptive, inferential and results)**	**Findings**	**Evidence Level of Research & Quality Johns Hopkins Nursing Evidence-Based Practice**
PubMed #1 Lai, 2022	Determine the impact of intensive blood glucose lowering regimens on the incidence of SSIs when compared to conventional strategies	N/A	Meta-Analysis of RCTS N=14,126	Intensive treatment group- blood glucose levels targeted between 80-120mg/dL Convention treatment group- blood glucose levels targeted below 250mg/dL	Meta-analyses were performed using a random-effects model with the construction of Forest plots with $p<0.05$ representing statistical significance	Diabetic patients that underwent intensive glycemic control treatment intraoperatively had a significant decrease in the incidence of SSIs ($P<0.00001$) Intraoperative and/or only postoperative administration of insulin lead to lower SSI risk ($P=0.01$, $P=0.004$, respectively)	Level I

						Risk of hypoglycemia and mortality were higher in the intensive treatment group (P=0.0006)	
CINAHL #1 Long, 2022	Evaluate whether perioperative glucose variability was a significant predictor of postoperative outcomes for diabetic patients after hip fracture	N/A	Observational Study n=1099	Retrospective data collection of hospital records from the Hip Fracture Database of the healthcare institution	IBM SPSS Statistics for Windows t-test with Welch correction for unequal variances Pearson correlation coefficient Multivariate survival analysis performed using the Cox regression model	Patients with diabetes were more likely to develop infections (P=.045), and experience mortality (1-month P=.052, 12-month P=.006)	Level III

PubMed #2 Kim, 2021	Evaluate the effect of intraoperative blood glucose level on incidence of myocardial injury after non-cardiac surgery (MINS) in the diabetic patient population	N/A	Single-Center Retrospective Observational Study N=11,302	Cardiac troponin levels were measured using an automated analyzer (Adbia Cantaur XP) -MINS defined as a peak CTNI level above the 99th percentile of the upper reference limit within 30 days after surgery -99th percentile URL= 40ng/L Intraoperative glucose levels were measured from blood obtained from an arterial line with a blood gas analyzer (RAPIDLab 1200 Blood Gas Analyzer)	Differences between the BST groups were determined using the Mann-Whitney test or Student's t-test for continuous data	Blood sugar glucose ≥ 180 group had significantly higher incidence of MINS and in-hospital and 30-day mortalities (P<0.001, P=0.001, P<0.001, respectively) when compared to blood sugar glucose <180 group	Level III
CINAHL #2 Shah, 2020	Assessment of the relationship between intraoperative hyperglycemia (glucose >180)and the primary outcome of 30 day morbidity and mortality and secondary outcome of infectious complications	N/A	Multicenter Retrospective Study n=5014	Hyperglycemia=>180 30 day morbidity/mortality=infections, cardiovascular complications, thrombotic complications, neuro complications Secondary outcome=30 day infections, such as surgical site, pneumonia, UTIs, sepsis, central line	Multivariable logistic regression modeling Post HOC sensitivity analysis	There was a statistically significant difference in 30 day morbidity and mortality among patients that had an increase in blood sugar over 180. For every 20 point increase in glucose level, the 30 day morbidity and mortality increased (P=<0.001)	Level III

Medline #1 Peacock, 2019	A review of the most current studies on the effects of stress hyperglycemia in both diabetic and non-diabetic populations, indicating the need for tight glucose control in the perioperative area	N/A	Literature Review n=16 studies	Studies reviewed included any type of glucose control in adult surgical patients with surgical complications. Both diabetic and non-diabetic patients were reviewed.	AORN research and non-research evidence appraisal tool was used to appraise each studies' strength and quality	There is a significant correlation with adverse surgical outcomes and perioperative hyperglycemia, and blood glucose should be monitored in both the diabetic surgical population, as well as the non-diabetic surgical population	Level V
CINAHL #3 Shanks, 2018	Evaluate the relationship between intraoperative glucose levels and postoperative outcomes in non-cardiac surgery	N/A	Single-Center Retrospective Observational study N=3150	Intraoperative glucose measurements were obtained from the Electronic Health Record- could be from point of care testing or formal laboratory testing Data was also extracted from data from the National Surgical Quality Improvement Program (NSQIP)	SPSS Version 20 was used for statistical analysis A multivariable logistic regression model was created to account for patient and surgical covariates associated with postoperative infectious complications	49% of patients experienced intraoperative hyperglycemia 15% experienced an infectious complication Mild (p=0.04) and moderate (p=0.02) hyperglycemia was associated with a increase in infectious complications	Level III

PubMed #3 Gruenbaum, 2017	Determine if severe intraoperative hyperglycemia (SIH) (BCG≥ 180) is an independent cause of postcraniotomy infection	N/A	Multicenter Prospective Single-cohort Observational Study N=224	Intraoperative blood glucose concentrations were measured using an intra-arterial catheter at two points during surgery-immediately after induction and prior to extubation at the end of surgery	A multiple logistic regression analysis was used to determine the association between SIH and postcraniotomy infection after adjusting for other statistically significant factors.	10 of 83 (26.3%) of patients that experienced SIH developed postoperative infection compared to 12 of 186 (6.5%) of normoglycemic patients (P<0.001) SIH was independently associated with postcraniotomy infection after adjusting for age≥65 years, LOS, and emergent nature of surgery (P=0.006)	Level III

Medline #2 Jackson, 2016	Determine whether or not national perioperative guidelines for patient with diabetes undergoing elective surgery were adhered to	N/A	Prospective observational study n=247	(8) Measurable data points from 22 principal recommendations in the national guidance for diabetics undergoing elective surgery. Sub-recommendations chosen: all patients have preop assessment, a capillary blood glucose checked before induction, and encouragement of eating and drinking at earliest opportunity.	Data presented as percentage of total cohort, standard deviation or median alongside interquartile range	National perioperative guidelines were not adhered to in a large majority of patients with diabetes undergoing elective surgery	Level III

PubMed #2 Frish, 2010	Determine the relationship between perioperative hyperglycemia and diabetes on clinical outcomes and the impact of perioperative hyperglycemia on survival after noncardiac surgery	N/A	Single-Center Observational Study N=3,184	Pre and post surgery glucose levels were identified through the patient's medical record	Nonparametric Wilcoxon tests, x tests, multiple logistic regression, adjusted odds ratios, and multivariate linear regression were used for data analysis	Perioperative hyperglycemia is associated with an increased risk of postoperative complications including pneumonia (P<0.001), urinary tract infections (P<0.001), systemic blood infection (P<0.001), ARF (P=0.005), acute myocardial infarction (P=0.005) and increased ICU LOS (P<0.001) in both nondiabetic and diabetic patients Risk of death increased in relation to increasing perioperative glucose levels in nondiabetics (P=0.008) Diabetics had higher rates of pneumoni	Level III

						a (P<0.001), systemic blood infection (P<0.001), skin and wound infection (P<0.001), UTI (PP<0.001), ARF (P<0.001), acute MI (P=0.008), and high ICU LOS (P<0.001) compared to nondiabetic patients.	

Table 3

Program Planning Matrix

lidate topics to be included in a teaching plan focused on appropriate blood glucose monitoring in the operating room. prove anesthesia providers' knowledge related to intraoperative blood glucose monitoring frequency, targeted blood glucose levels, and complications associated with hyper/hypoglycemia.					
Objectives	**Methods and Techniques**	**Timeline**	**Resources**	**Responsible Personnel**	**Outcomes**
Short-Term Objectives					
1. Perform needs assessment	Identify clinically relevant problem to be addressed through discussion with anesthesia providers and clinical experience	June 2021-August 2022	Clinical Expert (Dr. Robert Simon)	Brian Sabec & Christopher McMichael	Needs assessment identified safety threats Findings: Pt that develop hyper/hypoglycemia during surgery are at an increased risk for poor postoperative outcomes
1. Literature Review	Research databases for relevant articles/ studies	June 2021-August 2022	Pubmed, CINAHL, Medline, evidence-based literature	Brian Sabec & Christopher McMichael	Completed literature review with accompanying matrix
3. Appraisal of Evidence	Directed content analysis	June 2021-August 2022	Reviewed using Johns Hopkins Research Evidence Appraisal Tool	Brian Sabec & Christopher McMichael	Literature appraised
Intermediate-term Objectives					
1. Develop Teaching Plan	Content/Presentation plan development	June 2022-	Consult with project	Brian Sabec &	Complete teaching plan

		May 2023	team chair and LaSalle faculty	Christopher McMichael	
2. Expert review validation	Select CRNA and MDA experts	March 2023-May 2023	Collect and analyze data from experts	Brian Sabec & Christopher McMichael, CRNA and MDA experts	Validate content of teaching plan
Long-term Objectives					
1.Implement teaching plan	Present teaching plan to staff CRNAs and MDAs	TBD	Einstein Medical Center	Brian Sabec & Christopher McMichael	Provide evidence-based teaching plan to CRNAs and MDAs
2. Increase anesthesia provider knowledge	Present teaching plan to staff CRNAs and MDAs	TBD	Einstein Medical Center	Brian Sabec & Christopher McMichael	Increase knowledge of blood glucose monitoring among anesthesia providers

Table 4

Directed Content Analysis

Code	Citations (Full citation in references)	Educational Component
Insufficient monitoring of intraoperative blood glucose levels in diabetic patients undergoing non-cardiac surgery	(Morrison et al., 2014) (Dogra & Jialal, 2021) (Ehrenfeld et al., 2017)	• Inadequate monitoring may be related to lack of accessibility to glucometers or lack of anesthesia provider knowledge • Hyperglycemia is documented in 20% to 30% of general surgery cases (Dogra & Jialal, 2021) • Ehrenfeld et al. (2017) found that of 2,224 diabetic patients observed, only 19.8% had blood glucose measured in the operating room, and only 57% had their blood glucose rechecked after receiving insulin intraoperatively. • A study involving 3150 patients undergoing elective or emergency general, vascular, or urologic surgery found that 49% experienced hyperglycemia intraoperatively.
Impact of hyper/hypoglycemia on postoperative outcomes.	(Shanks, et al., 2018) (Kim, et al., 2021) (Gruebaum, et al., 2017)	• Mild to moderate intraoperative hyperglycemia led to a statistically significant increase in postoperative infections. • Myocardial injury after non-cardiac surgery, as well as in hospital and 30-day mortality rates, were greatly increased in diabetic patients with intraoperative blood glucose measurements >180 mg/dL • 26.3% of patients with blood glucose measurements >180 during craniotomy developed a postoperative infection, compared to 6.5% with normoglycemia throughout craniotomy
Strategies to improve intraoperative blood glucose monitoring	(American Diabetes Association, 2022) (American Diabetes Association, 2022)	• Check blood glucose levels of diabetic patients who are NPO or receive short-acting insulin every 2-4 hours in the perioperative setting • Maintain blood glucose levels between 80-180mg/dL throughout the perioperative period

	(Duggan et al., 2017)	• Blood glucose levels monitored every hour when on intravenous insulin therapy

Table 5

La Salle University
School of Nursing and Health Sciences
Graduate Nursing Program
Final Teaching Plan

Title of Educational Activity: Anesthesia Providers' Knowledge of the Importance of Intraoperative Glucose Monitoring of the Diabetic Patient Undergoing Noncardiac Surgery

Teachers: Christopher McMichael and Brian Sabec

Following completion of the educational intervention, the anesthesia provider will:

1. Analyze and understand causative factors and statistics related to insufficient intraoperative glucose monitoring.
2. Analyze and evaluate postoperative complications associated with perioperative stress-induced hyperglycemia and hypoglycemia.
3. Apply professional society recommendations and strategies to improve intraoperative glucose monitoring and create and foster the creation of new hospital policies.

Purpose: Following the completion of this learning activity, participants will be able to identify causative factors and statistics related to insufficient intraoperative glucose monitoring, postoperative complications associated with perioperative hyper/hypoglycemia, and professional recommendations and strategies to improve monitoring.					
Objectives	**Content for each Objective**	**Methods of Instruction**	**Media**	**Time**	**Evaluation**
Following completion of the teaching intervention, the anesthesia provider will:					
1. Evaluate literature related to inadequate intraoperative glucose monitoring	**Identify the patient safety concern and supporting literature for a teaching intervention:** • Hyperglycemia is documented in 20% to 40% of patients undergoing general surgery cases and approximately 80% of cardiac surgery cases (Dogra & Jialal, 2021) • 12 to 30% of patients that	Face-to-face educational presentation on intraoperative glucose monitoring	PowerPoint Presentation to be developed at later time	5mins	Pre and Post-test

	experience intraoperative or postoperative hyperglycemia do not carry a diagnosis of diabetes prior to surgery. • A Quality improvement project found that of 2,224 diabetic patients observed, only 19.8% had blood glucose measured in the operating room, and only 57% had their blood glucose rechecked after receiving insulin intraoperatively (Ehrenfeld, 2017) • A study involving 3150 patients undergoing elective or emergency general, vascular, or urologic surgery found that 49% experienced hyperglycemia intraoperatively.				
2. Evaluate the impact of stress-induced hyperglycemia and hypoglycemia on intraoperative and postoperative outcomes.	**Postoperative complications associated with stress-induced hyperglycemia include:** • Surgical stress-induced hyperglycemia leads to a statistically significant increase in postoperative infections, impaired wound healing, poor circulation,	Face-to-face educational presentation on intraoperative glucose monitoring	PowerPoint Presentation to be developed at later time	5mins	Pre and Post test

	acidosis, prolonged ICU/hospital stays, and increased healthcare costs. • Surgical stress-induced hyperglycemia can also contribute to serious diabetic pathologies postoperatively, including diabetic ketoacidosis (DKA) and hyperglycemia hyperosmolar syndrome (HHS). • Myocardial injury after non-cardiac surgery, as well as in hospital and 30-day mortality rates, are greatly increased in diabetic patients with intraoperative blood glucose measurements >180 mg/dL • Intraoperative hypoglycemia **Complications associated with intraoperative hypoglycemia include:** • Uncontrolled intraoperative hypoglycemia can contribute to a wide range of neurological complications including: somnolence, unconsciousness				

	, seizures, and irreversible cerebral ischemia of death when appropriate treatment is delayed. • Intraoperative hypoglycemia is challenging to recognize during the administration of anesthesia and requires close monitoring of blood glucose levels.				
3. Understand the most common factors related to insufficient intraoperative glucose monitoring	**Causes of insufficient monitoring:** • Lack of accessibility to glucometers in the operating room • Anesthesia provider unawareness of frequency in which to check blood glucose levels • Inadequate knowledge of diabetes and hyperglycemia management amongst anesthesia providers. • Fear of causing hypoglycemia from treating elevated blood glucose levels. • Lack of institutional protocols for management of diabetic or hyperglycemia patients.	Face-to-face educational presentation on intraoperative glucose monitoring	PowerPoint Presentation to be developed at later time	5mins	Pre and Post test
4. Apply Professional Society	**Professional society recommendations:**	Face-to-face educational	PowerPoint Presentatio	5mins	Pre and Post test

recommendations and strategies for improvement of intraoperative glucose monitoring and foster the creation of new policy.	• The American Diabetes Association (2021) recommends that blood glucose levels should be maintained between 80-180 mg/dL with blood sugars measured at least every 2-4hrs in the perioperative setting. • The American Society of Anesthesiologists (ASA), the Society of Ambulatory Anesthesia (SAMBA), and the Endocrine Society recommend that blood glucose levels be maintained less than 180 mg/dL intraoperatively. • The ASA also recommends that blood glucose levels be monitored at least every 2 hrs in the perioperative period when rapid-acting subcutaneous insulin is administered and 1 hr checks when an insulin infusion is deemed the best management strategy.	presentation on intraoperative glucose monitoring	n to be developed at later time		

	• According to the ASA, targeted perioperative glucose levels should also take into consideration the duration of surgery, type of anesthetic, invasiveness of the surgical procedure, and expected time until oral intake and diabetes medications can be resumed. **Strategies for improvement of intraoperative glucose monitoring:** • Ensure provider is aware of location of glucometers and lobby for purchase of more within budget if inadequate access. • Identify patients with a history of diabetes and develop a plan among anesthesia team members for the management of blood glucose levels perioperatively. • Lobby with the institution to incorporate a system in the electronic healthcare record that automatically identifies				

	diabetic patients, detects insulin administration, lists recent glucose measurement, and reminds provider when to check intraoperative glucose levels. • Encourage and participate in the development of a protocol for the management of diabetic patients undergoing noncardiac surgery.				

Figure 1

Expert Panel Survey

1) Please select your profession:
   a) Anesthesiologist
   b) Certified Registered Nurse Anesthetist

2) Years of clinical experience in your field
   a) 5-10 years
   b) 10-15 years
   c) >20 years

3) Please rank from 1-5 (1=least critical to 5=most critical), patient complications of perioperative hypoglycemia.

   a) Seizures
   b) Somnolence
   c) Unconsciousness
   d) Death
   e) Irreversible cerebral ischemia

4) Are you aware of any protocols at your facility regarding intraoperative blood glucose monitoring of diabetic patients undergoing non-cardiac surgery?
   a) Yes
   b) No
   c) Somewhat

5) In your clinical practice, how often do you follow your facility's protocols regarding intraoperative blood glucose monitoring of diabetic patients undergoing non-cardiac surgery?
   a) 0-25%
   b) 26-50%
   c) 51-75%
   d) 76-100%

6) How frequently are blood glucose levels monitored in the operating room in diabetic patients undergoing non-cardiac surgery?
   a) Every hour
   b) Every 2 hours
   c) Only when insulin is administered preoperatively
   d) Provider dependent

7) How many glucometers are available for your use in your OR?
   a) 1-2
   b) 2-3
   c) 3-4
   d) >4
   e) I am not sure

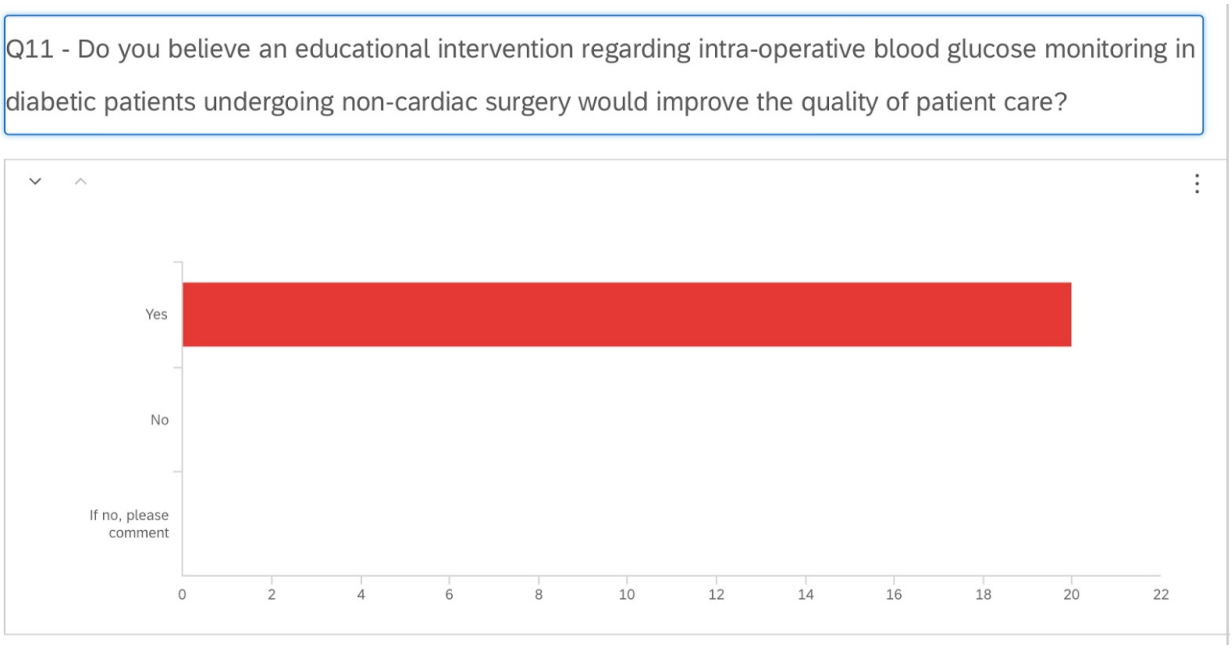
8) Do you believe there is adequate access to glucometers within the operating room?
   a) Yes
   b) No
   c) If no, please comment

9) Choose the correct statement regarding the current recommendations of the American Diabetes Association (ADA) and the American Society of Anesthesiologists (ASA) regarding targeted intraoperative blood glucose levels.
   a) The ASA and the ADA recommend maintaining blood glucose levels below 160 mg/dL and checking blood glucose levels every 1 hour when rapid-acting insulin has been administered in the perioperative setting.
   b) The ASA and the ADA recommend maintaining blood glucose levels below 180 mg/dL and checking blood glucose levels every 2 hours when rapid-acting insulin has been administered in the perioperative setting.
   c) The ASA and the ADA recommend maintaining blood glucose levels below 150 mg/dL and checking blood glucose levels every 2 hours when rapid-acting insulin has been administered in the perioperative setting.
   d) The ASA and the ADA recommend maintaining blood glucose levels below 180 mg/dL and checking blood glucose levels every 1 hour when rapid-acting insulin has been administered in the perioperative setting.

10) A review of your non-diabetic patient's preoperative blood work shows a blood glucose level of 205. They are scheduled for a non-cardiac procedure. According to the recommendations from the Enhanced Recovery after Surgery (ERAS) protocols at your institution, you would:
   a) Do nothing, as this patient is a non-diabetic and is not scheduled for a cardiac procedure.
   b) Repeat the measurement using a point of care blood glucose monitor in real-time, and treat the blood glucose level if greater than 200mg/dL.
   c) Treat the blood glucose aggressively, aiming for a target blood glucose measurement between 80-110 mg/dL.
   d) Recheck the blood glucose in 2 hours, and treat based on the new measurement.

11) Do you believe an educational intervention regarding intraoperative blood glucose monitoring in diabetic patients undergoing non-cardiac surgery would improve the quality of patient care?
   a) Yes
   b) No
   c) If no, please comment

Appendix A



CVI=1.0 This item is relevant

Appendix B

Einstein Healthcare Network

Human Subjects Research Determination

November 2, 2022

Type of Review: Initial
Project Title: Development of an intraoperative protocol for the management of glucose levels
Investigator: Robert Simon
IRB ID: IRB-2023-1043

Dear Robert Simon,

The planned activity noted above was reviewed by a member of the EHN IRB and determined not to be human subjects research. This decision only applies to the planned activity described in the materials provided to the IRB. As the person accountable for the conduct of the activity, you are responsible for ensuring that it is conducted as described in the materials provided.

Before this project can be initiated, you must email Derrick Crump, the Chief Privacy Officer, the following to confirm all HIPAA regulations will be followed:

- The activity description
- The plan for data use (Who will have access to the data? Will data be shared outside of Einstein?
  How long will it be stored?)
- The plan for data protection (e.g. limited access, where and how data will data be stored, data coded,
  deidentification, password protection, etc.)
- Any materials submitted within this determination and that will be used to carry out your planned
  activity:
    - Any surveys/questionnaires
    - Data collection sheet(s)
    - Master/Linking sheet
    - Description of recruitment activities including invitations (if applicable)
- Other relevant information not listed above

If any data that is being collected for this project will be used for student requirements to earn a degree for an external school or institution (ie, doing the study and collecting data for your dissertation, Master's Degree, etc, you must contact Tahirah Harrigan to confirm that all student requirements have been met and Derrick Crump, the Chief Privacy Officer, to confirm that a data sharing agreement is needed and/or signed.

Please note that any data collected for this activity cannot be analyzed and presented for another purpose, unless an updated project description and analysis plan is approved by the IRB. Although much can be learned from these types of activities and sharing your findings is strongly encouraged, this activity as currently described cannot be referred to as "human subject research" when discussed in publications and presentations. Innovative Programs (IP) and Quality Improvement (QI) projects should not be described or analyzed as a “study” or “research” in publications or presentations, but should be clearly identified as a "program", "program evaluation" or “QI project”. An acceptable statement that could be included in the manuscript would be, "This project was reviewed and determined not to meet the definition of human subject research by the EHN IRB."

If you wish to analyze and present the data collected for your project/program as part of a human subject research study, please call the IRB Office at 215-456-7217 to discuss whether a new application must be submitted to the IRB for review prior to initiating this activity.

Sincerely,
Beth Lynch, CIP
Senior IRB Analyst

Appendix C

18 February 2022

TO: Patricia Dillon, PhD, RN
Chair of Graduate, RN to BSN and RN to MSN Nursing Programs

FROM: Susan C. Borkowski, Ph.D.
Chair, Institutional Review Board

RE: Post BSN - DNP Anesthesia Students' Projects

The La Salle University Institutional Review Board [IRB] accepts Einstein Hospital's IRB assessment of the Post BSN - DNP Anesthesia Students' Projects as non-human research.

These projects focus on quality improvement and do not involve human subjects. Based on the Einstein determination, La Salle's IRB does not require the submission of a formal IRB proposal.

Appendix D

Pre/Post test

Hyperglycemia affects approximately 20-40% of patients undergoing general anesthesia.
- True
- False

General anesthesia causes an increase in catecholamines, glucagon, and cortisol, leading to hyperglycemia in surgical patients.
- True
- False

Volatile agents commonly used for anesthesia cause an increase in hepatic glucose production and inhibition of insulin secretion.
- True
- False

Mild to moderate intraoperative hyperglycemia leads to a significant increase in postoperative infections.
- True
- False

According to the ADA, blood glucose levels should be maintained between _____ in the perioperative setting
- 100-200 mg/dL
- 80-180 mg/dL
- 60-160 mg/dL
- 50-150 mg/dL

According to the ASA, blood glucose levels should be maintained to a target of less than ____
- 200 mg/dL
- 160 mg/dL
- 150 mg/dL
- 180 mg/dL

According to the ASA, blood glucose levels should be checked every _____ when rapid-acting insulin is administered in the perioperative period
- 30 minutes
- 1 hour
- 2 hours
- 3 hours

T/F: Patients receiving intravenous continuous insulin infusions should have blood glucose levels checked every hour while in the perioperative period
- True
- False