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Original Research Article

A Comparative Evaluation of Biochemical Changes in Blood Glucose and Serum Electrolytes (Na^+, K^+, Cl^-) During Surgery under General and Regional Anaesthesia

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Abstract:

Background: Anaesthesia, which is necessary for surgery, triggers systemic physiological reactions that impact metabolic and electrolyte homeostasis. General anaesthesia (GA) typically provokes a more significant stress response, accompanied by hyperglycemia and electrolyte imbalances, whereas regional anaesthesia (RA) may help mitigate these effects. It is imperative to understand such discrepancies to streamline perioperative care, especially in comorbid patients like diabetics, hypertensives, or patients with renal failure.

Objectives: The objective of the present study was to compare intraoperative and postoperative variations in blood glucose and serum electrolytes (sodium, potassium, chloride) in patients undergoing surgery under general versus regional anesthesia, assessing which modality provides more stable metabolic and electrolyte patterns.

Materials and Methods: A prospective, observational study was done on 214 adult patients (18–60 years, ASA I–II) undergoing elective surgeries longer than 45 minutes. The patients were divided equally between the GA and RA groups. Venous blood samples were obtained preoperatively, intraoperatively (60 minutes after the start of surgery), and postoperatively to assess blood glucose and serum electrolytes. Statistical analysis was done using SPSS with a $p < 0.05$ set as the level of significance.

Results: Demographic features were similar across groups ($p > 0.05$). During surgery, GA patients had a marked increase in blood glucose (118.6 ± 11.3 mg/dL) compared to RA patients (102.4 ± 10.6 mg/dL, $p < 0.001$). Both groups experienced increased postoperative glucose levels, which were more effectively controlled in the RA group. Serum sodium, potassium, and chloride levels fell more significantly in GA patients both intraoperatively and postoperatively, but remained closer to baseline in RA. The results demonstrate that GA causes more metabolic and electrolyte disturbances compared to RA.

Conclusion: Regional anaesthesia is linked with more stable intraoperative glucose and electrolyte levels, echoing its ability to suppress the surgical stress response. These findings favor consideration of RA in patients at risk of metabolic or electrolyte disturbances, reinforcing the need for close monitoring and personalized anaesthetic choice to maximize perioperative results.

Keywords: General Anaesthesia, Regional Anaesthesia, Blood Glucose, Serum Electrolytes, Perioperative Metabolic Changes, Surgical Stress Response.

Introduction

Anaesthesia is an essential part of contemporary surgical practice, providing patient comfort, immobility, and optimal operating conditions. Yet its administration is not without systemic physiological effects [1]. General and regional anesthesia both affect neuroendocrine responses, metabolic function, and electrolyte status, and can modify intraoperative and postoperative outcomes. The stress of surgery stimulates the hypothalamic–pituitary–adrenal (HPA) axis and the sympathetic nervous system, leading to augmented secretion of catecholamines, cortisol, and other stress mediators [2]. These answers are reputed to cause hyperglycemia because of increased gluconeogenesis, glycogenolysis, and insulin resistance. Similarly, serum electrolytes, particularly sodium (Na^+), potassium (K^+), and chloride (Cl^-), undergo dynamic alterations in response to changes in fluid balance, renal function, and neurohormonal modulation. As disturbances in electrolytes may result in arrhythmias, delayed recovery, and metabolic instability, their monitoring during anaesthesia becomes highly critical [3].

The nature of anaesthesia is a key factor in determining the extent of these biochemical alterations. General anaesthesia is linked with systemic cardiovascular and respiratory effects, increased release of stress hormones, and increased risk of postoperative metabolic disturbances [4]. In contrast, regional anaesthesia, such as spinal and epidural blocks, offers segmental nerve blockade that minimizes surgical stress response through interruption of afferent nociceptive transmission. This results in less cortisol release, improved glycemic control, and more regulated electrolyte shifts compared to general anesthesia [5]. A knowledge of these differences is essential to maximize anaesthetic selection, particularly in comorbid patients such as those with diabetes, hypertension, and renal impairment, in whom metabolic swings can have significant clinical ramifications [6].

In blood glucose and serum electrolytes during intraoperative procedures; however, comparative evidence for general anesthesia versus regional anesthesia is inconsistent and underresearched. Regional anaesthesia has been reported to be more effective in achieving homeostasis in some series, while others have described minimal differences [7]. With increasing interest in tailored patient treatment and ERAS protocols, it is essential to investigate these biochemical alterations systematically. A comparative strategy not only enhances our understanding of anaesthetic physiology but also enables clinicians to predict, prevent, and correct perioperative metabolic disturbances [8].

The current study aims to compare the biochemical alterations in blood glucose and serum electrolytes (Na^+, K^+, Cl^-) during surgery under general and regional anesthesia, with the intention of evaluating the degree of metabolic alterations caused by each modality and determining which anesthetic method provides more stable perioperative conditions.

Methodology

Study Design: This will be a comparative, prospective, observational study aimed at assessing biochemical alterations in blood glucose and serum electrolytes (Na^+, K^+, Cl^-) under general and regional anesthesia.

Study Setting: The study will be done in the Department of Anaesthesiology of a tertiary care hospital with modern surgical, diagnostic, and laboratory facilities.

Study Population: The study population will comprise adult patients undergoing elective surgical procedures under either general anesthesia or regional anesthesia.

Study Duration: The study will last for 1 year.

Sample Size: 214 patients will be recruited and divided equally into two groups: Group A (general anaesthesia) and Group B (regional anaesthesia).

Inclusion Criteria:

- 18–60 years old patients.
- ASA physical status I and II.
- Patients undergoing elective surgical procedures that last longer than 45 minutes.
- Patients who are willing to give informed consent.

Exclusionary Criteria:

- Patients with pre-existing diabetes mellitus, electrolyte imbalance, renal, hepatic, or endocrine conditions.
- Patients on drugs that influence glucose or electrolyte metabolism.
- Emergency procedures and patients with ASA status III or worse.

Sampling Technique: The Purposive sampling technique will be employed to enroll eligible patients.

Data Collection: Venous blood will be drawn at three intervals: baseline (preoperative), intraoperative (60 minutes after surgery), and postoperative (after surgery). Parameters to be measured are blood glucose, sodium, potassium, and chloride levels.

Study Procedure: Patients will be randomly assigned to receive either general anaesthesia or regional anaesthesia, based on their surgical needs. Anaesthetic methods will be according to standard procedures. Biochemical measurements will be done on automated analyzers in the hospital laboratory.

Statistical Analysis: Data will be input into SPSS software. Continuous variables will be reported as mean ± SD and compared using Student's t-test or ANOVA, whereas categorical variables will be compared using the Chi-square test. A p-value of <0.05 will be regarded as statistically significant.

Results

Table 1 illustrates that the demographic parameters of both groups were similar, with no statistically significant disparity in age, gender distribution, weight, ASA grade, or length of surgery ($p > 0.05$). This shows that the two groups were well matched at baseline. Therefore, any biochemical differences observed can be attributed to the nature of anesthesia, rather than to demographic factors.

Table 1: Demographic Characteristics of Study Participants (n=214)

Parameter	General Anaesthesia (n=107)	Regional Anaesthesia (n=107)	p-value
Age (years, Mean ± SD)	42.3 ± 10.8	41.7 ± 11.2	0.64
Gender (Male/Female)	58/49	55/52	0.72
Weight (kg, Mean ± SD)	65.2 ± 9.1	64.6 ± 8.8	0.58
ASA Grade I / II	62/45	64/43	0.81
Duration of Surgery (min)	96.4 ± 18.2	94.8 ± 17.9	0.47

Figure 1 illustrates that intraoperative blood glucose levels increased in both groups, but more significantly under general anesthesia compared to regional anesthesia. Both groups then had higher glucose levels postoperatively; however, patients who received regional anesthesia had improved glycemic control. This suggests that general anaesthesia is a greater stressor, causing more hyperglycemia. Regional anaesthesia is overall linked with superior perioperative glucose management.

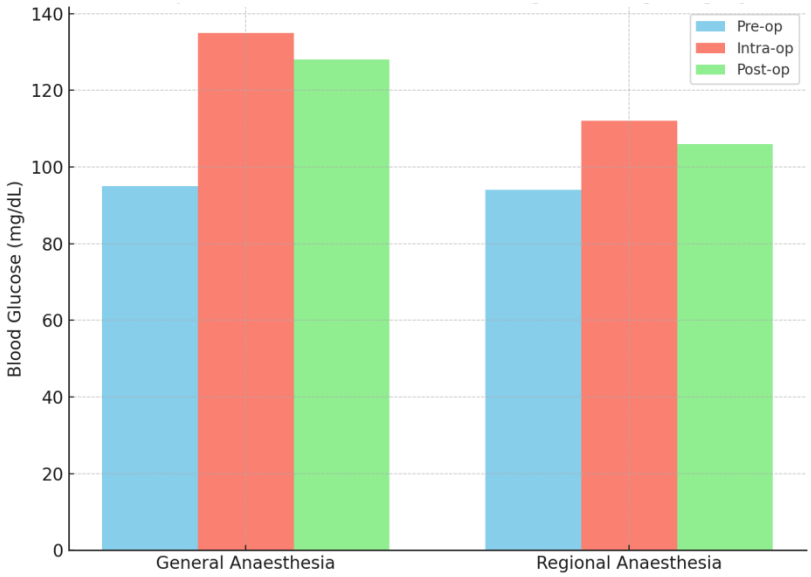

Figure 1: Comparison of Blood Glucose Changes During Surgery

Table 2 indicates that the baseline blood glucose levels were similar between the two groups ($p > 0.05$). Patients under general anaesthesia exhibited a significantly higher increase in blood glucose during surgery than those under regional anaesthesia ($p < 0.001$). Postoperatively, glucose levels remained high in both groups, but were more effectively controlled with regional anesthesia.

Table 2: Blood Glucose Levels During Surgery (mg/dl)

Time Interval	General Anaesthesia (Mean ± SD)	Regional Anaesthesia (Mean ± SD)	p-value
Preoperative (Baseline)	92.4 ± 8.7	91.6 ± 9.1	0.48
Intraoperative (60 min)	118.6 ± 11.3	102.4 ± 10.6	<0.001
Postoperative (End of Surgery)	110.8 ± 10.2	97.9 ± 9.4	<0.001

Figure 2 illustrates that serum electrolyte changes were more significant in the general anaesthesia group, with greater decreases in sodium and potassium levels than in the regional anaesthesia group. Regional anaesthesia maintained the levels of electrolytes closer to baseline, particularly for potassium and chloride. This implies that regional anaesthesia has a more stable perioperative electrolyte status.

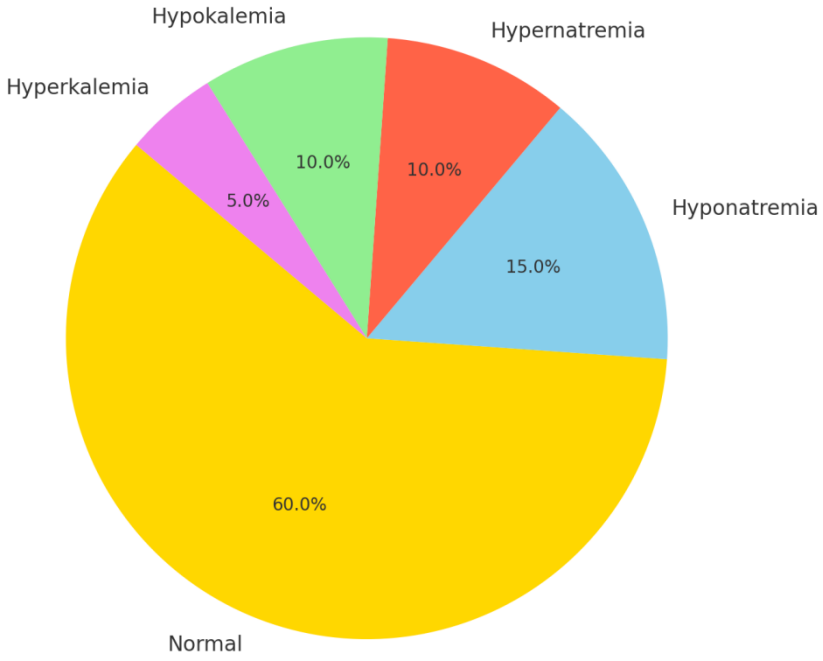

Figure 2: Distribution of Serum Electrolyte Changes

Table 3 reveals that patients receiving general anaesthesia during intraoperative procedures had a marked decrease in serum sodium, potassium, and chloride levels compared to those receiving regional anaesthesia. The differences were most remarkable intraoperatively and continued postoperatively, reflecting increased electrolyte shifts with general anaesthesia. The changes reflect the imperative of close monitoring and management of electrolytes intra- and postoperatively, particularly under general anaesthesia.

Table 3: Serum Electrolyte Changes During Surgery

Parameter	Time Point	General Anaesthesia (Mean ± SD)	Regional Anaesthesia (Mean ± SD)	p-value
Sodium (Na^+, mmol/L)	Preoperative	138.7 ± 3.1	138.9 ± 3.0	0.72
	Intraoperative	136.4 ± 3.2	138.1 ± 2.9	0.01
	Postoperative	137.1 ± 3.0	138.3 ± 2.8	0.04
Potassium (K^+, mmol/L)	Preoperative	4.12 ± 0.41	4.10 ± 0.39	0.83
	Intraoperative	3.88 ± 0.38	4.05 ± 0.37	0.01
	Postoperative	3.92 ± 0.35	4.08 ± 0.36	0.02
Chloride (Cl^-, mmol/L)	Preoperative	103.5 ± 2.8	103.7 ± 2.7	0.67
	Intraoperative	101.2 ± 2.9	103.1 ± 2.6	<0.01
	Postoperative	101.8 ± 2.7	103.3 ± 2.5	<0.01

Discussion

The current study provides valuable insights into the biochemical alterations that occur during surgery under general and regional anesthesia, particularly concerning blood glucose and serum electrolytes. The findings indicate that general anaesthesia is associated with more significant fluctuations in blood glucose and serum electrolytes compared to regional anaesthesia. These results align with previous studies highlighting the differential impacts of anaesthetic techniques on metabolic and electrolyte homeostasis [9,10].

The study observed a significant intraoperative rise in blood glucose levels under general anesthesia, with levels reaching 118.6 ± 11.3 mg/dL, compared to 102.4 ± 10.6 mg/dL under regional anesthesia. Postoperatively, blood glucose levels remained elevated in both groups; however, regional anesthesia appeared to offer better glycemic control. These findings corroborate previous researches indicating that general anaesthesia induces a more

pronounced stress response, leading to increased secretion of stress hormones such as cortisol and catecholamines, which in turn elevate blood glucose levels [11,12]. In contrast, regional anaesthesia, by attenuating the surgical stress response, results in a more stable glycemic profile. This is particularly pertinent in diabetic patients, where perioperative hyperglycemia can exacerbate complications.

Regarding serum electrolytes, the study found significant intraoperative reductions in sodium, potassium, and chloride levels under general anaesthesia, with levels of 136.4 ± 3.2 mmol/L for sodium, 3.88 ± 0.38 mmol/L for potassium, and 101.2 ± 2.9 mmol/L for chloride. In comparison, regional anaesthesia maintained electrolyte levels closer to baseline values. These observations are consistent with previous studies suggesting that general anesthesia can lead to electrolyte imbalances due to factors such as fluid shifts, hormonal influences, and the effects of medications [13,14]. The more stable electrolyte levels observed under regional anaesthesia may be attributed to the reduced physiological perturbations associated with this anaesthetic technique. This stability is crucial, as electrolyte disturbances can lead to complications such as arrhythmias and delayed.

The differential impacts of general and regional anaesthesia on blood glucose and serum electrolyte levels underscore the importance of anaesthetic choice in perioperative management. In patients with comorbid conditions like diabetes and hypertension, regional anaesthesia may offer advantages in maintaining metabolic and electrolyte homeostasis. However, individual patient factors and surgical requirements must be considered when selecting the appropriate anaesthetic technique. This study reinforces the notion that regional anaesthesia is associated with more stable blood glucose and serum electrolyte levels compared to general anaesthesia. These findings contribute to the growing body of evidence supporting the tailored approach to anaesthesia, aiming to optimize perioperative outcomes through informed anaesthetic choices.

Conclusion

The research concludes that general anaesthesia causes more significant intraoperative and postoperative rises in blood glucose and larger variations in serum electrolytes (sodium, potassium, chloride) than regional anaesthesia. Regional anaesthesia has a more stable metabolic and electrolyte balance, most probably through reduction of the surgical stress response and blunted neurohormonal activation. These results underscore the significance of anaesthetic selection, especially in patients with comorbid conditions like diabetes, hypertension, or renal failure, where stability of metabolism and electrolytes is paramount. Precise glucose and electrolyte monitoring and management remain necessary to provide optimal perioperative care and recovery.

Limitations

Limitations of the study included its single-center design and short follow-up period, which may have implications for the generalizability of the findings. Exclusion of comorbid patients limits applicability to high-risk patients. Secondly, differences in surgical practices and intraoperative fluid therapy may have modified biochemical alterations and could have acted as confounders to any difference in the anaesthetic technique observed.

Recommendations

Future research should incorporate multicenter trials using larger, more representative populations, including those with diabetes and renal disease. Standardization of the surgical technique and perioperative fluid regimen is advised. Intraoperative glucose and electrolyte monitoring can enhance patient safety, and personalized anesthetic management should be tailored to minimize metabolic disturbances.

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