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Association Between Perioperative Glycemic Control and Surgical Site Infection in Patients Undergoing Elective Abdominal Surgery

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Abstract

Background: The occurrence of surgical site infection (SSI) remains a significant cause of postoperative morbidity in patients undergoing elective abdominal surgery, with perioperative glycemic control identified as a potentially modifiable risk factor influencing outcomes.

Objectives: To determine the association between perioperative glycemic control and SSI in patients undergoing elective abdominal surgery.

Study design and setting: This was a prospective comparative study conducted in the Department of General Surgery of a tertiary care hospital from January 2026 to June 2026.

Methodology: A total of 150 patients aged 18-65 years undergoing elective abdominal surgery were included through consecutive sampling. Patients with pre-existing infections, immunocompromised status, or emergency surgeries were excluded. Perioperative blood glucose levels were monitored, and patients were categorized into controlled (⩽180 mg/dL) and uncontrolled (>180 mg/dL) groups. Patients were followed for 30 days postoperatively for the development of SSI. Data were analyzed using SPSS version 26 (IBM Corp., Armonk, NY), and the chi-square test was applied with $p \leqslant 0.05$ considered significant.

Results: The mean age was 42.6 ± 11.2 years and mean BMI was 27.4 ± 4.3 kg/m². Controlled glycemia was observed in 61.3% of patients, while 38.7% had uncontrolled glycemia. Overall SSI frequency was 18.7%. SSI occurred in 10.9% of patients with controlled glycemia compared to 31.0% in the uncontrolled group ($\chi^2 = 8.72$, $p = 0.003$). Stratification showed a significant association of SSI with age ($p = 0.047$) and diabetic status ($p = 0.021$), while gender and BMI were not significantly associated.

Conclusion: Poor perioperative glycemic control was significantly associated with an increased risk of SSI, highlighting the importance of optimal glucose management in improving surgical outcomes.

Categories: General Surgery, Public Health, Internal Medicine
Keywords: glycated hemoglobin (hba1c), glycemic control, major abdominal surgery, poor glycemic control, surgical site infection (ssi)

Introduction

Surgical site infection (SSI) is defined as an infection occurring at or near a surgical incision within 30 days of an operative procedure, or within one year if an implant is placed, and remains one of the most common postoperative complications [1]. Among patients undergoing elective abdominal surgery, perioperative glycemic control has emerged as a critical determinant of outcomes, as both diabetic and non-diabetic individuals may experience stress-induced hyperglycemia during the perioperative period [2]. This transient or sustained elevation in blood glucose levels has been increasingly recognized as a modifiable risk factor influencing wound healing and susceptibility to infection [3].

Globally, SSIs account for a significant proportion of healthcare-associated infections, contributing to prolonged hospital stays, increased healthcare costs, and higher morbidity and mortality [4]. The incidence of SSI varies widely depending on the type of surgery, patient population, and healthcare setting, ranging from 2% to 20% in abdominal procedures [5]. In low- and middle-income countries, including regions such as South Asia, the burden is comparatively higher due to resource limitations, variability in infection control practices, and a rising prevalence of diabetes mellitus. The growing global epidemic of diabetes further

amplifies the relevance of perioperative glycemic control in surgical populations [6].

The etiology of SSIs is multifactorial, involving microbial contamination, host immune status, and procedural factors. Hyperglycemia is a well-established risk factor, impairing host defense mechanisms and promoting bacterial proliferation. Other contributing factors include obesity, advanced age, malnutrition, prolonged operative time, and poor surgical technique [7]. Both pre-existing diabetes and perioperative stress-induced hyperglycemia independently increase the risk of postoperative infections, underscoring the importance of glycemic monitoring even in non-diabetic patients. A blood glucose threshold of 180 mg/dL is commonly used in inpatient and perioperative glucose-management guidance to identify hyperglycemia warranting clinical attention [8].

The pathophysiological basis linking hyperglycemia to infection involves multiple mechanisms, including impaired neutrophil function, reduced chemotaxis, and diminished phagocytic activity. Elevated glucose levels also impair collagen synthesis and angiogenesis, leading to delayed wound healing. Chronic glycemic status, commonly assessed using glycated hemoglobin (HbA1c), reflects long-term glucose control, whereas perioperative hyperglycemia represents elevated blood glucose levels around the time of surgery. These exposures are related but distinct, as acute hyperglycemia may occur in patients with or without previously diagnosed diabetes due to the physiological stress response to surgery [9].

Clinically, SSIs may present with localized signs such as erythema, swelling, warmth, pain, and purulent discharge, or with systemic manifestations including fever and leukocytosis [10]. Complications can range from superficial wound infections to deep incisional or organ-space infections, potentially resulting in wound dehiscence, sepsis, or even death if not promptly managed [11].

Evaluating this relationship in patients undergoing elective abdominal surgery may provide additional context-specific evidence from our clinical setting. Therefore, the present study assessed the association between perioperative glycemic control and SSI in patients undergoing elective abdominal surgery, with the hypothesis that SSI would be more frequent among patients with uncontrolled perioperative glycemia.

Materials And Methods

This prospective comparative study was conducted in the Department of General Surgery of a tertiary care hospital from January 2026 to June 2026. A total of 150 patients undergoing elective abdominal surgery were included using a non-probability consecutive sampling technique. Adult patients of either gender, aged between 18 and 65 years, who were scheduled for elective abdominal procedures were enrolled. Patients with pre-existing infections, immunocompromised states, chronic steroid use, malignancy, or those undergoing emergency surgeries were excluded from the study.

The sample size of 150 patients was calculated using the WHO sample size calculator (www.openepi.com), taking an anticipated frequency of SSIs of 12%, a confidence level of 95%, and a margin of error of 5%. The calculated sample size was 163; however, due to feasibility and resource constraints, a sample of 150 patients was included [12]. The final enrollment was below the calculated target, which may have reduced the precision of the estimates and the statistical power to detect differences between groups.

All patients were assessed preoperatively, and baseline demographic data including age, gender, body mass index, and diabetic status were recorded. Perioperative blood glucose levels were recorded during the preoperative, intraoperative, and postoperative periods. For each patient, the highest recorded glucose measurement across these periods was used to classify perioperative glycemic status. Patients whose highest recorded glucose level was ⩽180 mg/dL were classified as having controlled glycemia, whereas patients with a highest recorded glucose level >180 mg/dL were classified as having uncontrolled glycemia. This classification was used to assess the association between perioperative glycemic status and SSIs during the 30-day postoperative follow-up period.

Standard surgical protocols were followed for all patients, including appropriate skin preparation, antibiotic prophylaxis, and sterile operative techniques. Postoperatively, patients were monitored daily for signs of SSI, including redness, swelling, discharge, pain, and fever, for up to 30 days. SSI was diagnosed based on clinical criteria consistent with standard guidelines.

Data were analyzed using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY). Quantitative variables, including age and body mass index (BMI), were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The association between perioperative glycemic control and SSI was assessed using the Pearson chi-square test. SSI frequencies were also compared across the recorded age groups, gender, BMI categories, and diabetic status. Statistical significance was defined as a two-sided p-value of less than 0.05. As the analysis was based on unadjusted comparisons, the findings were interpreted as associations rather than evidence of an independent effect of perioperative glycemic control.

Results

The baseline demographic and clinical characteristics showed that the majority of patients were in the age

group of 18-40 years (n=62; 41.3%), followed by 41-55 years (n=54; 36.0%) and 56-65 years (n=34; 22.7%). The mean age of the study population was 42.6 ± 11.2 years. There was a male predominance with 88 (58.7%) men and 62 (41.3%) women. Regarding BMI distribution, most patients had a BMI between 25-30 kg/m² (n=64; 42.7%), followed by <25 kg/m² (n=48; 32.0%) and >30 kg/m² (n= 38; 25.3%), with a mean BMI of 27.4 ± 4.3 kg/m². In terms of diabetic status, 57 (38.0%) patients were diabetic while 93 (62.0%) were non-diabetic (Table *1*).

Variable	Category	n (%)
Age (years)	Mean±SD	42.6 ± 11.2
	18–40	62 (41.3%)
	41–55	54 (36.0%)
	56–65	34 (22.7%)
Gender	Male	88 (58.7%)
	Female	62 (41.3%)
BMI (kg/m²)	Mean±SD	27.4 ± 4.3
	<25	48 (32.0%)
	25–30	64 (42.7%)
	>30	38 (25.3%)
Diabetic Status	Diabetic	57 (38.0%)
	Non-diabetic	93 (62.0%)

TABLE 1: Baseline demographic and clinical characteristics of patients (n = 150)

The distribution of patients according to perioperative glycemic control revealed that the majority of patients had controlled blood glucose levels (n=92; 61.3%), whereas 58 (38.7%) patients had uncontrolled glycemic levels during the perioperative period. The overall frequency of SSI in the study population was 28 (18.7%), while the remaining 122 (81.3%) patients did not develop any infection following surgery, as shown in Table *2*.

Glycemic Control	n (%)
Controlled (≤180 mg/dL)	92 (61.3%)
Uncontrolled (>180 mg/dL)	58 (38.7%)
SSI	
Yes	28 (18.7%)
No	122 (81.3%)

TABLE 2: Distribution of patients according to perioperative glycemic control (n = 150)

SSI = surgical site infection

In contrast, among patients with uncontrolled glycemia, 18 (31.0%) developed SSI, and 40 (69.0%) did not. This difference was statistically significant with a chi-square value of 8.72 and a p-value of 0.003, indicating a strong association between poor glycemic control and increased risk of SSI, as shown in Table *3*. The association between perioperative glycemic control and SSI demonstrated that among patients with controlled glycemia, only 10 (10.9%) developed SSI, whereas 82 (89.1%) did not.

Glycemic Control	SSI Present; n (%)	SSI Absent; n (%)	Total; n (%)	χ^2	p-value
Controlled (≤180 mg/dL)	10 (10.9%)	82 (89.1%)	92 (100%)	8.72	0.003
Uncontrolled (>180 mg/dL)	18 (31.0%)	40 (69.0%)	58 (100%)		
Total	28 (18.7%)	122 (81.3%)	150 (100%)		

TABLE 3: Association between perioperative glycemic control and SSI (n = 150)

χ^2 = chi-square test; SSI = surgical site infection

Stratification analysis showed that SSI frequency increased with advancing age, with 12.9% in 18-40 years, 18.5% in 41-55 years, and 29.4% in 56-65 years, showing a statistically significant association ($\chi^2 = 6.11$, p = 0.047). In terms of gender, SSI was observed in 20.5% of males and 16.1% of females, but this difference was not statistically significant ($\chi^2 = 0.48$, p = 0.489). Regarding BMI, SSI was present in 12.5% of patients with BMI <25 kg/m², 18.8% in BMI 25-30 kg/m², and 26.3% in BMI >30 kg/m², though the association was not statistically significant ($\chi^2 = 3.92$, p = 0.141). Among diabetic patients, 28.1% developed SSI compared to 12.9% in non-diabetic patients, which was statistically significant ($\chi^2 = 5.32$, p = 0.021) (Table *4*).

Variable	Category	SSI Present; n (%)	SSI Absent; n (%)	Total; n (%)	χ^2	p-value
Age (years)	18–40	8 (12.9%)	54 (87.1%)	62 (100%)	6.11	0.047
	41–55	10 (18.5%)	44 (81.5%)	54 (100%)		
	56–65	10 (29.4%)	24 (70.6%)	34 (100%)		
Gender	Male	18 (20.5%)	70 (79.5%)	88 (100%)	0.48	0.489
	Female	10 (16.1%)	52 (83.9%)	62 (100%)		
BMI (kg/m²)	<25	6 (12.5%)	42 (87.5%)	48 (100%)	3.92	0.141
	25–30	12 (18.8%)	52 (81.2%)	64 (100%)		
	>30	10 (26.3%)	28 (73.7%)	38 (100%)		
Diabetic status	Diabetic	16 (28.1%)	41 (71.9%)	57 (100%)	5.32	0.021
	Non-diabetic	12 (12.9%)	81 (87.1%)	93 (100%)		
Total		28 (18.7%)	122 (81.3%)	150 (100%)		

TABLE 4: Stratification of SSI with respect to age, gender, BMI, and diabetic status (n = 150)

χ^2 = chi-square test; SSI = surgical site infection

Among the 150 patients, 28 (18.7%) developed SSIs. The incidence was higher in patients with uncontrolled glycemia than in those with controlled glycemia (31.0% vs. 10.9%). Uncontrolled glycemia was associated with a 2.86-fold higher risk of SSI (RR 2.86, 95% CI 1.42-5.75) and 3.69-fold higher odds (OR 3.69, 95% CI 1.56-8.72). The absolute risk difference was 20.2 percentage points (95% CI 6.7-33.7), with a statistically significant association ($\chi^2 = 9.53$, df=1, p = 0.002) (Table *5*).

Statistical measure	Result (95% CI where applicable)
Overall SSI frequency	28/150 (18.7%)
SSI in controlled glycemia group	10/92 (10.9%)
SSI in uncontrolled glycemia group	18/58 (31.0%)
Relative risk (RR)	2.86 (1.42–5.75)
Odds ratio (OR)	3.69 (1.56–8.72)
Absolute risk difference	20.2 percentage points (6.7–33.7)
Pearson chi-square (χ^2)	9.53
Degrees of freedom (df)	1
p-value	0.002

TABLE 5: Effect estimates for the association between perioperative glycemic control and SSI (n = 150)

SSI = surgical site infection; RR = relative risk; OR = odds ratio; CI = confidence interval. Effect estimates were unadjusted.

Discussion

SSI is a common postoperative complication that significantly contributes to patient morbidity and prolonged hospital stay. Perioperative hyperglycemia, observed in both diabetic and non-diabetic patients, has been identified as an important modifiable risk factor. Poor glycemic control impairs immune function and delays wound healing, increasing susceptibility to infection. Elective abdominal surgeries carry a relatively higher risk of SSI due to exposure of the gastrointestinal tract and potential contamination. The rising prevalence of diabetes further amplifies the clinical importance of maintaining optimal glucose levels [12]. Therefore, perioperative glycemic management plays a crucial role in improving surgical outcomes and reducing infection rates.

In the present study, SSI occurred in 31.0% of patients classified as having uncontrolled perioperative glycemia, compared with 10.9% of patients in the controlled glycemia group. This difference suggests an association between elevated perioperative glucose levels and SSI in the study population. However, these findings should be interpreted cautiously because the analysis was unadjusted. The observed difference may reflect the contribution of hyperglycemia itself, underlying diabetes, other patient-related characteristics, surgical factors, or a combination of these influences. Consequently, the present findings do not establish that perioperative glycemic control independently reduces SSI risk. Although the absolute SSI rates in our study were higher, possibly due to differences in population characteristics and surgical settings, the overall trend strongly aligns, reinforcing the role of hyperglycemia in increasing postoperative infection risk [13].

Similarly, the findings of the present study are supported by Lai et al. (2022), who, in a large meta-analysis of 29 randomized controlled trials involving 14,126 patients, reported that intensive perioperative glycemic control significantly reduced SSI incidence (RR = 0.63, 95% CI: 0.50-0.80, p = 0.0002). This corresponds well with our results, where controlled glycemia was associated with substantially lower SSI rates (10.9%), highlighting the protective effect of maintaining blood glucose within target ranges [14]. Furthermore, de Vries et al. (2017) concluded that perioperative hyperglycemia is clearly associated with increased SSI risk, which is directly reflected in our statistically significant findings [15].

Wang et al. (2018) also reported that tight glycemic control reduces postoperative infections and mortality, although it may increase the risk of hypoglycemia. While our study did not assess hypoglycemic events, the significant reduction in SSI in the controlled group supports the beneficial impact of optimized glycemic management, emphasizing the need for balanced control strategies [16].

Local and regional studies further strengthen our findings. Kabir et al. (2025) reported significantly higher SSI rates in diabetic patients (20.0%) compared to non-diabetics (7.3%, p = 0.002), which parallels our stratified results where SSI was more frequent among diabetic patients (28.1% vs 12.9%, p = 0.021) [17]. Similarly, Raja et al. (2024) reported a difference in SSI rates between patients with and without diabetes, highlighting the potential contribution of diabetic status to postoperative infection risk [18]. Although their comparison differed from the glycemic control groups evaluated in our study, their findings support the relevance of underlying diabetic status when interpreting the relationship between perioperative hyperglycemia and SSI [18].

Shahzadi et al. (2025) reported an overall SSI incidence of 14.1% and identified diabetes as an independent predictor (AOR = 2.89, p = 0.009). Although their overall SSI rate was slightly lower than ours (18.7%), the direction of association remains consistent [19]. Likewise, Maqsood et al. (2022) demonstrated that elevated HbA1c levels significantly increased SSI risk, emphasizing the importance of preoperative glycemic optimization, which complements our findings based on perioperative glucose levels [20].

Additional supporting evidence is observed in studies reporting markedly higher SSI rates among diabetics compared to non-diabetics, such as 50.0% versus 16.7% (p = 0.006), and 42.9% versus 17.1% (p < 0.05). These figures are comparable to our results and further highlight the strong association between poor glycemic control and infection risk [21,22]. Uncontrolled perioperative glycemia was associated with a higher incidence of SSI in patients undergoing elective abdominal surgery. However, because the analysis was observational and did not include multivariable adjustment, the potential influence of diabetes status and other patient- and procedure-related confounding factors cannot be excluded. Therefore, the findings should be interpreted as an association rather than evidence of a causal or independent effect of perioperative glycemic control on SSI risk.

Future perioperative glycemic management may benefit from individualized targets and patient phenotyping, particularly by distinguishing patients with established diabetes, previously unrecognized chronic dysglycemia, and stress hyperglycemia associated with surgical illness. These groups may differ in baseline metabolic status, insulin resistance, susceptibility to hypoglycemia, and postoperative infection risk. Future studies should also prioritize patients according to surgical complexity and anticipated physiological stress, while accounting for procedure type and wound contamination risk. The optimal glucose target should balance the potential risks of hyperglycemia against hypoglycemia rather than applying an unnecessarily intensive target to every patient. Continuous glucose monitoring (CGM) may provide additional information about glucose variability and the duration of hyperglycemia that cannot be captured by isolated measurements. The American Diabetes Association (ADA) Standards of Care in Diabetes-2026 recommend a preoperative HbA1c goal below 8% when appropriate and recognize a 14-day glucose management indicator below 8% and/or time in range above 50% as alternative indicators of preoperative glycemic management. The recommended perioperative blood glucose range is generally 100-180 mg/dL, with individualization according to clinical circumstances. However, CGM should not be used as the sole method for intraoperative glucose monitoring, and prospective studies are needed to determine whether CGM-guided interventions improve SSI outcomes. These recommendations provide a framework for future research but cannot be directly evaluated using the present study data [23].

Insulin may have effects beyond lowering circulating glucose. Experimental and mechanistic studies suggest that insulin can influence leukocyte activity, including neutrophil migration, phagocytosis, and bactericidal function, while modulating inflammatory signaling in monocytes and macrophages. Experimental evidence has also suggested restoration of neutrophil function and reduced infection severity following insulin treatment in diabetic animal models. Nevertheless, these findings should not be interpreted as proof that insulin independently prevents SSI in humans, and the relative contributions of glucose lowering and direct immunomodulatory effects remain incompletely established [24].

Further research should investigate whether individualized glycemic management and non-insulin therapies can improve postoperative outcomes beyond standard glucose management. Sodium-glucose cotransporter 2 (SGLT2) inhibitors and glucagon-like peptide-1 (GLP-1) receptor agonists have important metabolic effects, but their perioperative use requires particular attention to safety. SGLT2 inhibitors are generally withheld before elective surgery because of the risk of perioperative ketoacidosis, including euglycemic ketoacidosis, while GLP-1 receptor agonists require individualized assessment because of gastrointestinal effects and delayed gastric emptying. Large, adequately powered randomized controlled trials are therefore needed to evaluate the safety and effectiveness of these therapies in appropriate perioperative settings, including their effects on infection outcomes, while accounting for medication-specific risks. Such trials should use standardized SSI definitions, clearly specified glucose-monitoring protocols, and prespecified analyses of diabetes status, stress hyperglycemia, and surgical complexity [25].

Future perioperative management should emphasize personalized glycemic targets based on patient phenotyping, distinguishing established diabetes, chronic dysglycemia, and stress-induced hyperglycemia, while prioritizing patients according to surgical complexity and infection risk. Continuous glucose monitoring may provide additional information about glycemic variability, with the ADA recommending 14-day preoperative CGM metrics, including time-in-range (TIR) above 50% and/or glucose management indicator below 8%, as alternatives to HbA1c assessment in appropriate patients [26]. Insulin may also exert immunomodulatory effects by supporting leukocyte migration, neutrophil function, and phagocytosis at wound sites, potentially contributing to local host defense. Furthermore, SGLT2 inhibitors and GLP-1 receptor agonists have potential metabolic and anti-inflammatory effects that warrant further investigation. Large randomized controlled trials are needed to evaluate these therapies, individualized glucose targets, and CGM-guided interventions in reducing postoperative infections, while carefully considering medication-related perioperative risks [27].

Limitations

This study had several limitations. The final sample size was smaller than the calculated target, potentially limiting statistical power and precision. Data collection was restricted to the variables specified in the original proforma; therefore, important potential confounders, including procedure type, operative duration, wound contamination class, baseline HbA1c, nutritional status, and antibiotic practices, could not be comprehensively evaluated. The statistical analysis was unadjusted, and the independent association between perioperative glycemic control and SSI could not be established. In addition, the interpretation of glycemic classification and SSI occurrence was limited by the detail available in the original glucose-monitoring and follow-up records. The subgroup analyses examined the associations of age, BMI, sex, and diabetic status with SSI separately and did not evaluate the association between glycemic control and SSI within each subgroup.

Conclusions

Uncontrolled perioperative glycemia was associated with a higher frequency of SSI among patients undergoing elective abdominal surgery. These findings highlight the clinical relevance of perioperative glucose monitoring; however, the unadjusted analysis and observational study design preclude conclusions about causality or an independent effect of glycemic control. Further studies incorporating relevant procedural variables and adjusted analyses are warranted to clarify this association.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

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