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Research Article

Blood Glucose Dynamics in Diabetic Patients Undergoing Elective Surgery: A Descriptive-Analytical Cross-Sectional Investigation

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ABSTRACT

Background: Major surgeries cause metabolic stress and insulin resistance, leading to postoperative hyperglycemia and increased morbidity and mortality in diabetic patients. Therefore, this study aimed to assess blood sugar level changes in diabetic patients undergoing elective surgery and its confounding factors.
Methods: A cross-sectional study compared blood sugar levels (BS) in 100 diabetic patients undergoing elective surgeries. Demographic data, medical history, surgery type, and anesthetic technique were documented. Laboratory assessments included fasting blood sugar (FBS) and glycosylated hemoglobin (HbA1C). Statistical analysis used SPSS software and nonparametric tests.
Results: Postoperative blood sugar levels significantly increased compared to preoperative levels (mean change 11.40 ± 14.356 mg/dL). Age over 60 and general anesthesia were significant factors associated with elevated blood sugar.
Conclusion: This study reveals a significant postoperative increase in blood glucose levels in diabetic patients, particularly those aged over 60 and under general anesthesia.

Introduction

Metabolic stress and insulin resistance are consequences of major surgeries [1], which can result in postoperative hyperglycemia and increased mortality and morbidity [2-3]. Additionally, surgical stress responses can lead to failure in insulin secretion and increased insulin resistance, ultimately resulting in decreased insulin secretion and elevated blood sugar (BS) levels. Preoperative hyperglycemia (BS> 140 mg/dL) can cause dehydration, fluid shifts, abnormal electrolyte levels, infections, impaired wound healing, postoperative ketoacidosis, and hyperosmolarity [4].

An increase in sympathetic activity and noradrenaline levels can also result in reduced insulin secretion, leading to changes in patients' hemodynamic status as well as fluctuations in BS levels. It also causes hyperglycemia by increasing gluconeogenesis and decreasing glucose utilization. There is also evidence of insulin resistance [5]. Surgery-induced stress can lead to various complications during and after the procedure. These complications may include delayed wound healing, alterations in hemodynamic status, and even mortality. The exact mechanism underlying the relationship between hyperglycemia and negative outcomes has not

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been fully elucidated. Previous and ongoing studies indicate that there are physiological changes that occur in the hyperglycemic state, which can result in unfavorable outcomes. High BS levels impair neutrophil function, leading to an excessive production of reactive oxygen species, free fatty acids, and inflammatory mediators. These pathophysiological changes lead to direct cell damage, vascular disorders, and immune inefficiency [6].

Numerous studies have shown there is a negative relationship between preoperative hyperglycemia and clinical outcomes [7-9].

In several randomized clinical trials with careful monitoring of pre-operative BS levels (between 80 and 110 mg/dL), conflicting results have been reported. Some studies have indicated potential harm to the patient [4, 10-11]. In addition, accurate control requires frequent glucose measurements, which may increase the complexity of preoperative glucose management. Nevertheless, careful glycemic control during the preoperative period has been recommended by several professional organizations and targeted as a national quality improvement initiative by healthcare centers [12].

This study aimed to investigate changes in BS levels and identify its related factors in diabetic patients undergoing elective surgery.

Methods

Study Design

After obtaining ethical consideration from Research Ethics Committees of AJA University of Medical Sciences (Approval number: IR.AJAUMS.REC.1398.169), this study was conducted at Imam Reza Hospital, Tehran, Iran from April 2020 to January 2023. In this descriptive, analytical cross-sectional study, we compared the changes in BS levels among diabetic patients who underwent elective surgeries with different anesthetics techniques. The BS levels were recorded before transferring to the operating room and after entering the recovery room. All diabetic patients of either gender, between 18 and 72 years old with American Society of Anesthesiologists (ASA) physical status class 1 and 2, who were eligible for elective surgeries which was lasting for at least one hour, as determined by expert opinion, and had the freely written inform consent to participate, were included in this study through simple random sampling. Patients with a recent history of taking steroid, sepsis, heart disease and thyroid disease were excluded.

The demographic data, medical, history, type of surgery, and type of anesthetic technique were documented in the case report form (CRF). Height and weight were measured by a trained operator after a fasting period of 12 to 14 hours; Height was measured while standing upright and vertically, without wearing shoes, with an accuracy of 0.5 cm, and weight was measured using a standard scale with an accuracy of 0.1 kg. The body mass index (BMI) is calculated by dividing weight in kilograms by the square of height in meters.

Laboratory Assessment

Fasting blood sugar (FBS) and glycosylated hemoglobin (HbA1C) levels were measured in the patients prior to surgery (2 hours before the procedure). Subsequently, blood sugar was measured at the end of surgery in the recovery room. A volume of 5 cc of blood was drawn from the participants in the fasting state at timepoints through the right elbow vein and transferred to a glass container containing heparin. All samples were analyzed within an hour. The enzymatic method was used to measure BS, while the calorimetric method was used to measure HbA1C.

Statistical Analysis

At the end of the study, the data was analyzed by SPSS statistical software version 26. The data were described using the nonparametric Wilcoxon rank-sum and Kruskal-Wallis tests for statistical analysis. P-values below 0.05 were considered statistically significant.

Results

The primary objective of this study was to investigate and compare the fluctuations in blood sugar levels among diabetic patients who were scheduled for elective surgeries and recognized its confounding factors.

A total of 100 diabetic patients were included in the study, with 41% male gender distribution and a mean age of 61.53 ± 8.96 years. (Table 1) showed the participants' baseline data.

As (Table 2) presented, the post-op BS level were significantly higher than pre-op ones, with a mean of BS changes 11.40 ± 14.356 mg/dL.

To recognize the confounding factors for BS level alteration at pre- and post-op timepoints, relation between variables such as age, gender, BMI, history of addiction, history of hypertension, type of anesthetic technique, and type of elective surgery and BS level changes were assessed. As shown in (Table 3), age more than 60 years old ($P<0.001$) and general anesthesia ($P=0.012$) significantly altered the BS level in an increasingly manner.

Although higher BMI, addiction history, hypertension and having a neurosurgery had an increase effect on BS level but amounts of changes were not statistically significant.

Table 1- The baseline data of participants

variables	values
Demographic info	
Age, years old Mean ± SD	61.53 ± 8.96
Gender, Male N(%)	41(41)
BMI, kg/m2 Mean ± SD	24.32 ± 3.71
Medical History	
Diabetes mellites N(%)	100(100)
Hypertension N(%)	47(47)
Hyperlipidemia N(%)	53(53)
Addiction N(%)	4 (4)
Type of surgery	
General	43 (43)
Orthopedics	24 (24)
Neurosurgery	12 (12)
ENT	21 (21)
Anesthetic technique	
General	74 (74)
Spinal	26 (26)

Abbreviation-BMI: Body Mass Index; ENT: ear, Nose, Throat

Table 2- Blood sugar level changes at Pre- and Post- operation.

Variables	Minimum BS level Mg/dL	Maximum BS level Mg/dL	Mean ± SD	P value
Pre-op BS	84	165	114.07 ± 18.423	
Post-op BS	80	166	125.47 ± 16.093	<0.001
Blood Glucose changes	-33	+60	+11.40 ± 14.356	

Abbreviation- BS: Blood Sugar; pre-op: pre operation (before surgery); post op: post operation (post-surgery)

Table 3- BS level changes of participants based on variables.

Variables		BS level changes, mg/dL Mean ± SD	P value
Age	≤60 years	3 ±11.263	<0.001
	>60 years	16.55 ±13.662	
Gender	Male	11.68 ±14.964	0.633
	Female	11.20 ±14.045	
BMI	≤25 kg/m2	10.73 ±12.583	0.869
	>25 kg/m2	12.76 ±147.557	
History of Addiction	Yes	18 ±16.833	0.653
	No	11.12 ±14.280	
History of hypertension	Yes	13.39 ±15.332	0.723
	No	10.62 ±13.993	
Type of anesthesia	General	13.73 ±14.370	0.012
	Spinal	4.77 ±12.304	
Type of surgery	General	9.74 ±16.016	0.365
	Orthopedics	10.50 ±15.065	
	Neurosurgery	19.50 ±14.613	
	ENT	11.19 ±7.534	

Abbreviation- BMI: body Mass Index; ENT: Ear, Nose, Throat

Discussion

The present study was conducted to assess the BS level changes pre- and post-operation and identify its related factors in diabetic patients undergoing elective surgery.

Hyperglycemia was reported to be linked to higher mortality in critically ill patients in a 2012 review article [13]. Insulin resistance is frequently brought on by stress-induced hyperglycemia in surgical patients, and insulin injection therapy for hyperglycemia does not produce long-term advantages. Regarding the ideal glucose levels to improve outcomes for critically ill patients, there are conflicting findings available. However, it is agreed that hypoglycemia should be avoided, the risk of hyperglycemia should be countered too. Diabetic patients require intensive preoperative glucose management, while strict glycemic control may be beneficial, mild hyperglycemia seems to be tolerable.

Samdani Fard et al. [14] investigated the relationship between blood glucose levels and hemodynamic status of non-diabetic patients undergoing non-emergency surgery. They reported that pre-operative blood glucose levels and pre-operative diastolic and systolic blood pressure, as well as systolic blood pressure during surgery, were significantly correlated. However, there was no significant correlation seen between blood glucose levels and breathing rate, heart rate, or oxygen saturation. It is important to note that a number of factors, including sample size, patient demographics, inclusion/exclusion criteria, measurement techniques, and timing of blood glucose assessments, may have contributed to the study's lack of a significant relationship between these variables and blood glucose changes.

In a study, Tabatabai et al. [15] compared the variations in blood glucose levels between two anesthetic techniques used during coronary artery bypass surgery for diabetic patients: general anesthesia and general anesthesia combined with spinal anesthesia. According to the study, the combination anesthetic approach improved blood pressure and heart rate regulation, decreased the requirement for insulin, and efficiently managed blood glucose levels.

Madineh et al. [16] conducted a randomized clinical trial (RCT) comparing the effects of general anesthesia and spinal anesthesia on blood glucose changes during surgery. The findings demonstrated that, in comparison to general anesthesia, spinal anesthesia was more effective at controlling blood glucose levels. according to this study, spinal anesthesia could be a suitable alternative to general anesthesia, particularly in patients with metabolic issues. The results of this RCT are consistent with our own study, which also demonstrated improved blood glucose control with spinal anesthesia.

Parish et al. [17] compared the effects of general anesthesia versus spinal anesthesia on blood glucose fluctuations in diabetic patients having orthopedic surgery. Blood glucose levels were assessed before surgery, after the incision, an hour later, and after recovery. During repeated evaluations, blood glucose levels significantly increased with both anesthetic procedures; nevertheless, no significant differences were seen between the two groups. According to this their findings, blood glucose levels rose steadily both throughout surgery and anesthesia, with the general anesthetic group experiencing a more dramatic rise, which are consistent with our results, which found that spinal anesthesia improved blood glucose management.

A cohort study comparing blood glucose variations after cesarean section surgeries under spinal anesthesia with general anesthesia was carried out by Manafi et al. [18]. During a cesarean section, mothers' blood glucose fluctuations and related side effects were found to be lessened by spinal anesthetic. These results support our study's findings and indicate that spinal anesthesia improves blood glucose management.

According to Davis et al. [19] study, higher age is significantly correlate with stress-induced hyperglycemia in non-diabetic patients undergoing general surgeries. This report is also supported by Moorthy et al. [20] cohort study, and also is consistent with our study, in which age more than 60 years old had experience significantly higher BS more than patients with lower ages.

In summary, this study suggest that age and the type of anesthesia significantly affect blood glucose changes in diabetic patients undergoing elective surgeries. This knowledge can contribute to the development of customized management strategies to optimize glycemic control and enhance surgical outcomes in this specific patient population. Further research is needed to investigate the underlying mechanisms and potential interventions associated with these significant correlations.

The study is limited by its exclusive focus on diabetic patients undergoing elective surgeries in a single hospital, restricting the generalizability of findings. Additionally, the inclusion of diverse surgical procedures introduces variability. These limitations should be considered when interpreting the study's implications.

Conclusion

The results of our study showed that blood glucose increases significantly after surgery in diabetic patients. This increase is particularly pronounced in patients aged over 60 and those who undergo general anesthesia, but no statistically significant differences were observed in the changes of blood glucose levels based on gender, body mass index, history of addiction, hypertension, or type of surgery. Therefore, it appears that preoperative blood glucose screening and postoperative blood glucose control measures are more crucial in reducing complications in diabetic patients, especially elderly individuals under general anesthesia, due to the increase in blood glucose levels after surgery and the associated complications.

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