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RESEARCH ARTICLE
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A COMPARATIVE STUDY BETWEEN THE EFFECTS OF SPINAL ANAESTHESIA AND GENERAL ANAESTHESIA ON BLOOD GLUCOSE CONCENTRATION IN PATIENTS UNDERGOING TRANSURETHRAL LITHOTRIPSY

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ABSTRACT

Background: Any surgical procedure causes stress response, endocrine stimulation, and metabolic and immunological changes by activating the hypothalamic-pituitary-adrenal axis. The goal of the current study was to examine the impact of spinal anaesthesia with general anaesthesia on patients undergoing transurethral lithotripsy by measuring their random blood sugar levels.

Aim of the study: To compare blood glucose level in spinal anaesthesia with general anaesthesia for patients undergoing transurethral lithotripsy.

Patients and Methods: The group of participants included patients selected for spinal anaesthesia and the other group included patients selected for general anaesthesia. For both groups, blood glucose was measured at different times: five minutes before induction T1, five minutes after induction T2, five minutes before the end of the procedure T3, and 30 minutes after the end of the procedure T4. Significant differences in categorical variables among the parameters were confirmed through analytical statistical tests.

Results: The mean blood glucose in T3 (99.67±10.25) and T4 (100.87±7.67) in the spinal anaesthesia group was significantly lower than T3 (156.67±34.34) and T4 (194.27±43.61) in general anaesthesia group ($p<0.001$). Furthermore, in the general anaesthesia group, the increase in blood glucose in the time intervals T1-T2, T2-T3, T3-T4, and T1-T4 was significant respectively.

Conclusion: The results of this study showed that spinal anaesthesia is the better method to prevent increase in blood glucose than general anaesthesia.

Keywords: Blood glucose, General anaesthesia, Spinal anaesthesia, and Transurethral Lithotripsy.

INTRODUCTION

Every surgical procedure is associated with a stress response which comprises several endocrine, metabolic and immunological changes triggered by neuronal activation of the hypothalamic-pituitary-adrenal axis. The overall metabolic effect of the stress response to surgery includes an increase in the secretion of catabolic hormones, such as cortisol and catecholamine, and a decrease in the secretion of anabolic hormones, such as insulin and testosterone. The increase in levels of catabolic hormones in plasma stimulates glucose production, and there is a relative lack of insulin together with impaired tissue insulin sensitivity and glucose utilization, which is called insulin resistance. Consequently, blood glucose concentrations will increase, even in the absence of preexisting diabetes. (1) The release of adrenaline seen alongside sympathetic nervous system (SNS) activation results in the stimulation of glucagon and inhibition of insulin release. Secretion of the key anabolic hormone insulin is reduced by the SNS effect on pancreatic α_2-adrenergic receptors, and later a decrease in insulin sensitivity occurs in peripheral cells. These hormonal changes lead to hyperglycaemia and the release of fatty acids with relatively unopposed catabolism of muscle tissue (2)

The hyperglycemic response to surgical stresses in the perioperative period may harm patients since it is an independent risk factor associated with adverse outcomes such as impaired wound healing and an increased risk of wound infection. A number of different immunological parameters have been identified through which increased blood glucose affects the host's susceptibility to infection. In these disorders, the inflammatory cytokine cascade increases in response to the increase in blood glucose, and the levels of cytokines that activate the inflammatory wave including IL-6 and TNF-α increase. (3,4) The risk related to hyperglycemia is seen in patients both with and without a history of diabetes. Notably, even short-term hyperglycemia compromises immune function and increases the risk of infection. Also treating hyperglycemia results in an increased risk of hypoglycemia and the risks associated with hypoglycemia, and thus avoidance of stress-induced hyperglycemia is preferable than treating dysglycemia.

It has long been recognized that the type of anaesthetic technique has an influence on hyperglycemic response to surgery. During surgery, stress-induced hyperglycemia is more pronounced with inhalation anaesthesia. In animals, earlier studies revealed that inhalational anaesthetics such as enflurane and halothane impaired glucose tolerance in dogs and that was related to inhibition of insulin secretion and decreased tissue insulin sensitivity (5). Other studies on isoflurane inhalational anaesthetic demonstrated an increase in the plasma glucose concentration during anaesthesia even without surgical stress related to impairment of glucose tolerance and stimulation of whole-body glucose production. Furthermore, the hyperglycemic stress response in patients undergoing major abdominal surgery under isoflurane general anaesthesia could be related to an increase in endogenous glucose production accompanied by a decrease in glucose utilization, Tanaka et al. showed that there was glucose intolerance and impairment of insulin secretion and glucose utilization during sevoflurane and isoflurane anaesthesia in a dose-independent manner. (6)

In surgical patients, the stress response is activated by afferent neural activity from the site of trauma. These afferent neurons travel along sensory nerve roots through the dorsal root of the spinal cord up the spinal cord to the medulla to activate the hypothalamus. Neuraxial anaesthesia such as epidural or spinal anaesthesia blocks afferent neural impulses; consequently, the stress response to surgery including hyperglycemia is inhibited. (7)

Since few studies and investigations have been conducted in this regard and considering that hyperglycemia in the surgical process can clearly cause a decrease in the body's immunity level and worsen the prognosis of the disease, therefore, this study was conducted to determine the effect of spinal anaesthesia versus general anaesthesia on blood glucose concentration in patients undergoing transurethral lithotripsy.

MATERIALS AND METHODS

This prospective cross-sectional study was conducted among patients at a tertiary care facility in Eastern India for a period of 1 year after receiving approval from institutional ethical committee. A total of 100 study participants, posted for transurethral lithotripsy under department of anaesthesia were included in the study.

Inclusion Criteria: The study included the patients of either sex, aged 30-60 years, who had an American Society of Anaesthesiologists (ASA) grading of I or II and who were scheduled for elective transurethral lithotripsy with preoperative fasting of 8-12 hr.

Exclusion criteria: Patients were excluded if they had type 1 and type 2 diabetes, had advanced chronic kidney disease, heart failure, ischemic heart disease, and mental disorders, where spinal anaesthesia failed or in those patients where anaesthesia was changed from spinal anaesthesia to general anaesthesia.

Sample size estimation: The sample size was calculated using a parametric test (Independent sample t-test) to find the difference between two means. The sample size was determined manually by a statistician using a convenience sampling method, based on effect size (d/σ), at a 95% confidence interval, using the formula:

$$Z=2[\frac{Z_{1-\alpha/2}+Z_{1-\beta}}{(d/\sigma)^2}]^\wedge 2$$

$Z(1-\alpha/2)=1.96$ at a 95% confidence interval
$Z(1-\beta)=0.84$ at 80% power
d/σ=effect size (0.6) (8)
the calculated sample size was 44 per group. 44x2 groups=88 was the minimum sample size required Hence, n=100 study participants were included in the study with 50 participants in each group.

Study Procedure:

Patients who satisfied the criteria for inclusion were told about the anaesthetic technique and the study design, and informed written consent was obtained. Groups were assigned to patients based on computer-generated random numbers and group allocation was done by sealed envelopes.

Patients undergoing surgery under general anaesthesia were assigned to Group G, while patients undergoing surgery under subarachnoid block were assigned to Group S, with 50 patients in each group. Non-glucose based intravenous fluids (Ringer's lactate/normal saline) were started in the perioperative holding area, and CBG was checked 30 minutes before the administration of anaesthesia. In the operating room, the anaesthesia machine and other resuscitation equipment were checked. ASA standard monitors, including non-invasive blood pressure, SpO_2, Electrocardiogram (ECG), and end-tidal carbon dioxide ($ETCO_2$), were connected. All patients received 1 mg of anxiolytic medication (Tablet Ativan) at 10 PM on the night before surgery and 40 mg of injection pantoprazole one hour before surgery. For group S, spinal anaesthesia was performed under aseptic conditions, at the segments of L3-L4 or L4-L5 of the spine in sitting position and midline approach.

Spinal anaesthesia was performed with 2.5 ml of 0.5% hyperbaric bupivacaine using 22-gauge spinal needles. For group G, 100 % oxygen was administered through an anaesthetic mask with a flow of eight litres per minute. After breathing oxygen for 3-5 minutes through an anaesthetic face mask, pre-medication with 1 milligram of midazolam, induction with 1- 2 mg/kg of propofol, and 0.5 mg/kg/body weight of atracurium muscle relaxant was given to facilitate tracheal intubation.

Anaesthesia was maintained with 1 MAC isoflurane in 60% oxygen and 40% medical air. ETCO2 was maintained between 30 and 40 mmHg during the procedure. At the end of the surgery, anaesthetics were discontinued and reversed with neuromuscular reversal agent.
The blood glucose concentration was measured (T1) 5 minutes before the induction, in general anaesthesia group and 5 minutes before giving subarachnoid block, in spinal anaesthesia group as a baseline value, (T2) 5 minutes after the induction of general anaesthesia and 5 minutes after the complete block of spinal anaesthesia, (T3) 5 minutes before the end of the surgery in both groups and (T4) 30 minutes after the end of surgery in the recovery room in both groups. A monitoring kit of the blood glucose with a lancet device was used. After disinfecting with alcohol and waiting for dryness, the tip of the thumb of the right or left hand pricked with a lancet tip to measure the blood glucose concentration.

STATISTICAL ANALYSIS

Information from the questionnaire from all participants was entered into a data sheet and assigned a serial identifier number. Statistical Package for the Social Sciences (SPSS) version 26.0 was used for statistical analysis. For continuous data, means and Standard Deviations (SD) were utilised, while frequencies and percentages were employed for categorical data. Differences in participant characteristics, such as age and blood sugar levels, between the two groups were analysed using the independent samples t-test (two-tailed), and associations were examined using the Chi-square or Fisher's exact test. A significance level of 5% was set, with a p-value <0.05 considered statistically significant.

RESULTS

Mean age for participants were 29.8±12.5. (48%) age range of participants was (30-40) years old, (24%) of the patients were within (41-50) years, while (28%) of the patient were within the age range (51-60) years. Significant differences across the two treatment groups did not exist regarding the patient's baseline characteristics.

In this study, patients were divided into two groups: Spinal anaesthesia group (Group S) and General anaesthesia group (Group A). The time was fixed at 5 minutes before induction T1, 5 minutes after induction T2, 5 minutes before the end of the surgery T3, and 30 minutes after the surgery T4.

In Table 1, the results indicated that the group S showed a significant difference in the mean level 5 minutes before end of surgery and 30 minutes after surgery when compared to the group G. The level of glucose was decreased significantly in the group with spinal anaesthesia more than in the group with general anaesthesia, P values were <0.001.

Time Points	**Random Blood Sugar (mg/dL)**		
	Group S Mean±SD	**Group G Mean±SD**	**P value**
T1 (5 minutes before induction)	94.13±14.77	98.40±11.51	0.45[NS]
T2 (5 minutes after induction)	98.47±14.12	110.80±15.76	0.213[NS]
T3 (5 minutes before end of surgery)	99.67±10.25	156.67±34.34	**<0.001[S]**
T4 (30 minutes after surgery)	100.87±7.67	194.27±43.61	**<0.001[S]**
P value <0.05 considered statistically significant SD: standard deviation; NS: no-significant ; S: significant			

Table 1: Mean differences of the pre and post-test of Random Blood Sugar (RBS) (mg/dL) between two study groups

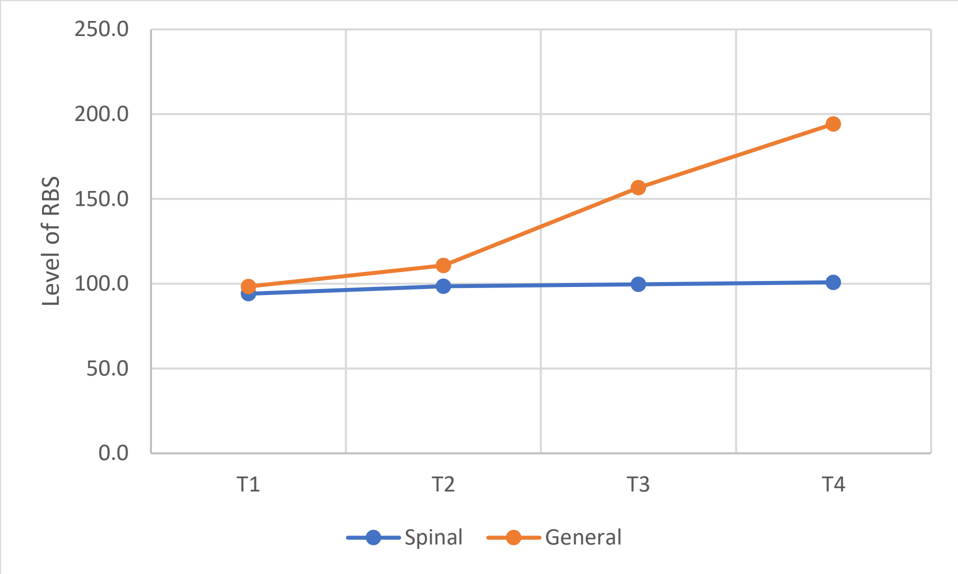

Figure 1: Estimation plot of the RBS levels in Spinal Anaesthesia and General Anaesthesia among Patients Undergoing Transurethral Lithotripsy in different Time points T1 = 5 minutes before induction, T2 = 5 minutes after induction, T3 = 5 minutes before end of surgery, T4 = 30 minutes after surgery test was S= significant at $p \leq 0.05$, NS= Non-significant

DISCUSSION

In this study, the mean blood glucose five minutes before the end of the operation and 30 minutes after the end of the operation in the general anaesthesia group was significantly higher than in the spinal anaesthesia group. Also in the general anaesthesia group, the increase in blood glucose in time intervals T1-T2, T2- T3, T3-T4, and T1-T4 was significant. However, in the spinal anaesthesia group, the increase in blood glucose in the mentioned time intervals was not significant. In the study of El-Radaideh et al., similar results obtained like our study, i.e., blood glucose levels generally increased in both groups of spinal anaesthesia and general anaesthesia, but the amount of blood glucose increased in different time intervals in people under general anaesthesia was significantly higher than spinal anaesthesia. The results of this study were completely consistent with the findings of our research.

Every surgical procedure is associated with a stress response which comprises a number of endocrine, metabolic, and immunological changes triggered by neuronal activation of the hypothalamic-pituitary-adrenal axis. (9) Hyperglycemia in non-diabetic patients, sometimes known as stress induced hyperglycemia is associated with poorer outcomes compared to hyperglycemia in patients with diabetes. There has been a great deal of interest in the potential beneficial effects of preservation of glucose homeostasis and early avoidance of stress-induced hyperglycemia in surgical patients by modification of the stress response. Acute hyperglycemia, a typical feature of the metabolic response to surgery, has been demonstrated to significantly compromise immune function and contributes to poor clinical outcome. The degree of this response was shown to be proportional to the severity and length of the surgical injury. It has long been recognized that the type of anaesthetic technique influences hyperglycemic response to surgery. The current study was also aimed to compare the effects of spinal and general anaesthesia on changes in blood glucose concentrations during the section in nondiabetic patients. Different time of glucose measurement during two types of anaesthesia was correlated with a higher risk of hyperglycemia towards the end of surgery. This fact may be justified by the sympathetic response associated with surgical stress and the release of counterregulatory hormones, which determine lower insulin secretion and peripheral tissue resistance to the action of insulin and produce hyperglycemia. The length and duration of the surgical intervention determine a great variation in the contribution of counterregulatory hormones, such as glucagon, epinephrine, norepinephrine, cortisol, and GH, to influence glycemic homeostasis. (7) This finding was supported by a subsequent study by El-Radaideh et al., who found that both groups of

patients undergoing spinal anaesthesia and general anaesthesia had an increase in blood glucose levels overall, but the amount of blood glucose increase in different time intervals in people under general anaesthesia was significantly higher than spinal anaesthesia. (10)
Furthermore, neuraxial anaesthesia, such as spinal and epidural anaesthesia, has efferent neurons that connect to the liver and adrenal gland and afferent neurons from the surgical site to the central nervous system and hypothalamic-pituitary-adrenal axis, which ultimately limits the adrenocortical and glycemic responses to surgical stress. (11) Greisen et al. also demonstrated in research that epidural anaesthesia inhibits the rise in blood sugar levels associated with heart surgery. (12)
In another study that investigated blood glucose changes after spinal anaesthesia in caesarean section, the results of the study showed that in the comparison between blood glucose before anaesthesia and blood glucose during recovery, there is a significant increase in blood glucose during recovery. (13) Additionally, the findings of a study that compared the effects of general anaesthesia and spinal anaesthesia on blood glucose changes during surgery revealed that spinal anaesthesia, when used instead of general anaesthesia, has a better ability to control blood glucose and may have adrenergic and metabolic reactions to stress, especially in patients with metabolic issues. (14)
The hyperglycemic stress response in patients undergoing major abdominal surgery under general anaesthesia could be related to an increase in endogenous glucose production accompanied by a decrease in glucose utilization. (11) Furthermore, Turina et al showed that short-term hyperglycemia is associated with an increased risk of infection and mortality in critically ill patients related to a significant decrease in monocyte HLA-DR expression due to hyperglycemia and hyperinsulinemia. (15)

As we mentioned previously, spinal anaesthesia is the most common technique used to provide anaesthesia for these patients due to the lower risk of complications associated with spinal anaesthesia than general anaesthesia. The results of our study add more weight to the use of spinal anaesthesia in such cases since spinal anaesthesia facilitates glycemic control in the perioperative period. This might be beneficial in reducing the incidence of previously mentioned complications associated with hyperglycemia complications. Therefore, these added benefits of spinal anaesthesia over general anaesthesia should be conveyed to patients during patient counselling about operations. Hyperglycemia is potentially deleterious because it acts as a procoagulant changes neutrophil functions, stimulates the release of inflammatory cytokines, increases the risk of infections, changes healing, and may be associated with increased mortality. (16)

Limitations: The study had certain limitations, including the inability to address the attenuation of the stress response during endotracheal intubation, which can be a cause of stress-induced hyperglycaemia in the GA group. Additionally, the use of different muscle relaxants, such as Vecuronium, Atracurium, or Succinylcholine, for different patients based on individual airway assessments can be a confounding variable that may affect the results. Hence, the use of larger sample size with a single muscle relaxant for all patients would be advisable to obtain more reliable results.

CONCLUSION

According to this study, there was an increase in mean blood glucose concentrations with both general anaesthesia and spinal anaesthesia. The effect of general anaesthesia on blood glucose concentrations was significantly greater than the effect of spinal anaesthesia, which indicates that the hormonal stress response is much greater in general anaesthesia than in spinal anaesthesia.

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