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# Effect of General Anesthesia Versus Spinal Anesthesia on Blood Glucose Concentration in Non-Diabetic Patients Undergoing Elective Cesarean Section

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## Abstract:
Surgical procedures induce a physiological stress response, leading to increased secretion of catabolic hormones and a rise in blood glucose concentration. The type of anesthesia used may influence this response, impacting perioperative glucose regulation. This study aims to compare the effects of general anesthesia (GA) and spinal anesthesia (SA) on blood glucose levels in non-diabetic patients undergoing elective cesarean section. A prospective comparative study was conducted at Al Wahda Hospital, Derna, including 40 non-diabetic women scheduled for elective cesarean section. Patients were divided into two groups: GA (n=20) and SA (n=20). Blood glucose concentrations were measured at four time points: before induction (T1), after induction (T2), before the end of surgery (T3), and 30 minutes postoperatively (T4). Statistical analysis was performed using repeated measures ANOVA. Blood glucose levels increased significantly in both groups during surgery. However, the rise was more pronounced in the GA group compared to the SA group ($p < 0.05$). The difference became more evident at T3 and T4, where GA patients exhibited a significantly higher glucose concentration than those in the SA group. General anesthesia is associated with a greater increase in blood glucose concentration compared to spinal anesthesia in non-diabetic patients undergoing elective cesarean section. This suggests that spinal anesthesia may be a preferable option for better perioperative glucose control, potentially reducing the risk of complications related to hyperglycemia. Further research with larger sample sizes is recommended to validate these findings.

**Keywords**: General anesthesia, Spinal anesthesia, Blood glucose, Cesarean section, Stress response

### Introduction
Spinal anesthesia has become the preferred anesthetic technique when providing anesthesia for patients undergoing elective cesarean section as the risk of maternal and fetal complications associated with spinal anesthesia is less than with general anesthesia (Reynolds F.,2010; Heng Sia A. T., Tan K. H., Sng B. L., Lim Y., Chan E. S. Y., Siddiqui F. J. Hyperbaric , 2015).
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 (Hadimioglu N., Ulugol H., Akbas H., Coskunfirat N., Ertug Z., Dinckan A., 2012 - Desborough J. P., 2000). The overall metabolic effect of the stress response to surgery includes an increase in secretion of catabolic hormones, such as cortisol and catecholamine, and a decrease in 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 (Hadimioglu N., Ulugol H., Akbas H., Coskunfirat N., Ertug Z., Dinckan A., 2012 - Geisser W., Schreiber M., Hofbauer H., et al.2003).
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 (Hadimioglu N., Ulugol H., Akbas H., Coskunfirat N., Ertug Z., Dinckan A., 2012 - Geisser W., Schreiber M., Hofbauer H., et al.2003 Gandhi G. Y., Nuttall G. A., Abel M. D., et al., 2005). The risk related to hyperglycemia is seen in patients both with and without a history of diabetes (Anderson R. E., Ehrenberg J.,

Barr G., et al., 2005). Notably, even short-term hyperglycemia compromises immune function and increases the risk of infection (Geisser W., Schreiber M., Hofbauer H., et al.,2003 , Turina M., Miller F. N., Tucker C. F., Polk H. C. , 2006 , Behdad S., Mortazavizadeh A., Ayatollahi V., Khadiv Z., Khalilzadeh S.,2014).
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 anesthesia such as epidural or spinal anesthesia blocks afferent neural impulses; consequently, the stress response to surgery including hyperglycemia is inhibited (Hadimioglu N., Ulugol H., Akbas H., Coskunfirat N., Ertug Z., Dinckan A.,2012 ; Desborough J. P. , 2000 ;Amiri F., Ghomeishi A., Aslani S. M., Nesioonpour S., Adarvishi S. , 2014 ; Gottschalk A., Rink B., Smektala R., Piontek A., Ellger B., Gottschalk A.,2014).

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**Material and methods**

**• Approval and Study Design:**

- The study was conducted after obtaining approval from the Faculty of Medicine in Derna.
- A prospective comparative study included **30 women** scheduled for **elective cesarean section** in the Obstetrics Department at Al Wahda Hospital, Derna.

**• Inclusion and Exclusion Criteria:**

- Inclusion criteria: Patients scheduled for elective cesarean section, fasting for **8-12 hours** before surgery.
- Exclusion criteria: Type 1 and Type 2 diabetes, heart failure, ischemic heart disease, preeclampsia, eclampsia, and psychiatric disorders.

**• Group Allocation:**

- Patients were divided into two groups:
  - **Group S:** Patients who chose **spinal anesthesia**.
  - **Group G:** Patients who chose **general anesthesia**.

**• Spinal Anesthesia Protocol (Group S):**

- Performed under aseptic conditions at **L3-L4 or L4-L5** vertebral levels.
- **2.3 ml** of **0.5% heavy bupivacaine** + **0.4 ml** of **0.005% fentanyl** was used.
- A **25- or 27-gauge spinal needle** was used.
- **100% oxygen** was administered via a simple face mask at a flow rate of **3 L/min**.

**• General Anesthesia Protocol (Group G):**

- Pre-oxygenation for 3 minutes using a face mask.
- Induction with 2–2.5 mg/kg propofol and 0.6 mg/kg rocuronium.
- Rapid sequence intubation with a 6.5 mm ID endotracheal tube.
- After delivery and umbilical cord clamping, 3 μg/kg fentanyl was administered.
- Before delivery: Anesthesia was maintained with 0.7% isoflurane in 50% oxygen and 50% nitrous oxide.
- After delivery: Maintenance continued with inhaled anesthetics.
- ETCO2 was maintained between 30–40 mmHg throughout the surgery.
- At the end of surgery, anesthesia was discontinued, and 2.5 mg neostigmine + 1 mg atropine IV was administered for neuromuscular blockade reversal.
- Extubation was performed once the patient was breathing spontaneously, fully awake, and able to sustain head elevation for >5 seconds.

- **Preoperative Medications for Both Groups:**
  - **1 g cefuroxime IV.**
  - 8 mg dexamethasone IV.
  - 50 mg ranitidine IV.
  - 10 mg metoclopramide IV before anesthesia.
  - After delivery, both groups received 20 IU oxytocin infusion over 1 hour.
  - 1000–1500 ml IV crystalloids were administered.

- **Blood Glucose Concentration (BGC) Measurement:**
  - **Group G (General Anesthesia):**
    - **T1:** 5 minutes before induction.
    - **T2:** 5 minutes after induction.
  - **Group S (Spinal Anesthesia):**
    - **T1:** Immediately before local anesthetic injection.
    - **T2:** 5 minutes after complete spinal block.
  - **Both Groups:**
    - **T3:** 1 minute before the end of surgery.
    - **T4:** 30 minutes postoperatively in the post-anesthesia care unit (PACU).
  - Blood glucose concentration was measured using a **Joycoo BG-102** monitoring kit (Joycoo, Amman, Jordan).
  - After disinfecting the non-dominant hand's fingertip with an alcohol swab, a lancet device was used for measurement.

## Results and Discussion

The two groups were statistically equivalent regarding age, weight, and fasting duration, as indicated in Table 1, which shows the means, standard deviations, and t-test statistic for the difference between the mean values. Table 2 shows the means and standard deviations for the four glucose-check readings for the two groups. The mean values for the general anesthesia group increased more rapidly than those in the spinal anesthesia group.

Table 1. Multivariate tests on glucose-check data and type of anesthesia for patients included in the study.

| Effect | Hypothesis | | | | |
|---|---|---|---|---|---|
| | Value | F | df | Error df | significance |
| Glucose-check wilks lambda | 0.168 | 88.838[b] | 3.000 | 54.000 | 0.00 |
| Glucose level wilks lambda *Type of anesthesia | 0.204 | 70.440[b] | 3.000 | 54.000 | 0.00 |

Table 2. Tests of within subject's effects for patients are included in the study.

| Measure: readings | | | | | |
|---|---|---|---|---|---|
| Source | Type III sum of squares | dr | $X^2$ | F | p-value |
| Glucose-check sphericity assumed | 21192.823 | 3 | 7064.274 | 131.448 | 0.00 |
| Glucose level*type of anesthesia sphericity assumed | 17143.099 | 3 | 5714.366 | 106.329 | 0.00 |
| Error (glucose-check) sphericity assumed | 9028.673 | 168 | 53.742 | - | - |

According to Tables 1 and 2, there was a statistically significant difference (at $\alpha = 0.01$) in glucose-check readings with regard to time of readings and its interaction with type of anesthesia (general anesthesia and spinal anesthesia).
The two groups were statistically equivalent regarding age, weight, and fasting duration, as indicated in Table 3, which shows the means, standard deviations, and t-test statistic for the difference between the mean values. Table 4 shows the means and standard deviations for the four glucose-check readings for the two groups. The mean values for the general anesthesia group increased more rapidly than those in the spinal anesthesia group.

Table 3. Age, weight, and fasting time of patients included in the study (n = 30).

| | **Group G, mean±SD (n=15)** | **Group S, mean ±SD (n=15)** | **T** | **P- value** |
|---|---|---|---|---|
| Age (years) | 28.2±4.2 | 28.9±5.6 | -0.470 | 0.640 |
| Weight(kg) | 69.4±8.3 | 70.4±2.5 | -0.330 | .0742 |
| Fasting (hrs) | 9.2±1.4 | 9.7±1.2 | -1.584 | 0.119 |

Data are given as a mean SD and the significance of the difference in age, weight, and fasting time between group G (general anesthesia) and group S (spinal anesthesia).

Table 4. Descriptive statistics for the mean blood glucose concentrations for spinal anesthesia and general anesthesia at different measurement times.

| | **Type of anesthesia** | **Mean** | **Std. D** | **N** |
|---|---|---|---|---|
| 5 min before induction | General anesthesia | 74.3 | 14.7 | 15 |
| | Spinal anesthesia | 78.3 | 18.2 | 15 |
| | Total | 76.7 | 16.9 | 30 |
| 5 min after induction | General anesthesia | 84.9 | 23.7 | 15 |
| | Spinal anesthesia | 79.2 | 18.3 | 15 |
| | Total | 81.4 | 20.6 | 30 |
| Min before the end of surgery | General anesthesia | 108.4 | 16.7 | 15 |
| | Spinal anesthesia | 80.2 | 18.1 | 15 |
| | Total | 91.4 | 22.3 | 30 |
| 30 Min before the end of surgery | General anesthesia | 121.1 | 17.4 | 15 |
| | Spinal anesthesia | 80.9 | 17.7 | 15 |
| | total | 96.8 | 26.4 | 30 |

The results in Table 4 were plotted as a graph in Figure 1. This shows the difference between the glucose-check readings according to glucose-check timing in both spinal anesthesia and general anesthesia and shows the difference in the effect of type of anesthesia (general anesthesia and spinal anesthesia) on blood glucose concentration. According to Figure 1, there is a significant proportional increase in mean blood glucose concentrations with glucose-check timing (5 minutes before induction, 5 minutes after induction, 1 minute before the end of surgery, and 30 minutes after the end of surgery), and this increase is significantly much greater in general anesthesia than it is in spinal anesthesia.

Figure 1. Relationship between glucose-check timing, type of anesthesia, and mean blood glucose concentrations for patients in the study.

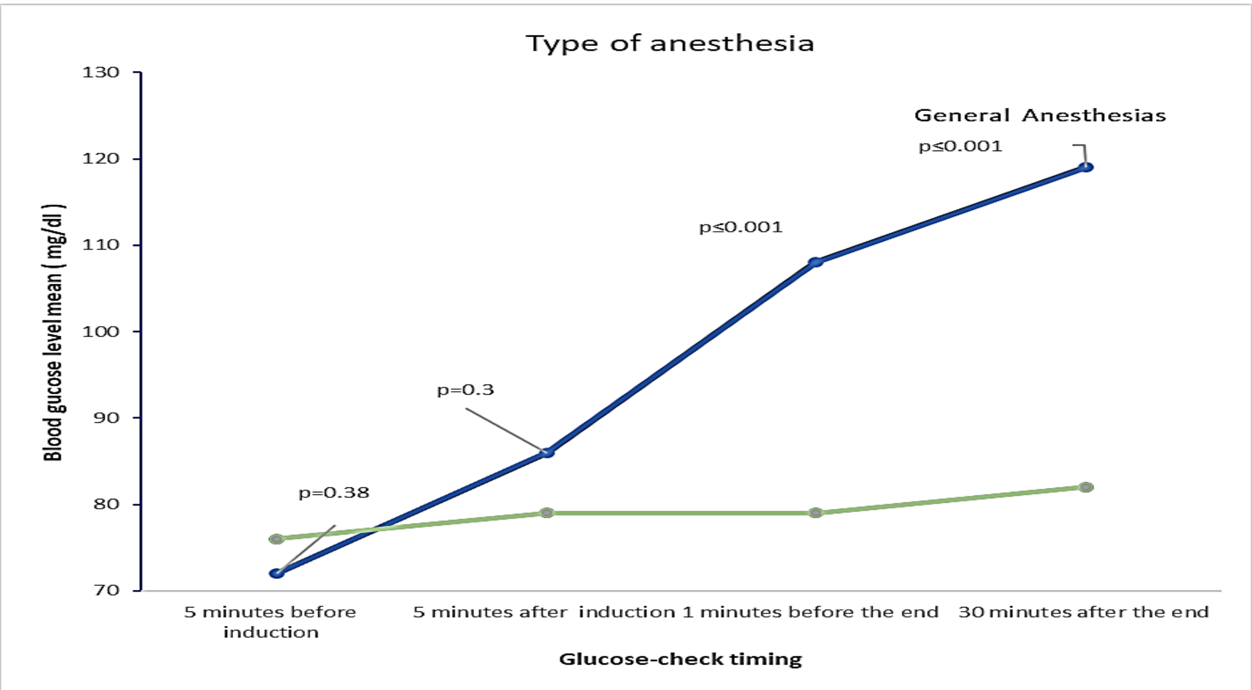


Figure 1 Relationship between glucose-check timing

The results of this study indicate that general anesthesia leads to a significant increase in blood glucose concentration compared to spinal anesthesia in non-diabetic patients undergoing elective cesarean section. This effect can be attributed to the physiological stress response to surgery, where general anesthesia activates the sympathetic nervous system, leading to increased secretion of stress hormones such as cortisol and catecholamines, which promote hyperglycemia.

In contrast, spinal anesthesia mitigates this response by blocking afferent neural signals from the surgical site to the brain, thereby reducing the release of stress-related hormones. This explains the lower rise in blood glucose levels observed in the spinal anesthesia group compared to the general anesthesia group.

These findings suggest that spinal anesthesia may be a preferable option for patients requiring better blood glucose control during surgery, potentially reducing complications associated with hyperglycemia, such as delayed wound healing and increased risk of infection. However, further studies with larger sample sizes are needed to confirm these results and provide a more comprehensive understanding of the mechanisms underlying the effects of different anesthesia types on blood glucose levels.

## Conclusion

This study demonstrates that general anesthesia is associated with a greater increase in blood glucose concentration compared to spinal anesthesia in non-diabetic patients undergoing elective cesarean section. The significant rise in blood glucose levels under general anesthesia is likely due to the activation of the physiological stress response, leading to increased secretion of catabolic hormones. In contrast, spinal anesthesia helps attenuate this response by blocking afferent neural impulses, resulting in a more stable blood glucose profile.

Given the potential risks associated with perioperative hyperglycemia, including impaired wound healing and increased risk of infection, spinal anesthesia may be a preferable choice for cesarean sections in non-diabetic patients. However, further research with larger sample sizes is needed to confirm these findings and explore additional factors that may influence perioperative blood glucose regulation.

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