Preoperative Hemoglobin A1C level and Preoperative Capillary Blood Glucose Level as Predictors of Clinical Outcomes of Patients who Underwent Low to Intermediate Risk, Non- Cardiovascular Surgical Procedures*

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ABSTRACT

Background: Hyperglycemia has been associated with poor clinical outcomes in both diabetic and non-diabetic patients. The aim of this study is to determine if preoperative hemoglobin A1C level and capillary blood glucose level can be used as predictors of clinical outcomes of patients who underwent low to intermediate risk, non-cardiovascular surgical procedures.

Methodology: A Single Center Cohort Retrospective Study was conducted and data were obtained from lists of patients who underwent low to intermediate risk, non-cardiovascular surgical procedures admitted for more than one day from January 2016 to December 2016. Chart review was done and provided information on demographics, presence and status of co-morbidities, availability of hemoglobin A1C ninety days prior to surgery or pre-operative capillary blood sugar, and surgical outcomes (length of hospital stay, surgical site infection, postoperative sepsis, acute renal failure or mortality). Comparison of outcomes among different levels of A1C was analyzed using Analysis of Variance and Fisher's exact test. Comparison of outcomes between normal and elevated CBG was analyzed using independent t-test and Fisher's exact test. The level of significance was set at 5%.

Results: A total of one hundred forty five patients were included in the final analysis. Of which, 69 patients had an HbA1C available within 90 days prior to surgery with the mean A1C at 8.04% ± 2.48%, and 93 patients had pre-operative capillary blood glucose with a mean value of 125.16 ± 55.94. Longer hospital stay was shown in patients with A1C level of 8-10% (4.7 ± 5.16 days). However, the association is insignificant with a *P* value of 0.1412. There were no significant difference in the length of hospital stay in patients with CBG level of <140mg/dL and ≥140mg/dL, with a mean value of 2.9014 ± 1.7167 days and 2.8636 ± 1.2834 days, respectively. (*P* = 0.9244) .There were too few events to meaningfully evaluate for secondary outcomes.

Conclusion: Our study suggests that neither preoperative capillary blood glucose level nor hemoglobin A1C is significantly associated with longer hospital stay. But the findings on patients with hemoglobin A1C values of 8.0% - 10% warrants further investigation. Providing a preoperative intervention to improve glycemic control in individuals with hemoglobin A1C values of 8.0% - 10% may improve surgical outcomes, but prospective studies are needed.

**3rd Place, 2018 Philippine Medical Association Original Research Presentation Contest*

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INTRODUCTION

Several parameters are included in the pre-operative evaluation of patients who will undergo surgical procedures, which includes assessment of co-morbidities, such as diabetes, and laboratory workups such as fasting blood sugar. Diabetes Mellitus, in particular, is a known risk factor for postoperative complications including infection and mortality primarily because uncontrolled hyperglycemia is associated with factors that can potentially affect the healing process of the surgical patients. In the review of literature, it has been shown that inadequate glycemic control increases morbidity and mortality. However, not all patients that will undergo low and intermediate risk surgical procedures have measures of glycemic control, especially if they are not known diabetic or do not have risk factors to develop diabetes.

The underlying mechanisms relating hyperglycemia to adverse clinical outcomes postoperatively is not completely understood. It has been suggested that elevated blood glucose levels may lead to vascular and immune system dysfunctions by impairing the neutrophil function and causing an overproduction of reactive oxygen species and inflammatory mediators, which contribute to direct cellular damage.

In the review of studies done on pre-operative hyperglycemia, it has been suggested that acute hyperglycemia, measured by random capillary blood glucose, is associated with poor clinical outcomes in patients with and without diabetes. However, there were few studies which examined the relationship between chronic hyperglycemia represented by pre-operative Hemoglobin A1C level and surgical outcomes. The American Diabetes Association has not provided recommendation for the optimal A1C in patients undergoing elective surgery but generally recommends an A1C less than 7% to avoid long term complications especially in patients with diabetes. Current evidence points toward a recommended preoperative A1C between 7% and 8.5%. Length of hospital stay postoperatively is a relative indicator of both patient morbidity and cost of care as each additional day in the hospital costs more than 2,000 pesos in our institution. This study was conducted to evaluate whether preoperative hemoglobin A1C level and capillary blood glucose level can be used as predictors of clinical outcomes of patients, who underwent low to intermediate risk, non-cardiovascular surgical procedures. The primary outcome is the length of hospital stay.

Research Question

Can preoperative hemoglobin A1C level and preoperative capillary blood glucose level be used as predictors of clinical outcomes of patients who underwent low to intermediate risk, non-cardiovascular surgical procedures?

RESEARCH OBJECTIVES

General Objectives

- To determine if preoperative hemoglobin A1C level and preoperative capillary blood glucose level can be used as predictors of clinical outcomes of patients who underwent low to intermediate risk, non-cardiovascular surgical procedures

Specific Objectives

- To determine the HbA1C level of patients who underwent low to intermediate risk, non-cardiovascular surgical procedures
- To determine the preoperative capillary blood glucose level of patients who underwent low to intermediate risk, non-cardiovascular surgical procedures
- To determine the association between hemoglobin A1C and capillary blood glucose levels of patients with length of hospital stay, surgical site infections, postoperative sepsis, renal failure and mortality

SIGNIFICANCE OF THE STUDY

According to some literature, more severe and prolonged hyperglycemia is likely to cause more severe damage than acute hyperglycemia alone. Other studies said otherwise. Given the conflicting results, with the increasing number of patients undergoing surgical procedures, it is timely and relevant to do this study to know if glycemic control, whether it is acute or chronic, is adequately addressed in our institution. The data that were gathered from this study were important because they will serve as a guide in the improvement of management of hyperglycemia preoperatively. Given the higher probability of postoperative complications in hyperglycemic patients, possible interventions targeted toward decreasing these complications may lead to improved surgical outcomes and minimize health care costs.

Definition of Terms

Low Risk Non-vascular Surgeries: procedures that have reported cardiac risk generally <1% which include endoscopic procedures, superficial procedures, cataract surgery, breast surgery.

Intermediate Risk Non-vascular Surgeries: procedures that have reported cardiac risk generally <5% which include intraperitoneal and intrathoracic surgery, head and neck surgery, orthopaedic surgery, prostate surgery.

High Risk Surgeries: procedures that have reported cardiac risk of >5% which include emergent major operations, particularly in the elderly, aortic and other major vascular surgery, peripheral vascular surgery, anticipated prolonged surgical procedures associated with large fluid shifts and/or blood loss.

Pre-operative Hemoglobin A1C: Hemoglobin A1C level that was done within 90 days prior to surgical procedure.

Pre-operative Capillary Blood Glucose: Random Capillary Blood Glucose that was done on the day of surgical procedure.

Postoperative Renal Failure: A 0.3 mg/dL or 50% or higher change in serum creatinine from baseline or a reduction on urine output of less than 0.5mL/kg/hr over a six-hour interval, within a 48-hour postoperative period.

Hospital Length of Stay: The number of days the patient stayed in the hospital postoperatively.

REVIEW OF RELATED LITERATURE

Hyperglycemia is associated with impaired neutrophil phagocytic activity, increased inflammation and oxidative stress, and poor endothelial function. These factors can potentially affect the healing process after surgical procedures. According to the study done by Raju, et.al, hyperglycemia has been associated with poor clinical outcomes in both diabetes and nondiabetes patients. Diabetes patients are more likely to present as surgical patients with glycemic control challenges. (Raju, 2009).

In diabetic and nondiabetic patients, the stress of the surgery causes a hyperglycemic response characterized by increased catecholamines, growth hormones, glucagon, and cortisol levels, with a concomittant depression in insulin levels. Hepatic glycogenolysis and gluconeogenesis, along with reduced insulin secretion and tissue insulin resistance, further contribute to the hyperglycemia. Surgical stress also increases the prothrombotic state, which may present issue in patients with diabetes; thus diabetes is an important risk factor for perioperative cardiac complications and death. (Raju, 2009).

Diabetes mellitus is rapidly increasing worldwide but the greatest increase is expected in developing countries including the Philippines, which is one of the world's emerging diabetes hotspots, ranked in the top 15 in the world for diabetes prevalence. According to the International Diabetes Federation Western Pacific, 415 million people have diabetes in the world and almost 153 million people in the Western Pacific region, and by 2040 this will rise to 215 million. According to data lifted from the WHO Western Pacific Region, the prevalence of diabetes in the Philippines reached to a total of 2,770,000 cases reported last 2000 and by the 2030, it is expected to rise to 7,798,000. There were 3.5 million cases of diabetes in the Philippines in 2015. With a 6.1% prevalence of diabetes in adults aged 20-79 years, approximately 204.2 USD cost per person with diabetes, total of 51,127 number of deaths in adults due to diabetes, and 1,840.6 number of cases of diabetes in adults that are undiagnosed.

In the study done by Underwood, et. al, acute hyperglycemia during the perioperative period, noted on the day of surgery, within 24 - 48 hours of surgery and during the entire hospital stay, is also associated with poor clinical outcomes in patients with and without diabetes (Underwood, et.al, 2014).

It was noted in the 2014 ESC-ESA Guidelines on Non-Cardiac Surgery: Cardiovascular Assessment and Management, a significant number of surgical patients will have previously undiagnosed pre-diabetes, and are at increased risk of unrecognized peri-operative hyperglycemia and the attendant adverse outcomes. Although there is no evidence that screening low- or moderate-risk adults for diabetes improves outcomes, it may reduce complications in high-risk adults.

Chronic hyperglycemia noted with high hemoglobin A1C is a clear predictor of long term complications of diabetes and is the main target for glycemic control in diabetes but it is unclear whether it has an adverse effect on surgical outcomes over and above acute perioperative and whether standards of care that address elevated A1C levels prior to surgery would improve clinical outcomes. Few studies have examined the relationship between preoperative A1C level and surgical outcomes. A study in patients undergoing coronary artery bypass surgery showed an association between high A1C values and surgical complications, including mortality, cerebrovascular accidents, and deep sternal wound infection. However, high A1C values in cardiac surgery patients may be associated with more severe primary cardiac disease; therefore, these data are probably not applicable to non-cardiac surgery patients. (Underwood, et.al, 2014)

In the review of related literature of the study done by Raju, a recent retrospective analysis showed that diabetic patients with elevated HbA1c had an augmented adverse event rate and higher 30-d mortality after cardiac procedures. In another small cohort of presumably non-diabetic patients, elevated HgbA1c concentrations were associated with an increased risk of complications after vascular surgery. If it holds true that poor preoperative glycemic control adversely affects outcomes of diabetic patients, it remains to be studied whether the timely improvement of glycemic control before surgery reduces complications seen in medical patient population. (Raju,et.al, 2009)

A high blood glucose level is one component of the anesthetic care that may need more stringent control, as evidence by many studies, but tight control may also have negative outcomes as shown in the data from the Normoglycemia in Intensive Care Evaluation Survival Using Glucose Algorithm Regulation (NICE-SUGAR) Study. It has been suggested that a blood glucose of <150mg/dL is generally considered clinically acceptable, although not always easily achieved, this is explained by the many factors that can lead to hyperglycemia or hypoglycemia. (Raju,et.al, 2009)

Furthermore, the risk of postoperative infection was found to be directly related to the perioperative blood glucose values rather than hemoglobin A1C. Postoperative hyperglycemia in diabetes or nondiabetes patients has been associated with an increased risk of 30 day postoperative infectious complications and a longer hospital stay. Every 40mg/dL increase in postoperative glucose led to a 30% increase in risk of postoperative infection. (Raju,et.al, 2009)

According to the 2014 ESC-ESA Guidelines on Non-Cardiac Surgery: Cardiovascular Assessment and Management, it is well established that surgery in patients with diabetes is associated with longer hospital stay, greater use of healthcare resources and higher perioperative mortality. Elevated levels of glycosylated hemoglobin - a marker of poor glycemic control- are associated with worse outcomes in surgical and critical care patients. More recently, the emphasis has shifted from diabetes to hyperglycemia, where new-onset hyperglycemia, compared with hyperglycemia in known diabetics, may hold a much higher risk of adverse outcome. Oxidative stress, a major cause of macrovascular disease, is triggered by swings in blood glucose, more than by sustained and persistent hyperglycemia. Minimization of the degree of glucose variability may be cardioprotective, and mortality may correlate more closely with blood glucose variability than mean blood glucose per se.

According to the recent recommendations of 2014 ESC-ESA Guidelines on Non-Cardiac Surgery: Cardiovascular Assessment and Management, post operative prevention of hyperglycemia with the targeting levels at least <180mg/dL by intravenous insulin therapy is recommended in adults after high risk surgery that requires admission to the intensive care unit, and was given Class 1b recommendations. It is further recommended that, in patients at high surgical risk, clinicians should consider screening for elevated HbA1C before major surgery and improving pre-operative glucose control, and intraoperative prevention of hyperglycemia with insulin may be considered, with Class IIa level C and Class IIb level C recommendations, respectively. Postoperative targets of <110mg/dL are not recommended with Class III recommendation.

RESEARCH METHODOLOGY

Study Design: This is a Retrospective Cohort Study of patients who underwent low to intermediate non-cardiovascular surgeries from January 2016 to December 2016. Charts and recorded data of patients were reviewed.

Study Setting: The study was conducted at a tertiary care hospital, at Mary Mediatrix Medical Center.

Time Frame: 1 year

Study Duration: Chart review covered patients who underwent surgical procedures admitted on January 2016 to December 2016. The study were conducted for 6 months, 3 months were allotted for data gathering and 3 months for the analysis of the data.

Study Population:

Inclusion Criteria

1. Patients, 18 years old and above, that were admitted for more than 1 day at Mary Mediatrix Medical Center from January 2016 to December 2016 who underwent low and intermediate risk surgical procedures. Subjects were identified and filtered using the Hospital Bizbox System ver. 7.0
2. All individuals with an HgbA1c measurement within 90 days before surgery were included in the analysis.
3. Randomly selected patients with pre-operative capillary blood glucose level were also included.

Exclusion Criteria:

1. Patients who underwent cardiovascular surgical cases and high risk cases
2. Individuals undergoing same day surgeries
3. If an individual underwent multiple surgeries, only the first surgery was taken into account.
4. Individuals who underwent endoscopic and ophthalmologic surgeries

Study Maneuver

Patients that are included in the study were patients that were admitted for more than one day at Mary Mediatrix Medical Center from January 2016 to December 2016 who underwent low to intermediate risk procedures. Lists of patients were obtained from the General Database provided by the Insitution's IT Department. Subjects were filtered using the Hospital Bizbox System ver. 7.0.

Data for this study were obtained from the Medical Records Department. Chart review of patients' demographics, co-morbidities, types of surgery, level of HgbA1C and preoperative capillary blood glucose, were done. Patients' study data were coded and a unique code number were given to each chart that was reviewed in the study. More specifically, personal identifying information, including hospital unit numbers, subject names/initials, phone numbers, and addresses were removed. (*See Appendix A for the Data Collection Form*)

All individuals with an HgbA1c measurement within 90 days before surgery were included in the study. Randomly selected patients with pre-operative capillary blood glucose level were also included.

Upon identification of patients with hemoglobin A1C, they were placed on four categories, namely: patients with HgbA1C <6.5%; patients with HgbA1C ≥6.5% - <8%; patients with HgbA1C 8-10%; patients with HgbA1C >10% for comparison of clinical outcomes. Patients with pre-operative capillary blood glucose were grouped into: patients with CBG <140mg/dL and patients with CBG ≥140mg/dL. Hospital length of stay was designated as the primary outcome thus, patients undergoing same day surgery were excluded. Other secondary outcomes such as surgical site infection, postoperative sepsis, renal failure, death during hospitalization were noted.

Statistical Analysis:

Data analysis was performed in Stata SE version 13. Quantitative variables were summarized as mean and standard deviation, while qualitative variables were tabulated as frequency and percentage. Comparison of outcomes among different levels of A1C was analyzed using Analysis of Variance for quantitative variables while Fisher's exact test for qualitative variables. Comparison of outcomes between normal and elevated CBG was analyzed using independent t-test for quantitative variables while Fisher's exact test for qualitative variables. The level of significance was set at 5%.

Ethical Considerations:

All data that were used for the study were obtained after the Institutional Review Board approved the protocol. (*See Appendix C for the copy of Certificate of Approval*). All study data regarding the patients were coded and a unique code number were given to each patient's chart that was reviewed in the study. More specifically, personal identifying information, including hospital unit numbers, subject names/initials, phone numbers, and addresses were removed. The requirement for written informed consent was waived.

Results

Excluding same day surgeries, high risk, cardiovascular, and endoscopic surgeries, there were a total of eight hundred ten patients who underwent low to intermediate risk procedures from January 2016 to December 2016. Patients were randomized and a total of 145 patients were included in the final analysis. There were 56 (38.62%) patients who underwent low risk procedures and 89 (61.38%) patients who underwent intermediate risk procedures (*see Figure 1*). Of which, 69 patients had an HbA1C available within 90 days prior to surgery with the mean A1C at 8.04% ± 2.48%, and 93 patients had pre-operative capillary blood glucose with a mean value of 125.16 ± 55.94mg/dL. Majority of patients underwent laparoscopic cholecystectomy and wound debridement. (*see Figure 2*)

Baseline characteristics of patients are shown in Table 1. The mean age was 53 years old, 63(43.45%) are males, 82 (56.55%) are females. Mean body mass index is 25.23kg/m2. Co-morbidities are as follows, diabetes mellitus type 2 (42.07%), hypertension (36.55%), bronchial asthma (2.76%), thyroid disease (4.83%), malignancy (0.69%) and others (6.21%). Only 26.90% were smokers and 22.07% were alcoholic beverage drinkers. Based on the data gathered, most of the diabetic patients underwent wound debridement and majority of non-diabetic patients underwent laparoscopic cholecystectomy.

Table 1: Patients' Baseline Characteristics and Surgical Outcomes

Baseline Characteristics (N = 145)	**Mean ± Standard Deviation or n (%)**
Age (years)	53.83 ± 15.68
Sex	
Male	63 (43.45%)
Female	82 (56.55%)
Body Mass Index (in kg/m2)	25.23 ± 4.04
Co-Morbidities	
Hypertension	53 (36.55%)
Diabetes Mellitus Type 2	61 (42.07%)
Chronic Obstructive Pulmonary Disease	0
Bronchial Asthma	4 (02.76%)
Malignancy	1 (00.69%)
Thyroid Disease	7 (04.83%)
Others	9 (06.21%)
Smoker	39 (26.90%)
Alcoholic Drinker	32 (22.07%)
Low Risk Procedures	56 (38.62%)
Intermediate Risk Procedures	89 (61.38%)
Capillary Blood Glucose Pre-operative (mg/dL) (n = 93)	125.16 ± 55.94
Hemoglobin A1C levels (%) (n = 69)	8.04% ± 2.48%

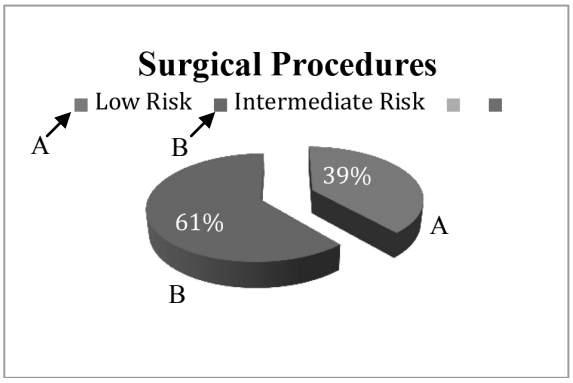

Figure 1: Percentage of Patients who Underwent Surgical Procedures

Breakdown of Surgical Procedures

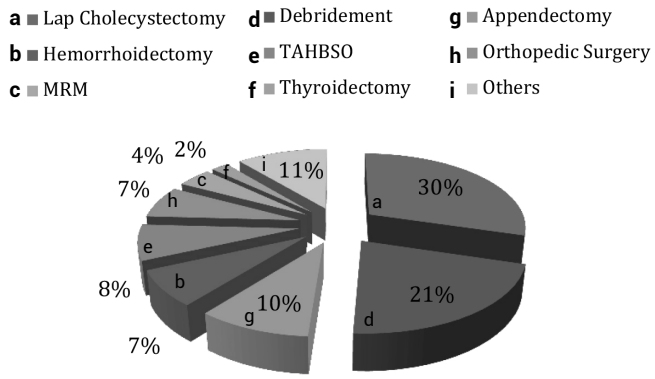

Figure 2. Breakdown of Surgical Procedures by Percentage

Comparisons among hemoglobin A1C categories with surgical outcomes, primarily length of hospital stay post-op, are shown in Table 2. Comparison of outcomes among different levels of A1C was analyzed using Analysis of Variance for quantitative variables while Fisher's exact test for qualitative variables. Among patients with A1C level ≥6.5% - <8%, the mean LOS was at 2.07 ± 1.07 days. Longer hospital stay was shown in patients with A1C level of 8-10% (4.7 ± 5.16 days). Even in patients with controlled A1C (<6.5%), the mean LOS was at 4.0 ± 3.0 days in comparison with patients with A1C level ≥6.5% - <8% (2.07 ± 1.07 days) and A1C >10% (3.588 ± 2.063 days). However, the association is insignificant with a P value of 0.1412. Surgical site infection (3.57%) and Sepsis (3.57%) were noted at A1C category of <6.5%, and Sepsis (11.76%) at A1C level of >10%, however these findings were not significant. There were no significant differences among other surgical outcomes (surgical site infection, sepsis, postoperative renal failure, and mortality).

Table 2: Surgical Outcomes by Hemoglobin A1C Category

Surgical Outcomes	A1C <6.5%	A1C ≥6.5% - <8% (n = 14)	A1C 8-10% (n = 10)	A1C >10% (n = 17)	*P* value
Length of Hospital Stay (days)	4.0 ± 3.0	2.07 ± 1.07	4.7 ± 5.16	3.588 ± 2.063	0.1412
Surgical Site Infection	3.57%	0	0	0	1.0000
Sepsis	3.57%	0	0	11.76%	0.483
Postoperative Renal Failure	0	0	0	0	0
Mortality	0	0	0	0	0

Comparison among Pre-operative Capillary Blood sugar level categories with surgical outcomes are shown in Table 3. Comparison of outcomes between normal and elevated CBG was analyzed using independent t-test for quantitative variables while Fisher's exact test for qualitative variables. Cut-off value of 140mg/dL was set because this was the level of CBG wherein interventions to control the blood sugar in non-critical patients are given. There were no significant difference in the length of hospital stay in individuals with CBG level of <140mg/dL with a mean value of 2.90 ± 1.71 days, and in individuals with CBG level of ≥140mg/dL with a mean value of 2.86 ±1.28 days (*P = 0.9244, 95% C.I = 2.5591 -3.2257*). No other outcomes were noted in CBG group.

Table 3: Surgical Outcomes by Capillary Blood Glucose Preoperatively

Surgical Outcomes	CBG <140mg/dL (n= 71) (mean ±	CBG ≥140mg/dL (n= 22) (mean ± SD)	*P* value	95% Confidence Interval
Length of Hospital Stay	2.90 ± 1.71	2.86 ±1.28	0.9244	2.5591 – 3.2257
Surgical Site Infection	0	0	0	0
Sepsis	0	0	0	0
Postoperative Renal Failure	0	0	0	0
Mortality	0	0	0	0

DISCUSSION

Patients at risk for perioperative hyperglycemia, whether they are diabetic or non-diabetic, deserve special consideration before surgery. But identifying patients at risk upon admission is difficult, especially patients with no previous consultations. Currently, data are limited to suggest that significant preoperative interventions aimed at controlling blood sugar have an impact on outcome and if such interventions are applicable to all patients who will undergo low and intermediate risk procedures, especially in non-diabetic patients wherein probability of hypoglycemia is a consideration. Majority of low and intermediate risk procedures are elective surgeries. In the review of literature, there are no guidelines that suggest delaying surgery until specific level of glycemic control is reached.

There are studies that evaluate the relationship of A1C and hospital length of stay in diabetic patients. Some studies evaluate the relationship between pre-operative, peri-operative and post-operative capillary blood glucose levels with surgical outcomes in diabetic patients also. Our study is different because we looked into both hemoglobin A1C and pre-operative capillary blood glucose level as possible predictors of clinical outcomes in all patients who underwent low and intermediate, non-cardiovascular procedures. We did not limit the study on diabetic patients only because we considered the possibility of undiagnosed diabetes in the said surgical patients.

According to the study done by Underwood, et. al., more severe and prolonged hyperglycemia represented by hemoglobin A1C level is likely to cause more damage than acute hyperglycemia (preoperative capillary blood sugar) alone. We evaluated the association of preoperative Hemoglobin A1C and preoperative capillary blood glucose with surgical outcomes, primarily hospital length of stay preoperatively, and other secondary outcomes in one hundred forty five diabetic and non-diabetic patients who underwent low and intermediate risk procedures. Primary outcome was length of hospital stay postoperatively, thus same day surgeries, endoscopic and cataract surgeries were excluded.

Baseline characteristics of Filipino patients included in our study are different from the baseline characteristics of subjects of the studies done in the literature which includes Caucasians and African Americans. In the study done by Underwood, et.al, they suggested that an A1C level of >8% may have an effect on surgical outcomes, increased length of hospital stay. The finding is consistent in our study wherein a hemoglobin A1C level of 8% - <10% showed increased hospital length of stay but results were insignificant due to the limited number of patients with hemoglobin A1C. However, there were noted differences in the baseline characteristics in between studies (BMI 34.8 ± 9.9 kg/m2 in their study, 25.23 ± 4.04 kg/m2 in our study) which could have an effect on the results that we have. Both studies have almost the same mean age at 53.83 ± 15.68 years and majority of subjects are females. Only 42.07% of subjects were diabetic and 36.55% were hypertensive.

The American Diabetes Association (ADA) has not provided recommendation for the optimal A1C in patients undergoing elective surgery but generally recommends an A1C less than 7% to avoid long term complications especially in patients with diabetes. Current evidence points toward a recommended preoperative A1C somewhere between 7% and 8.5%. Based on the data that we gathered, there is no significant association between the level of hemoglobin A1C and hospital length of stay postoperatively. In our study, longer hospital stay was noted at A1C levels of 8.0% - 10%. Worth noting in the results of the data was a longer hospital stay in individuals with HbA1C level of <6.5% than in patients with HbA1C >10% and A1C levels of ≥6.5% - <8.0%. Patients with HbA1C <6.5% may have had a higher incidence of hypoglycemia before hospital admission or may be related to severity of underlying illness which could also explain the occurrence of surgical site infections and sepsis in this A1C level category compared to the others. However, due to the limited number of patients with available A1C, the association is not significant and warrants further investigation. 11.76% of patients with hemoglobin A1C >10% had sepsis but the result was not significant. Occurrence of other secondary outcomes was also not significant. According to the American Diabetes Association, perioperative glycemic control between

80 – 180 mg/dL is recommended and advises against intensive insulin therapy due to lack of benefit and potential for increased hypoglycemic episodes. Based on the data gathered, there were no significant difference in the length of hospital stay in individuals with CBG level of <140mg/dL with a mean value of 2.90 ± 1.71 days, and in individuals with CBG level of ≥140mg/dL with a mean value of 2.86 ±1.28 days (*P = 0.9244, 95% C.I = 2.5591 -3.2257*). It has been shown in the results that only 42.07% of subjects are diabetics therefore preoperative hyperglycemia might not be totally related to diabetes per se but instead may also be a response to acute illness or injury. In line with this, a postoperative blood glucose monitoring should have also been done and management of hyperglycemia should have been taken into account. But the data were available for only a limited number of patients and it was difficult to obtain in retrospect.

Our results suggest that neither acute glycemic nor chronic glycemic control can be used as predictors of clinical outcomes of patients who underwent low to intermediate non-cardiovascular surgical procedures. However, the data in hemoglobin A1C categories showed promising results but due to the unavailability of hemoglobin A1C in majority of surgical patients, the above findings warrant further investigation.

Because of the retrospective nature of our study, it has several limitations. Our data had only one year coverage and with small sample size that limits the number of outcomes that we could evaluate. In the study, we excluded patients with unavailable preoperative hemoglobin A1C and preoperative capillary blood sugar levels which may have introduced selection bias. We did not also include in our study the interventions made in response to elevated CBGs preoperatively which could have an effect in the length of hospital stay. We, therefore recommend that a follow up study be done prospectively and in a longer time frame to evaluate the secondary outcomes. Further research is required to confirm the above findings and determine whether a preoperative glucose management strategy can improve outcomes after low to intermediate non-cardiovascular surgery in patients with and without diabetes mellitus.

CONCLUSION

Preoperative glucose control is important to maximize patient outcomes and reduce costs of care. Our study suggests that neither acute glycemic (CBG) nor chronic glycemic control (HbA1C), both done preoperatively, is significantly associated with the primary outcome, length of hospital stay. There were too few events to meaningfully evaluate for secondary outcomes. The findings on patients with hemoglobin A1C values of 8.0% - 10% warrants further investigation. Providing a preoperative intervention to improve glycemic control in individuals with hemoglobin A1C values of 8.0% - 10% may improve surgical outcomes, lessen hospital length of stay and reduce costs of care, but prospective studies are needed.

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