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Research Article

Comparison of Blood Glucose Levels, Blood Pressure, Heart Rate and Oxygen Saturation among Diabetic Patients Undergoing General Anesthesia and Local Anesthesia with Sedation: A Cross-Sectional Study

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ABSTRACT

Background: Due to the rapidly increasing prevalence of diabetes mellitus (DM), the number of patients undergoing surgery and therefore requiring anesthesia has become higher than ever. In this study we aimed to compare blood glucose levels and hemodynamic parameters of patients with and without overt DM who have received general anesthesia and local anesthesia with sedation for cataract surgery.
Methods: In this cross-sectional study, 120 patients with DM and 120 patients without DM were included. Each of these patients was randomly assigned to receive general anesthesia or local anesthesia with sedation. blood glucose levels and hemodynamic parameters were measured before surgery, 30 minutes after surgery and six hours after surgery.
Results: There was no significant difference between the four groups in terms of age, gender and duration of surgery (P > 0.05). Blood glucose levels didn't differ between non-diabetic patients receiving general and local anesthesia before or at any time after surgery (P > 0.05). Blood glucose levels were higher in diabetic patients compared to non-diabetics before or at any time after surgery (P < 0.001). 30 minutes and six hours after surgery, blood glucose levels of diabetic patients receiving general anesthesia were significantly higher than diabetic patients receiving local anesthesia with sedation (P < 0.001). No significant difference was noted regarding blood glucose changes during the study time frames in any of the 4 study groups. Diabetic patients receiving general anesthesia had higher blood glucose levels compared to non-diabetics and diabetic patients receiving local anesthesia with sedation (p < 0.001). Before surgery, the four study groups did not differ significantly in SBP, DBP, HR, RR and O2 sat (P > 0.05DBP, HR and RR were not different among the study groups 30 minutes after surgery (P > 0.05). SBP, DBP, HR and RR were not different among the study groups six hours after surgery (P > 0.05).

Conclusion: Patients receiving general anesthesia should be monitored more closely to prevent anesthesia-induced respiratory depression. Using local anesthesia with sedation instead of general anesthesia can help prevent the detrimental effects of perioperative hyperglycemia in diabetic patients undergoing cataract surgery.

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Diabetes mellitus (DM) is a systemic disease characterized by chronic hyperglycemia. Type 1 DM is caused by autoimmune destruction of insulin-secreting pancreatic cells whereas type 2 DM is caused by resistance of target cells to insulin [1]. According to the international diabetes federation (IDF), approximately 463 million adults were living with diabetes in 2019 and by 2045 this number will rise to 700 million. Middle East and North Africa (MENA) region had the the highest prevalence of diabetes (12.2%) in 2019. Iran had a prevalence of 9.4%, which has been projected to increase to 10% by 2030 [2-3]. DM is associated with several microvascular complications such as nephropathy, retinopathy, neuropathy, coronary artery disease and cerebrovascular disease which contribute to the large public health burden caused by the disease [1,4].

Patients with DM undergo surgery more than people without DM for several reasons. For example, some of the complications of DM such as diabetic foot, cataract and coronary artery disease often require surgical treatment [1, 5-6]. Also, bariatric surgeries can lead to disease remission in obese patients with type 2 DM and are routinely performed [7]. Diabetic patients have longer hospital stays and higher morbidity and mortality after surgery compared to the general population [8-9]. Perioperative hyperglycemia has been linked to post-operative complications such as infection and increased mortality in several studies [8, 10-11].

The proposed underlying causes for perioperative hyperglycemia in diabetic patients include the stress-induced increase in counterregulatory hormones (glucagon, cortisol and epinephrine) and pro-inflammatory cytokines and body’s inability to respond to the increased demand for insulin [8-9, 11]. Some medications such as anesthetic drugs have also been implicated in the induction of hyperglycemia. Anesthesia can alter blood glucose through modification of pancreatic insulin release and neurohormonal mechanisms [11]. For example, studies have shown that benzodiazepines can reduce insulin secretion or that volatile anesthetics can increase the risk of perioperative hyperglycemia [12]. Anesthetics can also cause changes in cardiovascular function (leading to hypertension or hypotension) and respiratory function (leading to respiratory depression) [13-14]. Due to the susceptibility of diabetic patients to cardiovascular and cerebrovascular events [4], it is reasonable to use an anesthetic method that causes the least alteration in cardiovascular and respiratory system.

Due to the large number of diabetic patients undergoing surgery and the importance of perioperative glycemic control as mentioned above, identification of agents that cause perioperative hyperglycemia is imperative. Previous studies have investigated the effect of various anesthetic drugs and methods on diabetic patients’ blood glucose levels and vital signs, however, data regarding the comparsion of the effects of general and local anesthesia on these parameters is lacking. In this study we aim to compare blood glucose levels, blood pressure, heart rate, respiratory rate and oxygen saturation of patients with and without overt DM who have received general anesthesia and local anesthesia with sedation for cataract surgery.

Methods

This cross-sectional study was performed in the Feiz hospital of Isfahan, Iran. 240 patients (age range = 65-75) who were candidates for elective cataract surgery were included in the study. Half of these patients had type 2 DM and the other half were non-diabetics. Non-diabetics were defined as those without overt DM (those with impaired fasting glucose or glucose tolerance were defined as non-diabetics).

Exclusion criteria included alcoholism, uncontrolled endocrine problems (except uncontrolled DM), uncontrolled liver, kidney or cardiovascular disease (based on medical history), substance abuse, contraindication on induction of general anesthesia, history of taking antipsychotic drugs, blood sugar ≥ 250 mg/dl in the first measurement immediately before induction of anesthesia and patient's refusal to continue participation at any point of the study. In the event of cardiac arrest or any complication that led to a required change in the anesthesia method, the patient was excluded from the study.

Permission of the Isfahan university ethics committee and patients’ written consent were obtained prior to the study. Patients were non-consecutive in the sense that all patients were included in the study until the required sample size was reached. The patients were divided into four groups using a computer software (random allocation):

Group A: Diabetic patients recieving local anesthesia with sedation

Group B: Diabetic patients receiving general anesthesia

Group C: Non-diabetic patients receiving local anesthesia with sedation

Group D: Non-diabetic patients receiving general anesthesia

In the groups receiving general anesthesia, anesthesia was induced by sodium thiopental (6 mg/kg), atracurium (0.6 mg/kg), fentanyl (1-2 µg/kg) and midazolam (0.02 mg/kg). Propofol was used at a rate of 100-150 µg/kg/min and a N2O to O2 ratio of of 50% to maintain anesthesia. In the groups receiving local anesthesia with sedation, topical ocular tetracaine drops with opioids and sedatives including fentanyl (1-2 µg/kg) and midazolam (0.05 mg/kg) were used. If sedation score did not reach the desired level (Ramsey score 3-4), propofol at a rate of 25-50 µg/kg was used to reach the desired score. The following items were measured before surgery, 30 minutes after surgery and six hours after surgery: Blood glucose levels, systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), respiratory rate (RR) and arterial oxygen saturation (O2 sat).

Statistical analysis

All data were analyzed using SPSS software version 18. Qualitative variables were reported as frequencies and percentages. Quantitative variables were reported as means and standard deviations. According to the result of Kolmogorov-Smirnov test which indicated the normal distribution of data, Chi-square test was used to compare the distribution of gender among the four groups. One-way analysis of variance (ANOVA) and Duncan's post hoc test were used to compare the means of quantitative variables. To exclude the effects of confounders, ANOVA was repeated using age, sex and duration of surgery as confounding factors. P value ≤0.05 was considered statistically significant.

This study is registered and approved by Isfahan University of Medical Sciences Ethics Committee with the approval number: IR.MUI.MED.REC.1398.294

Results

Out of 60 diabetic patients recieving local anesthesia with sedation, 29 (48.3%) were female and 31 (51.7%) were male with a mean age of 68.98 ± 3.88 years. Out of 60 diabetic patients recieving general anesthesia, 30 (50%) were Female and 30 (50%) were male with a mean age of 69.33 ± 3.39 years. Out of 60 non-diabetic patients recieving local anesthesia, 27 (45%) were female and 33 (55%) were male with a mean age of 69.3 ± 3.57 years. Out of 60 non-diabetic patients recieving general anesthesia, 33 (55%) were female and 27 (45%) were male with a mean age of 69.3 ± 3.56 years. There was no significant difference between the four groups in terms of age, gender and duration of surgery (P > 0.05) (Table 1).

Table 1- age, gender and surgery duration of study subjects

	Non-diabetics		Diabetics		
Variables	**General anesthesia**	**Local anesthesia**	**General anesthesia**	**Local anesthesia**	**P value**
Gender					
Female	33 (55.0%)	27 (45.0%)	30 (50.0%)	29 (48.3%)	0.741
Male	27 (45.0%)	33 (55.0%)	30 (50.0%)	31 (51.7%)	
Age (year)	69.35±3.56	69.30 ± 3.57	69.33 ± 3.39	68.98 ± 3.88	0.937
Surgery duration (minute)	34.33 ± 7.94	31.42 ± 10.38	33.75 ± 8.27	30.42 ± 9.53	0.058

Chi-square test was used to compare gender distribution and one-way analysis of variance (ANOVA) test was used to compare age and surgery duration among study groups.

Before surgery, the four study groups did not differ significantly in SBP, DBP, HR, RR and O2 sat (P > 0.05). 30 minutes after surgery, diabetic and non-diabetic patients receiving general anesthesia had similar mean SBPs (P > 0.05), but their means were higher than diabetic and non-diabetic patients receiving local anesthesia with sedation (P = 0.014). Diabetic patients receiving general anesthesia had lower O2 sats compared to the other three groups 30 minutes after surgery (P = 0.006). DBP, HR and RR were not different among the study groups 30 minutes after surgery (P > 0.05). Six hours after surgery, diabetic and non-diabetic patients receiving general anesthesia had similar mean O2 sats, but their means were lower than diabetic and non-diabetic patients receiving local anesthesia with sedation (P = 0.003). SBP, DBP, HR and RR were not different among the study groups six hours after surgery (P > 0.05). No significant difference was noted regarding SBP, DBP, HR, RR and O2 sat in each group over time (P > 0.05) (Table 2).

Table 2- systolic and diastolic blood pressure, O2 saturation, heart rate and respiratory rate among study subjects

	Non-diabetics		Diabetics		
Variables	**General anesthesia**	**Local anesthesia**	**General anesthesia**	**Local anesthesia**	**P value[1]**
SBP (mmHg)					
Before surgery	127.58 ± 7.62	127.58 ± 6.61	127.67 ± 8.31	126.42 ± 8.88	0.793
30 minutes after surgery	134.42 ± 5.21[a]	133.08 ± 6.11[b]	135.08 ± 5.41[a]	131.75 ± 7.18[b]	0.014
6 hours after surgery	129.08 ± 5.93	128.58 ± 6.11	129.50 ± 6.15	127.50 ± 6.86	0.335
P value[2]	0.375	0.171	0.233	0.145	
DBP (mmHg)					
Before surgery	76.58 ± 6.34	76.58 ± 6.61	76.50 ± 7.32	75.00 ± 7.01	0.506
30 minutes after surgery	81.58 ± 5.33	81.25 ± 6.35	82.00 ± 6.56	79.08 ± 6.79	0.053

6 hours after surgery	78.67 ± 5.28	77.75 ± 6.07	78.67 ± 6.39	75.75 ± 6.02	0.068
P value[2]	0.192	0.441	0.265	0.421	
O_2 sat (%)					
Before surgery	95.27 ± 1.01	95.70 ± 1.47	95.00 ± 1.36	95.47 ± 1.36	0.071
30 minutes after surgery	96.15 ± 1.02[a]	96.40 ± 1.24[a]	95.63 ± 1.25[b]	96.10 ± 1.3[a]	0.006
6 hours after surgery	95.90 ± 1.04[b]	96.17 ± 1.22[a]	95.57 ± 1.33[b]	96.07 ± 1.34[a]	0.005
P value[2]	0.896	0.200	0.286	0.858	
HR (bpm)					
Before surgery	78.43 ± 4.51	77.88 ± 4.29	77.82 ± 4.41	77.62 ± 4.72	0.779
30 minutes after surgery	80.85 ± 4.27	80.17 ± 4.21	81.22 ± 4.55	79.55 ± 4.90	0.185
6 hours after surgery	79.47 ± 4.25	79.05 ± 4.28	79.05 ± 4.57	78.25 ± 4.87	0.513
P value2	0.361	0.216	0.203	0.445	
RR (per minute)					
Before surgery	16.15 ± 0.97	16.25 ± 0.97	16.30 ± 0.99	16.68 ± 1.03	0.201
30 minutes after surgery	16.87 ± 0.87	16.95 ± 0.85	17.12 ± 0.96	17.05 ± 0.96	0.457
6 hours after surgery	16.60 ± 0.91	16.72 ± 0.99	16.77 ± 0.85	16.88 ± 1.03	0.430
P value[2]	0.681	0.703	0.388	0.192	

mmHg= millimeters mercury, bpm = beats per minute, SBP = systolic blood pressure, DBP = diastolic blood pressure, HR= heart rate, RR = respiratory rate, O2 sat = oxygen saturation.

[1]Significance level obtained from one-way analysis of variance (ANOVA) test by comparing the means of variables at a specific time among the four groups studied.

[2]Significance level obtained from ANOVA by comparing the means of variables in each study group over time.

[abc]Duncan's post hoc test was used to compare the means of variables in pairwise groups. Similar letters indicate no difference whereas different letters indicate significant difference.

Blood glucose levels didn't differ between non-diabetic patients receiving general and local anesthesia before or at any time after surgery (P> 0.05). Blood glucose levels were higher in diabetic patients compared to non-diabetics before or at any time after surgery (P< 0.001). Before surgery, blood glucose levels of diabetic patients who were about to receive general and local anesthesia were not significantly diferrent (P> 0.05). 30 minutes and six hours after surgery, blood glucose levels of diabetic patients receiving general anesthesia were significantly higher than diabetic patients receiving local anesthesia with sedation (P< 0.001). No significant difference was noted regarding blood glucose changes during the study time frames in any of the 4 study groups (P> 0.05) (Table 3).

Table 3- blood glucose levels among study subjects

	Non-diabetics		Diabetics		
Blood glucose (mg/dl)	**General anesthesia**	**Local anesthesia**	**General anesthesia**	**Local anesthesia**	**P value[1]**
Before surgery	100.67 ± 9.59[b]	100.92 ± 9.63[b]	180.42 ± 22.26[a]	176.50 ± 16.16[a]	<0.001
30 minutes after surgery	110.50 ± 10.40[c]	106.83 ± 9.68[c]	196.83 ± 21.11[a]	179.92 ± 15.08[b]	<0.001
6 hours after surgery	106.17 ± 9.97[c]	103.67 ± 11.49[c]	201.50 ± 21.99[a]	189.00 ± 16.07[b]	<0.001
P value[2]	0.126	0.082	0.053	0.074	

mg/dl = milligrams per deciliter.

[1]Significance level obtained from one-way analysis of variance (ANOVA) test by comparing the means of variables at a specific time among the four groups studied.

[2]Significance level obtained from ANOVA by comparing the means of variables in each study group over time.

[abc]Duncan's post hoc test was used to compare the means of variables in pairwise groups. Similar letters indicate no difference whereas different letters indicate significant difference.

Discussion

In this cross-sectional study, the relationship between general and local anesthesia with sedation and SBP, DBP, HR, RR, O2 sat and blood glucose levels of diabetic and non-diabetic patients undergoing cataract surgery was investigated. A possible association was found between general anesthesia and hyperglycemia after surgery in diabetic patients.

Several studies have demonstrated the effects of anesthetic drugs on the cardiovascular system. For example, a study by Oliveira et al. showed that neuromuscular blocking agents were associated with a significant drop in blood pressure during mechanical thrombectomy [15]. Another study by Samuels et al. showed that sedative drugs (eg. propofol) were associated with more blood pressure drops and worse outcomes during endovascular procedures compared to local anesthesia without sedation [16]. Propofol alters gamma-aminobutyric acid (GABA) binding sites which causes synaptic inhibition leading to a reduction in blood pressure [17]. In a study by Omran et al., effects of midazolam on cardiac function were evaluated using cardiac magnetic resonance imaging (MRI). The results indicated that midazolam decreased both right and left ventricular stroke volume [18]. Midazolam is a benzodiazepine acting by stimulation of GABA receptors leading to neuronal inhibition [17]. In the present study, patients receiving general anesthesia had higher SBP compared to patients receiving local anesthesia with sedation in both diabetic and non-diabetic groups 30 minutes after surgery despite having received higher doses of midazolam, propofol and a neuromuscular blocking agent (atacurarium). However, this difference was transient because it disappeared six hours after surgery. Also, the difference between mean SBPs in the mentioned groups was relatively small and may be clinically insignificant. In addition, no difference was observed regarding DBP between patients undergoing general and local anesthesia with sedation after surgery. The observed rise in SBP 30 minutes after surgery could be explained by the high patient anxiety associated with general anesthesia [19], as anxiety has been found to elevate blood pressure in previous studies [20]. However, no difference in SBP was observed between the patients undergoing general and local anesthesia with sedation before surgery. Patients' blood pressure was not recorded during the procedure, therefore, the hypotensive effects of the previously mentioned anesthetics might have worn off 30 minutes after surgery. Patients may also have received intravenous fluids for blood pressure control.

There was no significant difference regarding HR between the four groups in our study before and after surgery. This is in line with the results of a study by Keerthy et al., which showed that after administration of midazolam and propofol there was an increase in HR intraoperatively (possibly due to surgery-induced stress), but it returned to baseline after surgery. The proposed mechanism for this return is propofol's central sympatholytic effect [17].

Previous studies have indicated that anesthetics alter respiratory dynamics. For example, a study by Hagiwara et al. showed that administration of propofol and midazolam decreases patients' O2 sat [21]. Results of Keerthy et al.'s study showed a decrease in patients' RR compared to baseline after surgery which was attributed to the respiratory depressant activity of propofol and midazolam. Patients in this study also had a decreased O2 sat intraoperatively, but administration of supplemental oxygen returned their after surgery O2 sat to normal [17]. Fentanyl is an opioid anesthetic that is also associated with respiratory depression due to it is inhibitory effects on central respiratory drive [22]. Sodium thiopental is a barbiturate anesthetic that can also cause respiratory depression via stimulating GABA receptors [23]. In the present study, both diabetic and non-diabetic patients recieving general anesthesia had lower O2 sat compared to patients receiving local anesthesia with sedation six hours after surgery. This can be attributed to the accumulated respiratory depressing effects of sodium thiopental, fentanyl, midazolam and propofol. However, no difference was found regarding RR between the four groups before and after surgery in the present study. Also, the difference in O2 sat and RR before and after surgery in each group was not statistically significant. These findings may be due to the short half-life of the administered anesthetics and administration of supplemental oxygen to the patients.

Several studies have investigated the relationship between anesthetics and blood glucose levels. For example, Kaviani et al. showed that blood glucose levels increase in patients undergoing implant surgery after administration of propofol and midazolam [24]. In a review by Kadoi, it was stated that midazolam can alter blood glucose level through decreasing cortisol secretion and increasing growth hormone (GH) secretion [25]. In the present study, diabetic patients receiving general anesthesia had significantly higher blood glucose levels compared to diabetic patients receiving local anesthesia with sedation both 30 minutes and six hours after surgery. This finding can be attributed to the anesthetic-induced alterations in insulin and other catabolic hormones' secretion [25]. In diabetic patients, the stress-induced increase in counterregulatory hormones (glucagon, cortisol and epinephrine) and pro-inflammatory cytokines and body's inability to respond to the increased demand for insulin contribute to perioperative hyperglycemia [8-9, 11]. Perioperative hyperglycemia can be associated with increased morbidity and mortality in diabetic patients [8, 10-11]. Therefore, implementation of an anesthetic method that has the lowest risk of hyperglycemia is necessary in diabetic patients to prevent possible harmful consequences.

Conclusion

Due to the rapidly increasing prevalence of DM, the number of patients undergoing surgery and therefore requiring anesthesia has become higher than ever. Thus, it is crucial to implement the best anesthetic method in order to minimize perioperative complications in these patients. No difference was found between diabetic and non-diabetic patients receiving general and local anesthesia with sedation regarding DBP, HR and RR before and after surgery in our study. However, patients receiving general anesthesia had lower O2 sat compared to those receiving local anesthesia with sedation, which must be taken into account in order to avoid respiratory depression in patients undergoing the former method. In addition, diabetic patients receiving general anesthesia were found to have higher blood glucose levels compared to those receiving local anesthesia with sedation after surgery. Therefore, using local anesthesia with sedation may be more appropriate in diabetic patients undergoing cataract surgery when possible to minimize the detrimental effects of perioperative hyperglycemia on patients' prognosis. Further studies are required to confirm this hypothesis.

Abbreviations

DM= diabetes mellitus, mmHg = millimeters mercury, mg/dl = milligrams per deciliter, bpm = beats per minute, SBP= systolic blood pressure, DBP= diastolic blood pressure, HR = heart rate, RR = respiratory rate, O2 sat= oxygen saturation, MENA = middle east and north Africa, GH= growth hormone, GABA= gamma-aminobyutric acid, ANOVA= one-way analysis of variance, MRI= magnetic resonance imaging.

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