ISSN: 3065-0607

Journal of Medical Technology and Innovation

Research Article

# EXPLORING FACTORS INFLUENCING POSTOPERATIVE GLUCOSE LEVELS IN SURGICAL PATIENTS

**Samir Hadi Al-Bayati, M.D., FRCS**

Al-Hussein Teaching Hospital, Samawah, Al-Muthanna, Iraq

DOI: 10.5281/zenodo.14809439

## Abstract

**Background:**

Hyperglycemia is a common postoperative complication that has been associated with poor outcomes in critically ill patients, including impaired wound healing and increased morbidity. Postoperative hyperglycemia is a result of a hyper-metabolic stress response triggered by surgery, which leads to increased glucose production and insulin resistance. This stress response is influenced by various factors, such as the type and duration of the surgery, the anesthesia used, and patient-specific variables like age, gender, and pre-existing conditions such as diabetes.

**Methods:**

This study involved 200 patients (168 females and 32 males), aged between less than 1 year and 80 years, who underwent various types of surgeries. These patients received either general anesthesia or spinal anesthesia. Capillary blood samples were collected at the time of admission for surgery and on the first postoperative day. Blood glucose levels were measured using the HMG method to analyze the impact of surgery and anesthesia on postoperative glucose levels.

**Results:**

The study population had a mean age of 31.51 years, with the majority being female (84%) and non-diabetic (96.5%). The most common procedure performed was cesarean section (68%), and spinal anesthesia was administered in 72.5% of cases. The mean postoperative glucose level was 123.28 mg/dL (SD = 30.765), with minor variations in glucose levels observed across different types of surgery and anesthesia. No statistically significant difference was found in postoperative glucose levels based on surgery type, surgery duration, or anesthesia type ($p > 0.05$).

**Conclusion:**

This study highlights the complex relationship between surgical stress and postoperative glucose metabolism. While factors such as surgery type, duration, and anesthesia did not significantly affect postoperative glucose levels in this cohort, the results underscore the importance of vigilant monitoring and management of glucose levels in surgical patients. Further research with larger sample sizes and more comprehensive perioperative glucose management protocols is needed to optimize patient care and improve surgical outcomes.

Keywords: Hyperglycemia, Postoperative, Surgery, Insulin Resistance, Anesthesia

ISSN: 3065-0607

Journal of Medical Technology and Innovation

Research Article

## INTRODUCTION

Surgery, while a critical intervention in modern medicine, invokes a complex cascade of physiological responses in the body. These responses are multifactorial, influenced by anesthesia, medications, tissue damage, blood loss, and variations in body temperature. Together, these factors contribute to a significant metabolic change, resulting in a postoperative stress response that can impact the patient's recovery process. A key feature of this stress response is the release of counter-regulatory hormones, such as catecholamines, glucagon, and cortisol, which collectively help the body cope with the trauma of surgery. However, while these hormones play a protective role, their actions can also have detrimental effects on metabolic processes, particularly glucose metabolism. This disruption is most evident in the development of insulin resistance and hyperglycemia, conditions commonly seen in postoperative patients, which can compromise the healing process and overall recovery.

Metabolic changes after surgery occur on multiple levels, involving not only endocrine and metabolic systems but also the immune system. The severity of these changes largely depends on the amount of stress the body is exposed to during the surgical procedure. The stimulation of the central nervous system in response to injury is the primary trigger for the release of various hormonal mediators. These include tumor necrosis factor-alpha (TNF-α) and interleukin-1 (IL-1), which are released from damaged tissues and have well-documented effects on the hypothalamus. Recent studies have also suggested the involvement of nuclear factor kappa B (NF-kB) in regulating these responses, indicating that the inflammatory response to surgery extends beyond the traditional mediators.

The endocrine response to surgical stress begins with afferent neuronal impulses originating from the injury site. These impulses travel through sensory nerve roots to the spinal cord, ultimately activating the hypothalamus. This activation leads to the release of stress hormones, such as cortisol and catecholamines, that drive the body's adaptive responses. However, these responses are not without consequences. The stress induced by surgery results in impaired insulin action, primarily due to the inhibitory effects of catecholamines on insulin secretion from the pancreas. Additionally, target cells in the body become less responsive to insulin, a phenomenon known as insulin resistance, which further exacerbates hyperglycemia. During the perioperative period, patients experience a state of functional insulin deficiency, which is further compounded by the action of glucagon, which promotes the production of glucose by the liver through glycogenolysis and gluconeogenesis.

The presence of cortisol, a glucocorticoid hormone secreted by the adrenal glands in response to adrenocorticotropic hormone (ACTH), is another critical factor in postoperative hyperglycemia. Cortisol plays a pivotal role in elevating blood glucose levels by stimulating gluconeogenesis, suppressing the immune system, and increasing the metabolism of fats, proteins, and carbohydrates. While these mechanisms are designed to provide energy to vital organs during times of stress, they also contribute to the dysregulation of glucose homeostasis. As a result, hyperglycemia becomes a hallmark feature of the postoperative stress response, with significant implications for the healing process. High blood sugar levels inhibit normal immune function, promote glycosylation of proteins, impair collagen formation, and compromise wound healing. These factors collectively contribute to poor postoperative outcomes, including delayed recovery and increased risk of infection and complications.

In addition to hyperglycemia, undiagnosed preoperative hyperglycemia can further complicate the patient's recovery. This condition may be the result of undiagnosed diabetes or physiological stress that goes unrecognized before surgery. Hyperglycemia in the absence of proper management can signal a primary pathologic process or indicate a predisposition to poor outcomes. Furthermore, in critically ill or trauma patients, glucose becomes a crucial energy source, as mitochondrial respiration may not be feasible in certain cells, such as leukocytes and macrophages. In these cases, glucose synthesis is upregulated to meet energy demands, particularly since oxygen is not required for some stages of glycolysis.

The magnitude of the surgical stress response varies between individuals, influenced by both patient-related factors and the nature of the surgical procedure. Age is a key determinant of metabolic response, with children and elderly patients exhibiting different metabolic reactions to surgery. For example, metabolic responses tend to be more prolonged in older adults compared to younger patients. In neonates, metabolic responses can also vary depending on whether they are term or preterm. Nutrition and diet are additional factors that can significantly influence postoperative recovery. A patient's nutritional status impacts the metabolic response to surgery, with malnourished patients typically experiencing more severe metabolic disturbances. The type of intraoperative fluid administered also affects the body's ability to manage the stress response, influencing both metabolic and immunologic outcomes.

Anesthesia plays a crucial role in modulating the inflammatory and metabolic responses to surgery. Both general and regional anesthesia have been shown to reduce the inflammatory response to surgery, though their effects on the metabolic response vary. For instance, some studies suggest that epidural blocks with local anesthetic agents can alter the postoperative metabolic response by decreasing protein degradation without affecting overall protein synthesis in the first 24 hours after surgery. This suggests that while anesthesia has a role in modifying metabolic responses, its effects are more related to the inflammatory cascade rather than direct changes in metabolic processes.

The type and technique of surgery also influence the metabolic stress response. Procedures such as laparoscopic surgery, where the abdominal cavity is inflated with gases like $CO_2$, can elicit both local and systemic reactions that alter the body's metabolic response. Similarly, the degree of surgical damage plays a critical role in determining the intensity of the metabolic and inflammatory responses. More invasive surgeries tend to result in more pronounced metabolic disruptions, which can significantly impact postoperative recovery.

Overall, the metabolic response to surgery is complex and influenced by a variety of factors, including patient characteristics, the nature of the surgery, and the anesthesia used. The understanding of these factors is critical for managing postoperative complications such as hyperglycemia and insulin resistance, which can have profound effects on healing and recovery. Optimizing perioperative care, including glucose management, is essential to improving outcomes for surgical patients, particularly those at high risk for metabolic disturbances.

ISSN: 3065-0607
Journal of Medical Technology and Innovation
Research Article

**Objectives of study**

1-This study aims to evaluate the random blood sugar before and after surgery.

2-To assess the effect of surgery as a stressful condition on the metabolic and endocrine function of the body according to the type and duration of surgery, type of anesthesia.

**Methodology**

This study was done in Iraq, Al-Muthanna government, Al-Hussein teaching hospital.

From the period of 18th of October, 2023 to 10th of march, 2024.

Samples of blood for estimation of Random blood sugar were taken from the patients at time of admission to the hospital for surgery and on day zero postoperatively. Total 200samples that is 32 males and 168 females were collected.

Each sample was then tested for Random blood sugar level by HMG (Hansa Medical Germany) method. 5patients have diabetes mellitus 4 on insulin and one on metformin.

**Results Demographic Distribution**

The study included a total of 200 participants with a mean age of 31.51 years (SD = 10.971). The majority of participants were female, comprising 81.0% of the sample. Regarding diabetic status, 93% of participants were not diabetic, while only 7% reported having diabetes (Table 1, Fig. 1 and 2).

Table 1 presents the demographic distribution of participants, including age, gender, and diabetic status.

**Table 1: Demographic Distribution**

| Demographic Characteristic | Category | Frequency | Percent |
|---|---|---|---|
| Age | Mean ± Sd (Years) | 31.51 ± 10.971 | |
| Gender | Female | 162 | 81.0 |
| | Male | 38 | 19.0 |
| Diabetic Status | Not | 186 | 93 |
| | Yes | 14 | 7 |

ISSN: 3065-0607
Journal of Medical Technology and Innovation
Research Article

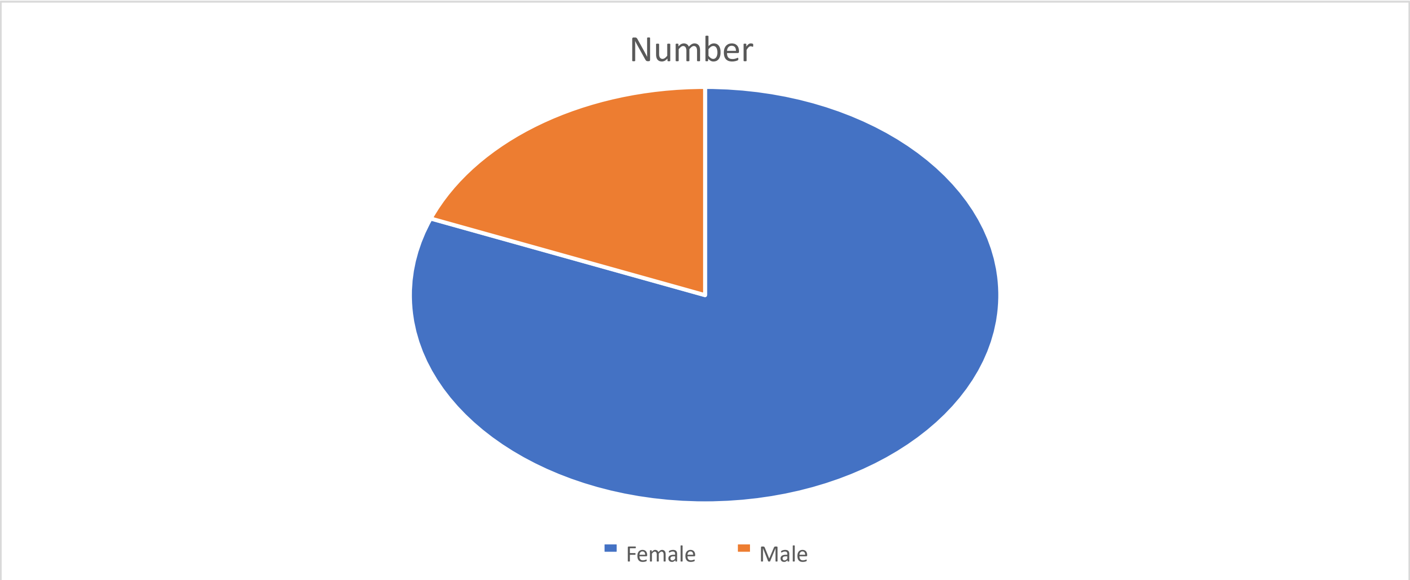


**Figure 1. Number of patients according to gender**

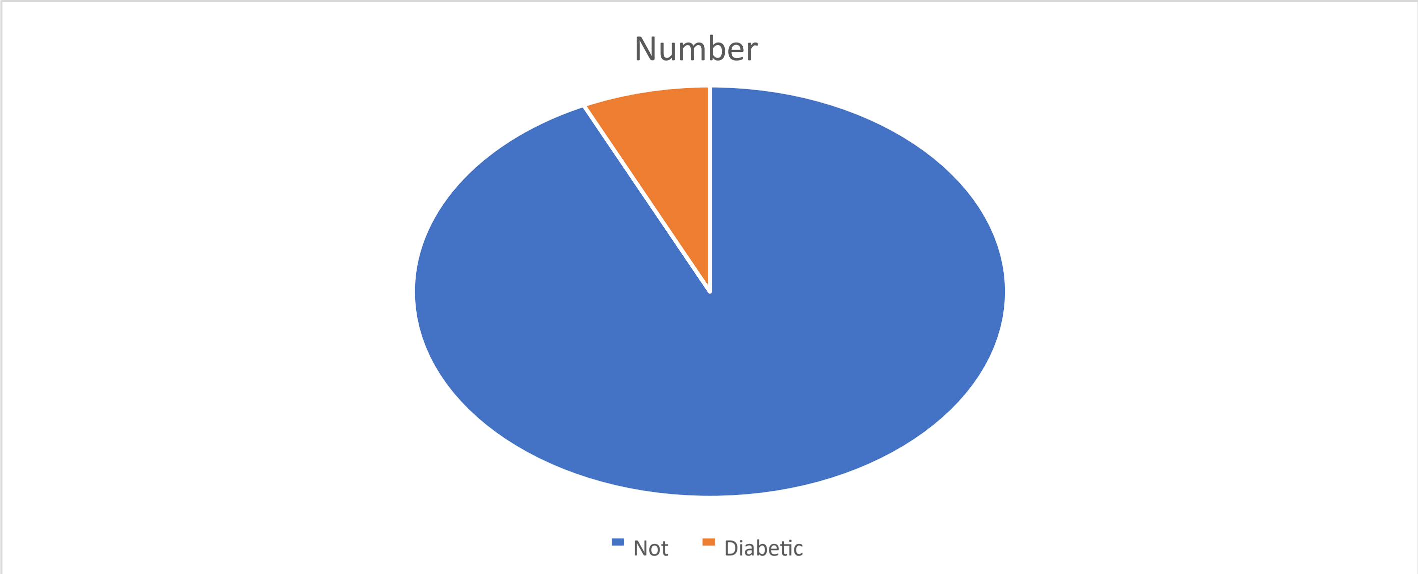


**Figure 2. Number of patients according to diabetic status**

ISSN: 3065-0607
Journal of Medical Technology and Innovation
Research Article

**Type of Operation and Anesthesia**

Table 2 illustrates the distribution of types of surgeries and anesthesia utilized in the study. Among the surgical procedures, Cesarean section was the most common (69%), followed by Laparoscopic cholecystectomy (5.5%). The majority of participants received spinal anesthesia (74%), while 23.5% underwent general anesthesia and 2.5% received local anesthesia (Table 2, Fig. 3,4).

**Table 2: Type of Operation and Anesthesia**

| Variable | Category | Frequency | Percent |
|---|---|---|---|
| Type of Surgery | | | |
| | Cesarean section | 138 | 69 |
| | Laparoscopic cholecystectomy | 11 | 5.5 |
| | Other surgical procedures | 51 | 25.5 |
| Type of Anesthesia | Spinal anesthesia | 148 | 74 |
| | General anesthesia | 47 | 23.5 |
| | Local anesthesia | 5 | 2.5 |

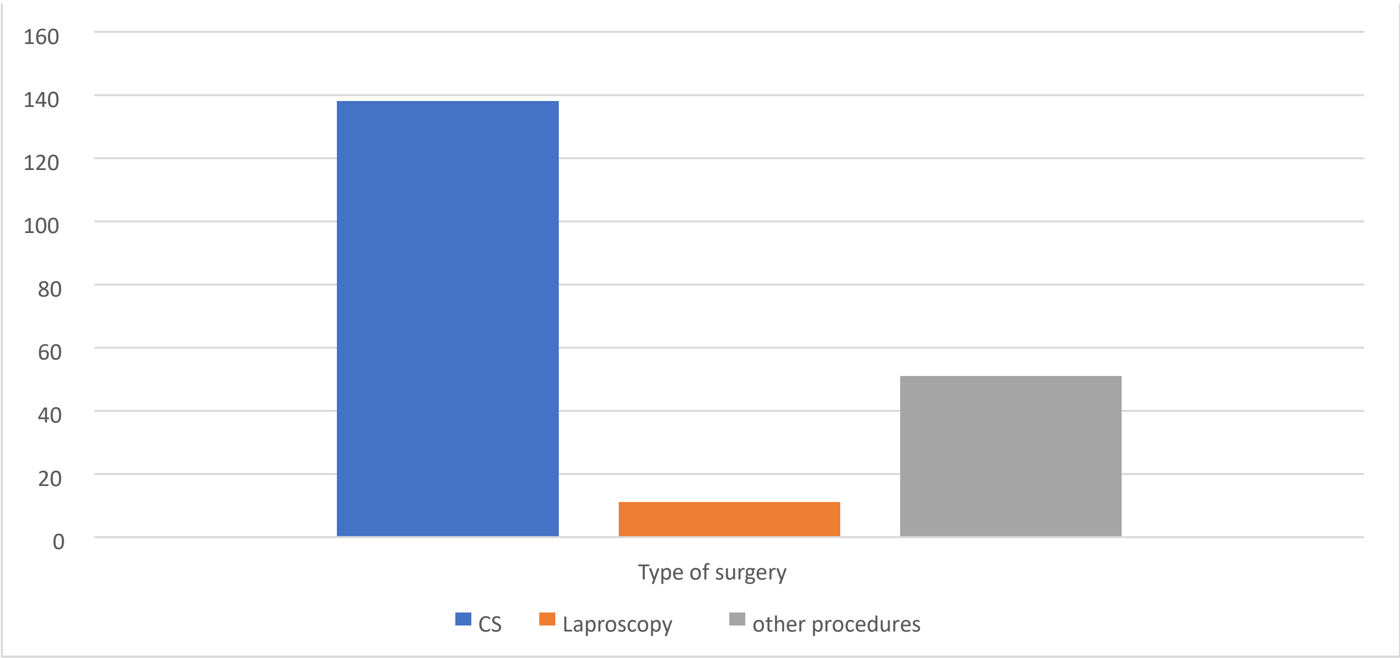


**Figure 3. Types of operations**

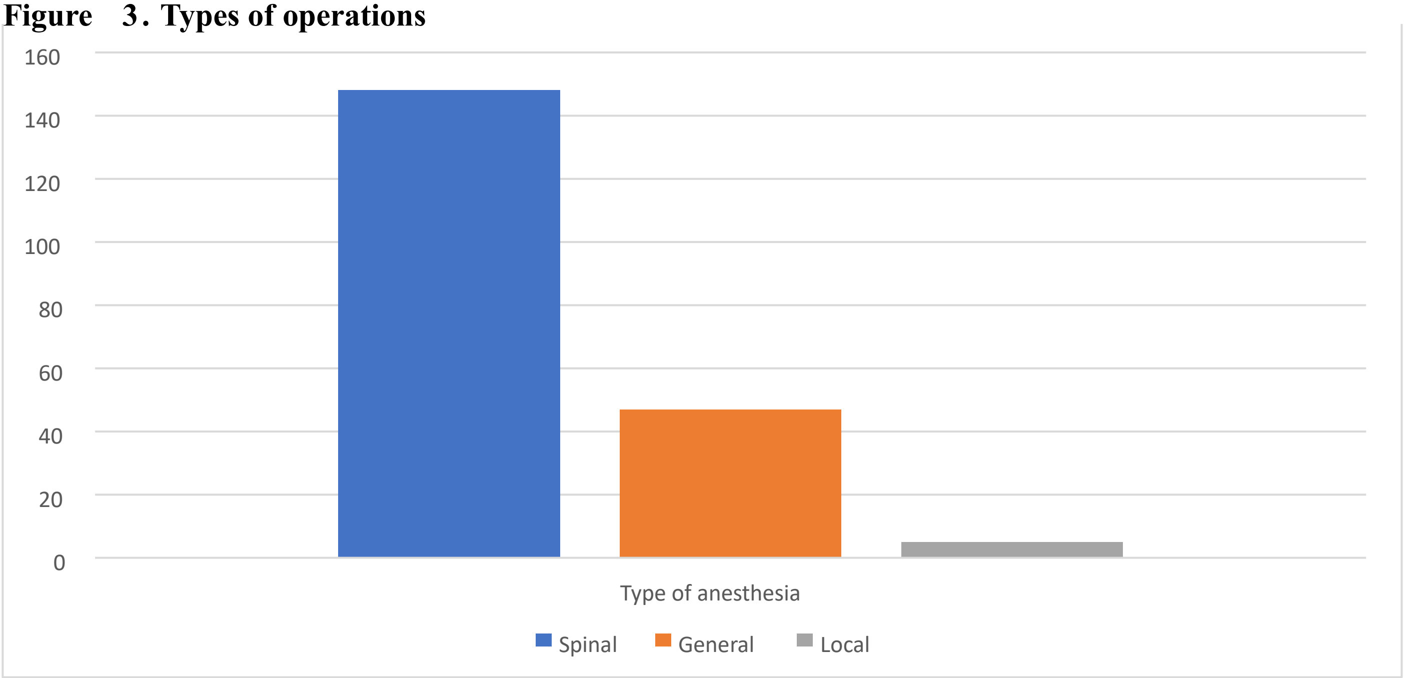


**Figure 4. Types of anesthesia**

**Glucose Levels**

Descriptive statistics for pre-operative and post-operative glucose levels are presented in Table 3. The mean pre-operative glucose level was 109.33 mg/dL (SD = 28.380), while the mean postoperative glucose level was 123.28 mg/dL (SD = 30.765).

**Table 3: Glucose Levels**

| Variable | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|
| Pre-op Glucose | 70 | 333 | 109.33 | 28.380 |
| Post-op Glucose | 15 | 279 | 123.28 | 30.765 |

**Difference of Post-op Glucose based on Surgery Type**

Table 4 presents the mean post-operative glucose levels categorized by different types of surgeries. The mean post-operative glucose levels varied across different operation types, with minor surgeries having a mean glucose level of 114.00 mg/dL (SD = 41.154), above major surgeries with a mean of 128.84 mg/dL (SD = 46.560), major surgeries with a mean of 121.92 mg/dL (SD = 23.503), and intermediate surgeries with a mean of 126.40 mg/dL (SD = 30.419). Overall, the mean post-operative glucose level for all surgeries was 123.28 mg/dL (SD = 30.765). However, p value was 0.495, this means that the difference in mean was not statistically significant.

ISSN: 3065-0607

Journal of Medical Technology and Innovation

Research Article

**Table 4: Difference of Post-op Glucose based on Surgery Type**

| Operation Type | Mean Post-op Glucose (mg/dL) | Count | Std. Deviation |
|---|---|---|---|
| **Minor** | **114.00** | **7** | **41.154** |
| **Above major** | **128.84** | **44** | **46.560** |
| **Major** | **121.92** | **144** | **23.503** |
| **Intermediate** | **126.40** | **5** | **30.419** |
| **ANOVA *p* value** | **0.495** | | |
| **Association** | **Not statistically significant** | | |

**Mean Difference in Post-op Glucose Based on Duration of Operation** Table 5 displays the mean difference in post-operative glucose levels based on the duration of the operation. The mean post-operative glucose levels varied across different durations of surgery, ranging from 110.00 mg/dL (SD = 28.284) for surgeries lasting 15 minutes to 155.56 mg/dL (SD = 59.534) for surgeries lasting 2 hours. The analysis of variance (ANOVA) indicated that there was no statistically significant difference in post-operative glucose levels based on the duration of surgery ($F = 1.888$, $p = 0.064$).

ISSN: 3065-0607
Journal of Medical Technology and Innovation
Research Article

**Table 5: Mean Difference in Post-op Glucose Based on Duration of Operation**

| Duration | Mean Post-op Glucose (mg/dL) | Count | Std. Deviation |
|---|---|---|---|
| 1 hour | 126.00 | 31 | 36.489 |
| 1:30 hours | 144.00 | 3 | 64.506 |
| 15 min | 110.00 | 2 | 28.284 |
| 2 hours | 138.50 | 2 | 44.548 |
| 20 min | 119.35 | 26 | 24.456 |
| 25 min | 116.81 | 16 | 20.821 |
| 2hour | 155.56 | 9 | 59.534 |
| 30 min | 122.11 | 93 | 23.570 |
| 40 min | 116.22 | 18 | 36.444 |
| ANOVA *p* value | 0.064 | | |
| Association | Not Statistically Significant | | |

**Mean Difference in Post-op Glucose Based on Type of Anesthesia**

Table 6 presents the mean difference in post-operative glucose levels based on the type of anesthesia used. The mean post-operative glucose levels were 127.08 mg/dL (SD = 36.979) for general anesthesia, 109.00 mg/dL (SD = 46.422) for local anesthesia, and 122.46 mg/dL (SD = 27.750) for spinal anesthesia. The analysis of variance (ANOVA) indicated that there was no statistically significant difference in postoperative glucose levels based on the type of anesthesia used ($F = 0.972$, $p = 0.380$).

**Table 6: Mean Difference in Post-op Glucose Based on Type of Anesthesia**

| Type of Anesthesia | Mean Post-op Glucose (mg/dL) | Count | Std. Deviation |
|---|---|---|---|
| GA | 127.08 | 50 | 36.979 |
| Local | 109.00 | 5 | 46.422 |
| Spinal | 122.46 | 145 | 27.750 |
| ANOVA *p* value | 0.972 | | |
| Association | Not Statistically Significant | | |

## Discussion

This study investigated the demographic distribution, types of surgeries and anesthesia, and the impact of various factors on post-operative glucose levels in 200 participants. The findings shed light on important aspects of surgical care and metabolic outcomes, contributing to the existing body of literature in this field.

The demographic profile of the participants revealed a predominance of females (81.0%) and a relatively young mean age of 31.51 years. This distribution contradicts with previous stud y conducted by [24] highlighting the higher prevalence of males undergoing surgical intervention, in which 68% of those presenting to the general surgery were males, and women had significantly higher odds of non-operative management when compared to men [25]. Additionally, the overwhelming majority of participants were not diabetic (93%), consistent with the general population's prevalence of diabetes.

Cesarean section emerged as the most frequent surgical procedure (69%), reflecting the significant demand for obstetric surgeries in healthcare settings.

The preference for spinal anesthesia (74%) over general and local anesthesia corresponds to established trends in surgical practice, emphasizing its safety and efficacy, particularly in lower abdominal and lower extremity surgeries [26]. This finding aligns with findings of previous study conducted by [27], in which 54% of participants had chosen spinal anesthesia, 22% had chosen general anesthesia [27].

ISSN: 3065-0607

Journal of Medical Technology and Innovation

Research Article

The analysis of post-operative glucose levels based on surgery type revealed no statistically significant differences. While minor variations were observed, they did not reach significance levels. This finding contrasts with some previous studies suggesting an association between the invasiveness or duration of surgery and post-operative glucose dysregulation [28]. The discrepancy may stem from sample size differences, variations in patient populations, or differences in surgical techniques and perioperative care protocols.

Similarly, the duration of surgery did not exert a significant influence on postoperative glucose levels. Although longer surgeries tended to exhibit slightly higher glucose levels, the differences were not statistically significant. This finding contradicts some literature suggesting a positive correlation between prolonged surgical duration and increased post-operative glucose levels [29]. However, methodological differences, such as the inclusion criteria and surgical complexity, may contribute to these disparities.

The type of anesthesia administered also failed to demonstrate a significant impact on postoperative glucose levels. Despite variations in mean glucose levels across different anesthesia types, the differences did not reach statistical significance. This finding is contradicting with several studies indicating different metabolic outcomes between general and regional anesthesia techniques, for instance a study conducted by [30] found that Glycemia was significantly higher in the general anesthesia group. However, the influence of anesthesia depth, intraoperative glucose management strategies, and patient-specific factors warrants further exploration.

## Conclusions and Recommendations

### Conclusions:

1. **Demographic and Surgical Trends**: The study reveals a notable demographic profile with a majority of female participants and a prevalence of cesarean sections. This contrasts with previous findings, indicating shifting patterns in surgical demographics. Understanding these trends is crucial for tailoring healthcare services to meet evolving patient needs.
2. **Anesthesia Preferences and Glucose Levels**: Despite established trends favoring spinal anesthesia and its perceived safety, no significant impact on post-operative glucose levels was observed across different anesthesia types. This challenges previous research suggesting metabolic differences between anesthesia techniques, highlighting the need for nuanced exploration of intraoperative glucose management strategies.
3. **Post-operative Glucose Regulation**: The absence of significant associations between surgery type, duration, and post-operative glucose levels underscores the complexity of metabolic responses to surgical interventions. Further investigations incorporating larger sample sizes and standardized perioperative care protocols are warranted to elucidate the underlying mechanisms and optimize metabolic outcomes in surgical patients.

### Recommendations:

1. **Further Research**: Future studies should explore the interplay between anesthesia depth, intraoperative glucose management strategies, and patientspecific factors to better understand their collective impact on post-

ISSN: 3065-0607
Journal of Medical Technology and Innovation
Research Article

operative glucose regulation. This will facilitate the development of tailored perioperative care protocols to optimize metabolic outcomes in diverse patient populations.

2. **Clinical Practice Guidelines**: Healthcare providers should consider the evolving demographic trends and anesthesia preferences highlighted in this study when developing clinical practice guidelines for surgical care. Emphasizing individualized approaches to anesthesia selection and perioperative glucose management may help mitigate potential metabolic complications and enhance patient outcomes.

3. **Education and Training**: Given the variability in surgical practices and patient populations, ongoing education and training programs for healthcare professionals are essential. Clinicians should stay abreast of emerging research findings and best practices in perioperative glucose management to deliver optimal care and improve patient safety and satisfaction.

**REFERENCES**

Hager P (2008) Systemic stress response and hyperglycemia after abdominal surgery in rat and man. Stockholm: Karolina University Hospital Huddige.

Jovanovski-Srceva M, Kuzmanovska B, Mojsova M, Kartalov A, Shosholcheva M, et al. (2015) Insulin Resistance, Glycemia and cortisol levels in Surgical Patients who had Preoperative Caloric Load with Amino Acids. Pril (Makedon Akad Nauk Umet Odd Med Nauki) 36: 61-70.

Guyton AC, Hall JE (2006) Textbook of Medical Physiology. Eleventh edition. Elsevier Inc, Philadelphia. pp: 829-834.

Gjessing PF (2014) Postoperative insulin resistance and the metabolic and cellular responses to single-dose preoperative oral carbohydrate supplementation. Experimental studies in pigs (dissertation). The Arctic University of Norway, Norway.

Bekyarova G, Apostol ova M, Kotzev I. Melatonin protection against burn-induced hepatic injury by down-regulation of nuclear factor kappa B activation. Int J Immunopathol Pharmacol. 2012; 25:591–596.

Baumann and Gauldie, 1994 H Baumann, J Gauldie. The acute phase response Immunology Today, 15 (1994), pp. 74-79.

Desborough, 2000 JP Desborough. The stress response to surgery Br J Anaesth, 85 (2000), pp. 109-117.

ISSN: 3065-0607

Journal of Medical Technology and Innovation

Research Article

Kehlet, 1997 H Kehlet. Multimodal approach to control postoperative pathophysiology and rehabilitation, Br J Anaesth, 78 (1997), pp. 606-617.

Thorell A, Nygren J, Ljungqvist O. İnsulin resistance: a marker of surgical stress. *Curr Opin Clin Nutr Metab Care.* 1999; 2:69–78.

Jan BV, Lowry ST. Systemic response to injury and metabolic support. In: Brunicardi FC, Andersen DK, Billiar TR, Dunn DL, Hunter JG, Matthews JB, Pollock RE, editors. Schwartz's Principles of Surgery. 9th ed. New York: Mc Graw-Hill; 2010. pp. 15–49.

Fellander G, Nordenstrom J, Tjader I, Bolinder J, Arner P. Lipolysis during abdominal surgery. *J Clin Endocrinol Metab.* 1994; 78:150–155.

Carli F, Lattermann R, Schricker T. Epidural analgesia and postoperative lipid metabolism:

stable isotope studies during a fasted/fed state. *Reg Anesth Pain Med.* 2002; 27:132–138.

Nygren J, Soop M, Thorell A, Efendic S, Nair KS, Ljungqvist O. Pre-operative oral carbohydrate administration reduces postoperative insulin resistance. *Clin Nutr.* 1998; 17:65–71.

Zerr KJ, Furnary AP, Grunkemeier GL, Bookin S, Kanhere V, Starr A. Glucose control lowers the risk of wound infection in diabetics after open heart operations. *Ann Thorac Surg.* 1997; 63:356–361.

Leskovan JJ, Justiniano CF, Bach JA, Cook CH, Lindsey DE, Eiferman DS, et al. Anion gap as a predictor of trauma outcomes in the older trauma population: correlations with injury severity and mortality. *Am Surg.* 2013; 79:1203–1206.

Essen P, Thorell A, McNurlan MA, Anderson S, Ljungqvist O, Wernerman J, et al. Laparoscopic cholecystectomy does not prevent the postoperative protein catabolic response in muscle. *Ann Surg.* 1995; 222:36–42.

Desborough JP, Hall GM. Endocrine response to surgery. In: Kaufman L. Anaesthesia Review, Vol. 10. Edinburgh: Churchill Livingstone, 1993; 131–48.

Pierro A. Metabolic response to neonatal surgery. Curr Opin Pediatr. 1999; 11:230– 236.

ISSN: 3065-0607

Journal of Medical Technology and Innovation

Research Article

Ward Platt MP, Tarbit MJ, Aynsley-Green A. The effects of anesthesia and surgery on metabolic homeostasis in infancy and childhood. J Pediatr Surg. 1990; 25:472–428.

Kehlet H. Manipulation of the metabolic response in clinical practice. World J Surg. 2000; 24:690–695.

Cuthbertson DP, Fell GS, Smith CM, Tilstone WJ. Metabolism after injury. I. Effects of severity, nutrition, and environmental temperature on protein potassium, zinc, and creatine. Br J Surg. 1972; 59:926–931.

Carli F, Galeone M, Gzodzic B, Hong X, Fried GM, Wykes L, et al. Effect of laparoscopic colon resection on postoperative glucose utilization and protein sparing: an integrated analysis of glucose and protein metabolism during the fasted and fed states using stable isotopes. Arch Surg. 2005; 140:593–597.

Nygren J, Soop M, Thorell A, Efendic S, Nair KS, Ljungqvist O. Pre-operative oral carbohydrate administration reduces postoperative insulin resistance. Clin Nutr. 1998; 17:65–71.

McHoney M, Eaton S, Pierro A. Metabolic response to surgery in infants and children. Eur J Pediatr Surg. 2009;19:275–285.

Reid TD, Wren SM, Grudziak J, Maine R, Kajombo C, Charles AG. Sex disparities in access to surgical care at a single institution in Malawi. World journal of surgery. 2019 Jan 15;43:60-6

KALARIA RT, UPADHYAY MR. Spinal Anaesthesia for Lower Abdominal Surgery: Levobupivacaine versus Racemic Bupivacaine. Journal of Clinical & Diagnostic Research. 2018 Mar 1;12(3.)

Tawfeeq NA, Hilal F, Alharbi NM, Alowid F, Almaghrabi RY, Alsubhi R, Alharbi SF, Fallatah A, Aloufi LM, Alsaleh NA, Alharbi S. The prevalence of acceptance between general anesthesia and spinal anesthesia among pregnant women undergoing elective caesarean sections in Saudi Arabia. Cureus. 2023 Sep 10;15(9.)

Polito A, Thiagarajan RR, Laussen PC, Gauvreau K, Agus MS, Scheurer MA, Pigula FA, Costello JM. Association between intraoperative and early postoperative glucose levels and adverse outcomes after complex congenital heart surgery. Circulation. 2008 Nov 25;118(22):223542.

Dougherty SM, Schommer J, Salinas JL, Zilles B, Belding-Schmitt M, Rogers WK, ShibliRahhal A, O'Neill BT. Immediate preoperative hyperglycemia correlates with complications in non-cardiac surgical cases. Journal of clinical anesthesia. 2021 Nov 1; 74:110375.

Milosavljevic SB, Pavlovic AP, Trpkovic SV, Ilić AN, Sekulic AD. Influence of spinal and general anesthesia on the metabolic, hormonal, and hemodynamic response in elective surgical patients. Medical science monitor: international medical journal of experimental and clinical research. 2014;20:1833.