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Blood Glucose Management in the Surgical Patient

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PERMISSION

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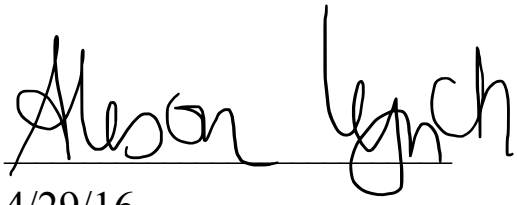
Signature 

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Abstract

In 2010, there were 51.4 million surgical procedures performed in the United States alone (Centers for Disease Control, 2012). Many people have surgery at some point in their life, whether it is an unavoidable or elective procedure. Diabetes, including blood glucose management, must be taken into account when undergoing a surgical procedure. For the provider, coming into contact with diabetic patients is common due to the high prevalence of the disease. Fifty percent of diabetics will have surgery at some point in their life (Miller & Richman, 2016, p. 155). This paper will review the case of a 67-year-old diabetic patient who is scheduled to have a right total knee arthroplasty. An examination of the literature will help to determine the best way to manage blood sugars and avoid complications in diabetics undergoing surgery. Specifically identifying target blood glucose for surgical patients, and the effects of blood glucose levels on patient outcomes. As providers it is in our patients' best interest to review the most recent literature and drive our policies based off of evidence based practice.

Background

Diabetes is a prevalent condition in the United States, and one that can't be ignored by providers. It had a prevalence of 29.1 million of the U.S. population in the year 2012 (American Diabetes Association, 2016). World-wide, the prevalence of diabetes is around 387 million (Dhatariya, Levy, & Hall, 2016). This number is expected to increase to 600 million people by the year 2035 (Dhatariya, Levy, & Hall, 2016). Due to the high number of diabetic patients who may at some point have surgery, it will be essential to determine the best way to manage their disease during this time of high stress.

When diabetics are under stress of any kind, blood sugars rise. Surgery is a type of stress, that could potentially increase blood sugars. The long-term effects of high blood sugars on patients have been well established. The research shows complications including peripheral neuropathy, poor wound healing, increased risk of infection, increased blood pressure, and kidney disease (Mayo Clinic, 2015). One goal in this review is to determine complications arising from periods of hyperglycemia.

Hyperglycemia is prevalent in surgical patients due to compounding factors. Surgery is a type of stress on the body. During this time of stress, the body has an increased release of hormones including epinephrine, cortisol, and inflammatory mediators from activation of the sympathetic nervous system (Evans, Lee, & Ruhlamn, 2015). This combination results in an increase in glucose throughout the body (Evans, Lee, & Ruhlman, 2015). Patients undergoing surgery may have periods of immobility after surgery. Immobility can cause higher blood glucose concentrations from decreased utilization of glucose (Evans, Lee, & Ruhlman, 2015). Medications, such as intravenous fluids containing dextrose, or steroids, may be administered during surgery (Evans, Lee, & Ruhlman, 2015). Both of these may increase a patient's blood

sugar. Due to this described phenomenon, a literature review was completed to determine the most effective methods to manage of diabetes in the surgical patient and prevent complications.

We will discuss the case of a 67-year-old male who is scheduled for a right knee replacement. This patient has a 43-year history of Type I Diabetes Mellitus. He has an insulin pump and uses 80-90 units of fast acting insulin each day, with average blood sugars around 125mg/dL. Keeping the patient's best interest in mind, this paper will explore the literature to determine the best way to manage his disease so that he may have the best outcome with his surgical procedure.

Case Report

On February 5th, 2016, a 67-year-old male, who will be referred to as J.H., presented to the clinic for a pre-operative physical for a right total knee arthroplasty. He has a history of osteoarthritis and is scheduled for his procedure on February 28th. J.H. stated the arthritis pain was constant in his right knee, and he rated it 5/10 on the pain scale. He reported the pain was worse with activity and was starting to give him balance issues, although he hadn't had any falls. He reported when he needed to do a lot of walking he would use a cane. Moving about the house he did not require any assistive devices. He had a left total knee arthroplasty done in December. He reported nausea on post-op day 1 that was controlled with antiemetic medication. Otherwise, he healed quickly and tolerated the procedure well with no complications.

His past medical history consisted of the following: type I diabetes since 1973, hyperlipidemia, hypertension, and osteoarthritis. He denied a history of any difficulty with anesthesia or any bleeding disorders. The medications he was taking were: Losartan 10mg daily, Novolog insulin pump (average of 80-90 units/day), Simvastatin 80mg daily, Aspirin 81mg daily, and Ibuprofen 3 tabs daily at night as needed for pain. His surgical history consisted of

ligament repairs in both knees, left total knee arthroplasty, appendectomy, two hernia repairs, and wrist surgeries.

J.H. was married with a supportive wife who will be there to assist him after surgery. He was still working as a construction worker as he was able to tolerate with his knee pain. He was a current smoker with a 30-pack-year history. He drank 1-2 cans of beer daily, with no history of alcohol abuse. He denied recreational drug abuse.

His family history was reviewed and was significant for a brother who had a stroke at age 69. His father died at 69 due to "heart problems." He denied any knowledge of anyone in the family having difficulty with anesthesia, or bleeding disorders. No other heart disease in the family, and no lung disease in the family.

For his review of systems, this patient reported feeling well despite his knee pain. He denied any recent colds, cough, or respiratory infections. No chest pain, shortness of breath, palpitations, or racing heart beats. He denied any history of poor wound healing, or changes to his skin including on his feet. He does foot exams on a daily basis. He denied nausea or vomiting. He has had constipation troubles in the past, particularly after his last arthroplasty, but it was relieved with stool softeners. He denied any bloody, black, or tarry stools. He has had no trouble with urination except for frequency. He denied dysuria or urgency. As stated in his history of presenting illness, he has had some difficulty with ambulating which required utilization of a cane. He did experience some numbness in his left leg, but stated he still had full sensation.

On physical examination, his vitals were found to be: blood pressure of 158/94, heart rate of 76, respiratory rate of 20, and afebrile at 98.8. His head was normocephalic, and atraumatic. Tympanic membranes were pearly grey bilaterally with some cerumen noted in ear canals. Oral

mucosa was pink and moist, with no lesions noted to oropharynx. No lymphadenopathy to head or neck.

Auscultation of his heart revealed S1 and S2 of regular rate and rhythm. No murmurs, clicks, or rubs were identified. No edema to bilateral lower extremities. His capillary refill on his toes were less than 3 seconds. Lung sounds were clear to auscultation bilaterally. Equal respiratory expansion, with nonlabored breathing.

Bowel sounds were normoactive. Abdomen was flat. No hepatosplenomegaly was identified. His abdomen was nontender to palpation.

Skin inspection revealed pale lower extremities, which were warm to the touch. No open lesions or color changes to his feet. On musculoskeletal examination, the patient was able to get onto the exam table with relative ease, and required no assistance. Deep tendon reflexes were 3+ to the upper extremities, 1+ in the right lower extremity, and unable to assess in his left lower extremity after two attempts. He was able to sense touch on bilateral lower extremities. His affect was appropriate and he appeared well groomed.

His assessment for the exam with corresponding ICD-10 codes were:

1. Pre-operative physical - Z01.81
2. Type I Diabetes Mellitus – E10
3. Hypertension – I10
4. Nicotine dependence, cigarettes – F17.21
5. Hyperlipidemia – E78.5

Recent laboratory work reviewed from surgical procedure in December. CMP, CBC, chest x-ray, and EKG were done for this pre-operative examination. The testing revealed a blood glucose of 96, which was within normal limits. His last A1C was drawn in November by his

physician managing his diabetes. His kidney function was normal with a BUN of 9, and creatinine of 0.8. His electrolytes and liver function studies were also within normal limits. His hemoglobin and hematocrit were 12 and 34.5% respectively, which will need to be monitored by orthopedics following surgery, but is not a concern for him going under anesthesia. His chest x-ray was within normal limits, showing no effusions or infiltrates. His EKG revealed he was in sinus rhythm with a rate in the 70s.

Patient was hypertensive at 158/94. He reported he does check his blood pressure at home 1-3 times per week and usually was in the 130s/80s. Patient requested to not make any changes to his medication at the time. Patient will return to clinic in a couple of days to have his blood pressure re-checked by a nurse. If his blood pressure was still elevated at that time, the plan was to increase his Losartan to 25mg and re-check his blood pressure one week later. Provider stressed the importance of good blood pressure control prior to going under anesthesia. Patient instructed to follow-up with his orthopedic surgeon regarding their wish about his Ibuprofen and Aspirin use prior to surgery. Patient instructed to quit smoking. He was to continue managing his diabetes as he normally did. This consisted of monitoring his blood sugar frequently throughout the day, and utilizing his pump to keep his glucose under control.

Literature Review

This section will review the current evidence regarding diabetic control in patients undergoing surgery, as J.H. has had this disease for 43 years. A literature search was done utilizing Pub Med, CINAHL, and Up-To-Date databases. Keywords used in the searches included “hyperglycemia,” “diabetes,” “surgery,” “complications,” “perioperative,” “management.” This section will review ten pieces of literature that contribute to determining

what the consequences are of hyperglycemia, and how to best manage blood glucose levels in these patients.

Consequences of Hyperglycemia

After a review of four studies, the most common complications from hyperglycemia were found within the surgical wound. Infections and poor wound healing were by far the most common complication. From those complications, surgical revisions seemed to be a common requirement. Having a patient undergo a second surgery in itself brings additional potential compromise. Infection was not limited to the wound however, as infection was found to be increased throughout the body including pneumonia, and urinary tract infections.

The first study reviewed by Stryker et. al (2013), evaluated blood sugar control in diabetics before and after total joint arthroplasty and the effects on wound healing. The initial patient sample had a total of 1,702 patients undergoing joint replacement in the years 2004-2011. From those, they looked specifically for anyone who had a wound complication within the next thirty days; specifically, hematomas, superficial infections, delayed healing, necrosis, or dehiscence of the wound.

Of those 1,702 patients, 237 were found to have wound complications in the thirty days following surgery. Exclusions for the study were made, including those who didn't have at least 48 hours of inpatient post-operative glucose levels available. This left a total of 41 patients. The study then matched a control group accounting for age, sex, procedure, approach, tourniquet use, and bone cement with and without antibiotic impregnation. After the control group was matched, a total of thirty patients were used for the study.

The group consists of twenty-two total knee arthroplasty patients, seven total hip arthroplasty patients, and a shoulder arthroplasty patient. What they found was patients with a

glucose level above 200 after surgery were at a higher risk of wound complications (Stryker et. al, 2013). They also correlated hemoglobin A1C greater than 6.7% to have a significant association with complications in the thirty days following the surgical procedure (Stryker et. al, 2013). The most common complication being delayed wound healing, drainage, contained and draining hematomas, and superficial infections (Stryker et. al, 2013). From this study, they allow you to make the conclusion that better glucose control leads to decreased complications. However, this ended up being a small study of only thirty patients.

A retrospective study done in 2011 reviewed 55,408 patients with diabetes who had non-cardiac surgeries between the years 1999-2004. Relating to our case at hand, 2,496 patients were having total knee arthroplasties (King, Goulet, Perkal, & Rosenthal, 2011). These patients were part of the Veterans Affairs patient population in the Connecticut Healthcare System. Fifty-one percent of all patients had pre-operative blood glucose levels greater than 150 mg/dL. Of those patients with pre-operative hyperglycemia, 72% had post-operative blood glucose levels greater than 150 mg/dL (King, Goulet, Perkal, & Rosenthal, 2011). That percentage is high, making the outcomes for those patients more intriguing.

Infections developed in eight percent of that population. The highest offender was superficial skin infections, followed by urinary tract infections, pneumonia, deep skin infections, and sepsis (King, Goulet, Perkal, & Rosenthal, 2011). There wasn't a statistical significance found between blood glucose levels maintained between 111-149 mg/dL and infection rates. Those with the highest rates of infections were noted to have post-operative glucose levels of 150-250 mg/dL (King, Goulet, Perkal, & Rosenthal, 2011). This study did not find that the pre-operative glucose levels and the hemoglobin A1C to have effects on infection rates (King, Goulet, Perkal, & Rosenthal, 2011). Interestingly, a 10.3% increase in perioperative rates were

found in those with glucose levels less than 80 mg/dL (King, Goulet, Perkal, & Rosenthal, 2011). Those in the blood glucose range of 80-110 mg/dL had the least amount of post-op infections at 6.7%, followed by those with blood glucose levels maintained at 111-149 had a 7% rate of infection (King, Goulet, Perkal, & Rosenthal, 2011). This leads to a conclusion of better glucose control also leading to fewer complications, although hemoglobin A1C was not found to be a factor here as it was in the previous study.

The study did have drawbacks, as it was predominately white (67% of the population) males (97% of the population). These patients did have other risk factors that were taken into account such as age, cigarette smoking, alcohol abuse, steroid use within thirty days of surgery, cancer, radiation therapy and chemotherapy (King, Goulet, Perkal, & Rosenthal, 2011). It's important this bias was addressed to not skew the results of the study.

A separate study by Watts et. al, (2016) was done to review the outcomes of insulin-dependent diabetics (IDD) who underwent a total knee joint arthroplasty. They compared the results to non-diabetics, and type II diabetics who were not insulin-dependent. The study included 17 years of data from one facility, with a total of 1,284 in the non-diabetic group, 530 in the diabetic group, and 164 in the insulin-dependent diabetic group. All of these patients were classified as morbidly obese with a BMI > 40. They excluded type I diabetics for the study.

They found that the insulin-dependent diabetics had higher rates of prosthetic joint infections, surgical revisions, and re-operation requirements compared to the diabetic and non-diabetic group. (Watts et. al, 2016). From the insulin-dependent patients, those requiring surgical revision were mostly under the age of 65. Twenty percent of the IDD patients required re-operation, compared to only twelve percent of both the diabetic group and non-diabetic group (Watts et. al, 2016). Infection rates were found in eight percent of the IDD group, compared to

four percent in both the non-diabetic group and diabetic group (Watts et. al, 2016). Overall, survivor rates were lowest in the insulin-dependent group (Watts et. al, 2016). The take-away message here is those who depend on insulin to control their diabetes had more complications.

The next analysis looked at a retrospective cohort study which examined glucose control in surgical patients in the state of Washington. It evaluated the outcome of insulin administration to patients with hyperglycemia, with or without a diagnosis of diabetes, prior to having elective colorectal or bariatric surgery. The study spanned over a five-year period in 47 different institutions, and a total of 11,633 patients. The level of hyperglycemia was defined as anything over 180 mg/dL. The authors found the effects of hyperglycemia on surgical patients to be significant. Patients experienced a two-fold increased risk of infections, increased in-hospital mortality, and increased requirement of re-operative interventions (Kwon et. al, 2013). The study also determined that for every 10-unit increase in blood glucose level, there was a seven percent increase in the patient's odds of contracting an infection (Kwon et. al, 2013). The highest odds of infection found in those who were hyperglycemic on post-op days 1-3, compared to those who were hyperglycemic just on the day of surgery (Kwon et. al, 2013). This compounds on the previous information that good glucose control is imperative to decrease post-operative complications.

From this review, it's clear that maintaining patient's glucose levels in the range of 110-180mg/dL is imperative to prevent the numerous complications outlined above. Keeping tight control of levels below 110 mg/dL didn't draw a benefit in any of the studies reviewed.

Management of Blood Glucose Levels

From the review of literature, blood glucose levels should be maintained between 110-180mg/dL for the best outcomes in the patient. Diligent glucose monitoring should be

performed, starting before surgery, continuing during surgery, and throughout the hospital stay. Patients glucose levels are better controlled with an insulin regimen. This could be either maintaining use of an existing insulin pump, or a basal and bolus regimen which more closely mimics the insulin release in a non-diabetic patient. With use of insulin, watching for episodes of hypoglycemia is important, which is another important reason for close monitoring. Evaluating A1C prior to surgery had mixed reviews in terms of usefulness. Generally, if the patient's glucose levels are extremely elevated, or the patient is in ketoacidosis, surgery should be postponed if possible. Using a standard plan of care that is followed for every patient is encouraged.

J.H. was a type I diabetic with an insulin pump. As he readies for surgery, the literature supports continuing insulin during surgery, perhaps even using his pump. Reviewing an article from the Current Diabetes Report by Thompson et. al (2016) stated there were no current standards in perioperative care regarding insulin pump use, but research had been ongoing. This article supported the use of incorporating care process models (CPM), which was a protocol used for patients undergoing elective surgery under general anesthesia. The general guideline of this protocol included treating patients with insulin if their blood glucose rose over 140 mg/dL. Blood glucose was checked prior to surgery, during surgery, and in the post-anesthesia care unit (PACU). If the surgical procedure was longer than 60 minutes, the patient's blood glucose was monitored hourly. By incorporating a CPM, glucose monitoring in the perioperative period in diabetics were increased, as well as increased insulin administration in those with glucose levels above 140mg/dL (Thompson et. al, 2016). Over a 12-month period of utilizing this CPM, they were found to have lower blood glucose levers in the pre-operative period, and in the PACU, with no increase in hypoglycemic events (Thompson et. al, 2016). This suggested if facilities

utilized protocols, there would be improvement of glucose monitoring, allowing for quicker recognition of hypo or hyperglycemia. More studies should be done regarding the safety of using patient's insulin pumps, but this information was promising.

Another study looked at the comparison of using a sliding scale insulin (SSI) regimen, versus a basal/bolus insulin regimen for surgical patients. Many facilities have turned towards discontinuing patients home diabetic agents when they're admitted to the hospital, and using SSI instead (Umpierrez et. al, 2011). However, successful results from the use of SSI were lacking (Umpierrez et. al, 2011). The goal of therapy in this study was to maintain fasting and pre-meal glucose levels between 100-140 mg/dL. The study concluded that better glycemic control was maintained when the patient was administered a basal/bolus insulin regimen, instead of the SSI (Umpierrez et. al, 2011). Twelve percent of the patients held blood sugars over 240 mg/dL despite increasing the SSI to the maximum scale (Umpierrez et. al, 2011). Those on SSI incidentally were also found to have higher wound infection rates (30.8% vs 7.5%) (Umpierrez et. al, 2011). This concludes that switching the patient over to a basal/bolus treatment regimen will result in better glucose control, which could result in decreased complications.

An observational study by Frisch et. al (2010), was done on general surgery patients in a Georgia hospital over a 6-month time span. After excluding patients with multiple admissions, and those over the age of 90, they reviewed 3,184 patients. Six-hundred-forty-three of those patients were known diabetics. Non-diabetic patients had lower blood sugars on the day of surgery, as you would suspect, with an average of 113 mg/dL. Diabetic patients had an average blood glucose of 145 mg/dL on the day of surgery. The day following surgery, diabetic averages were 155 mg/dL, compared to 132 mg/dL in non-diabetics (Frisch et. al, 2010). Forty percent of

the total number of patients had blood glucose levels above 140 mg/dL. Of that group, 75% of those patients maintained blood sugars between 141-180 mg/dL (Frisch et. al, 2010).

The researchers found that those who were non-diabetic with hyperglycemia during the perioperative phase had higher levels of mortality (Frisch et. al, 2010). Hyperglycemic patients also had higher rates of pneumonia, urinary tract infections, skin infections, and acute renal failure (Frisch et. al, 2010). These complications aren't to be made light of, and could pose significant threats to patients. This also draws attention to the fact that even if patients don't have diabetes, hyperglycemia can lead to poor outcomes.

An article by Evans, Lee, & Ruhlman (2015) reviewed glucose management in surgical patient, and recommended a goal blood glucose of 140-180mg/dL. Through their examination of the research, there were higher episodes of adverse effects with hypoglycemia with tighter glucose control of 80-110 mg/dL, and little to no benefit of having such tight control (Evans, Lee, & Ruhlman, 2015). The hypoglycemic levels had poor outcomes especially in the pediatric and traumatic brain injury patients (Evans, Lee, & Ruhlman, 2015). They also recommend intravenous insulin therapy versus subcutaneous insulin therapy in the following cases: type 1 diabetics who are NPO, any patient during the perioperative period, or in labor having a baby, any patient in ICU with glucose levels over 180mg/dL, poorly controlled glucose ranges with subcutaneous insulin therapy, any cardiac surgery patient, post myocardial infarction patients with levels greater than 180mg/dL, and those presenting with diabetic ketoacidosis (Evans, Lee, & Ruhlman, 2015, p. 349). They found no data to support using intravenous therapy in non-critically ill patients, so other patients who do not fall into the above categories may be treated with subcutaneous insulin (Evans, Lee, & Ruhlman, 2015). This evidence supports not having

"over-control" of glucose levels. For our patient at hand, possibly the use of intravenous insulin for better control.

Looking at another article reviewing management of diabetic patients undergoing surgery by Miller & Richman (2016) provided a different set of guidelines. In contrast to one of the previous studies reviewed, this article did correlate findings of A1C greater than nine percent with associated complications (Miller & Richman, 2016). They recommended consideration of delaying surgery for those patients (Miller & Richman, 2016). They also recommended delaying surgery for patients in diabetic ketoacidosis (Miller & Richman, 2016). They recommended scheduling diabetics as the first surgical cases of the day if possible, as it may allow decreased interference with the patient's regular blood glucose management depending on the length of procedure (Miller & Richman, 2016). Blood glucose checks should be done in the holding area before surgery to detect hypo or hyperglycemia, and treated as needed with either dextrose IV fluids or insulin (Miller & Richman, 2016). If glucose levels were stable, they should be checked hourly during surgery, or more frequently if their glucose had been unstable (Miller & Richman, 2016).

Pertaining to this patient case with an insulin pump, Miller and Richman (2016), recommend consulting endocrinology prior to surgery on those wishing to use their insulin pump during surgery. Most procedures may allow patients to continue to use their pump with prior guidance from the endocrinologist. However, those who are having cardiac surgery, open abdominal surgeries, or vascular surgery should be switched to intravenous therapy instead (Miller & Richman, 2016). The site of the pump should be moved away from the site of surgery (Miller & Richman, 2016). Per this study, J.H. would qualify for use of his insulin pump versus switching to intravenous therapy.

A study by Nair, Horibe, Neradilek, Newman & Peterson, (2016) examined the effects of managing glucose levels during surgery and the outcomes of glucose in the post-operative period. It was a retrospective cohort study of 2,440 non-cardiac surgical patients from 2011-2013. These patients were either diagnosed with diabetes, or had glucose levels greater than 140mg/dL during surgery. They compared a group that had insulin initiated when glucose levels reached 140mg/dL, and a group that had insulin started once they reached 180mg/dL. Overall they found that if they started giving the patients insulin when their glucose reached levels above 140mg/dL during surgery, around 59% of the patients had hyperglycemia in the first 24 hours post-operatively (Nair, Horibe, Neradilek, Newman, & Peterson, 2016). That number is compared to the 70% of the 180mg/dL group of patients that experienced 24-hour hyperglycemia (Nair, Horibe, Neradilek, Newman, & Peterson, 2016). They experienced hypoglycemia levels in both groups. The 140mg/dL group had a 1.8% post-operative hypoglycemia rate, and the 180mg/dL group had a 2.2% rate, with conclusions of no statistical difference between the two groups (Nair, Horibe, Neradilek, Newman, & Peterson, 2016).

This study recommended instituting intra-operative insulin for patients when their blood glucose went above 140mg/dL to decrease the risks of being hyperglycemic in the post-operative period (Nair, Horibe, Neradilek, Newman, & Peterson, 2016). Recommendations included watching carefully for hypoglycemia, especially in the post-operative period, and continuous monitoring of the patient (Nair, Horibe, Neradilek, Newman, & Peterson, 2016).

This review provides evidence to assist with managing diabetic surgical patients. It makes sense to monitor blood sugars closely, looking for hyper or hypoglycemia, especially while the patient is under anesthesia. Implementing a facility protocol may assist with improving scheduled monitoring of glucose levels. By doing this, catching episodes of hypo or

hyperglycemia may occur more quickly than without a protocol requiring diligent monitoring. As the evidence suggests, preventing these extreme alterations of normal will improve patient outcome. Insulin, which may have a "bad" connotation to many patients, may improve outcomes for patients. Using insulin versus a pill allows a greater capability to fine-tune glucose levels. This information also had some suggestions to monitor glucose levels of all surgical patients, having higher mortality rates in non-diabetics with hyperglycemia.

Providers are equipped with the ability to manage these patients, and have the evidence to back these decisions. Implementing change into practice is the next step. With the mountain of evidence regarding the importance of the outcome to the patient, implementation into practice should be done in timely fashion.

Learning Points

- Diabetics have special considerations for surgery. Even those who are not diagnosed with diabetes but have a high blood sugar preoperatively, may require special considerations to avoid complications post-operatively
- Glycemic target for surgical patients is most consistently reported between 110-180 mg/dL
- Blood sugars should be monitored before, during, and after surgery, and throughout the hospital stay for diabetics
- Keeping blood glucose levels under 180mg/dL has shown improved patient outcomes avoiding complications such as skin infections, pneumonia, sepsis, urinary tract infections, longer hospital stays, repeat surgical interventions, and overall mortality
- Practitioners should determine if switching to a basal/bolus insulin regimen instead of a sliding-scale protocol during a time of acute stress would benefit the patient, as well as

consider use of intravenous insulin therapy if it's appropriate. Some patients may be able to use their insulin pump during surgery with consideration and consultation from an endocrinologist

References

American Diabetes Association. (2016). *Statistics about diabetes.* Retrieved from http://www.diabetes.org/diabetes-basics/statistics/?loc=db-slabnav

Centers for Disease Control. (2012). *National hospital discharge survey.* Retrieved from ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHDS/NHDS_2010_Documentation.pdf.

Dhatariya, K., Levy, N., & Hall, G.M. (2016). The impact of glycaemic variability on the surgical patient. *Anaesthesia and medical disease, 29*(00), 1-8. doi:10.1097/ACO.0000000000000326

Evans, C.H., Lee, J., & Ruhlman, M.K. (2015). Optimal glucose management in the perioperative period. *Surgical Clinics of North America, 95,* 337-354. doi:http://dx.doi.org/10.1016/j.suc.2014.11.003

Frisch, A., Chandra, P., Smiley, D., Peng, L., Rizzo, M., Gatcliffe, C., Hudson, M., Mendoza, J., Johnson, R., Lin, E., Umpierrez, G. (2010). Prevalence and clinical outcome of hyperglycemia in the perioperative period in noncardiac surgery. *Diabetes Care, 33*(8), 1783-1788

Jackson, M.J., Patvardhan, C., Wallace, F., Martin, A., Yusuff, H., Briggs, G., & Malik, R.A. (2016). Perioperative management of diabetes in elective patients: A region-wide audit. *British Journal of Anaesthesia, 116*(3), 1-6, doi: 10.1093/bja/aev554

King, J.T., Goulet, J.L., Perkal, M.F., & Rosenthal, R.A. (2011). Glycemic control and infections in patients with diabetes undergoing noncardiac surgery, *Annals of Surgery, 253*(1), 158-164. doi: 10.1097/SLA.0b013e3181f9bb3a

Kwon, S., Thompson, R., Dellinger, P., Yanez, D., Farrohki, E., & Flum, D. (2013). Importance of perioperative glycemic control in general surgery. *Annals of Surgery, 257*(1), 8-14

Mayo Clinic. (2015). *Hyperglycemia in diabetes.* Retrieved from http://www.mayoclinic.org/diseases-conditions/hyperglycemia/basics/complications/con-20034795

Miller, J.D., & Richman, D.C. (2016). Preoperative evaluation of patients with diabetes mellitus. *Anesthesiology Clinics, 34*(1), 155-169.

Nair, B.G., Horibe, M., Neradilek, M.B., Newman, S., & Peterson, G.N. (2016). The effect of intraoperative blood glucose management on postoperative blood glucose levels in noncardiac surgery patients. *Anesthesia and Analgesia, 122*(3), 893-902. doi: 10.1213/ANE.0000000000001100.

Stryker, L.S., Abdel, M.P., Morrey, M.E., Morrow, M.M., Kor, D.J., & Morrey, B.F. (2013). Elevated postoperative blood glucose and preoperative hemoglobin A1C are associated with increased wound complications following total joint arthroplasty. *The Journal of Bone & Joint Surgery, 95*(9), 808-814. doi: 10.2106/JBJS.L.00494

Thompson, B.M., Stearns, J.D., Apsey, H.A., Schlinkert, R.T., & Cook, C.B. (2016). Perioperative management of patients with diabetes and hyperglycemia undergoing elective surgery. Current Diabetic Report, 16(2), doi: 10.1007/s11892-015-0700-8

Umpierrez, G.E., Smiley D., Jacobs, S., Peng, L., Temponi, A., Mulligan, P., Umpierrez, D., Newton, C., Olson, D., & Rizzo, M. (2011). Randomized study of basal-bolus insulin therapy in the inpatient management of patients with type 2 diabetes undergoing general surgery (RABBIT 2 surgery). *Diabetes Care, 34,* 256-261.

Watts, C.D., Houdek, M.T., Wagner, E.R., Abdel, M.P., & Taunton, M.J. (2016). Insulin

dependence increases the risk of failure after total knee athroplasty in morbidly obese patients. *The Journal of Arthroplasty, 31,* 256-259.