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Original Research Article

A Prospective Study Determining the Impact of Spinal Anaesthesia on Perioperative Hyperglycemia in Diabetic Patients Undergoing Lower Limb Orthopaedic Surgeries

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Abstract

Aim: The aim of the present study was to assess the effect of spinal anaesthesia on perioperative hyperglycemia in diabetic patients undergoing lower limb orthopaedic surgeries and also to state the trend of perioperative hyperglycemia.

Material & Methods: A prospective study conducted in the Department of Anaesthesia for the duration of 12 months including 100 patients having either Type I or Type II Diabetes Mellitus controlled on either oral hypoglycaemic drugs or injectable insulin aged 30 to 65 years, belonging to either sex and American Society of Anesthesiologists (ASA) physical status II and III undergoing elective lower limb orthopaedic surgeries under spinal anaesthesia.

Results: The mean age, weight, height and duration of anaesthesia was 50.52±12.68 years, 62.8±5.6 kg, 160.8±4.6 cm and 104.6±10.5 respectively. Mean BG value preoperatively or 10min before induction was 111.58±11.084. Then at SI, there was statistically significant decrease in BG value to mean value 106.84±13.57. 30min after SI, mean BG value was 108.72±18.92. This value was lower as compared to the pre-operative BG value, but not statistically significant. 1hr after SI, BG value was 110.60±12.228. This value was also lower as compared to the pre-operative BG value, but not statistically significant. 2hrs after SI, BG value increased to mean value 121.86±18.442. Even, 3 hrs after SI, BG value continued increasing and the mean value became 124.12±16.004. 4 hrs after SI, BG value was maximum with the value being 126.24±15.385. There was statistically significant difference (p=.000). Blood glucose (BG) value decreases till 1hr after surgical incision (SI), and then increases till 4th hr after SI. This change in blood glucose values is statistically significant at SI, 2nd hr after SI, 3rd hr after SI and 4th hr after SI.

Conclusion: Spinal anaesthesia blunts surgical stress response and hence, at SI, BG values decrease. But BG values increase at other times in perioperative period owing to the regression of sensory analgesia.

Keywords: Spinal Anaesthesia, Perioperative, Hyperglycemia, Diabetic.

Introduction

Surgery is considered to be the combination of numerous factors including anaesthesia, medication, tissue trauma, blood loss, and temperature changes. All these factors cause metabolic changes. Together, they produce perioperative adaptive stress response. [1,2,3] Surgery and anesthesia elicit a stress response that produces marked neurophysiological changes with release of adrenaline, noradrenaline, cortisol, glucagon, and growth hormone. This increase in counter-regulatory hormones and cytokines raises glucose levels and increases insulin resistance. In susceptible patients, this may result in significant hyperglycemia. [4] Surgery is also associated with increased stress response which results in sympathetic activations and the release of pituitary hormones that accelerate glycogenolysis and gluconeogenesis and result in stress hyperglycaemia. [5]

Stress hyperglycaemia is defined as any blood glucose concentration >7.8 mmol/l (140 mg/dl) without evidence of previous diabetes by the American Diabetes Association and American Association of Clinical Endocrinologists consensus. [6] Stress-induced hyperglycaemia is common and more than 50% occurs in previously non-diabetic patients. [7,8] Perioperative stress-induced hyperglycaemia is reported in 20–40% of patients undergoing general surgical procedures. [9-11] The magnitude of stress hyperglycaemia relates to the extent of surgical procedures, the technique of anaesthesia, the anatomic location of the surgery, and the types of intraoperative fluids. [12,13] The associated factors for the incidence of stress hyperglycaemia include age, body mass index, duration of surgery, baseline blood glucose level, and intraoperative blood transfusion. [7,14,15] However, a prolonged, high magnitude stress response has harmful effects on metabolism and immune function.

Surgical stress also causes hypothalamic activation of the sympathetic nervous system. This in turn results in increased secretion of catecholamines from the adrenal medulla and release of norepinephrine from presynaptic nerve terminals. High catecholamine levels have catabolic effect. They inhibit insulin release and also enhance glycogenolysis, hepatic glucose production and peripheral insulin resistance, producing hyperglycemia. [16] that also attenuate protein anabolism, wound healing and the activity of the immune defense system after surgery by causing hyperglycemia, thereby increasing perioperative morbidity and mortality. [17-20] There are three main methods for attenuating surgical stress response including neural blockade by epidural or spinal anesthesia, which prevent nociceptive signals from the surgical area from reaching the central nervous system. This inhibitor effect involves both afferent and efferent pathways. Cortisol response is suppressed by neural blockade from T4 to S5. Other methods are intravenous administration of high-dose of strong opioid analgesics which block hypothalamic pituitary gland function and infusion of anabolic hormones such as insulin that causes change in the hormonal status of the patient. [21]

Hence the aim of study was to assess the effect of spinal anaesthesia on perioperative hyperglycemia in diabetic patients undergoing lower limb orthopaedic surgeries and also to state the trend of perioperative hyperglycemia

Material & Methods

A prospective study conducted in the Department of Anaesthesia, BMIMS Pawapuri, Nalanda, Bihar, India for the duration of 12 months including 100 patients having either Type I or Type II Diabetes Mellitus controlled on either oral hypoglycaemic drugs or injectable insulin aged 30 to 65 years, belonging to either sex and American Society of Anesthesiologists (ASA) physical status II and III undergoing elective lower limb orthopaedic surgeries under spinal anaesthesia.

Inclusion Criteria

Only patients having preoperative blood glucose level between 80-120mg/dl were included in the study.

Methodology

After obtaining approval from the Hospital Ethics Committee and written informed consent from the patients. Patients on recent intravenous or oral steroid therapy within 30 days, although inhaled steroids were permitted, known case of chronic obstructive respiratory disease and asthma on intravenous steroid therapy; having coagulation abnormalities, hypovolemia or hypotension, pre-existing severe bradycardia, or ejection fraction 20% from basal HR) and hypotension (mean atrial pressure 20% from basal BP) were recorded and managed as per the standard protocols. When blood glucose concentrations exceeded 180mg/dL, it was treated as hyperglycaemia as per continuous insulin infusion (CII) protocol. When blood glucose concentrations lowered below 60mg/dl, it was treated as hypoglycaemia as per the standard protocol.

Statistical Analysis

Statistical testing was conducted with the statistical package for the social science system version (SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc.,). Ages, weight, height, duration of anaesthesia and blood glucose (BG) values were reported as mean ± standard deviation. Comparison of BG before, during and after surgery was done using Student's t-test. For statistical test, $P < 0.05$ was taken to indicate a significant difference.

Results

Table 1: Demographic characteristics (age, weight, and height) and duration of anaesthesia

Variables	Mean±SD
Age in years	50.52±12.68
Weight (kg)	62.8±5.6
Height (cm)	160.8±4.6
Duration of anaesthesia (min)	104.6±10.5

The mean age, weight, height and duration of anaesthesia was 50.52±12.68 years, 62.8±5.6 kg, 160.8±4.6 cm and 104.6±10.5 respectively.

Table 2: Blood glucose (BG) values (mg/dl)

Time	Mean±SD
10 min before induction	111.58±11.084
SI	106.84±13.57
30 min after SI	108.72±18.92
1hr after SI	110.60±12.228
2hr after SI	121.86±18.442
3hr after SI	124.12±16.004
4hr after SI	126.24±15.385

Mean BG value preoperatively or 10min before induction was 111.58±11.084. Then at SI, there was statistically significant decrease in BG value to mean value 106.84±13.57. 30min after SI, mean BG value was 108.72±18.92. This value was lower as compared to the pre-operative BG value, but not statistically significant. 1hr after SI, BG value was 110.60±12.228. This value was also lower as compared to the pre-operative BG value, but not statistically significant. 2hrs after SI, BG value increased to mean value 121.86±18.442. Even, 3 hrs after SI, BG value continued increasing and the mean value became 124.12±16.004. 4 hrs after SI, BG value was maximum with the value being 126.24±15.385. There was statistically significant difference (p=.000).

Table 3: Trend of blood glucose (BG) values taking BG value at 10min before induction as reference value (mg/dl)

Time	Mean±SD	P Value
SI	4.736±7.833	.005
30min after SI	.902±12.478	.720
1hr after SI	.928±14.276	.732
2hr after SI	-10.230±22.098	.012
3hr after SI	-12.500±15.076	.000
4hr after SI	-16.634±15.635	.000

Blood glucose (BG) value decreases till 1hr after surgical incision (SI), and then increases till 4th hr after SI. This change in blood glucose values is statistically significant at SI, 2nd hr after SI, 3rd hr after SI and 4th hr after SI.

Discussion

Spinal anesthesia (SA) is a commonly performed regional anesthesia technique in current practice. Drops of cerebrospinal fluid during SA provide an objective criterion for application field compared to other neuraxial anesthesia procedures. Even so, failure of SA is observed depending different causes (failed lumbar puncture, dose selection, drug solution error, anatomical abnormalities, solution= density, inactive local anesthetic solution and local anesthetic resistance). [22]

The stress of surgery results in increased levels of gluco-regulatory hormones (catecholamines, cortisol, glucagon, and growth hormone) and excessive release of interleukin-6 and interleukin-1. The counter-regulatory response produces alterations in carbohydrate metabolism, including insulin resistance, increased hepatic glucose production, impaired peripheral glucose utilization, and relative insulin deficiency. [17,18] The mean age, weight, height and duration of anaesthesia was 50.52±12.68 years, 62.8±5.6 kg, 160.8±4.6 cm and 104.6±10.5 respectively. Mean BG value preoperatively or 10min before induction was 111.58±11.084. Then at SI, there was statistically significant decrease in BG value to mean value 106.84±13.57. 30 min after SI, mean BG value was 108.72±18.92. This value was lower as compared to the pre-operative BG value, but not statistically significant. 1hr after SI, BG value was 110.60±12.228. This value was also lower as compared to the pre-operative BG value, but not statistically significant. 2hrs after SI, BG value increased to mean value 121.86±18.442. Even, 3 hrs after SI, BG value continued increasing and the mean value became 124.12±16.004. 4 hrs after SI, BG value was maximum with the value being 126.24±15.385. There was statistically significant difference (p=.000). During anesthesia induction and surgery, insulin concentration may decrease due to α adrenergic inhibition of β-cell secretion. Plasma glucose concentrations increase in perioperative period. In fact, anaesthesia itself results in hyperglycemia, which is then further aggravated by the surgical procedure. The initial increase in plasma glucose after injury is due to activation of glycogenolysis. But later hepatic gluconeogenesis becomes the major factor in liver glucose release because liver glycogen stores are limited. The usual mechanisms that maintain glucose homeostasis are ineffective in the perioperative period and catabolic hormones promote the production of glucose, thereby resulting in hyperglycemia. [5,19,20]

Blood glucose (BG) value decreases till 1hr after surgical incision (SI), and then increases till 4th hr after SI. This change in blood glucose values is statistically significant at SI, 2nd hr after SI, 3rd hr after SI and 4th hr after SI. Poon et al [23] achieved better stress response control by combining epidural anesthesia with general anesthesia. Opioids also suppress the stress response by inhibiting hypothalamic pituitary gland function. In a study of lower abdominal surgery, 50 µg/kg fentanyl suppressed the stress response by reducing growth hormone, cortisol, and glucose concentrations. But, systemic opioids may be insufficient to suppress this response in upper abdominal surgeries. In other study of cholecystectomies using 100 µg/kg fentanyl, the stress response was suppressed; however, patients also required postoperative ventilator support. Most studies of neural blocks have assessed the effect of epidural anesthesia, but, few have addressed spinal anesthesia and stress. Moller et al [24] (1984) compared stress responses following spinal and general anesthesia in abdominal hysterectomies, and reported that spinal anesthesia had a temporary inhibitory effect, which was correlated with the sensorial block level. According to Basem et al [25] (2013) for all patients combined, mean glucose increased slightly from preoperative to incision, substantially from incision to surgery midpoint, and then remained high and fairly stable through emergence, with nondiabetic patients showing a greater increase. For nondiabetics, the mean increase in glucose concentration was more in patients given dexamethasone than placebo. However, there was no dexamethasone effect in diabetics. They assessed this response in patients undergoing non-cardiac surgery under general anaesthesia.

Conclusion

Spinal anaesthesia blunts surgical stress response and hence, at SI, BG values decrease. But, BG values increase at other times in perioperative period owing to the regression of sensory analgesia.

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