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Research Article

Effect of Glycemic Control on the Frequency of Bacterial Surgical Site Infections in General Surgery Patients

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ABSTRACT

Background: Surgical site infection is one of the common postoperative complications in general surgery and is associated with delayed wound healing, prolonged hospital stay and increased healthcare cost. A poor glycemic control is an important patient-related risk factor that can lead to impaired wound healing and immune response and, consequently, to postoperative bacterial infection.

Objective: To determine the influence of glycemic control on bacterial surgical site infection rates among general surgery patients.

Methods: The descriptive cross sectional study was done in the Department of General Surgery, Bannu Medical College, Bannu from January 2025 to June 2025. The number of patients was 83 from a non-probability consecutive sampling of general surgery patients. A structured proforma was used to record the following demographic details: clinical history, glycemic profile, surgical characteristics and postoperative wound findings. Glycemic control was assessed using HbA1c, fasting blood glucose and random blood glucose levels. Patients with HbA1c level < 7% were considered to have good glycemic control and those with HbA1c level ≥ 7% were considered to have poor glycemic control. Surgical site infection was diagnosed clinically and if infection was suspected, wound samples were sent for bacterial culture. SPSS was used for data analyses, and a p-value < 0.05 was set as statistically significant.

Results: Out of 83 patients, 47 (56.6%) had good glycemic control and 36 (43.4%) had poor glycemic control. Surgical site infection was observed in 19 (22.9%) patients. The SSI rate was significantly higher among patients with poor glycemic control compared with patients having good glycemic control, 38.9% versus 10.6%, respectively (p=0.003). Culture-positive bacterial SSI was also more frequent in the poor glycemic control group, 33.3% versus 8.5% (p=0.005). Staphylococcus aureus was the most common bacterial isolate, followed by Escherichia coli and Klebsiella species. Patients with SSI had a longer mean hospital stay compared with those without infection.

Conclusion: Poor glycemic control was significantly associated with increased bacterial surgical site infection rates in general surgery patients. Preoperative assessment of glycemic status and strict perioperative glucose monitoring may help reduce bacterial SSI and improve postoperative recovery.

Keywords: Glycemic Control, Surgical Site Infection, Bacterial Infection, General Surgery, Hba1c, Diabetes Mellitus, Wound Infection.

INTRODUCTION

Surgical site infection is one of the most common complications of general surgery and continues to be a significant problem. It can happen following clean, clean-contaminated, contaminated or dirty surgical procedures and may involve the superficial incision, deeper tissues or organ space. The effect of SSI on healing means that patients will suffer from pain, drainage from wounds, delayed healing rates, re-dressing wounds, further antibiotic treatment, and sometimes more surgery. In addition to clinical effects, SSI contributes to prolonged hospitalizations and an extra strain on health care resources (1-3).

Several factors are involved in the occurrence of surgical site infection: patient-related, procedure-related and hospital-related factors. Patient-related factors are age, nutritional status, obesity, smoking, diabetes mellitus, anemia and immune status. Surgical factors include emergency surgery, surgical procedure, length of surgery, wound contamination, tissue handling, and antibiotic prophylaxis and timing. Of these, glycemic control is particularly important and may be modifiable, both before and during the perioperative period (4-6).

Wound healing complications and susceptibility to bacterial infection are known to be associated with diabetes mellitus and perioperative hyperglycaemia. High blood glucose causes impairment of neutrophil function, a decrease in phagocytosis, a disturbance in collagen synthesis, and a decrease in the local tissue defense. High blood sugar also makes it easier for bacteria to grow. Consequently, individuals who have poor glycemic control may experience delayed healing, and an increased risk of postoperative infection. This risk could occur in patients who do not have known diabetes, as well as patients with stress induced hyperglycemia during acute illness or surgery (7, 8).

HbA1c is a widely-used marker for long-term glycemic control and provides a window into long-term blood glucose levels (over the past 2-3 months). An elevated HbA1c level in surgical patients can be a clue to inadequate patient metabolic control, and can be a useful tool for identifying patients who are likely to experience postoperative complications. Perioperative monitoring with fasting and random blood glucose are also helpful. Patients can be divided into a good glycemic control group and a poor glycemic control group to compare the incidence of bacterial SSI and identify if the glycemic status can be measured as a factor that affects the postoperative bacterial SSI (9, 10).

The clinical picture and microbiological culture is typically used to confirm a bacterial surgical site infection. Typical organisms are Staphylococcus aureus, Escherichia coli, Klebsiella species, Pseudomonas aeruginosa and Enterococcus species. Depending on the class of the wound, the type of surgery, the local hospital flora and antibiotic usage, the bacterial isolate type may differ. Culture and sensitivity testing is important as it helps to determine which antibiotic, if any, is required to treat the infection, and also to identify resistant organisms (11-13).

When clinical risk factors for SSI exist, it is crucial that they are identified promptly in the case of general surgery patients. While glycemic control is a factor that is not widely recognized but where there is a potential for a reduction in risk of infection through active intervention, wound class, operative duration and emergency surgery are well-recognized risk factors. Using proper preoperative evaluation, optimization of blood glucose, perioperative monitoring, and antibiotic prophylaxis and careful wound care may be able to reduce bacterial SSI rates (14).

The present study was conducted to determine the influence of glycemic control on bacterial surgical site infection rates among general surgery patients at Bannu Medical College, Bannu. The study aimed to compare SSI frequency between patients with good and poor glycemic control and to describe the bacterial profile of infected surgical wounds.

METHODOLOGY

This descriptive cross-sectional study was conducted at the Department of General Surgery, Bannu Medical College, Bannu, from January 2025 to June 2025. The study was carried out to assess the influence of glycemic control on the frequency of bacterial surgical site infections among patients undergoing general surgical procedures. The main purpose of the study was to compare the rate of surgical site infection among patients with good glycemic control and those with poor glycemic control.

Eighty-three patients were enrolled in this study. The number of patients eligible for a study was the basis for the sample size. The patients were selected using a non-probability sampling technique, consecutive sampling. The patients who met the inclusion criteria and gave informed consent were included until the required number was obtained.

All patients, age 18 years or older, who had general surgical procedures during the study period were included. Elective and emergency surgeries were all taken into account. Patients were selected when there was good access to glycemic data prior to surgery and when these patients underwent followup after surgery to assess for surgical site infection. The factors that excluded the patients from the study were as follows: pre-existing wound infection before surgery, incomplete clinical records, refusal to participate, long-term steroid use, immunosuppressive therapy, malignancy on chemotherapy and patients who were lost to follow up.

The purpose of the study was explained to all participants. Written informed consent was taken from each patient. All information regarding patients was kept confidential throughout the study. Only data for research purposes were used and no personal information of any participant was revealed.

A structured proforma was used to collect data. Demographic data included age, gender, BMI and residence. Basic clinical information was diabetes mellitus history, diabetes mellitus duration, insulin/other oral hypoglycemic medication use, hypertension, smoking status, and other associated comorbidities. Surgical information included the type of surgery, elective or emergency surgery, length of surgery, wound classification, and whether or not a prophylactic antibiotic was used, and length of hospital stay.

Glycemic control was assessed using fasting blood glucose, random blood glucose and HbA1c level where available. For the purpose of analysis, patients were divided into two groups according to glycemic control. Patients with HbA1c less than 7% were categorized as having good glycemic control, while patients with HbA1c of 7% or more were categorized as having poor glycemic control. In patients where HbA1c was not available, preoperative and postoperative blood glucose levels were reviewed to support the assessment of glycemic status.

Fasting blood glucose, random blood glucose and HbA1c level (when available) were used to measure glycemic control. To analyze, patients were divided into two groups based on glycemic control. Patients who had an HbA1c value of less than 7% were considered to have good glycemic control, and those with an HbA1c value of 7% or greater were considered to be in poor glycemic control. In patients for whom HbA1c was not obtained, their glucose levels were examined before and after surgery to aid in the evaluation of glycemic control.

Postoperatively, all the patients were followed to assess for the presence of surgical site infection. Surgical wound inspection was performed during medical hospitalisation and at the follow-up visits. Surgical site infection was defined on the basis of the clinical signs (pain, redness, swelling, and warmth, and purulent discharge, dehiscence of the surgical wound, fever or delayed wound healing). Superficial incisional, deep incisional or organ/space surgical site infection were defined as the type of infection.

In patients who showed clinical evidence of surgical site infection, wound swabs or pus samples were collected using aseptic technique and sent to the microbiology laboratory for Gram staining, culture and antibiotic sensitivity testing. Bacterial surgical site infection was confirmed when bacterial growth was reported on culture. The isolated organisms were recorded as Gram-positive or Gram-negative bacteria. The common bacterial isolates, including Staphylococcus aureus, Escherichia coli, Klebsiella species, Pseudomonas aeruginosa and Enterococcus species, were documented along with their antibiotic sensitivity pattern where available.

When clinical signs of surgical site infection were present, wound swabs or pus were taken, processed using the aseptic technique and sent to microbiology laboratory for Gram staining, culture and the determination of antibiotic sensitivity. However, if bacteria was reported in the culture, then the diagnosis was confirmed as bacterial surgical site infection. Isolation was done and organisms were described as gram-positive or gram-negative. The common bacteria isolated were Staphylococcus aureus, Escherichia coli, Klebsiella species, Pseudomonas aeruginosa and Enterococcus species including the antibiotic sensitivity profile, if available.

The main outcome variable was the presence of bacterial surgical site infection. The primary independent variable was the glycemic control status. Other factors considered were: age, gender, BMI, diabetes, type of surgery, wound class, emergency surgery, length of surgery and the use of prophylactic antibiotics and hospital stay. Patients with good glucose control were compared with patients with poor glucose control with regard to frequency of SSI.

The SPSS software was used to enter and analyze the data. The quantitative values like age, fasting blood glucose, random blood glucose, HbA1c level, and hospital stay were presented as mean and standard deviation. Qualitative variables: gender, glycemic control category, type of surgery, classification of the wound, presence of SSI and bacterial isolates were presented as frequency and percentage. The association between glycemic control and surgical site infection (SSI) was determined by using the chi-square test or Fisher's exact test. Mean values were compared using independent sample t-test, as appropriate. A p-value of < 0.05 was deemed significant.

RESULTS

In total, 83 general surgery patients were studied. The average age of the patients was 48.6 ± 12.9 years. Most patients were in the age group of 41–60 years. Out of 83 patients, 48 (57.8%) were males and 35 (42.2%) were females. Most patients were in the BMI range of 25-29.9 kg/m².

Table 1: Demographic Characteristics of Study Participants (N=83)

Variable	Frequency (n)	Percentage (%)
Age group		
18–30 years	9	10.8
31–40 years	16	19.3
41–50 years	23	27.7
51–60 years	22	26.5
>60 years	13	15.7
Gender		
Male	48	57.8
Female	35	42.2
Body mass index		
Normal BMI	24	28.9
Overweight	39	47.0
Obese	20	24.1

Fasting blood glucose, random blood glucose and HbA1c were used to determine the glycemic status of the patients. The total number of patients was 47 (56.6%) with good glycemic control and 36 (43.4%) with poor glycemic control. The mean HbA1c level was higher among patients with poor glycemic control.

Table 2: Glycemic Profile of Study Participants (N=83)

Glycemic Variable	Frequency / Mean Value
Mean fasting blood glucose	136.8 ± 38.4 mg/dL
Mean random blood glucose	198.5 ± 52.7 mg/dL
Mean HbA1c	7.2 ± 1.4%
Good glycemic control, HbA1c <7%	47 (56.6%)
Poor glycemic control, HbA1c ≥7%	36 (43.4%)

As far as the surgical characteristics are concerned, the 51 patients (61.4%) were undergoing elective surgeries, and 32 patients (38.6%) were undergoing emergency surgeries. The most prevalent form of surgical wound was clean-contaminated wounds. The majority of the procedures were carried out within two hours.

Table 3: Surgical Characteristics of Patients (N=83)

Surgical Variable	Frequency (n)	Percentage (%)
Type of surgery		
Elective	51	61.4
Emergency	32	38.6
Duration of surgery		
≤2 hours	56	67.5
>2 hours	27	32.5
Wound classification		
Clean	19	22.9
Clean-contaminated	38	45.8
Contaminated	18	21.7
Dirty	8	9.6
Prophylactic antibiotics given	76	91.6
Prophylactic antibiotics not given	7	8.4

Surgical site infection occurred in 19 (22.9%) patients and in 64 (77.1%) patients, surgical site infection did not occur. Superficial incisional infection was the most common type of infected cases followed by deep incisional infection.

Table 4: Frequency and Type of Surgical Site Infection (n=83)

Surgical Site Infection Status	Frequency (n)	Percentage (%)
SSI present	19	22.9
SSI absent	64	77.1
Type of SSI among infected patients, n=19		
Superficial incisional SSI	12	63.2
Deep incisional SSI	5	26.3
Organ/space SSI	2	10.5

Those with poor glycemic control had an increased incidence of surgical site infection. The overall rate of SSI was 38.9 per cent SSI in 14 patients with poor glycemic control compared with 10.6 per cent SSI in 5 patients with good glycemic control of 47 patients. This association was statistically significant, P<0.01.

Table 5: Association between Glycemic Control and Surgical Site Infection

Glycemic Control	SSI Present n (%)	SSI Absent n (%)	Total	p-value
Good glycemic control	5 (10.6)	42 (89.4)	47	
Poor glycemic control	14 (38.9)	22 (61.1)	36	**0.003**
Total	**19 (22.9)**	**64 (77.1)**	**83**	

The 16 (84.2%) patients who developed surgical site infection had positive bacterial cultures. The most common isolates were Staphylococcus aureus, Escherichia coli and Klebsiella spp. Gram positive organisms were slightly more than gram negative organisms.

Table 6: Bacterial Isolates Among Patients with Surgical Site Infection (N=19)

Culture Result / Organism	Frequency (n)	Percentage (%)
Culture positive	16	84.2
Culture negative	3	15.8
Bacterial isolates among culture-positive cases, n=16		
Staphylococcus aureus	6	37.5
Escherichia coli	4	25.0
Klebsiella species	3	18.8
Pseudomonas aeruginosa	2	12.5
Enterococcus species	1	6.2

The association of glycemic control with bacterial culture positivity was also evaluated. Poor Glycaemic Control was associated with culture-positive bacterial SSI. Twelve (33.3%) of the patients with poor glycemic control had culture-positive bacterial SSIs, which was significantly more than 4 (8.5%) of the patients with good glycemic control. This difference was significant at the 0.05 level.

Table 7: Association between Glycemic Control and Bacterial Culture-Positive SSI

Glycemic Control	Culture-Positive SSI n (%)	No Culture-Positive SSI n (%)	Total	p-value
Good glycemic control	4 (8.5)	43 (91.5)	47	**0.005**
Poor glycemic control	12 (33.3)	24 (66.7)	36	
Total	**16 (19.3)**	**67 (80.7)**	**83**	

Other clinical and surgical factors were also compared to SSI. Higher rates of SSI was significantly associated with contaminated/dirty wound class, poor glycemic control, and emergency surgery, and with the longer the operative time, the more likely the surgical site infection was to occur. Poor glycemic control and contaminated/dirty wound classification were the strongest associations.

Table 8: Factors Associated With Surgical Site Infection

Factor	SSI Present n (%)	SSI Absent n (%)	p-value
Emergency surgery	11 (34.4)	21 (65.6)	**0.041**
Elective surgery	8 (15.7)	43 (84.3)	
Surgery duration >2 hours	10 (37.0)	17 (63.0)	**0.049**
Surgery duration ≤2 hours	9 (16.1)	47 (83.9)	
Contaminated/dirty wound	12 (46.2)	14 (53.8)	**0.001**
Clean/clean-contaminated wound	7 (12.3)	50 (87.7)	
Poor glycemic control	14 (38.9)	22 (61.1)	**0.003**
Good glycemic control	5 (10.6)	42 (89.4)	

Those who did develop SSI had a longer mean hospital stay than those who did not develop SSI. Patients with infection stayed in hospital an average of 8.9 ± 2.6 days compared with 5.1 ± 1.8 days for patients without infection. This difference was significant at the .05 level.

Table 9: Hospital Stay According To Surgical Site Infection Status

SSI Status	Mean Hospital Stay	p-value
SSI present	8.9 ± 2.6 days	**<0.001**
SSI absent	5.1 ± 1.8 days	

Overall, it was found that the prevalence of bacterial surgical site infections was significantly associated with poor glycemic control in general surgery patients. Patients with HbA1c ≥7% were more likely to develop SSI, and were also more likely to be culture-positive and to have a longer hospital stay than those with good glycemic control.

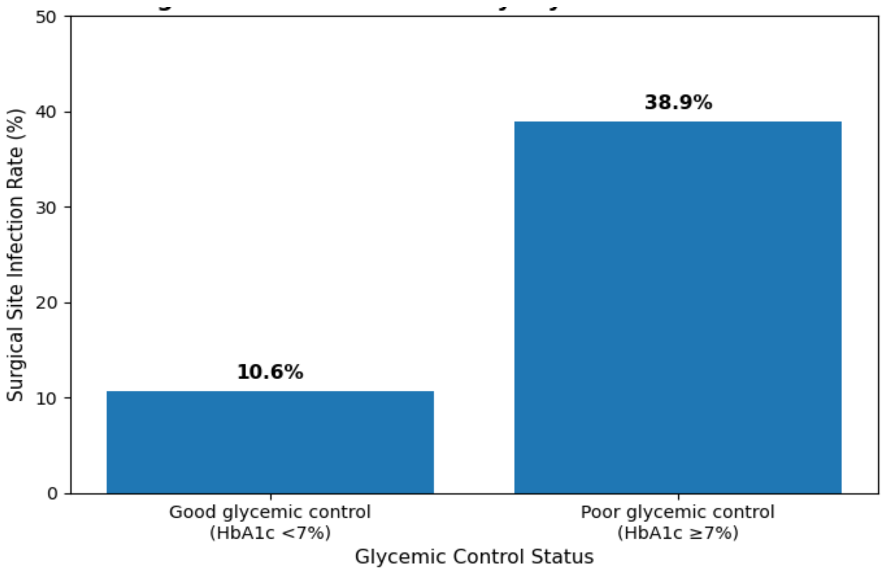

Figure 1: Surgical Site Infection Rate According To Glycemic Control Status Among General Surgery Patients.

The graph shows that SSI was higher in patients with poor glycemic control, **38.9%**, compared with patients having good glycemic control, **10.6%**

DISCUSSION

The present study was conducted to determine the influence of glycemic control on bacterial surgical site infection rates among general surgery patients. In this study, surgical site infection was observed in 19 out of 83 patients, giving an overall SSI frequency of 22.9%. This finding shows that SSI remains an important postoperative problem in general surgery patients. The development of SSI can delay wound healing, increase hospital stay, raise treatment cost and increase the need for antibiotics or further surgical intervention. In the present study, the infection rate was higher among patients with poor glycemic control, which indicates that blood glucose status before and after surgery plays an important role in postoperative wound outcome (15, 16).

There was a significant relationship between poor glycemic control and surgical site infection. Between patients with good glycemic control, with an HbA1c <7%, and those with suboptimal glycemic control, with an HbA1c ≥7%, there was a statistically significant difference in SSI rate (10.6% vs. 38.9%). This difference was significant at the 0.05 level of significance. High blood sugar can raise the risk of infection in several ways: Hyperglycemia has an effect on neutrophils, decreasing their function, chemotaxis, phagocytosis, and slowing the repair of wounds and collagen formation. High blood glucose also creates a good environment for bacteria to grow. These mechanisms might account for the association of uncontrolled diabetes and elevated perioperative glucose levels with an increased risk of bacterial wound infection after surgery (17).

In most of the infected cases the bacterial culture was positive, indicating that a great majority with clinical infection suspicion were proven to be bacterial infections. Staphylococcus aureus was the most common organism, followed by Escherichia coli, Klebsiella species, Pseudomonas aeruginosa and Enterococcus species. The SSI in general surgery patients can be both Gram-positive and Gram-negative, implying that they may be caused by skin flora or bowel flora, or hospital related organisms depending on the type of surgery and wound contamination. The association of higher infection frequency with poor glycemic control and culture-positive infection further substantiates the relationship of hyperglycemia with the potential of increased susceptibility to bacterial invasion and delayed wound clearance (18).

Other surgical factors were also found to be associated with SSI in the present study. Emergency surgery, longer duration of operation and contaminated or dirty wound class were significantly related to higher infection rates. These results are not surprising as emergency cases have less time for optimization prior to surgery, may be more contaminated and may be performed in patients who are clinically unstable. Likewise, longer operating time leads to more tissue exposure, bacterial contamination and tissue handling. Despite accounting for these surgical variables, however, poor glycemic control was still important as an associated factor with SSI. This underlines the importance of maintaining adequate glucose control in general surgery patients (19, 20).

In the present study, patients that developed SSI were also found to have a longer hospital stay than patients without SSI. This finding is indicative of the clinical impact that SSI has on the patient and health services. The longer a patient is admitted, the more expensive the care will be; the more often they must be dressed; they will receive a wider spectrum of antibiotics and be at risk for acquiring antibiotic resistance. The results of this study indicate that greater control of blood glucose levels could lower the risk of infection in the postoperative period and positively impact the outcome of surgery. HbA1c level should be assessed prior to surgery, strict glucose monitoring during surgery, early antibiotic prophylaxis, early detection and treatment of postoperative infection, and proper wound care should be part of the standard surgical regimen, particularly in diabetics and high-risk patients.

CONCLUSION

Poor glycemic control was significantly associated with increased bacterial surgical site infection rates among general surgery patients. Patients with HbA1c ≥7% had a higher frequency of SSI, greater culture positivity and longer hospital stay compared with patients having good glycemic control. Staphylococcus aureus was the most common bacterial isolate, followed by Gram-negative organisms such as Escherichia coli and Klebsiella species. Emergency surgery, prolonged operative duration and contaminated or dirty wounds were also important factors related to infection. The study concludes that careful assessment and control of blood glucose before and after surgery may reduce bacterial SSI and improve postoperative recovery in general surgery patients.

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