

A Cross-sectional Observational Analysis of Preoperative Blood Glucose Levels in Nondiabetic Patients presenting for Surgery

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ABSTRACT

Introduction: Abnormal blood glucose levels alter the course and result of surgery. This study aims to quantify the incidence of hypoglycemia or hyperglycemia in the preoperative period and to assess the impact of duration of nil per os (NPO), age, intravenous fluids (IVFs), blood transfusion, severity of pain and anxiety, and steroid or antibiotic administration on preoperative blood glucose levels in nondiabetic patients.

Materials and methods: The NPO duration, age, IVF, blood transfusion, pain and anxiety score, steroid and antibiotic administration were noted in 1,000 nondiabetic patients presenting for both elective and emergency surgery. Blood glucose level was measured before induction of anesthesia by capillary finger-prick method. The values of blood glucose levels were analyzed for correlation with above-mentioned parameters.

Results: Overall incidence of hypoglycemia was found to be 23.3%. About 27.2% of patients including 34.95% children posted for elective surgery and 33.37% of patients including 8.73% children posted for emergency surgery group were hypoglycemic. The incidence of hyperglycemia was 1.51 and 1.08% for adults in elective and emergency category respectively. Age showed widely varied association to preoperative blood glucose levels; blood glucose levels increased with age in male patients, with patients aged between 18 and 40 years admitted for emergency surgery ($p = 0.006$), but decreased with age in patients older than 60 years irrespective of gender and type of surgery ($p = 0.014$). The preoperative blood glucose levels increased with higher preoperative pain and anxiety ($p = 0.05$) and administration of steroids ($p = 0.00043$). Similarly, with increase in duration of NPO, preoperative blood glucose levels decreased in adult females ($p = 0.000$) and males over 40 years ($p = 0.049$), both admitted for emergency surgery. Only preoperative normal saline (NS; $p = 0.001$), 6% hydroxyethyl

starch (HES; $p = 0.043$), Isolyte P ($p = 0.000$), and blood transfusion ($p = 0.05$) showed significant correlation.

Conclusion: Preoperative blood glucose monitoring is recommended mandatorily for all patients posted for emergency surgery. It is also recommended for elective pediatric and geriatric surgery patients, patients with high anxiety and/or pain, increased NPO duration, and preoperative administration of steroid, NS, 6% HES, or blood.

Keywords: Age, Anxiety, Blood glucose, Blood sugar, Intravenous fluids, Nil by mouth, Nil per os, Nondiabetic, Pain, Preoperative, Steroids.

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INTRODUCTION

Abnormal blood glucose levels alter the course and result of surgery. Preoperative hypoglycemia results in neuroendocrine stimulation by central nervous system-mediated sympathoadrenal discharge.¹ Similarly, preoperative hyperglycemia prolongs wound healing and increases the chances of infection.² Various factors affecting the blood sugar levels in the preoperative period include age,³⁻⁶ duration of starvation,^{3,6} operative and anesthesia stress,^{7,8} steroid use,⁹⁻¹² antibiotic given,¹³⁻¹⁷ as also type and amount of IVFs given.¹⁸⁻²² However, it is not a routine practice to measure blood glucose perioperatively in nondiabetic patients. Relatively inexpensive, point-of-care blood glucose monitors, which are easy to use and show good correlation with laboratory values, have become available.

Hence, this study aimed to estimate the incidence of hypoglycemia and hyperglycemia in preoperative nondiabetic patients posted for surgery as well as to analyze the impact of factors mentioned above on preoperative blood glucose levels.

MATERIALS AND METHODS

The study was approved by the institutional ethics committee and registered at Clinical Trial Registry of India

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(CTRI/2017/09/009713). Considering surgical patient population to be 954 per 100,000 population in the year 2012 to 2013 with total population of 1.28 billion for Indian context, with a confidence interval of 4 and confidence level of 95 to 99%; the sample size was estimated to be 839 to 1,210. Sample size was decided as 1,000 and all consenting patients of either sex and any American Society of Anesthesiologists (ASA) class, between age 1 and 90 years, admitted for various elective or emergency surgeries during the period April 2014 to August 2015, at the study institute were included in the study. Infants, pregnant and lactating females, uncooperative patients, patients on IVFs for more than 24 hours, patients where IV access could not be secured prior to induction of anesthesia, patients with diabetes mellitus, patients with other endocrine disorders known to affect blood sugar levels were excluded from the study. We used convenient, consenting, consecutive sampling method for collection of data.

The demographic details, duration of preoperative NPO, any IVFs/blood transfusion, steroid administration, and antibiotic given were collected. The NPO span was calculated from the time of last oral ingestion, excluding sips of water for oral medication purpose. The subjective assessment of anxiety and pain was calculated from Numerical Analog Scale for pain and anxiety, with 1 for the minimal pain/anxiety and 5 for the maximum extreme. The blood sample was collected preoperatively by capillary finger-prick method. Blood glucose levels were measured with the help of a Glucometer (One Touch Select Simple Blood Glucose Monitor, Johnson and Johnson Private Ltd, Mumbai, Maharashtra, India) and recorded in milligram per deciliter.

The data were compiled in Excel sheet and statistically analyzed using software version Statistical Package for the Social Sciences 12.0 (SPSS Inc., Chicago, Illinois).

Statistical Analysis

All continuous variables like age, duration of starvation, and blood glucose levels were assessed for normality and were log transformed if not found to be distributed normally, to make the data best fit for reliable interpretability. The numerical anxiety and pain scale were considered as the categorical variables. Administration of preoperative steroids, preoperative blood transfusion, and infusion of 6% HES was interpreted as binary variables (the data presented as 1 or 0 for YES or NO respectively). The numerical data were subdivided into different subgroups and transformed to categorical data for ease of multiple statistical analysis. Pearson correlation and Student's t-test were used to test the bivariate association of the above-mentioned continuous and binary

variables, respectively, with preoperative blood glucose levels. Analysis of variance (ANOVA) and multiple linear regression model were used to test the association of the categorical variables. Data were assessed for collinearity before possible inclusion in multiple linear regression model. A p-value <0.05 was considered to be significant, <0.01 highly significant, and <0.001 very highly significant for all statistical comparisons.

RESULTS

The demographic characteristics of the study population are presented in Table 1.

The mean duration of preoperative fasting (Table 2) was 11.872 hours with a range from 4 to 48 hours. About 52.4% of patients were NPO for more than 10 hours; 64.4% of patients were infused some kind of IVFs during NPO hours, which included 9.2% with dextrose normal saline (DNS) and 6.5% with blood transfusion. Anxiety and pain scores were as follows: I for 18.10%, II for 34.9%, III for 31.8%, IV for 15%, and V for 0.2% of population. Only 2.9% of total study population had received steroid injections for different indications. None of the patients in the study were administered any antibiotic that has a known action on glucose metabolism.

In our study, 15.15% of adults and 34.95% of children from elective surgery group and 24.64% of adults and 8.73% of children in emergency surgery group were hypoglycemic (Table 3). Overall incidence of hypoglycemia

Table 1: Demographic characteristics

Parameters	Distribution
Adult (>18–90 years): Pediatric (1–18 years)	688:312
Elective: Emergency	318:682
Male: Female	747:253
ASA class I/II/III	837/150/13

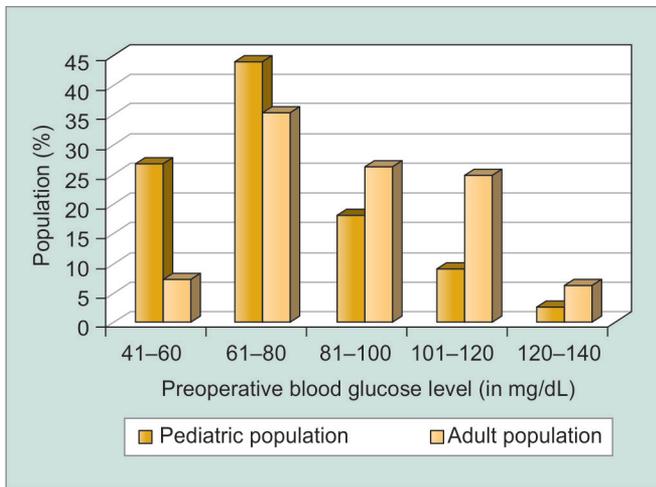
Table 2: Duration of preoperative starvation

Duration (in hours)	Frequency	Mean \pm SD	Percentage
4–6	39	5.59 \pm 0.71	3.9
>6–8	186	7.69 \pm 0.46	18.6
>8–10	251	9.53 \pm 0.5	25.1
>10–12	236	11.5 \pm 0.5	23.6
>12–24	254	16.1 \pm 3.57	25.4
>24	34	30.2 \pm 7.68	3.4

SD: Standard deviation

Table 3: Incidence of hypoglycemia

Age of patient (in years)	In elective surgery		In emergency surgery	
	Incidence	Percentage	Incidence	Percentage
Adult (>18)	20/132	15.15	137/556	24.64
Pediatric (1–18)	65/186	34.95	11/126	8.73



Graph 1: Preoperative blood glucose levels in pediatric vs adult patients

in adults was 22.81 and 24.35% in children (Graph 1). Similarly, 1.15 and 1.08% of adults in elective and emergency surgery study group respectively, were hyperglycemic. None of the children were hyperglycemic.

The difference of mean blood glucose level (Tables 4 and 5) is significantly correlated with age ($p = 0.000$), type of surgery ($p = 0.000$), administration of Isolyte P ($p = 0.000$), duration of starvation ($p = 0.0092$), anxiety ($p = 0.0023$), and pain ($p = 0.000$). Steroid recipients show a higher blood glucose levels ($p = 0.00043$).

Subgroup analysis using ANOVA and multiple linear regression was done. Male patients, aged 18 to 40 years, presenting for emergency surgery showed an increase in blood glucose values as age increased ($p = 0.006$), preoperative 6% HES (p -value = 0.043), or steroid ($p = 0.000$) was administered, and as pain and anxiety score increased ($p = 0.000$). Blood glucose levels showed a fall with preoperative NS infusion ($p = 0.001$), age more than 40 years with increased duration of starvation ($p = 0.049$). Female patients, aged more than 18 years, posted for emergency surgery showed a fall in blood glucose values with increased duration of starvation ($p = 0.000$) and preoperative 6% HES infusion (negative, $p = 0.01$) but an increase with preoperative blood transfusion ($p = 0.05$) and higher anxiety and pain scores ($p = 0.01$). Patients more than 60 years of age, of either sex, irrespective of surgical indication showed a decrease in blood glucose values with increasing age ($p = 0.014$).

DISCUSSION

Blood glucose levels show a wide range of fluctuations in the perioperative period. Perioperative dysglycemia is recognized as one of the risk factors of increased morbidity and mortality during and after surgery.²³ Preoperative hypoglycemia results in neuroendocrine stimulation and may lead to behavioral changes, confusion, seizure,

Table 4: Comparative analysis of outcomes of categorical variables (age, sex, type of surgery, and IVFs) on blood glucose level

Parameters	Mean diff. of blood glucose in mg/dL	p-value
Age (adults vs pediatrics)	6.422 ± 1.088	0.000 ^a
Sex (male vs female)	0.0719 ± 1.1	0.9479
Surgery (elective vs emergency)	8.225 ± 1.394	0.000 ^a
NS (given vs not given)	1.535 ± 1.332	0.2495
RL (given vs not given)	2.521 ± 1.601	0.1155
DNS (given vs not given)	0.364 ± 2.286	0.1802
HES (given vs not given)	5.001 ± 3.695	0.5578
Isolyte P (given vs not given)	21.91 ± 1.708	0.000 ^a
Blood (given vs not given)	5.195 ± 2.651	0.1210

^aVery highly significant

Table 5: Comparative analysis of duration of starvation, ASA grade, and anxiety and pain scale on blood glucose level

Parameters	p-value
Duration of starvation	0.0092 ^a
ASA grade	0.0897
Anxiety and pain scale	0.0023 ^a

^aHighly significant

palpitation, tremor, anxiety, diaphoresis, pallor, etc. On the contrary, preoperative hyperglycemia prolongs wound healing and increases the chances of surgical site infection. Thus, blood glucose monitoring coupled with treatment of dysglycemia is vital to reduce morbidity and mortality.²⁴

Our study conducted in 1,000 patients showed that duration of starvation was unnecessarily prolonged in 52.4% of patients. Fasting guidelines have been repeatedly updated by many organizations including the ASA.²⁵ In spite of this, fasting is prolonged in many countries as per previous studies.^{3,26-31} Aroni et al²⁶ observed durations between 8 and 37 hours, Hong and Yoon³ found that patients starved for up to 14 hours, Gul et al²⁹ in their review showed mean fasting time to be 12 to 14 hours, while Gunawardhana²⁸ found fasting to solids to be 13.86 hours with range of 8 to 18 hours. Hamid²⁷ performed an interventional study and proved that simple interventions like staff training, patient information leaflets, and posters significantly improved patient comfort.

Overall incidence of hypoglycemia was found to be 23.3% in our study with a distribution of 27.2% patients including 34.95% children in elective surgery group and 33.37% patients including 8.73% children in emergency surgery group. The adult incidence is similar to that reported by Hong and Yoon³ who studied the impact of longer preoperative fasting time in nondiabetic patients of more than 60 years of age and found 17.6 to 32.4% of patients showing blood glucose level of <79 mg/dL at 8 to 14 hours preoperative fasting. Gul et al²⁹ enumerated hypoglycemia as one of the adverse effects of prolonged

fasting preoperatively. However, Sharma et al³² found no incidence of hypoglycemia in children who fasted for various periods from midnight as against control cases with 10 mL per kg 5% dextrose water orally 3 to 4 hours before the expected time of start of surgery. A diurnal variation in blood sugar levels, inclusion of emergency cases, timing of sampling by finger-prick method may explain the high incidence of hypoglycemia found in our study. The incidence of 2.23% hyperglycemia was lower than 7.9% found in a study by Frisch et al³³ who studied effects of hyperglycemia in noncardiac surgery patients probably due to inclusion of pediatric patients in our study.

Our study showed statistically significant difference between the mean blood glucose levels of subgroups based on age (higher in adults), type of surgery (higher in emergency surgery), and were higher in patients who received steroid, Isolyte P, 6% HES, or blood transfusion, and lower with nonglucose-containing fluids like NS (Tables 3 and 4). Ringer's lactate (RL) may have shown no correlation due to hepatic conversion to glucose.

Young male patients posted for emergency surgery showed higher blood glucose level, which may be due to higher levels of stress and more frequent incidence of trauma and subsequent glucocorticoid use for head injuries. Roberts et al³⁴ concluded age and male gender to be independent predictors of high fasting blood glucose, from a prospective study on prevalence of hyperglycemia in nondiabetic population. Desborough⁸ described the pathophysiology of trauma and surgical stress and their role in hyperglycemia by activation of sympathetic system and pituitary hormone release. Singh et al⁷ found the frequency of stress hyperglycemia to be 47.89% from a prospective observational analysis of 126 nondiabetic patients of hip fracture. Preoperative hyperglycemia can adversely affect intraoperative blood glucose levels,²² postoperative surgical site infection,² and wound healing. Though surgical stress causes intraoperative hyperglycemia in most patients, induction of anesthesia may lead to hypoglycemia by suppressing the excessive sympathetic response, and hence, blood glucose needs to be measured and managed aggressively in patients with preoperative hyperglycemia.

Use of systemic glucocorticoids and higher pain and anxiety score were directly related to incidence of hyperglycemia. van Raalte and Diamant¹¹ studied in detail the diabetogenic mechanisms of glucocorticoids. Hwang and Weiss¹² gave an estimate of 40% incidence of new-onset diabetes in patients administered steroids. Abdelmalak et al⁹ showed increase in blood glucose after dexamethasone administration in nondiabetic patients.

In our study, the infusion of nondextrose-containing IVFs showed association to lower blood glucose levels though the difference was statistically insignificant

compared with that of recipients of dextrose-containing IVFs and to that of nonrecipients. The present study also showed that males between 18 and 40 years showed high blood glucose levels on receiving 6% HES and females posted for emergency surgery showed high blood glucose levels with preoperative blood transfusion, while males who received NS had a lower blood glucose level. Murty et al¹⁸ found that 6% HES increases blood glucose levels but to physiological extent, while RL has no effect on blood glucose. Jung et al¹⁹ found statistically insignificant rise in blood sugar with 6% HES infusion and RL. Cheng et al²⁰ did a retrospective study regarding impact of IVFs and blood transfusion over blood glucose levels but found no significant difference. Tilak et al²² found significant association of blood administration with maximum intraoperative blood glucose level and total amount of IVF with maximum postoperative blood glucose level. Eder and Chambers²¹ related both hypoglycemia and hyperglycemia to blood transfusion.

As no antibiotics affecting blood sugar were administered to the study population, the correlation could not be established. Other limitations of our study were higher number of adults, males, and emergency surgeries included in the study population due to convenient, consenting, consecutive sampling. More studies with larger samples of matched cohorts need to be carried out to establish the correlation of various factors with incidence of preoperative hypoglycemia and hyperglycemia in nondiabetic patients coming for surgery.

CONCLUSION

Our study detected significant correlation of hypoglycemia with adult females, preoperative NS infusion, apart from an expected correlation with extremes of age, duration of starvation, and emergency surgery. Thus, patients in these groups should be carefully monitored and treated for hypoglycemia preoperatively. Also hyperglycemia showed a significant correlation in young adult males posted for emergency surgery apart from expected correlation with prior steroid treatment, blood transfusion, 6% HES infusion, high stress, and pain. Thus, preoperative blood glucose monitoring is recommended mandatorily for all patients posted for emergency surgery irrespective of age or gender. It is also recommended for elective pediatric and geriatric surgery patients, patients with high anxiety and/or pain, increased duration of starvation, preoperative administration of steroid, NS, 6% HES, or blood.

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