OPEN ACCESS Freely available online

Journal of Anesthesia and Clinical Research

Research Article

Magnitude and Associated Factors of Post-Operative Hyperglycaemia among Adult Non-Diabetic Patient Who Undergone Surgery at Two Tertiary Hospitals in Ethiopia, 2021 Cross Sectional Study

Mitiku Desalegn[1*], Tewoderos Shitemaw[2], Mulualem Sitot[3], Lemlem Getachew[3]

[1]Departemnt of Anesthesia, Wachemo University, Hossana, Ethiopia;[2]Department of Anesthesia, Kotebe Metropolitan University, Addis Ababa, Ethiopia;[3]Department of Anesthesia, Addis Abeba University, Addis Abeba, Ethiopia

ABSTRACT

Background: Patients with post-operative hyperglycaemia develop complications like surgical site infection, delayed wound healing and increased length of hospital stay. However, hyperglycaemia in postoperative period remains high in surgical patients. This study assessed the magnitude and associated factors of hyperglycaemia in postoperative period among non-diabetic adult patients who undergone elective surgery at Tikur Anbessa and Nigist Elleni Mohamed Memorial specialized hospital, Ethiopia.

Methods: Institutional based cross-sectional study was conducted among 359 non diabetic adult patients who undergone elective surgery at Tikur Anbessa and Nigist Elleni Mohamed Memorial specialized hospitals from January 1 to March 30, 2021. Systematic random sampling technique was used and quantitative data were collected by pre tested questionnaire through interview and data retrieval from chart. Both bivariable and multivariable logistic regression analysis were done to evaluate the association between independent and dependent variable. Level of statistical significance was declared at p-value less than 0.05.

Results: A total of 359 patients data were collected with response rate of 84%. The study revealed that 152(42%) of patients developed postoperative hyperglycaemia. Being in age group between 41 and 60 [AOR=4.9, 95% CI (2.5-9.7)], age above 60 [AOR=5.3, 95% CI (2.36-11.8)], dexamethasone use [AOR=2.65, 95% CI (1.1-5.9)], general anaesthesia [AOR=5.8, 95% CI (2.5-13.59)], combined general-regional anaesthesia [AOR=4.8, 95% CI (2.6-10.3))], neurosurgery [AOR=3.5, 95% CI (1.8-6.8)], duration of surgery above 1hr [AOR=3.9, 95% CI (1.9-8.0)] were statistically associated with postoperative hyperglycaemia.

Conclusion: Magnitude of hyperglycaemia is higher in postoperative period. Age, type of anaesthesia, type of procedure, dexamethasone use and duration of surgery were identified predictive factors.

Keywords: Addis Abeba; Elective; Ethiopia; Hyperglycaemia; Hossana; Anesthesia

Abbreviations: ASA : American Society of Anaesthesiologists; BMI: Body mass index; CBG: Capillary Blood Glucose; CI: Confidence Interval; DM: Diabetes Mellitus; EC: Ethiopian Calendar; FBS: Fasting Blood Sugar; HgA1c: Glycated Haemoglobin; ICU: Intensive care unit; LEB: Lower extremity bypass; NEMMSH: Nigist Elleni Mohamed Memorial Specialized Hospital; PACU: Post Anesthesia Care Unit; SPSS: Statistical Packages for Social Science; SD: Standard Deviation; SBP: Systolic Blood Pressure; TASH: Tikur Anbessa Specialized Hospital; WHO: World Health Organization.

INTRODUCTION

Hyperglycaemia is common after acute trauma, injury and illness in both diabetic and non-diabetic patient [1]. Surgical trauma commonly results in a postoperative insulin resistance [2]. This exerts altered insulin and glucose metabolism [3]. Perioperative hyperglycaemia is a common outcome with reported prevalence between 20%-40% of patients undergoing general surgery [4]. The American Association of Clinical Endocrinologists (AACE) and ADA have developed consensus statement on inpatient glycaemic control that defines hyperglycaemia as any BG value >140 mg/dl without evidence of previous diabetes [5]. Elevated blood glucose level has harmful effect on patients secondary to increased

Correspondence to: Dr. Mitiku Desalegn, Departemnt of Anesthesia, Wachemo University, Hossana, Ethiopia, Tel: +918510955882; E-mail: mitikudesalegn44@gmail.com

Received: September 14, 2021; **Accepted:** September 28, 2021; **Published:** October 05, 2021

Citation: Desalegn M, Shitemaw T, Sitot M, Getachew L (2021) Magnitude and Associated Factors of Post-Operative Hyperglycaemia among Adult Non-Diabetic Patient Who Undergone Surgery at Two Tertiary Hospitals in Ethiopia, 2021 Cross Sectional Stud. J Anesth Clin Res. 12:1023

morbidity and mortality [4]. There is a clear association between inpatient hyperglycaemia (>180 mg/dL, 10 mmol/l) and adverse clinical outcomes including surgical site infections, delayed wound healing and increased length of stay [6]. Review of study shows perioperative hyperglycaemia is associated with wound infection, skin infection, urinary tract infection, myocardial infarction, pneumonia and acute renal failure in non-cardiac surgery [4,6].

There are a variety of protocols used to control blood glucose level in different set up. Insulin infusion in postoperative period for hyperglycaemic patient was effective and another study shows a bolus of subcutaneous insulin is effective in reducing the blood glucose level, but tight glycaemic control in recovery room results in hypoglycaemia in some patients. The aim of this study is to determine the magnitude and contributing risk factors of postoperative hyperglycaemia, thus allowing targeted steps to be taken to improve the quality of care delivered to postsurgical patients.

MATERIALS AND METHODS

Study design and settings

An institutional based cross sectional study was conducted in two public specialized hospitals, Ethiopia from January 1, to March 30, 2021. Tikur Anbessa Specialized Hospital (TASH) is found in Addis Ababa, capital city of Ethiopia and Nigist Elleni Mohamed Memorial Specialized Hospital (NEMMH) found in Hossana town, the capital of Hadya zone.

Population

All adult non-diabetic patients who underwent elective surgery at Tikur Anbessa and Nigist Elleni Mohamed Memorial specialized hospital were the source population and all eligible non-diabetic adult patients who fulfil inclusion criteria during data collection period were the study population. Patients with confirmed pregnancy and baseline hyperglycaemia were excluded from the study.

Sample size determination and sampling technique

The sample size was determined using the single population proportion method for the first objective which is magnitude of postoperative hyperglycaemia after elective surgery. Since no related study was found in Ethiopia and Africa, P=0.5 was used for calculation to get maximum sample size, 95% level of significance, 5% margin of error and 10% for incomplete or as contingency data was used as parameters. The sample size was 384 and adding 10% for non-response rate, the final sample was 424.

Systematic random sampling method was used. Potential study subjects were all patients scheduled for elective surgery and their name selected and included in the surgery list. A list of all adult patients scheduled for elective surgery was collected from the theatre lists submitted to operating theatre by different surgical specialties a day prior to the scheduled surgical procedures.

After Situational analysis was done for 3 months before the start of the study, an average of 365 elective surgery are found to be done per month on both hospitals. So the number for 3 month is 1100. K was determined using the formula: K=N/n; where, n=total sample size, N=population per 3 months. K=1100 /359 ≈ 3. Therefore, the sampling interval was three and the first study participant (random start) was selected using lottery method from each surgical specialty. Each day before elective surgery begun patients were selected by systematic random sampling technique from each group of surgical specialty.

Then, every third cases from the daily surgical procedures were included in the study during the study period. The intention to include them in the study, the aim and benefit of the study, the data collection procedures were explained. A preliminary assessment whether the patient fulfills the inclusion criteria was made and those who met the inclusion criteria are included. This procedure was repeated in each day of data collection till the required sample size attained.

Operational definition

- Hyperglycaemia: Subjects with abnormally high blood glucose level or fasting blood sugar above 140mg/dl for non-diabetic and above 200 mg/dl for diabetic [7].
- Baseline value: Measurement taken before induction of anaesthesia
- Postoperative: Period after the patient is transferred to PACU.
- Perioperative: the period comprises all the three periods (preoperative, intraoperative and postoperative).
- Body mass index: A measure of body fat based on weight and height that applies to adult men and women.
- Immediate post-operative period: The time that extends from patient admission to PACU until the first vital sign and blood glucose level is taken by a nurse.
- Confirmed pregnancy: Pregnancy confirmed by pregnancy tests.

Data collection tool, method and procedure

Data was collected using structured pretested questioner by data collectors from January 01, to March 30, 2021. Questions in the questioner include socio demographic data, Clinical patient characteristics and different surgical and anaesthetic variables. Patients are allocated proportionally to each surgical type. Socio demographic and preoperative clinical data were extracted from patient's record on the morning of surgery. Intraoperative Anaesthetic and Surgical data were collected from intraoperative anaesthesia chart. Data was collected by four trained anaesthetists; this was done on the morning of surgery, in intraoperative period and immediately after surgery at PACU and this continues until the desired number of patient is achieved for each surgical type.

Immediately, after the patient transferred to PACU, the data collector records fasting blood glucose level after the PACU nurse took and record it on the chart. The glucometer used at PACU to check for capillary blood glucose by PACU nurse was hemocue201 glucose analyser which is based on glucose dehydrogenase method. The completeness of data was checked by principal investigator every day.

Data quality control

To assure the quality of data, training on the objectives and relevance of the study and brief Orientations on the assessment tools were provided for data collector. The questionnaires were prepared in English and pretested on 5% of the study population in Tikur Anbessa and Nemmsh. The result of the pre-test weren't included in the final analysis. During data collection, each questioner was revised by the investigator for being complete and appropriate. In case of missed measurement during intra-operative period, electronic data store of the monitoring equipment were recalled and back traced and data was filled.

Data analysis

Data were coded, edited and then entered and cleaned using Epi Info version 7 and exported to Statistical Package For Social Sciences (SPSS) software version 20.0. Bivariate and multivariate logistic regression analysis were done to determine presence of associations between dependent and independent variables, and odds ratio with 95% confidence intervals were used to determine the degree of association between dependent and independent variables. The prevalence was calculated as proportion of patients with postoperative hyperglycaemia with 95% confidence interval. Variables with a p-value less than 0.25 in the bivariate logistic regression analysis were considered for multivariable analysis. After checking for multicollinearity, multivariable analysis were performed to adjust for possible confounders and to come up with significant predictors. All the statistical tests were performed at 5% significance level. The results were presented by using text, tables, charts and graph.

Ethical considerations

Ethical approval and clearance were obtained from an ethical review committee of Addis Abeba and Wachemo University, College of Medicine and Health sciences. Confidentiality was maintained by making the data collectors aware not to record any identification information found.

RESULTS

Socio demographic and preoperative clinical characteristics of patients

A total of 359 patients data were collected during the study period with response rate of 84%. The mean age of patients was 47.5 with ± 16 standard deviation. The total number of female was 167 (46.5%) almost near to males 192 (53.5%). Majority (40.4%) of patient's age was found in 18-40 age group followed by age group 41-60 (32.6%) and the rest are above 60 years. With regard to American society of anaesthesiologist (ASA) status, most of the patients were under ASA class II (58.5%), the rest were under class I (Table 1).

Anaesthetic and surgical characteristics of patients

The total, majority of patients underwent surgeries under General anaesthesia 152 (42%), the rests underwent under Regional anaesthesia 116 (32%) and Combined General-regional anaesthesia 91 (26%). Majority of procedures took more than 60 minutes of duration 236 (65.7%). Numeric rating scale of pain was used to asses pain during immediate post-operative period, of which 198 (55.2%) of patients developed mild pain and the rest didn't show any sign of pain (Table 2 and Figure 1).

Magnitude of postoperative hyperglycaemia

Of total, six patients developed immediate post-operative hypoglycaemia (fasting blood glucose <70mg/dl) and managed with 40% dextrose IV bolus by PACU nurses (Figure 2).

Determinant factors of postoperative hyperglycaemia

According to results of bivariable binary logistic regression analysis, Age, ASA class, Administration of dexamethasone, type of procedure, type of anaesthesia, duration of surgery were associated with post-operative hyperglycaemia. In the final model (multivariable binary logistic regression analysis), after excluding variables which doesn't fit for the model using P-value >0.25 in Likelihood ratio test, multivariate analysis was performed for those variables; Gender, Age, ASA class, Body mass index, Administration of dexamethasone, type of procedure, type of anaesthesia, duration of surgery and pain were associated with post-operative hyperglycaemia. Patients with age between 41 and 60 were 5 times (AOR=4.9; 95% CI: (2.5-9.7) and age group >60 were 5.3 times (AOR=5.3; 95% CI: (2.36-11.8) more likely of developing post-operative hyperglycaemia compared to patients with age group of 18-40. Duration of surgery greater than 1hr were 3.9 times more likely to develop postoperative hyperglycaemia than surgery that took less than or equal to 1hr.

Patients who undergone neurosurgery were 3.5 times [(AOR=3.5; 95%CI :(1.8-6.8)] higher risk of developing post-operative hyperglycaemia than patients who undergone orthopaedic surgery. Among the study subjects, patients who took General anaesthesia were 5.8 times [(AOR=5.8; 95% CI: (2.5-13.59)] and those who took combined general-regional anaesthesia were [(AOR=4.8;95 % CI:(2.6-10.3)] more likely of developing post-operative hyperglycaemia than patients who undertook regional anaesthesia. Patients who took dexamethasone were 2.65 times more likely of developing post-operative hyperglycaemia than patients who don't [(AOR=2.65; 95% CI: (1.1-5.9)] (Table 3).

Table 1: Socio demographic and preoperative characteristic of patients who undergone elective surgery at TASH and NEMMSH from January 1, to March 30, 2021. (n=359).

Variables	Category	Frequency (%)
Gender	Male	192 (53.5)
	Female	167 (46.5)
Age	18-40	145 (40.4)
	41-60	117 (32.6)
	>60	97 (27)
ASA status	Class I	149 (41.5)
	Class II-III	210(58.5)
BMI	Non obese	278 (77.4)
	Obese	81 (22.6)

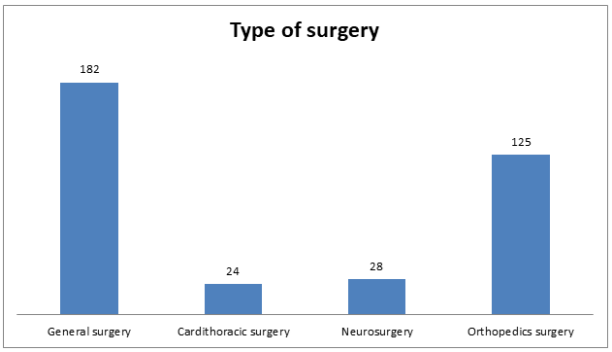

Figure 1: Type of elective surgery performed among adult patients at TASH and NEMMSH from January 1, to March 30, 2021.

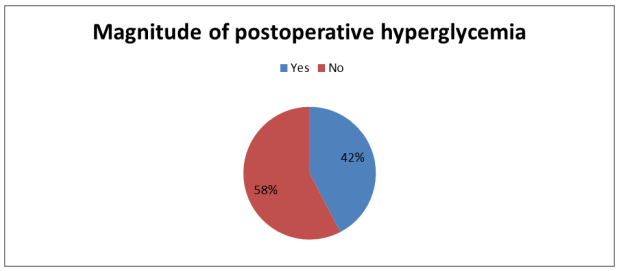

Figure 2: Type of elective surgery performed among adult patients at TASH and NEMMSH from January 1, to March 30, 2021.

Table 2: Anaesthetic and surgical characteristic of patients who underwent elective surgery at TASH and NEMMSH from January 1, to March 30, 2021. (n=359).

Variables	Category	Frequency (%)
Type of anaesthesia	Combined	91 (26)
	Regional	116 (32)
	General	152 (42)
Duration of surgery	≤ 60min	123 (34.3)
	>60min	236 (65.7)

Table 3: Determinants of postoperative hyperglycaemia among adult patients who undergone elective surgery at TASH and NEMMSH hospital from January 1, March 30, 2021. (n=359)

Variables	Category	COR 95% CI	AOR 95% CI	p value
Gender	Male	1	1	
	Female	0.67 [0.44-1.02]	1.1 [0.63-1.9]	0.7
Age	18-40	1		
	41-60	6.6 [3.8-11.4]	4.9 [2.486-9.7]	0.001
	>60	3.7 [2.1-6.6]	5.29 [2.36-11.8]	0.001
ASA class	Class I	1	1	
	Class II-III	2.17 [1.39-3.36]	1.81 [0.97-3.39]	0.062
BMI	Non obese	1	1	
	Obese	0.7 [0.4-1.17]	0.5 [0.254-1.3]	0.184
Dexamethasone	No	1	1	
	Yes	2.2 [1.4-3.5]	2.65 [1.1-5.9]	0.018
Type of surgery	Orthopedic	1	1	
	Neurosurgery	3 [1.844-4.9]	3.5 [1.8 -6.8]	0.001
	Cardiothoracic	2.57 [1.05-6.26]	1.3 [0.4-4.0]	0.58
	General	0.7 [0.26-1.87]	0.58 [0.15-1.8]	0.3
Type of Anesthesia	Regional	1	1	

	General	13 [6.5-26]	5.88 [2.5-13.59]	0.001
	Combined	6.9 [3.68-12.9]	4.8 [2.26-10.3]	0.001
Duration of surgery	≤ 60min	1	1	
	>60min	3.53 [2.1-5.7]	3.9 [1.9 -8]	0.001
Immediate post-operative Pain	No	1	1	
	Yes	0.5 [0.36-1.84]	0.26 [0.135-1.5]	0.06

Statistically Significant: ** P < 0.05, AOR: Adjusted Odds Ratio; COR: Crude Odds Ratio; CI: Confidence Interval.

DISCUSSION

According to this study, there is higher magnitude of post-operative hyperglycaemia 42% among adult non-diabetic patients who undergone elective surgery. Age, dexamethasone use, type of anaesthesia, type of procedure and duration of surgery were associated with post-operative hyperglycaemia. Our study finding is higher than study conducted in Brazil at university of Sao Paulo (BG>120 mg/dl) 26.4% [8]. USA at university of Washington (BG>180 mg/dl) 29.1% [9] and study conducted at Tampere university hospital in Finland is nearly equal with our study (BG>140 mg/dl) 41% [10]. The magnitude of current finding is lower than study conducted at Lucknow medical college in India (BG>140 mg/dl) 56.4% [11] and at Singapore general hospital in Singapore (BG>180 mg/dl) 56.1% [12]. These variations could be attributed to size, setting and difference in the definition of post-operative hyperglycaemia of the studies. Of course genetic and behavioural factors (diet) as the result of difference in insulin resistance may have played role on this disparity [13,14].

In this study age is strongly associated with post-operative hyperglycaemia. Patients with age group between 41 and 60 were 5 times and age above 60 was 5.3 times more likely to develop postoperative hyperglycaemia compared to patient whose age is between 18 and 40. This result is consistent with the retrospective study conducted on 837 patients at PACU in university of Sao Paulo [8] and study has done at two hearts Centre in Singapore [14]. This might be explained by the fact that, with aging there are changes in insulin secretion and peripheral resistance to its effect, as the result of increased abdominal fat mass [15-17]. It was also observed in this study that, an increase in the duration of surgery is strongly associated with post-operative hyperglycaemia. Procedure that took greater than 1hr was 3.9 times more likely to result in post-operative hyperglycaemia than procedure below or equal to 1hr. This finding is in line with the prospective observational study conducted on a patients who undergone primary hip and knee replacement surgery at Tampere University in Finland [10]. The possible reason for this increase might be alteration in glucose metabolism associated with insulin resistance due to increased stress during intraoperative period. Such alterations are due to adaptive activation of endocrine response, including increased release of catecholamine, cortisol and glucagon and reduced glucose uptake capacity [18].

Patients who took general anaesthesia were 5.8 times and combined general-regional anaesthesia was 4.8 more prone to hyperglycaemia than patients who undertook regional anaesthesia. This finding is in line with the study done to identify the effect of different type of anaesthesia on blood glucose level; the combined general-regional anaesthesia has better blood glucose level than general anaesthesia [19]. Another study conducted to compare the effect of general anaesthesia and spinal anaesthesia on changes in blood glucose concentration in non-diabetic patients also supports our study result [20]. This might also be related with volatile anaesthetic agents inhibit insulin production and increasing hyperglycaemic response to surgery [21]. Administration of dexamethasone during intraoperative period is another factor associated with the likelihood of exhibiting postoperative hyperglycaemia. This finding is consistent with the study conducted in Brazil at university of Sao Paulo [8]. Administration of 8mg of dexamethasone between diabetic and non-diabetic patient who underwent laparoscopic surgery, blood glucose level observed at 30min and 120min marks were statistically significant relative to the pre-induction blood glucose [22]. Another study predicted the maximum increase in 24 h postoperative blood glucose to be 1.9 mmol.l1 (95% CI: 1.0–2.9) higher in patients receiving dexamethasone compared with patients receiving Ondasteron [23]. The likely explanation is increased stimulation of adrenal gland by steroid, which might result in increased sympathetic nervous system activation [2,3].

Limitation of the study

Pre diabetic patients have impaired fasting glucose and impaired glucose tolerance test. The only way to identify this group of patient is to test for % of HgbA1c, IGT test and IFG test. These tests are expensive and are not done routinely in our setup. Some patients may have undiagnosed endocrine metabolic disorder (Thyroid and liver disease) which will predispose patients to have altered glucose metabolism. These factors might have effect on outcome variable, thus, the finding of this study should be interpreted with these limitations.

CONCLUSION

Nearly, half of the patients had post-operative hyperglycaemia, age, dexamethasone administration, type of anaesthesia, type of procedure and duration of surgery were predictors of post-operative hyperglycaemia. Anaesthetist's and PACU staffs understanding of these factors is important for close follow up of this group of patients.

DECLARATIONS

Ethics approval and consent to participate

The required data were collected after obtaining ethical clearance from Addis Abeba and Wachemo University College of medicine and health science institutional review committee. In addition permission from both health institutions and verbal consent from each patient was taken.

Consent for publication

The Author declares that any person named as co-author of the contribution is aware of the fact and has agreed to being so named. The Authors guarantees that the Work has not been previously published elsewhere. All authors read and approved the final manuscript and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Competing interests

The authors have no conflicts of interest to declare.

Research registration number

Not required.

Availability of data and material

The data used in this study was collected by trained data collectors and the lead author is willing to share the data upon request from peer researchers.

FUNDING

This work was funded by Addis Abeba University.

AUTHORS CONTRIBUTION

Authors will take public responsibility for the contents, have contributed substantially to the drafting, and have approved the final version.

Mitiku Desakegn (MSc): This author helped on substantial intellectual contributions to conception, design, and acquisition of data, analysis, and interpretation of data as well as on preparing the manuscript to this study.

Mulualem Sitot (MSc): have made substantial contributions to conception, design, analysis and interpretation of data and participated in the critical review and editing of the manuscript drafts for scientific merit and depth.

Lemlem Getachew (MSc): have made substantial contributions to conception, design, analysis and interpretation of data and participated in the critical review and editing of the manuscript drafts for scientific merit and depth.

Tewoderos Shitemaw (MPH, M.Sc.): has been involved in analysis, interpretation of data and drafting the manuscript and revising it critically for important intellectual contents.

ACKNOWLEDGEMENTS

We would like to thank Addis Abeba University College of Medicine and Health Science for funding this research. Our gratitude goes to supervisors, data collectors and study respondents. Finally, we would like to thank all those, who in one way or another have contribute in this work.

REFERENCES

1. Martinez-Riquelme AE, Allison SP. Insulin revisited. Clin Nutr. 2003;22(1):7-15.
2. Lisa S, Feng W, Margery K H. Early impairment of insulin secretion in rats after surgical trauma. Eur J Endocrinol. 2002;147(6):825-833.
3. Huang MLC, Dobson G. Epinephrine enhances glycogen turnover and depresses glucose uptake in vivo in rat heart. FASEB J. 1997;11(12):973-978.
4. Anna Frisch PC, Dawn Smiley, Limin Peng, Monicca Rizzo. Prevalence and clinical outcome of hyperglycemia in the perioperative period in noncardiac surgery. Diabetes Care. 2010;33(8):1783–1788.
5. Moghissi ES KMT, DiNardo M, Einhorn D, Hellman R, Hirsch I B, Umpierrez GE. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. Diabetes Care. 2006;36(6):1119-1131.
6. Cook CBAV, Anderson M. Inpatient glucose control: a glycemic survey of 126 U.S. hospitals. J Hosp Med. 2009;4(9):7-14.
7. Stephen clement SB, Michelle magge, Andrew ahmann, Elizabeth smith. Management of diabetes and hyperglycemia in hospitals. Diabets care. 2004;27(2):553–591.
8. Pereira VR, Azuma RA, Gatto BEO, Silva Junior JM, Carmona MJC, Malbouisson LMS. Avaliação de hiperglicemia na sala de recuperação pós‐anestésica. Rev Bras Anestesiol. 2017;67(6):565-570.
9. Kwon S, Thompson R, Dellinger P, Yanez D, Farrohki E, Flum D. Importance of perioperative glycemic control in general surgery: a report from the Surgical Care and Outcomes Assessment Program. Ann Surg. 2013 ;257(1):8-14.
10. Jämsen E, Nevalainen PI, Eskelinen A, Kalliovalkama J, Moilanen T. Risk factors for perioperative hyperglycemia in primary hip and knee replacements. Acta Orthop. 2015;86(2):175-182.
11. Ghildiyal JP, Ghildiyal A, Sharma S, Iqbal B, Singh S. Association of perioperative hyperglycemic state with postoperative infection. Asian Journal of Med Sci .2016; 7(6):32-35.
12. Moorthy V, Sim M A, Liu W, Chew STT, Sophia TH,Ti LK. Risk factors and impact of postoperative hyperglycemia in nondiabetic patients after cardiac surgery. Medicine: 2019 ;98(23) :15911-15920.
13. Barik A, Mazumdar S, Chowdhury A, Rai RK. Physiological and behavioral risk factors of type 2 diabetes mellitus in rural India. BMJ Open Diabetes Res Care. 2016;4(1):1-3.
14. Moorthy V, Sim MA, Liu W, Ti LK, Chew STH. Association Between Ethnicity and Postoperative Hyperglycemia in a Southeast Asian Population Undergoing Cardiac Surgery. J Cardiothorac Vasc Anesth. 2019;33(2):388-393.
15. Desai D, March R, Watters JM. Hyperglycemia after trauma increases with age. J Trauma. 1989;29(6):719-723.
16. Mooradian AD. Mechanisms of age-related endocrine alterations. Part II. Drugs Aging. 1993;3(2):131-146.
17. Kalyani RR, Egan JM. Diabetes and altered glucose metabolism with aging. Endocrinol Metab Clin North Am. 2013;42(2):333-347.
18. 18.Strömmer L, Wickbom M, Wang F, Herrington MK, Ostenson CG, Arnelo U, et al. Early impairment of insulin secretion in rats after surgical trauma. Eur J Endocrinol. 2002;147(6):825-833.
19. Li X, Wang J, Chen K, Li Y, Wang H, Mu Y, et al. Effect of different types of anesthesia on intraoperative blood glucose of diabetic patients: A PRISMA-compliant systematic review and meta-analysis. Medicine (Baltimore). 2017;96(13):6451-6455.
20. El-Radaideh K, Alhowary AA, Alsawalme M, Abokmael A, Odal H, Sindiani A. Effect of Spinal Anesthesia versus General Anesthesia on Blood Glucose Concentration in Patients Undergoing Elective Cesarean Section Surgery: A Prospective Comparative Study. Anesthesiol Res Pract. 2019 ;20(5);748-753.
21. Tanaka T, Nabatame H, Tanifuji Y. Insulin secretion and glucose utilization are impaired under general anesthesia with sevoflurane as well as isoflurane in a concentration-independent manner. J Anesth. 2005;19(4):277-281.
22. O'Connell RS , Clinger BN, Donahue EE. Dexamethasone and postoperative hyperglycemia in diabetics undergoing elective hip or knee arthroplasty: a case control study in 238 patients. Patient Saf Surg 2018 ;12(5):25-30
23. Zhou MS, Schulman IH, Zeng Q. Link between the renin-angiotensin system and insulin resistance: implications for cardiovascular disease. Vasc Med. 2012;17(5):330-341.