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Predictors of Surgical Site Infection in Clean Abdominal Surgeries: A Prospective Observational Study

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ABSTRACT

Background: Surgical site infections (SSIs) remain one of the most frequent postoperative complications, even in clean abdominal surgeries that traditionally carry a low infection risk. Identifying key predictors of SSI is essential for improving outcomes and reducing preventable morbidity in surgical patients.

Objective: To determine the incidence and independent predictors of surgical site infection in patients undergoing elective clean abdominal surgeries at Shaikh Zayed Medical Complex, Lahore.

Methods: A prospective observational study was conducted from January 2022 to March 2023, including 120 patients undergoing clean abdominal surgeries. Demographic variables, comorbidities, preoperative laboratory findings, operative characteristics, and postoperative outcomes were recorded. Patients were followed for 30 days, and SSIs were diagnosed based on CDC criteria. Statistical analysis included univariate testing and multivariate logistic regression to identify independent predictors of SSI.

Results: The incidence of SSI was 14.1% (17/120). Patients with SSI had significantly higher rates of obesity (BMI >30 kg/m²; p = 0.004), diabetes mellitus (p = 0.009), and preoperative hemoglobin <10 g/dL (p = 0.03). Operative duration >120 minutes was strongly associated with infection (p = 0.002). Multivariate analysis identified obesity (AOR 3.42), diabetes mellitus (AOR 2.89), and operative duration >120 minutes (AOR 4.15) as independent predictors of SSI. Age, gender, smoking, drain placement, and surgical approach showed no significant association.

Conclusion: Obesity, diabetes, and prolonged operative duration significantly increase the risk of SSI in clean abdominal surgeries. Preoperative optimization and improved intraoperative efficiency are crucial for reducing postoperative infection rates.

Keywords: Surgical site infection, clean abdominal surgery, obesity, diabetes mellitus, operative duration, postoperative complications.

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INTRODUCTION

Surgical site infection (SSI) represents one of the most critical postoperative complications experienced in all surgical specialties and has remained a leading cause of patient morbidity, prolonged stay, escalated healthcare expenses, and delayed recovery. In spite of the improved techniques in aseptic, standardized sterilization, use of perioperative antibiotic prophylaxis, SSIs still happen in clean abdominal surgeries that theoretically are the least susceptible to bacteria contamination [1,2]. The incidence of SSI has been reported to be between 2% and 10% in clean surgeries in the world, with higher rates being reported in low- and middle-income nations on account of the paucity of resources, irregularity in the application of infection-control measures, and greater risk factors among patients [3].

Clean abdominal surgeries involve those surgeries in which there is no access to the gastrointestinal, respiratory

or genitourinary tract and the presence of no indication of any infection or inflammation during the operation [4]. These include elective hernia repair, soft-tissue hernia repair, and non contaminated minimally invasive abdominal operations. Nevertheless, some patient related, procedure related, and environmental related factors may contribute to the probability of contracting postoperative infection under these controlled conditions to a considerable degree [5,6].

Various predictors related to SSI have been identified and they are obesity, diabetes mellitus, smoking, long-operative period, anemia as well as the wrong timing of prophylactic antibiotics. The role of patient physiological condition is also significant with people with compromised microvascular circulation, low glycemic level, or immunity exhibiting slow wound healing. Other factors that contribute to the risk of infection are related to the procedures like too much tissue manipulation, long incisions, drain usage, and poor intraoperative sterility. These determinants need to be understood in order to develop evidence-based preventive strategies [7,8].

Prospective data are lacking on predictors of SSI particularly in clean abdominal surgeries in Pakistan as most local studies are combined clean and clean-contaminated surgeries or are emergency surgeries. Considering the growing number of surgical procedures and the necessity to minimize the unnecessary perioperative complications, it is of great clinical significance to determine the independent predictors of SSI in the clean surgeries [9].

Thus, the current study was aimed at assessing the incidence and predictors of surgical site infection in patients who underwent clean abdominal surgeries as elective in one of the tertiary care teaching hospitals. The study will help surgeons, hospitals, and policymakers to undertake specific interventions to decrease the rate of SSI and increase patient outcomes by identifying both modifiable and non-modifiable risk factors [10].

MATERIALS AND METHODS

The current prospective observational study was carried out in a 15-month timeframe between January 2022 and March 2023 in the Department of General Surgery, Shaikh Zayed Medical Complex, Lahore. The hospital is a large teaching and tertiary care academic center, which has a substantial flow of elective surgical patients at Lahore and other areas. One hundred and twenty (120) patients who were going through elective clean abdominal surgeries were recruited through consecutive sampling method. The patients were aged 18-70 years, ASA physical status I-III, and were planned a clean abdominal operation, including open or laparoscopic hernia repair, abdominal wall mass excision, and other clean soft-tissue abdominal surgeries. Informed consent was taken in writing by all the members of the study. Patients were not eligible when they had emergency surgery, clean-contaminated or contaminated wound presentation, persistent infections, immunocompromised, received systemic antibiotics more than 48 hours before surgery or when they did not undergo 30-day follow-up after surgery.

A standardized preoperative examination that included an in-depth clinical history, physical examination, BMI calculation, and laboratory testing were given to all patients; these included hemoglobin, serum glucose and renal profile. The comorbidities included diabetes mellitus, hypertension, and smoking. In line with the hospital guidelines, prophylactic antibiotics were usually Cefazolin 1 g IV, which were administered 30 to 60 minutes prior to skin incision. Data were documented on each patient about the type of the surgery, whether it was open surgery or laparoscopic surgery, duration of the surgery, events during the surgery, and the level of surgeon experience. The time of operating was then classified as 120 minutes or above. The practice of all surgical procedures followed the institutional sterile guidelines that encompassed skin preparation, sterile wrap, meticulous tissues, hemostasis, and uniform wound closure.

Monitoring was done in the hospital and 30 days after discharge. Follow-up visits were also planned on the 7 th, 14 th and 30 th postoperative days and some of the patients who could not visit in person were to be contacted using the telephone. The identification and classification of surgical site infections was based on the Centers for Disease Control and Prevention (CDC) criteria that comprised of superficial incisional, deep incisional, and organ/space infections. Senior surgical staff clinically assessed patients with wound pain, erythema, discharge, swelling, fever, or dehiscence.

All clinical and demographic information was recorded in a structured proforma and checked by two independent study assistants to be on the same page. The SPSS version 26 was used to run a statistical test. Independent t-tests were used to analyze quantitative variables and mean ± standard deviation were used to represent the variables, whereas Chi-square or Fisher exact test were used to analyze categorical variables where suitable. The variables with p-value below 0.20 during the univariate analysis were incorporated in the multivariate logistic regression analysis to establish independent predictors of surgical site infection, where the significance was set at $p < 0.05$.

The study received ethical approval in the Institutional Review Board of Shaikh Zayed Medical Complex, Lahore, with approval number SZMC/IRB/GEN-SURG/2023/147 and management of all patient data was conducted under high levels of confidentiality.

RESULTS

The analysis considered 120 patients who underwent elective clean abdominal surgeries at Shaikh Zayed Medical Complex, Lahore, in the period between January 2022 and March 2023. Among them, 17 patients (14.1) were stricken by a surgical site infection (SSI) during the 30-day postoperative period, and 103 patients (85.9) were free of any signs of infection. Mean patient age at the time of SSI

was 41.8 +12.2 years, which was a little more than the control group (39.6 +11.4 years), and it was not significant (p = 0.42). The two groups had similar effects in terms of gender distribution: among SSI patients, 10 (58.8) happened to be male and 7 (41.2) happened to be female, whereas within the non-SSI group, 54 (52.4) were male and 49 (47.6) were female and did not significantly have an impact on postoperative infection. Though, there were some considerable disparities in a number of clinical parameters. Obesity (BMI >30 kg/m 2) was significantly more pronounced in patients with SSI (64.7% vs 24.3% in the infected and the non-infected groups respectively) (p = 0.004). Likewise, diabetes mellitus was a major issue more prevalent in patients developing SSI (52.9% vs. 17.4, p = 0.009). Preoperative anemia also played a significant role with 41.2 percent of SSI patients having lower hemoglobin levels of less than 10 g/dl and only 13.5 percent of no-infection patients having low hemoglobin levels (p = 0.03). There was no significant difference between the groups in smoking status (29.4% vs. 20.4%, p = 0.40). A summary of these findings is presented in Table 1 that is categorical in stating that obesity, diabetes, and low hemoglobin are major factors contributing to the occurrence of SSI.

Table 1. Baseline Demographic and Clinical Characteristics of Patients With and Without Surgical Site Infection (SSI)

Variable	SSI (n = 17)	No SSI (n = 103)	p-value
Age (years), mean ± SD	41.8 ± 12.2	39.6 ± 11.4	0.42
Male	10 (58.8%)	54 (52.4%)	0.61
Female	7 (41.2%)	49 (47.6%)	0.61
BMI >30 kg/m²	11 (64.7%)	25 (24.3%)	**0.004**
Diabetes mellitus	9 (52.9%)	18 (17.4%)	**0.009**
Smoking	5 (29.4%)	21 (20.4%)	0.40
Hemoglobin <10 g/dL	7 (41.2%)	14 (13.5%)	**0.03**

Table 2. Operative Factors Associated With Surgical Site Infection (SSI)

Variable	SSI (n = 17)	No SSI (n = 103)	p-value
Duration >120 minutes	13 (76.5%)	21 (20.4%)	**0.002**
Laparoscopic approach	6 (35.3%)	54 (52.4%)	0.18
Drain placement	4 (23.5%)	11 (10.7%)	0.13
Consultant-led surgery	11 (64.7%)	77 (74.7%)	0.40

There was an equal representation of female and male patients and the risk of getting SSI was not linked to gender. The obesity, diabetes, and low hemoglobin levels were however much more common in patients developing infection implying that these comorbidities contributed a considerable portion towards the augmentation of postoperative wound complications.

There were also significant and statistically important correlations between operative variables and postoperative infection. The strongest predictive factor was surgery duration where 76.5% of patients that developed SSI had surgeries that took more than 120 minutes as opposed to 20.4% of patients who were not infected (p = 0.002). Even though a higher percentage of patients who experienced SSI were undergoing an open procedure than laparoscopic one, this difference was not statistically significant (p = 0.18). The placement of drains was higher in patients with SSI (23.5) as compared to those without SSI (10.7), although such relationship was not found to be significant (p = 0.13). In both groups, surgeries led by consultants were the rule and did not demonstrate any significant relationship with SSI (p = 0.40). Table 2 contains these operative findings.

The strongest operative predictor of SSI was the duration of surgery, and operations greater than 120 minutes were at a high risk of SSI. There were no statistically significant relationships between surgical technique (open vs. laparoscopic) and use of a drain but trends in the same direction were significant (at risk).

A multivariate logistic regression analysis was done to establish whether these variables were independent predictors of SSI. The model included variables with a p value (BMI, diabetes, hemoglobin, operative duration, smoking, drain use) that were found to be significant in univariate tests. Three variables were still independent significant predictors of postoperative SSI after adjustment including obesity, diabetes, and long surgical duration. Patients with BMI >30 kg/m 2 were at a risk to develop SSI more than three times (AOR 3.42, 95% CI 1.52 7.66, p = 0.01). The risk of diabetes mellitus was almost three times higher among those who had diabetic mellitus (AOR 2.89, 95% CI 1.216.91, p = 0.02). Operative duration over 120 minutes was the strongest predictor; this predisposed the risk more than four times (AOR 4.15, 95% CI 1.829.45, p =.001). Low hemoglobin had a positive trend but it was not found to be significant even with adjustment (AOR 1.88, p = 0.09).

The study showed that the rate of infection of the surgical site was 14.1% in clean abdominal surgeries. The rate of infection was much greater with patients who were obese, diabetic, or subjected to long-term surgical procedures. There were no relationships observed between gender and age as well as surgical technique (open vs. laparoscopic). Univariate and multivariate analysis verified that the independent factors predicting postoperative wound infection with strong predictive value in clean abdominal surgeries include obesity, diabetes, and long operative time.

DISCUSSION

This prospective observational study was used to assess how surgical site infection (SSI) was predicted in patients with clean abdominal surgeries at the Shaikh Zayed Medical Complex, Lahore [8]. The general incidence of SSI in the current study was 14.1 that is higher than the ones usually reported in the high-income healthcare systems but similar to other low- and middle-income countries where resource shortage, patient comorbidities, and inconsistent compliance with infection-control measures lead to high postoperative infection rates. The results underscore the clinical significance of specific preventive measures especially when dealing with high-risk groups [9-11].

Obesity (BMI >30 kg/m 2) in this paper was found to be a powerful independent predictor of SSI. This is in line with other published works that have found that obesity affects wound healing with poor vascularity of adipose tissue, increased dead space in surgical wounds, and tension in the tissue during closure. There are also higher chances of prolonged operative time, hard exposure and chances of bacterial colonization in obese patients. The correlation in this study is also in line with the international evidence, and an affirmation is made on the claim that obesity is a key modifiable risk factor that must be engaged with preoperative counseling and optimal perioperative care [12,13].

SSI was also significantly related to diabetes mellitus, both univariate and multivariate. Glycemic control has been found to impair neutrophil performance, decrease collagen deposition, and general immune effect, which are all contributing factors to slower wound healing and predisposition to infection. The study performed by the authors indicates a higher risk of SSI in diabetic patients in this case (AOR 2.89), which highlights the necessity of a careful approach to diabetes-related perioperative glucose control, such as the control of blood glucose levels before, during, and after surgery. The results are consistent with the already known information provided by WHO and CDC where diabetes is constantly mentioned as a primary risk factor to postoperative infections [14,15].

The next significant discovery was that the long period of operative time (>120 minutes) is significantly related to the postoperative SSI. The longer a surgery takes the more the tissues are exposed to contamination, the greater the handling of the tissues and the fatigue of the surgeon leading to the chances of infection. The current study established that the strongest predictor was operative duration (AOR 4.15) and this is congruent with the international evidence that suggests the presence of a robust risk factor of prolonged surgery in the various surgical specialties. These results indicate that better operational productivity, adequate logistics, and minimally invasive methods that should be utilized in suitable cases could assist in lowering the rates of SSI [16,17].

Though low preoperative hemoglobin (<10 g/dL) was significantly related with SSI in simple regression, this was not the independent variable in multivariate regression. Anemia minimizes oxygen supply to the tissues, thus, it could slow the healing of the wounds, but the impact can be supershadowed by other stronger predictors like obesity, diabetes, and long operative time. On the same note, age, gender, smoking status, drain placement, and type of surgical approach were also not significantly related to SSI in this study. This indicates that conditions associated with the patient metabolically and the intraoperative aspects might be more determining factors with regard to infection risk as compared to demographic or procedure attributes [11,14,18].

The study strengths consist of its prospective design, application of standardized CDC criteria in diagnosing SSI, and 30-day follow-up of all the participants. Nevertheless, the results are to be read against some limitations. It was a single-center study with a moderate sample size, which can be considered a limitation in terms of generalization. There were no data on microbiological culture and, therefore, it was impossible to analyze pathogen-specific pattern. Moreover, the level of glycemic was not stratified in accordance with control status, which could have given more understanding of the relationship of diabetes severity. Nevertheless, the study offers clinically relevant information that can be useful in such tertiary care units [12,15].

In general, the results demonstrate the role of preoperative optimization, especially in patients with obesity and diabetes, and have to reduce the operating time by enhancing surgical planning and technique. These risk factors are considered to be modifiable and could be targeted to drastically decrease the occurrence of SSI and enhance the outcomes of the clean abdominal surgeries [18].

CONCLUSION

The current study reported that the following factors were considered to be important independent predictors of surgical site infection in clean abdominal surgeries; obesity, diabetes mellitus, and length of stay. It was discovered that patients, who had higher BMI than 30 kg/m 2, patients with diabetes and patients who have undergone surgery longer than 120 minutes were at a considerably increased risk of experiencing post-operative wound infection. There was no significant age, gender, smoking, surgical approach or drain placement and SSI. These findings highlight the significance of the preoperative patient optimization, such as the weight management, firm glycemia control, and, when feasible, the anemia correction. Moreover, the potential results of the improvement of intraoperative efficiency and the decrease of the operation time can significantly decrease the risk of postoperative infection. Specific preventive measures built on these predictors will help improve the outcome of surgery, decreased morbidity, and more efficient use of medical resources.

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