

UNIVERSITY OF RWANDA

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SCHOOL OF MEDICINE

DEPARTEMENT OF ANESTHESIOLOGY

***NEWLY DIAGNOSED HYPERGLYCEMIA IN THE PERIOPERATIVE
SETTINGS AT KIGALI UNIVERSITY TEACHING HOSPITAL (CHUK):
Prevalence, risk factors and impact on immediate patients' clinical outcome***

*A dissertation submitted as partial fulfilment of the requirements for the award of the Degree of
Master of Medicine in Anesthesiology and Intensive Care Medicine*

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DECLARATION

I hereby declare that this dissertation: “Newly diagnosed hyperglycemia in perioperative settings at Kigali university teaching hospital (CHUK): prevalence, risk factors and impact on immediate patients’ clinical outcome: an observational prospective and analytical study” is my own work.

This study in whole or in part has neither been submitted for publication anywhere nor has been submitted for the award of a degree in any other university.

Signed Date

Dr. NGARUYE Sylvestre

I hereby declare that this dissertation has been submitted with my approval as the supervisor

Signed Date

Dr. TWAGIRUMUGABE Théogène

DEDICATION

To my parents: Faustin MUHIRE and Gaudence MUKANDARUHUTSE,

To my lovely spouse: Corsine MURORUNKWERE,

To my children: Jean de la Croix ISHIMIRWE and Sylvie INEZA,

This work is dedicated.

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ABBREVIATIONS

- ACH: adrenal corticotropic hormone
- ASA: American Society of Anesthesiologists
- BP: Blood pressure
- CASIEF: Canadian Anesthesiologists' Society International Education Foundation
- CHUB: Centre hospitalier universitaire de Butare
- CHUK: Centre hospitalier universitaire de Kigali
- CRH : corticotropin-releasing hormone
- DBP: diastolic blood pressure
- ENT: Eye – Nose – Throat
- GA: General Anesthesia
- HRH: Human resources for health Rwanda
- KFH: King Faical Hospital
- LOPHS: Length of postoperative hospital stay
- MOH: Ministry of health
- OR: operating room
- RMH: Rwanda military hospital
- SA: spinal anesthesia
- SBP: Systolic blood pressure
- USA: United States of America
- WHO: World Health Organization

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ABSTRACT

Background: Perioperative hyperglycemia is a common condition in adult patients presenting at hospital for surgery and is associated with poor clinical outcome including the risk of developing postoperative infection, cardiovascular and neurological events, increased hospital stay and mortality. No study has described so far the prevalence, risk factors and complications related to perioperative hyperglycemia among adult patients attending Rwandan hospitals for surgical procedures. The aim of our study was to determine the prevalence of newly diagnosed perioperative hyperglycemia, its risk factors and its impact on immediate patients' clinical outcome in terms of infectious complications and length of hospital stay at CHUK.

Methods: This was prospective cross-sectional study of adult patients presenting for surgery at CHUK from October 16th 2013 to January 13th 2014. We recorded the patients' characteristics and the pre-, intra- and postoperative fasting capillary blood sugar. The clinical outcome (length of hospital stay and infection) has been assessed within 30 days during the postoperative hospital stay. Risk factors were studied by univariate and multivariate logistic regression analysis. P-value ≤ 0.05 was significant.

Results: The study enrolled 400 adult patients with a mean age of 40.29 ± 16.89 years. The majority 261 (65.2%) of patients were male. The pre-, intra- and postoperative prevalence of hyperglycemia were respectively 35.0%, 62.5% and 31.0%. Older adults, ASA class II&III, surgical wound class II&III and hypertension were independent risk factors of preoperative hyperglycemia which predicted the intraoperative and postoperative hyperglycemia.

The postoperative infection happened in 16.8% patients. Those who were preoperatively hyperglycemic had 5.4 times the risk of developing the postoperative infection and 3 times the risk of having prolonged postoperative hospital stay.

Conclusion: The perioperative hyperglycemia is common in adult patients undergoing surgery at CHUK. Its associated risk factors included older adults, ASA class II&III, surgical wound class II&III and hypertension. The intraoperative and postoperative hyperglycaemia correlated with preoperative hyperglycemia which independently was the risk factor of postoperative infection and long hospital stay.

I. INTRODUCTION

I.1. Background and Justification of the study

Before the operation, a patient has to be assessed by anesthetist/anesthesiologist with the aim of obtaining a pertinent history including a review of medical records, doing a good physical examination, and requesting any indicated laboratory tests (1). That preoperative evaluation helps to know if the patient is in optimal medical conditions for the procedure. If not, apart from emergencies that require particular considerations, elective cases will be optimized before the operation for his/her safety.

Hyperglycemia should preoperatively attract the interest of the anesthesiologist since the patient may be hyperglycemic and remains asymptomatic. It has been shown that in fasting subjects, the glucose levels in arterial, capillary, and venous samples are practically the same; the capillary blood sample can be used in measurement of blood sugar level. In capillary blood sugar test, it is easy and fast to obtain the sample at several possible sites of the body preferentially on fingertips, much smaller blood sample is used, the result is obtained in seconds and that test can be done with minimal training. When the blood sugar is measured after a fasting period of at least eight hours, a subject will be considered normoglycemic if blood sugar level ranges from 70 mg/dl to 110 mg/dl. A consistent range of glycemia between 110 mg/dl and 126 mg/dl is considered as hyperglycemia or prediabetes or impaired fasting glucose, while 126 mg/dL or higher is considered hyperglycemia or diabetes (2, 3, 4, 5, 6, 7, 8, 9, 10).

Anesthesia and metabolic stress (including critical illness, severe injury, infection, trauma, and major surgery) can lead to metabolic derangements that result in hyperglycemia. Stress-induced hyperglycemia results from the release of counterregulatory hormones (cortisol, glucagon, epinephrine, and growth hormone) and inflammatory cytokines which lead to peripheral insulin resistance, increased hepatic glucose production (by upregulation in hepatic gluconeogenesis and glycogenolysis) and impaired insulin secretion.

Acute hyperglycemia has many deleterious effects, including decreased vasodilation, impaired reactive endothelial nitric oxide generation, decreased complement function, increased expression of leukocyte and endothelial adhesion molecules, increased cytokine levels, and

impaired neutrophil chemotaxis and phagocytosis, leading to increased inflammation, vulnerability to infection, and multiorgan system dysfunction. Hyperglycemic patients have high circulating levels of proinflammatory cytokines, which can lead in turn to organ injury (2, 8, 11, 12, 13).

Worldwide 285 million of people (6.6% of the world population) have diabetes, but at least 50% of all diabetic patients are unaware of their condition and in some countries, this figure may reach 80% (13, 14). In Africa, the prevalence of diagnosed diabetic patients is 3.8% although most of them are undiagnosed like in South Africa where more than 85% of diabetic patients are unaware of their condition (15). In a study done in an urban general hospital, it was reported that one third of patients admitted to general medicine and surgery wards had hyperglycemia. In those patients, 26% had a known history of diabetes, and 12% had no history of diabetes before admission (8). Levetan et al found that 37.5% of all hyperglycemic medical patients and 33% of hyperglycemic surgical patients did not have a diagnosis of diabetes at the time of admission (2). In USA, a study showed that nearly one in five adult inpatients had probable unrecognized diabetes (16). Hatzakorzian et al. observed fasting hyperglycemia in more than 25% of presumably nondiabetic patients presenting for elective surgery (17). National Health and Nutrition Examination Survey statistics have identified 12.9% of the United States ambulatory population aged ≥ 20 years as having diabetes, 40% of which are undiagnosed. An additional 29.5% have prediabetic conditions. With regard to ambulatory patients, 42.4% have a hyperglycemic condition at baseline. The experts estimate that this number may be even higher in the inpatient setting. Due to stress-induced hyperglycemia which comes with surgery, it is reasonable to consider the surgical patient as hyperglycemic until proven (14, 18, 19).

Apart of metabolic stress that increases the blood sugar level, the following factors are known to be the risk factors of hyperglycemia: age of 45 years and greater, sedentary lifestyle, diet (high carbohydrates, high sugar and high fat diet), arterial hypertension (systolic arterial blood pressure ≥ 140 mmHg and diastolic blood pressure ≥ 90 mmHg), obesity (BMI ≥ 30 Kg/M²), smoking, history of gestational diabetes and family history of diabetes (20, 21, 22, 23, 24,25).

Perioperative hyperglycemia is associated with varied postoperative complications among which

there are infections, cardiovascular and neurological events, increased hospital stay and mortality. Regardless of the presence of diabetes or not, a study of Jackson R. S. et al. on the day of surgery for 7500 patients undergoing colectomy for cancer showed that even relatively mild elevations (121-160mg/dl) in glucose levels were associated with increased infectious risk (26). For the surgical patients, preoperative hyperglycemia strongly increased more than two times the risk of nosocomial infection (27). The study of Sato et al showed that a fall in insulin sensitivity by 50% after surgery increased the risk for a severe infection by more than 10-fold (28). In a retrospective study, Ramos et Al. found that postoperative glucose increased the risk of postoperative infections by 30% with every 40 mg/dL increase from normoglycemia considered as < 110 mg/dL (2, 18, 29).

Other studies have shown that stress or new hyperglycemia was associated with higher in hospital mortality rates (16%) compared to those patients with a prior history of diabetes (3%) and subjects with normoglycemia (1.7%) (8, 30). Umpierrez et al found that patients with new hyperglycemia have an 18.3-fold increase in mortality rate compared to a 2.7-fold increase in patients with known diabetes (2). In a study of Loveleena R., it has been shown that mortality rates in diabetic patients have been estimated to be up to 5 times greater than in non diabetic patients (31). Krinsley reported that hospital mortality was 42.5% among patients with mean blood glucose levels exceeding 300 mg/dL. Patients with new hyperglycemia have increased lengths of hospital stay (2). Longer hospitalization also was observed for patients with postoperative glucose greater than 110 mg/dL (18, 32). It has been observed that patients with blood sugar levels of 110 mg/dL to 200 mg/dL had a 0.4-day longer hospital stay and those with blood sugar levels greater than 200 mg/dL had a 0.8-day longer stay (18, 29).

Determination of prevalence of perioperative hyperglycemic patients should be a public health priority regarding the high prevalence of undiagnosed perioperative hyperglycemia and its associated postoperative complications (increased risk of infections and mortality) which lead to delayed postoperative hospital stay, and therefore to increased bill of patient at discharge. In Rwanda, the perioperative blood sugar is only measured in patients with history of diabetes/coma. A study on the determination of prevalence of newly diagnosed perioperative hyperglycemia, its risk factors, the LOPHS and the associated infectious complications is needed

as there is no similar study done in this country. We have decided to conduct this study at one of the referral hospital of the country, CHUK.

I.2. Research question

- What is the prevalence of perioperative hyperglycemia amongst adult patients at CHUK, without a known history of diabetes?
- What is the impact of perioperative hyperglycemia on immediate patients' clinical outcomes?

I.3. Hypothesis

- Perioperatively hyperglycemic patients have higher incidence of postoperative infections than normoglycemic patients.
- Perioperatively hyperglycemic patients have longer postoperative hospital stay than normoglycemic patients and are prone to have infectious complications.

I.4. General objective

- Describe the prevalence of newly diagnosed perioperative hyperglycemia, its risk factors and its impact on immediate patients' clinical outcome in terms of infections and length of postoperative hospital stay at CHUK.

I.5. Specific Objectives

- Determine the prevalence of newly diagnosed perioperative hyperglycemia among adult patients at CHUK
- Determine the incidence of postoperative infections
- Determine risk factors associated with hyperglycemia
- Determine the association of perioperative hyperglycemia with postoperative infections
- Determine the association of perioperative hyperglycemia and hospital length of stay

II. METHODS

II.1. Study design

This is prospective cross-sectional study.

II.2. study setting

The study has been carried out at CHUK.

CHUK is a national referral hospital in Rwanda located in Kigali city, Nyarugenge district. It has been built in 1918. Its mission is to provide health care of standardized quality, to develop the competences of health professionals, to contribute to the development of human resources, to conduct research of high level and to bring technical support to health system.

II.3. Study population

The target was all adult patients who have undergone surgery (major/intermediate/minor) at CHUK from October 2013 to January 2014 have been eligible for the study. Those patients have been followed up postoperatively within the first 30 days of their hospital stay.

II.4. Sample size

The sample size has been calculated using a formula by Cochran as follows:

$$n = Z^2 P(1-P)/d^2 \quad (33)$$

Where n = sample size required,

Z = Z statistic for a level of confidence. At confidence interval of 95%, $Z=1.96$

P = expected prevalence or proportion. In this study, the value of P is not known in Rwanda for patient admitted for surgery. As we don't have a similar study done in Rwanda, we have considered the expected prevalence of 50%.

d = level of precision which is 5%.

$$n = Z^2 P(1-P)/d^2$$

$$n = (1.96)^2 * 0.5 * (1-0.5) / (0.05)^2 \approx 384$$

We have opted for a sample size of 400 patients.

II.5. Procedure

All adult patients attending CHUK for surgery were enrolled in the study day and night during the study period until we got the sample size. The researcher and the study nurse briefed eligible patients about the study. After obtaining a written consent, a data collection sheet was completed (appendices 1&2). On the day of surgery, a preoperative capillary blood sample has been taken on fingertip of fasted patients (minimum eight hours of fasting) with lancet or sterile needle. A small drop of blood has been placed on a disposable test strip that the meter reads and uses to calculate the blood glucose level. The glycemia has been displayed in mmol/L within seconds on the screen of glucometer. Then the blood sugar has been converted into mg/dl by multiplying with 18 the value in mmol/L. The patient has been considered as normoglycemic when blood sugar level is included in the interval of 70 mg/dl-110 mg/dl and the patient is considered hyperglycemic when the result of his capillary blood sugar level is > 110 mg/dl. For the same patients, intraoperatively and on first day postoperatively, the capillary blood sample has been taken, measured, read and recorded.

II.6. Selection criteria

This study has included all consented patients with 18 years old and more coming for surgery at CHUK from October 2013 to January 2014. This study has concerned emergency and elective cases for patients who have been on fasting period of at least eight hours. The following patients have been perioperatively excluded from the study: Known diabetic, hypoglycemic (glycemia level less than 70 mg/dl), under 18 years old, comatose, ASA V or ASA VI, preoperative infection, patients who have received glucose therapy within less than eight hours ago, patients with peripheral circulatory failure, patients with fasting period less than eight hours, bilateral amputation of lower limbs, pregnant women, women in postpartum period (considered as a period made of 42 days in post delivery), patients with mental disorders, patient who refused to participate in the study and patients coming for reoperation with history of surgery at CHUK from October 2013 to January 2014 already involved in this study.

II.7. Data collection

Nurses to help in collecting were trained by the principal investigator. Information was provided preoperatively to potential subjects of the study for getting a consent. On the day of surgery, by using a data collection sheet, we have preoperatively noted from patient and medical file:

Patient's identification number, patient's age in years, sex, department, province of origin, occupation, family history of diabetes, history of gestational diabetes, history of smoking, we have measured and noted weight in Kg, height in Cm, systolic blood pressure in mmHg, diastolic blood pressure in mmHg, case status (emergency, elective), type of procedure, ASA classification of patient, we have measured and noted the blood sugar level with calibrated glycometer in mmol/L. Intraoperatively, we have recorded the blood sugar level of the patients in mmol/L, the type of anesthesia and the surgical wound classification with agreement of the surgeon and according to Altemeier classification of surgical site (34).

Postoperatively, on day one, we have measured and recorded weight (anthropometric measurements have been done by combining abdominal circumference at the level of the umbilicus and thigh circumference at 10 cm above the superior pole of the patella:

Male: Actual body weight = $- 47.8 + 0.78 * \text{Abdominal Circumference} + 1.06 * \text{Thigh Circumference}$;

Female: Actual body weight = $- 40.2 + 0.47 * \text{Abdominal Circumference} + 1.30 * \text{Thigh Circumference}$) (35) and we have measured and noted the capillary blood sugar level for the same patients.

In the ward, we have noted the type of postoperative infection according to surgeon notes in medical file and the length of postoperative hospital stay within 30 days postoperatively.

II.8. Data management

Data have been first recorded on data collection sheet, then entered into a computer using Epi-data 3.1 and finally transferred into SPSS software version 16 for analysis. Calculations including BMI and conversion of blood sugar unit from mmol/L to mg/dl have been done using Excel.

II.9. Statistical analysis

Using SPSS software version 16, descriptive analyses have been done to quantify the frequency of patient's characteristics, perioperative glycemia level, postoperative infections and immediate

patients' outcome. Univariate analysis: Chi-square test has been used for categorical variables and T-test for numerical variables to compare the outcome between normoglycemic and hyperglycemic patients. Multivariate logistic regression analysis has been applied to determine adjusted odds ratios and 95% confidence intervals for the association of perioperative hyperglycemia with risk factors, postoperative infection and length of postoperative hospital stay. For all analyses, $p \leq 0.05$ was statistically significant.

II.10. Ethical considerations

An approval was obtained from the ethical/scientific committee of the school of Medicine in the University of Rwanda. Written informed consent was obtained from the patient before enrolment into the study and participation in the study was voluntary.

III. RESULTS

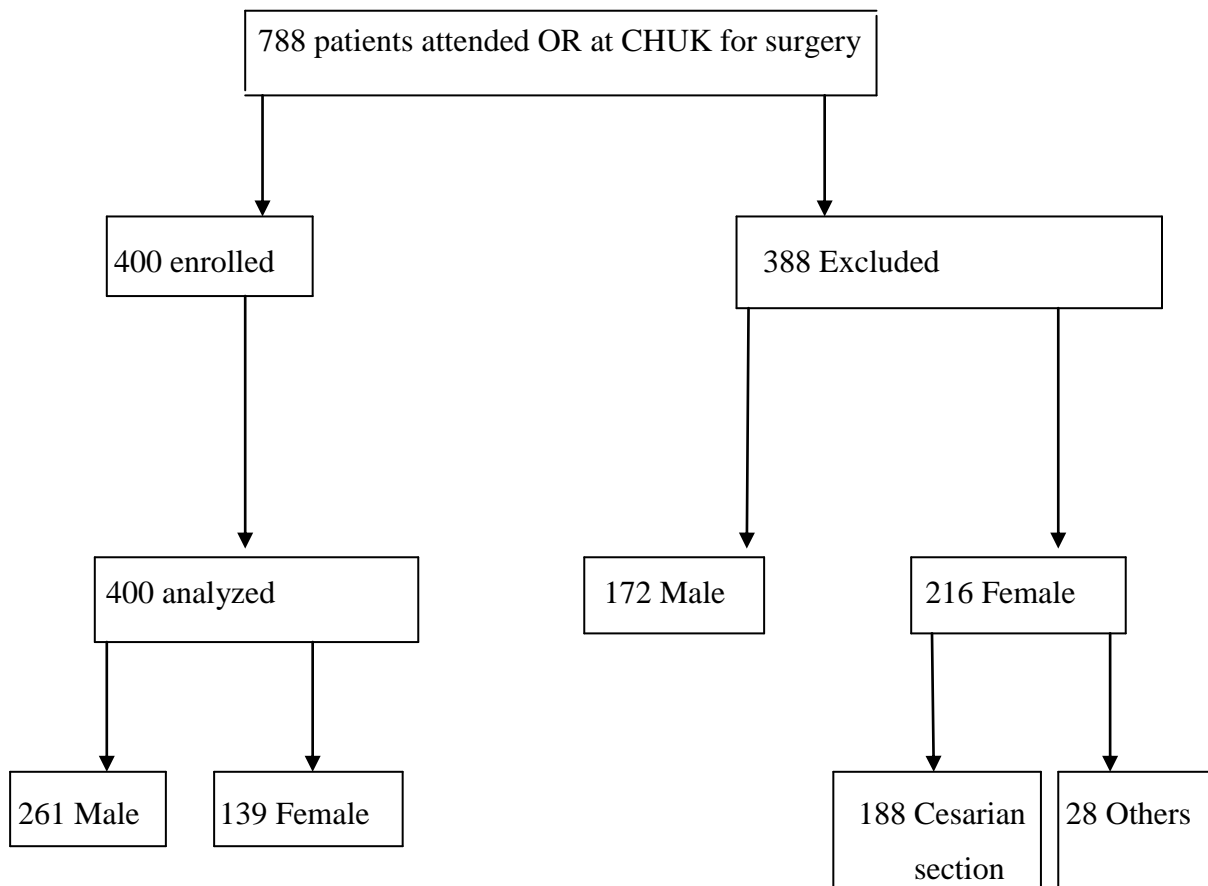
III.1. Description of the study participants

Data were collected at CHUK in a period of 3 months (from October 16th 2013 to January 13th 2014).

III.1.1 Patients profile

788 adult patients attended operating rooms for surgery with 433 (54.9%) male. We enrolled 400 adult patients with a mean age of 40.29 ± 16.89 years.

Figure 1: Patients profile



III.1.2. Patients' characteristics

196 (49.0%) of patients were young adults. The majority 261 (65.2%) of participants were male, while female were represented in 139 (34.8%). 166 (41.5%) of patients came from Kigali city. Most of surgical procedures 209 (52.2%) were elective. 246 (61.5%) cases attended for general surgery. Other details are shown in table 1 below.

Table 1: Patients' characteristics

Variable		Frequent	Percent
Age	Young adult (18-35 years)	196	49.0
	Middle-aged adult (36-55 years)	125	31.2
	Older adult (> 55 years)	79	19.8
Sex	Male	261	65.2
	Female	139	34.8
Department	ENT	10	2.5
	Obstetrics and gynecology	25	6.2
	Surgery	365	91.2
Province of origin	East	92	23.0
	Kigali city	166	41.5
	North	60	15.0
	South	42	10.5
	West	40	10.0
Occupation	Civil servant / Government employee	28	7.0
	Private sector employee	336	84.0
	Others	36	9.0
ASA classification	I	286	71.5
	II	92	23.0
	III	22	5.5
Schedule	Elective	209	52.2
	Emergency	191	47.8
Body mass index classification	Underweight (BMI < 18.5)	2	0.5
	Normal weight (≥ 18.5 BMI < 25)	190	47.5
	Overweight ($25 \leq$ BMI < 30)	203	50.8
	Obesity (BMI ≥ 30)	5	1.2
Surgical site classification of Altemeier	I	151	37.8
	II	99	24.8
	III	150	37.5
Family history of diabetes	No	396	99.0
	Yes	4	1.0
Smoking	No	392	98.0
	Yes	8	2.0
Hypertension	No	367	91.8
	Yes	33	8.2

III.2. Perioperative hyperglycemia

The overall mean blood sugar was respectively 110.93 ± 22.180 mg/dl, 122.98 ± 24.317 mg/dl and 107.32 ± 23.947 mg/dl in preoperative, intraoperative and postoperative periods.

In perioperative settings, the hyperglycemia was obvious.

Preoperatively 140 (35.0%) of patients were hyperglycemic with mean blood sugar of 135.06 ± 19.374 mg/dl; Intraoperatively 250 (62.5%) of patients were hyperglycemic with mean blood sugar of 135.57 ± 22.224 mg/dl; And postoperatively 124 (31%) of patients were hyperglycemic with blood sugar mean of 137.18 ± 19.095 mg/dl.

Table 2: Distribution and prevalence of hyperglycemia in perioperative settings

Variable		N (%)	Mean in mg/dl	SD	95% CI for mean
Preoperative hyperglycemia	Yes	140(35.0%)	135.06	19.374	131.83-138.30
	No	260 (65.0%)	97.94	8.497	96.90-98.98
Intraoperative hyperglycemia	Yes	250 (62.5%)	135.57	22.224	132.80-138.33
	No	150 (37.5%)	101.78	6.212	100.77-102.78
Postoperative hyperglycemia	Yes	124 (31.0%)	137.18	19.095	133.78-140.57
	No	276 (69.0%)	93.91	9.303	92.81-95.02

III.3. Risk factors of perioperative hyperglycemia

III.3.1. Risk factors of preoperative hyperglycemia

III.3.1.1. Univariate analysis for risk factors of preoperative hyperglycemia

Factors associated with hyperglycemia at univariate analysis were summarized in table 3 below. Older adult, ASA class II&III, surgical site class II&III and hypertension were significantly associated with preoperative hyperglycemia ($P < 0.0001$).

Table 3: Risk factors for preoperative hyperglycemia

Variable	Preoperative Hyperglycemia		Total	P-value
	No	Yes		
Older adult (> 55 years)				
No	228 (71.0%)	93 (29.0%)	321 (100.0%)	
Yes	32 (40.5%)	47 (59.5%)	79 (100.0%)	< 0.0001
Sex				
Male	173 (66.3%)	88 (33.7%)	261 (100.0%)	
Female	87 (62.6%)	52 (37.4%)	139 (100.0%)	0.461
ASA classification				
I	206 (72.0 %)	80 (28.0%)	286 (100.0%)	< 0.0001
II&III	54 (47.4%)	60 (52.6%)	114 (100.0%)	
Surgical site classification				
I	121 (80.1%)	30 (19.9%)	151 (100.0%)	< 0.0001
II&III	139 (55.8%)	110 (44.2%)	249 (100.0%)	
BMI				
Low to normal	127 (66.1%)	65 (33.9%)	192 (100.0%)	0.644
High	133 (63.9%)	75 (36.1%)	208 (100.0%)	
Hypertension				
No	248 (67.6%)	119 (32.4%)	367 (100.0%)	< 0.0001
Yes	12 (36.4%)	21 (63.6%)	33 (100.0%)	
Schedule				
Elective	133 (63.6%)	76 (36.4%)	209 (100.0%)	
Emergency	127 (66.5%)	64 (33.5%)	191 (100.0%)	0.550

III.3.1.2. Multivariate analysis by logistic regression for risk factors of preoperative hyperglycemia

In table 4 below, we analyzed the significant risk factors of preoperative hyperglycemia in multivariate analysis by logistic regression. We found that each of the following factors independently increased more than two times the risk of being hyperglycemic preoperatively: older adult, ASA class II&III, surgical site class II&III and hypertension with respectively P-value of < 0.0001 , 0.001 , < 0.0001 and 0.026 .

Table 4: Multivariate binary regression analysis for risk factors of preoperative hyperglycemia

Variable	P-value	OR	95% CI
Age group Older adult versus young&middle-aged adult	< 0.0001	2.834	1.648-4.893
ASA classification II&III versus I	0.001	2.313	1.436-3.725
Surgical site classification of Altemeier II&III versus I	< 0.0001	2.716	1.649-4.474
Hypertension Hypertensive patients versus no hypertensive patients	0.026	2.506	1.116-5.628

III.3.2. Risk factors of intraoperative hyperglycemia

III.3.2.1. Univariate analysis for risk factors of intraoperative hyperglycemia

Factors associated with hyperglycemia at univariate analysis were summarized in table 5 below.

Older adult, ASA class II&III, hypertension, major surgery and preoperative hyperglycemia were significantly associated with intraoperative hyperglycemia.

Table 5: Univariate analysis for risk factors of intraoperative hyperglycemia

Variable	Intraoperative Hyperglycemia		Total	P-value	
	No	Yes			
Older adult (> 55 years)	No	133 (41.4%)	188 (58.6%)	321 (100.0%)	< 0.0001
	Yes	16 (20.3%)	63 (79.7%)			79 (100.0%)
Sex	Male	99 (37.9%)	162 (62.1%)	261 (100.0%)	0.699
	Female	50 (36.0%)	89 (64.0%)	139 (100.0%)	
ASA classification	I	120 (42.0%)	166 (58.0%)	286 (100.0%)	0.002
	II&III	29 (25.4%)	85 (74.6%)	114 (100.0%)	
Surgical wound classification	I	63 (41.7%)	88 (58.3%)	151 (100.0%)	0.150
	II&III	86 (34.5%)	163 (65.5%)	249 (100.0%)	
BMI	Low to normal	79 (41.1%)	113 (58.9%)	192 (100.0%)	0.122
	High	70 (33.7%)	138 (66.3%)	208 (100.0%)	
Hypertension	No	142 (38.7%)	225 (61.3%)	367 (100.0%)	0.047
	Yes	7 (21.2%)	26 (78.8%)	33 (100.0%)	
Schedule	Elective	74 (35.4%)	135 (64.6%)	209 (100.0%)	0.425
	Emergency	75 (39.3%)	116 (60.7%)	191 (100.0%)	
Category of surgery	Minor / Intermediate	31 (59.6%)	21 (40.4%)	52 (100.0%)	< 0.0001
	Major	118 (33.9%)	230 (66.1%)	348 (100.0%)	
Type of anesthesia	Spinal	30 (29.7%)	71 (70.3%)	101 (100.0%)	0.07
	General	119 (39.8%)	180 (60.2%)	299 (100.0%)	
Preoperative hyperglycemia	No	147 (56.5%)	113 (43.5%)	260 (100.0%)	< 0.0001
	Yes	2 (1.4%)	138 (98.6%)	140 (100.0%)	

III.3.2.2. Multivariate binary regression analysis for risk factors of intraoperative hyperglycemia

In table 6 below, we analyzed the significant risk factors of intraoperative hyperglycemia in multivariate analysis by logistic regression. We found that each of the following factors independently increased the risk of being hyperglycemic intraoperatively: major surgery and preoperative hyperglycemia with respectively P-value of 0.017 and < 0.0001

Table 6: Multivariate binary regression analysis for risk factors of intraoperative hyperglycemia

Variable	P-value	OR	95% CI
Age group Older adult versus young&middle-aged adult	0.260	1.540	0.727-3.264
ASA classification II&III versus I	0.739	1.108	0.606-2.024
Hypertension Hypertension versus Normal BP	0.818	0.875	0.280-2.728
Category of surgery Major versus Minor/intermediate	0.017	2.419	1.170-5.002
Preoperative Hyperglycemia versus normoglycemia	< 0.0001	80.196	19.187-335.151

III.3.3. Risk factors of postoperative hyperglycemia

III.3.3.1. Univariate analysis for risk factors of postoperative hyperglycemia

Older adult, ASA class II&III, surgical wound class II&III, hypertension, major surgery, preoperative hyperglycemia and intraoperative hyperglycemia were significantly associated with postoperative hyperglycemia.

Table 7: Univariate analysis for risk factors of postoperative hyperglycemia

Variable	Postoperative Hyperglycemia		Total	P-value	
	No	Yes			
Older adult (> 55 years)	No	235 (73.2%)	86 (26.8%)	321 (100.0%)	< 0.0001
	Yes	41(51.9%)	38 (48.1%)	79 (100.0%)	
Sex	Male	181 (69.3%)	80 (30.7%)	261 (100.0%)	0.836
	Female	95 (68.3%)	44 (31.7%)	139 (100.0%)	
ASA classification	I	214 (74.8%)	72 (25.2%)	286 (100.0%)	< 0.0001
	II&III	62 (54.4%)	52(45.6%)	114 (100.0%)	
Surgical site classification	I	116(76.8%)	35 (23.2%)	151 (100.0%)	0.008
	II&III	139 (64.3%)	110 (35.7%)	249 (100.0%)	
BMI	Low to normal	137 (71.4%)	55 (28.6%)	192 (100.0%)	0.328
	High	139 (66.8%)	69 (33.2%)	208 (100.0%)	
Hypertension	No	262 (72.4%)	105 (28.6%)	367 (100.0%)	0.001
	Yes	14 (42.4%)	19 (57.6%)	33 (100.0%)	
Schedule	Elective	143 (68.4%)	66 (31.6%)	209 (100.0%)	0.793
	Emergency	133 (69.6%)	58 (30.4%)	191 (100.0%)	
Category of surgery	Minor / Intermediate	45 (86.5%)	7 (13.5%)	52 (100.0%)	0.003
	Major	231 (66.4%)	117 (33.6%)	348 (100.0%)	
Anesthesia	General	64 (63.4%)	37 (36.6%)	101 (100.0%)	0.157
	Spinal	212 (70.9%)	87 (29.1%)	299 (100.0%)	
Preoperative hyperglycemia	No	245 (94.2%)	15 (5.8%)	260 (100.0%)	< 0.0001
	Yes	31 (22.1%)	109 (77.9%)	140 (100.0%)	
Intraoperative hyperglycemia	No	149 (100.0%)	0 (0.0%)	149 (100.0%)	< 0.0001
	Yes	127 (50.6%)	124 (49.4%)	251 (100.0%)	

III.3.3.2. Multivariate binary regression analysis for risk factors of postoperative hyperglycemia

In table 8 below, we analyzed the significant risk factors of postoperative hyperglycemia in multivariate analysis by logistic regression. Only preoperative hyperglycemia independently increased the risk of being hyperglycemic postoperatively with $P < 0.0001$.

Table 8: Multivariate binary regression analysis for risk factors of postoperative hyperglycemia

Variable	P-value	OR	95% CI
Age group Older adult versus young&middle-aged adult	0.784	0.797	0.412-1.952
ASA classification II&III versus I	0.481	1.286	0.639-2.591
Surgical site classification II&III versus I	0.058	0.466	0.212-1.026
Hypertension Hypertensive patients versus no hypertensive patients	0.220	1.965	0.667-5.788
Category of surgery Major versus Minor/intermediate	0.066	2.892	0.934-8.954
Preoperative Hyperglycemia versus normoglycemia	< 0.0001	67.949	31.459-146.761

III.4. Incidence of postoperative infections

The incidence of postoperative infection represented 67 (16.8%) of the population of study.

III.5. Risk factors for postoperative infection

III.5.1. Univariate analysis for risk factors of postoperative infection

ASA class II&III, surgical site class II&III, emergency, preoperative hyperglycemia, intraoperative hyperglycemia, postoperative hyperglycemia and major surgery were significantly associated with postoperative infection. Other details are shown in table 9 below.

Table 9: Risk factors for postoperative infection

Variable		Postoperative infection		Total	P-value
		No	Yes		
Older adult (> 55 years)	No	272(84.7%)	49 (15.3%)	321 (100.0%)	0.109
	Yes	61(77.2%)	18 (22.8%)	79 (100.0%)	
Sex	Male	215 (82.4%)	46 (17.6%)	261 (100.0%)	0.521
	Female	118(84.9%)	21 (15.1%)	139 (100.0%)	
ASA classification	Healthy person	255(89.2%)	31 (10.8%)	286 (100.0%)	< 0.0001
	Systemic disease	78 (68.4%)	36 (31.6%)	114 (100.0%)	
Surgical site classification	I	142 (94.0%)	9 (6.0%)	151 (100.0%)	< 0.0001
	II&III	191 (76.7%)	58 (23.3%)	249 (100.0%)	
BMI	Low to normal	161(83.9%)	31 (16.1%)	192 (100.0%)	0.756
	High	172(82.7%)	36 (17.3%)	208 (100.0%)	
Hypertension	No	307 (83.7%)	60 (16.3%)	367 (100.0%)	0.474
	Yes	26 (78.8%)	7 (21.2%)	33 (100.0%)	
Schedule	Elective	183 (87.6%)	26 (12.4%)	209 (100.0%)	0.016
	Emergency	150 (78.5%)	41 (21.5%)	191 (100.0%)	
Preoperative hyperglycemia	No	244 (93.8%)	16 (6.2%)	260 (100.0%)	< 0.0001
	Yes	89 (63.6%)	51 (36.4%)	140 (100.0%)	
Intraoperative hyperglycemia	No	140 (94.0%)	9 (6.0%)	149 (100.0%)	< 0.0001
	Yes	193 (76.9%)	58 (23.1%)	251 (100.0%)	
Postoperative hyperglycemia	No	250 (90.6%)	26 (9.4%)	276 (100.0%)	< 0.0001
	Yes	83 (66.9%)	41(33.1%)	124 (100.0%)	
Category of surgery	Minor/Intermediate	52 (100.0%)	0 (0.0%)	52 (100.0%)	0.001
	Major	281 (80.7%)	67 (19.3%)	348 (100.0%)	
Anesthesia	Spinal	83 (82.2%)	18 (17.8%)	101 (100.0%)	0.739
	General	250 (83.6%)	49 (16.4%)	299 (100.0%)	

III.5.2. Multivariate analysis by logistic regression for risk factors of postoperative infection

In table 10 below, we analyzed the significant risk factors of postoperative infection in multivariate analysis by logistic regression. Each of the following factors independently increased the risk of getting infection postoperatively: ASA class II&III, surgical site class II&III, emergency and preoperative hyperglycemia with respectively P-value of 0.002, 0.016, 0.009 and 0.001.

Table 10: Multivariate analysis independent variables associated with postoperative infection

Variable	P-value	OR	95% CI
ASA classification II&III versus I	0.002	2.639	1.438-4.844
Surgical site classification of Altemeier II&III versus I	0.016	2.678	1.202-5.964
Schedule Emergency versus Elective	0.009	2.286	1.234-4.247
Preoperative Hyperglycemia versus normoglycemia	0.001	5.412	2.083-14.061
Intraoperative Hyperglycemia versus normoglycemia	0.515	1.392	0.515-3.766
Postoperative Hyperglycemia versus normoglycemia	0.783	1.123	0.492-2.261

III.6. Postoperative hospital stay

III.6.1. Length of postoperative hospital stay (LOPHS)

The overall mean of postoperative hospital stay is 8.54 ± 6.14 days.

Each one of the following factors significantly increased the LOPHS: Older adult, ASA class II&III, surgical site class II&III, emergency, hyperglycemia (preoperatively, intraoperatively or postoperatively), major surgery and postoperative infection.

Table 11: Length of postoperative hospital stay (LOPHS)

Variable	N (%)	Mean \pm SD for LOPHS (days)	Mean difference of LOPHS (days)	95% CI of mean	P-value	
Older adult	No Yes	321 (80.2%) 79 (19.8%)	8.17 \pm 6.041 10.01 \pm 6.354	1.838	0.331-3.345	0.017
Sex	Male Female	261 (65.2%) 139 (34.8%)	8.49 \pm 6.324 8.63 \pm 5.800	0.147	- 1.122-1.415	0.821
ASA Classification	I II&III	286 (71.5%) 114 (28.5%)	7.52 \pm 5.285 11.09 \pm 7.314	3.565	2.275-4.858	< 0.0001
Surgical site classification	I II&III	151 (37.8%) 249 (62.2%)	6.04 \pm 3.784 10.05 \pm 6.774	4.012	2.830-5.195	< 0.0001
BMI	Low to normal High	192 (48.0%) 208 (52.0%)	8.18 \pm 5.923 8.87 \pm 6.330	0.683	- 0.525-1.891	0.267
Hypertension	No Yes	367 (91.8%) 33 (8.2%)	8.38 \pm 6.186 10.24 \pm 5.397	1.858	-0.331-4.043	0.096
Schedule	Elective Emergency	209 (52.2%) 191 (47.8%)	7.92 \pm 5.726 9.21 \pm 6.511	1.296	0.093-2.499	0.035
Preoperative hyperglycemia	No Yes	260 (65.0%) 140 (35.0%)	6.25 \pm 3.871 12.78 \pm 7.240	6.525	5.433-7.616	< 0.0001
Intraoperative hyperglycemia	No Yes	149 (37.2%) 251 (62.8%)	5.95 \pm 4.181 10.08 \pm 6.591	4.129	2.948-5.311	< 0.0001
Postoperative hyperglycemia	No Yes	276 (69.0%) 124 (31.0%)	6.97 \pm 5.256 12.03 \pm 6.533	5.065	3.857-6.272	< 0.0001
Category of surgery	Minor/Intermediate Major	52 (13.0%) 348 (87.0%)	5.19 \pm 3.036 9.04 \pm 6.330	3.845	2.089-5.601	< 0.0001
Anesthesia	Spinal General	101 (25.2%) 299 (74.8%)	8.29 \pm 9.092 8.62 \pm 6.164	0.335	- 1.056-1.725	0.636
Postoperative infection	No Yes	333 (83.2%) 67 (16.8%)	6.32 \pm 2.823 19.55 \pm 6.313	13.231	12.272-14.189	< 0.0001

III.6.2. Risk factors for prolonged postoperative hospital stay

Postoperatively, many factors can contribute to delay the patient's hospital stay. A prolonged length of postoperative hospital stay appears when the length of postoperative hospital stay is greater than or equal to the 75th percentile (in days) for each operation (36).

III.6.2.1. Univariate analysis for risk factors of prolonged postoperative hospital stay

Older adult, ASA class II&III, surgical site class II&III, hypertension, hyperglycemia (preoperatively, intraoperatively or postoperatively) major surgery and infection were significantly associated with prolonged postoperative hospital stay.

Table 12: Univariate analysis for risk factors for prolonged postoperative hospital stay

Variable		Prolonged postoperative hospital stay		Total	P-value
		No	Yes		
Older adult (> 55 years)	No	256 (79.8%)	65 (20.2%)	321 (100.0%)	0.004
	Yes	51 (64.6%)	28 (35.4%)	79 (100.0%)	
Sex	Male	203 (77.8%)	58 (22.2%)	261 (100.0%)	0.505
	Female	108 (84.9%)	21 (15.1%)	139 (100.0%)	
ASA classification	ASA I	237 (82.9%)	49 (17.1%)	286 (100.0%)	< 0.0001
	ASA II&III	70 (61.4%)	44 (38.6%)	114 (100.0%)	
Surgical site classification	Class I	135 (89.4%)	16 (10.6%)	151 (100.0%)	< 0.0001
	Class II&III	172 (69.1%)	77 (30.9%)	249 (100.0%)	
BMI	Low to normal	155 (80.7%)	37 (19.3%)	192 (100.0%)	0.070
	High	152 (73.1%)	56 (26.9%)	208 (100.0%)	
Hypertension	No	287 (78.2%)	80 (21.8%)	367 (100.0%)	0.022
	Yes	20 (60.6%)	13 (39.4%)	33 (100.0%)	
schedule	Elective	166 (79.4%)	43 (20.6%)	209 (100.0%)	0.185
	Emergency	141 (73.8%)	50 (26.2%)	191 (100.0%)	
Preoperative hyperglycemia	No	237 (91.2%)	23 (8.8%)	260 (100.0%)	< 0.0001
	Yes	70 (50.0%)	70 (50.0%)	140 (100.0%)	
Intraoperative hyperglycemia	No	139 (93.3%)	10 (6.7%)	149 (100.0%)	< 0.0001
	Yes	168 (66.9%)	83 (33.1%)	251 (100.0%)	
Postoperative hyperglycemia	No	240 (87.0%)	36 (13.0%)	276 (100.0%)	< 0.0001
	Yes	67 (54.0%)	57 (46.0%)	124 (100.0%)	
Category of surgery	Minor/Intermediate	47 (90.4%)	5 (9.6%)	52 (100.0%)	0.013
	Major	260 (74.7%)	88 (25.3%)	348 (100.0%)	
Type of anesthesia	Spinal	76 (75.2%)	25 (24.8%)	101 (100.0%)	0.679
	General	231 (77.3%)	68 (22.7%)	299 (100.0%)	
Infection	No	302 (90.7%)	31 (9.3%)	333 (100.0%)	< 0.0001
	Yes	5 (7.5%)	62 (92.5%)	67 (100.0%)	

III.6.2.2. Multivariate analysis by logistic regression for risk factors of prolonged postoperative hospital stay

In table 13 below, we analyzed the significant risk factors of prolonged postoperative hospital stay in multivariate analysis by logistic regression. Each of the following factors independently prolonged postoperative hospital stay: Preoperative hyperglycemia and postoperative infection with respectively P-value of 0.048 and < 0.0001 .

Table 13: Multivariate analysis for independent variables associated with prolonged postoperative hospital stay

Variable	P-value	OR	95% CI
Age group Older adult versus young&middle-aged adult	0.562	1.287	0.549-0.017
ASA classification II&III versus I	0.748	1.139	0.517-2.509
Surgical site classification of Altemeier II&III versus I	0.247	1.648	0.707-3.848
Hypertension Hypertensive patients versus no hypertensive patients	0.371	1.657	0.548-5.007
Preoperative Hyperglycemia versus normoglycemia	0.048	3.068	1.011-9.307
Intraoperative hyperglycemia Hyperglycemia versus normoglycemia	0.057	3.109	0.965-10.016
Postoperative hyperglycemia Hyperglycemia versus normoglycemia	0.809	1.136	0.404-3.190
Category of surgery Major versus Minor/Intermediate	0.473	0.665	0.218-2.028
Postoperative infection Present versus absent	< 0.0001	97.968	32.444-295.824

IV. DISCUSSION

The prevalence, risk factors and clinical outcome of perioperative hyperglycemia among adult patients attending CHUK have not been described before. In Africa, few studies describe hyperglycemia in perioperative settings. Most researches about perioperative hyperglycemia in adults are derived from the developed countries.

IV.1. Population and perioperative hyperglycemia

In this study, 400 adult patients have been enrolled. The majority 65.2% were male. According to the results of general census done in Rwanda in 2012, the majority 51.8% were female (37). The difference between our study and the results of general census concerning gender frequency in Rwanda is due to the dual fact. During the period of data collection for this study, on one side the overall 54.9% of adult patients received at CHUK for surgery were male; on the other side, pregnant women and women in postpartum period were excluded. Those reasons have lead to the low female representation in our study population.

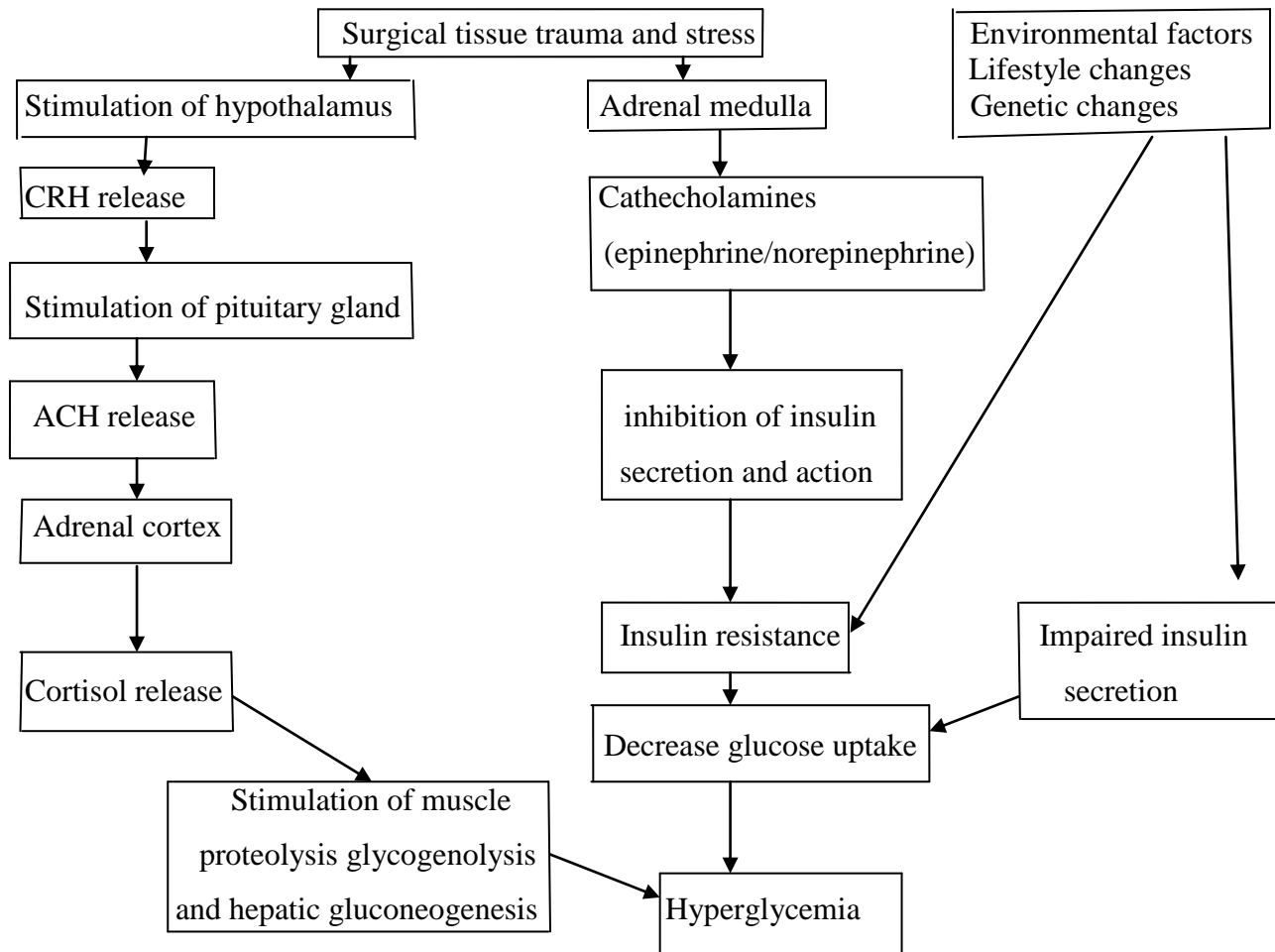
In perioperative settings, the overall mean intraoperative blood sugar of 122.98 ± 24.317 mg/dl was the highest, while the mean postoperative hyperglycemia of 137.18 ± 19.095 mg/dl was the highest. In Netherlands, Eshuis W. J. et al found that the mean postoperative blood glucose of 142 mg/dl has been the highest perioperatively (38). Pre-, intra- and postoperative hyperglycemia were respectively 35.0%, 62.5% and 31.0%. The same results have been observed by Levetan et al who reported 33% of newly diagnosed hyperglycemia in perioperative settings (2, 39). Hatzakorzian et al. observed fasting hyperglycemia in more than 25% of presumably nondiabetic patients coming for elective surgery (17).

IV.2. Risk factors and perioperative hyperglycemia

A multivariate binary regression analysis of significant variables was performed. Older adults, ASA class II&III (systemic disease), class II&III of surgical site classification of Altemeier (contaminated wound) and hypertension were independent risk factors of preoperative hyperglycemia which independently predicted intra- and postoperative hyperglycemia. The major surgery was an added independent risk factor of intraoperative hyperglycemia. As described in figure 1, other studies found that many risks factors of stress induced and no stress

induced hyperglycemia may be present together or separately in perioperative settings (21, 22, 23, 24, 25, 33, 40, 41, 42).

Figure 2: Pathophysiology of hyperglycemia



IV.2. Risk factors and postoperative infection

The postoperative infection has been present in 16.8% of surgical procedures.

This result falls in the range described by Sarkar B.B where postoperative surgical site infection developed in 3% to 20% of operative procedures (43).

Significant risk factors of postoperative infection have been controlled in multivariate binary logistic regression analysis. Patients who were preoperatively hyperglycemic have 5.4 times the risk of developing the postoperative infection ($P \leq 0.0001$). The Australian Diabetes Society found that preoperative hyperglycemia strongly increased more than two times the risk of postoperative infection (27). Ramos et al. found that patients had increased risk of postoperative infection by

30% with every 40 mg/dL increase from normoglycemia (2, 32). The results of other studies have shown that perioperative hyperglycemia leads to increased risk of postoperative infection (44, 45).

We found that patients with systematic disease (ASA II&III) have 2.6 times the risk of developing the postoperative infection compared to healthy persons (ASA I) ($P = 0.017$) and patients with contaminated wound (class II&III) have 2.7 times the risk of developing the postoperative infection compared to patients with clean wounds (class I) ($P = 0.016$). Woodfield JC et al. found that the ASA classification of patients and the surgical wound classification have statistical significance and strength for predicting postoperative wound infection (46, 47).

We observed that patients with emergency surgery have 2.3 times the risk of developing the postoperative infection compared to patients with elective surgery ($P = 0.009$). Reichman D.E. and Greenberg J. A. found that the emergency surgery was a significant, independent risk factor associated with surgical site infection (46, 48).

IV.3. Length of postoperative hospital stay

Young and middle-aged adults had a mean LOPHS of 8.17 ± 6.041 days, while older adults had a mean LOPHS of 10.01 ± 6.354 days ($P = 0.017$). Weintraub W. S. found that young adults had a mean LOPHS of 6.9 ± 1.4 days, while older adults had a mean LOPHS of 10.9 ± 12.1 days (49).

We found that pre-, intra- and postoperative hyperglycemia have significantly increased the mean LOPHS by 6.525 days, 4.129 days and 5.065 days respectively. Ramos et al. found that patients who had postoperatively blood glucose levels of 110 mg/dL to 200 mg/dL had a 0.4-day longer hospital stay and the patients who had blood glucose levels greater than 200 mg/dL had a 0.8-day longer stay (2). We observed that patients with preoperative hyperglycemia have three times the risk of having prolonged postoperative hospital stay compared to normoglycemic patients ($P = 0.048$). Frisch A. et al. found that perioperative hyperglycemia has increased significantly the length of hospital stay (50). Other studies found longer hospitalization among patients with postoperative glucose greater than 110 mg/dl (2, 18, 29).

Patients with ASA II&III increased the mean LOPHS by 3.565 days compared to patients with ASA I ($P < 0.0001$). McDonald M.R. et al found 3.42 days increase in LOPHS with increase in ASA classification (51).

In our study, the mean LOPHS was 7.92 ± 5.726 days for elective surgery and 9.21 ± 6.511 days for emergency surgery with respectively the median LOPHS of 6 days and 7 days. Kelly M. et al. found median LOPHS was 14 days for elective and 21 days for emergency surgery (52).

We observed that contaminated wound (surgical site class II&III) and major surgery were associated with postoperative infection which led to a mean LOPHS of 19.55 ± 6.313 days, while patients without postoperative infection had a mean LOPHS of 6.32 ± 2.823 days ($P < 0.0001$). Weintraub W. S. found that Patients without postoperative infection had a mean LOPHS of 8.7 ± 8.9 days, while Patients with postoperative infection had a mean LOPHS of 32.2 ± 25.8 days (49). We found that patients who postoperatively developed infection have more than 97 times the risk of having prolonged postoperative hospital stay compared to patients without postoperative infection ($P < 0.0001$). Green J. W. and Wenzel R. P observed that patients with infection remained in hospital 19.5 days longer than controls (53). Taylor G. D. et al found that patients with infection have more than two times the risk of having prolonged postoperative hospital stay (54).

IV.4. Study limitations

The postoperative follow up of the participants has been done within 30 days only during their hospital stay. Limited by financial means, we didn't obtain the information about the postoperative infectious status of 391 (83.2%) patients from their day one at home until their 30th postoperative day. Also we had 4 (1.0%) patients who prolonged their hospital stay while they were waiting their families to pay the medical care and the stay. This last percentage is very small and unlikely to affect the results of the study.

V. CONCLUSION AND RECOMMENDATION

V.1. CONCLUSION

The perioperative hyperglycemia is common in adult patients undergoing surgery at CHUK. Its associated risk factors included older adults, ASA class II&III, surgical site class II&III and hypertension. The intraoperative and postoperative hyperglycaemia correlated with preoperative hyperglycemia which independently increased both the infection and the length hospital stay in postoperative period.

V.2. RECOMMENDATION

- 1) CHUK should provide functional materials and accessories for rapid diagnosis of perioperative hyperglycemia.
- 2) Clinicians should be aware of perioperative hyperglycaemia and its associated postoperative complications including infections and long hospital stay.
- 3) Further studies should evaluate the impact of the control of perioperative hyperglycemia on the postoperative outcome at CHUK.

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VII. APPENDICES

Appendix 1: participant information and consent form

Title of the Project:

Newly diagnosed hyperglycemia at Kigali University Teaching Hospital (CHUK): Prevalence, risk factors and impact on immediate patients' clinical outcome

Principal investigator:

Dr NGARUYE Sylvestre, University of Rwanda

Supervisor:

Dr TWAGIRUMUGABE Théogène, University of Rwanda

Co-supervisor:

Professor Franco CARLI, McGill University

INTRODUCTION

You are invited to take part in this research study because you will be having an operation at the Kigali University Teaching Hospital. We need to identify patients with high blood sugar without having signs and symptoms of diabetes. Your participation is voluntary. It is up to you to decide whether or not you wish to take part. If you wish to participate, you will be asked to sign this form. If, after signing the form, you wish to withdraw from the study, you are free to do so without giving any reason. If you do not want to participate, you will not lose the benefit of any medical care to which you are presently receiving. It will not affect your relationship with your caregivers. Please feel free. You can ask the researcher to explain any words or information that you do not clearly understand.

WHY IS THIS STUDY BEING DONE?

By taking capillary blood sample, we will identify patients at risk of high blood sugar status in perioperative period. We will find in addition if there is an association between perioperative hyperglycemia status and both postoperative infections and length of hospital stay.

WHAT DOES THE STUDY INVOLVE?

If you agree to take part in the study, we will collect the following information from you: your age, sex, current province, family history of diabetes, history of gestational hyperglycemia, type of surgery, weight, blood pressure, smoking, schedule, ASA classification, surgical wound classification, perioperative glycemia level, type of postoperative infection, length of postoperative hospital stay, category of surgery, type of anesthesia and evolution until the day of discharge if that does not go beyond 30 days. On the day of operation preoperatively, intraoperatively and on day one postoperatively, we will take blood sample from the patient by using a finger stick, then we will read the result on the screen of the glucometer.

WHAT ARE THE BENEFITS OF PARTICIPATING IN THIS STUDY?

Although you may not benefit from the results of this study directly, you will receive standard care. The blood sugar test is free for the patient. By participating to this study, you will promote the research. If there is an evidence of association between perioperative hyperglycemia and both postoperative infections and length of hospital stay at Kigali University Teaching Hospital, this study will help to recommend the decision makers and the clinicians to manage the perioperative hyperglycemia in order to improve postoperative outcome of patients.

ARE THERE POSSIBLE RISKS AND DISCOMFORTS?

There is no risk of harm or discomfort being placed on you by participating on this study.

WHAT HAPPENS IF I DECIDE TO WITHDRAW?

Your participation in this research is voluntary. You may withdraw from this study at any time. You do not have to provide a reason. Your future medical care will not be affected. If you choose to enter the study and then decide to withdraw later, all data collected about you during your enrolment will be retained for analysis.

WILL I BE INFORMED OF THE RESULTS OF THE STUDY?

The results of the study will be available in April 2014 from principal investigator and supervisors. Also, a summary of results will be posted at the University of Rwanda, Department of Anesthesiology's website.

WHAT WILL THE STUDY COST ME?

You will not be charged or paid for participating in this study. You will not receive any compensation, or financial benefits for being in this study, or as a result of data obtained from research conducted under this study.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?

Your confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent to the disclosure. However, research records and medical records identifying you may be inspected in the presence of the Investigator. Thus, no records that identify you by name or initials will be allowed to leave the Investigator's office. The results of this study may be presented in a scientific meeting or published, but your identity will not be disclosed.

WHO DO I CONTACT IF I HAVE QUESTIONS ABOUT THE STUDY?

If you have any questions or desire further information about this study before or during participation, you can contact Dr. NGARUYE Sylvestre at telephone number: (+250)788750518. If you have any concerns about your rights as a research participant and/or your experiences while participating in this study, contact the University of Rwanda ethics committee.

CONSENT TO PARTICIPATE

Study Title: “Newly diagnosed hyperglycemia in perioperative settings at Kigali university teaching hospital (CHUK): prevalence, risk factors and impact on immediate patients’ clinical outcome”

- I have read (or someone has read to me) the information in this consent form.
- I understand the purpose and procedures and the possible risks and benefits of the study.
- I was given sufficient time to think about it.
- I had the opportunity to ask questions and have received satisfactory answers.
- I understand that I am free to withdraw from this study at any time for any reason and the decision to stop taking part will not affect my future relationships.
- I give permission to the use and disclosure of my de-identified information collected for the research purposes described in this form.
- I understand that by signing this document I do not waive any of my legal rights.

I agree to participate in this study:

Name of participant:

Signature

Date

Appendix 2: Data collecting sheet

No	Question	Answer
01	Patient's ID	.....
02	Patient's age in years	.....
03	Sex	1 male 2 female
04	Department	1 ENT 2 Obstetrics and gynecology 3 Surgery
05	Province of origin	1 Kigali 2 East 3 West 4 North 5 South
06	Occupation	1 Public official 2 Self-employed person 3 Student 4 Others
07	ASA classification	1 I 2 II 3 III 4 IV
08	Weight	..... Kg
09	Height	..... Cm
10	Surgical wound classification	1 I 2 II 3 III 4 IV 5 Unclassified

11	Family history of diabetes	1 yes 2 no
12	History of gestational diabetes	1 yes 2 no
13	Do you smoke?	1 yes 2 no
14	SBP	..... mmHg
15	DBP	..... mmHg
16	Type of procedure	1 ENT surgery 2 Neurosurgery 3 Genitourinary surgery 4 General surgery 5 Orthopedic surgery 6 Gynecological surgery
17	Case status	1 Emergency 2 Elective
18	Type of anesthesia	1 Spinal anesthesia 2 General anesthesia
19	Preoperative fasting capillary blood sugar	..... mmol/L
20	Intraoperative fasting capillary blood sugar	..... mmol/L
21	Postoperative fasting capillary blood sugar	..... mmol/L
22	Type of anesthesia	1 Spinal anesthesia 2 General anesthesia
23	Postoperative infection	1 Surgical wound infection 2 Septicemia 3 Pneumonia 4 Urinary tract infection 5 Other (specify)
24	Length of postoperative hospital stay	..... days
25	Status at the end of follow up	1 Improved 2 Death 3 Escapee 4 Transferred 5 Still in hospital

Appendix 3: Surgical site classification according to Altemeier (34)**Surgical Wound Classification**

Wound Class	Definition	Examples	Reminders
Class I Clean	<ul style="list-style-type: none"> ▶ Operative wound clean ▶ Non-traumatic, with no inflammation encountered ▶ No break in technique ▶ Respiratory, gastrointestinal and genitor-urinary tracts not entered ▶ Caesarean Section, elective, no pre-rupture of membranes or trial of labor 	<ul style="list-style-type: none"> ▶ Vascular Procedures ▶ Neurological procedures (inflamed II, infected III) ▶ Endocrine procedures ▶ Eye surgery (inflamed II, foreign body III, infected III) ▶ Orthopedic procedures (unless: trauma III, old wound IV, amputation II) ▶ Penile prosthesis ▶ Skin (mastectomy, lumpectomy, lesions, lipoma, cosmetic, I&D IV, old wounds III, inflamed III, infected IV) ▶ Exploratory Lap (no bowel involvement II) ▶ Miscellaneous procedures (lymph node excision/Bx unless inflamed III or infected IV, splenectomy, tenckhoff cath unless replacement II) 	
Class II Clean - contaminated	<ul style="list-style-type: none"> ▶ Operative wound clean-contaminated ▶ Non-traumatic wound with minor break in technique ▶ Gastrointestinal, respiratory or genitor-urinary tracts entered without significant spillage Includes: <ul style="list-style-type: none"> ○ Transection of appendix or cholecystic duct in the absence of infected bile or urine ○ Hysterectomy ○ Caesarean Section, emergency involving pre-rupture of membranes and / or trial of labor 	<ul style="list-style-type: none"> ▶ Thoracic procedures (except mediastinoscopy I, inflammation III, infected IV, foreign body III) ▶ GI procedures (including: laparoscopy, colonoscopy, gastroscopy) (gross spillage III, acute inflammation III, fresh accidental wound III) (itis III, Lithiasis II) ▶ GU procedures (infected III) ▶ Ear surgery (infected III) ▶ Nose/Oropharynx procedures (infected IV) ▶ GYN procedures (Oophorectomy I, inflamed III, infected IV) 	<ul style="list-style-type: none"> ▶ Any wound open for drainage II (except total hip / knee) ▶ Removing old implants (wires, pins, etc...) ▶ Re-operation at the same site
Class III contaminated	<ul style="list-style-type: none"> ▶ Operative wound contaminated ▶ Fresh traumatic wound from clean source ▶ Operative wound with a major break in technique ▶ Gross spillage from the gastrointestinal tract ▶ Entrance into the genito-urinary or biliary tracts ▶ When infected urine or bile is present ▶ Incision encountering acute non-purulent inflammation. 	<ul style="list-style-type: none"> ▶ Inflammation ▶ Gross spillage ▶ Fresh accidental wound 	<ul style="list-style-type: none"> ▶ Foreign bodies in a wound (bullets, etc...)
Class IV Dirty - infected	<ul style="list-style-type: none"> ▶ Operative wound dirty ▶ Traumatic wound from dirty source ▶ Traumatic wound with delayed treatment ▶ Fecal contamination ▶ Foreign body ▶ Retained devitalized tissue ▶ Operative wound w/ acute bacterial inflammation or perforated viscus ▶ Operative wound where clean tissue is transected to gain access to a collection of pus 	<ul style="list-style-type: none"> ▶ Infected ▶ I&D abscess ▶ Wound debridement 	
Unclassified	<ul style="list-style-type: none"> ▶ When unable to classify accurately an operative wound 		<ul style="list-style-type: none"> ▶ Communicable disease (aids, hepatitis, TB) is not classified the surgical wound is what is being classified

Appendix 4: Preoperative physical status classification of patients according to the American Society of Anesthesiologists (ASA)(1)

Class ASA	Definition
I	A normal healthy patient
II	A patient with mild systemic disease (no functional limitations)
III	A patient with severe systemic disease (some functional limitations)
IV	A patient with severe systemic disease that is a constant threat to life (functionality incapacitated)
V	A moribund patient who is not expected to survive without the operation
VI	A brain-dead patient whose organs are being removed for donor purposes
If the procedure is an emergency, the physical status is followed by "E" (for example, "IIE")	