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Prospective Study of Surgical Site Infection in Diabetic Patients.

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Abstract: *In the 1960s, surgery for diabetic patients had a mortality rate of 4 to 13%. Since then, advances in perioperative care—including improved preoperative assessments and careful insulin management—have lowered these risks. Today, approximately 9% of hospital beds are occupied by diabetic patients, and around 11.3% of surgeries are performed on individuals with diabetes. On average, a person with diabetes has a 50% chance of undergoing surgery at some point in their life. Diabetic patients tend to have surgeries more frequently than those without diabetes. Many studies have investigated the link between diabetes and surgical site infections (SSIs) after procedures such as cardiothoracic, spinal, oesophageal, gastric, breast, and orthopaedic surgeries. However, research on other surgical fields and general surgery remains limited. The rise of antibiotic-resistant organisms poses a significant concern. This study also aims to identify the microorganisms responsible for SSIs, assess their antibiotic susceptibility, and evaluate the effectiveness of preoperative antibiotic prophylaxis across various surgeries at ZMC Hospital—particularly in diabetic patients. Ultimately, this research seeks to help healthcare providers optimize antimicrobial use and develop strategies to limit the spread of drug resistance.*

Background*: The increasing prevalence of antibiotic-resistant organisms is of great concern. This research work also seeks to study the pattern of organisms isolated from Surgical Site Infections, antibiotic susceptibility, and the effectiveness of the preoperative antibiotic prophylactic regimen commonly used in various operations performed at the Department of Surgery, ZMC Hospital, especially among diabetic patients. This study will also enable institutions to restrict antimicrobial use and take active measures to prevent the spread of drug resistance within a hospital.*
Materials and Methods*: This study was conducted on 70 known diabetic patients (DM-I & II). All cases underwent elective surgical procedures in the ZMC, Aizawl, surgery department during the period from August 2021 to July 2024. A study of the bacteriological profile and antimicrobial susceptibility patterns of Surgical Site Infection cases was conducted in the Department of Microbiology, ZMC, Aizawl, during the same period.*
Results*: Out of 70 consecutive patients with diabetes mellitus, 11 developed surgical site infections, resulting in a crude SSI rate of 15.7%. The wound classification affects the SSI rate, with 5.5% in clean wounds and 19.2% in clean-contaminated wounds.*
Conclusion: *The level of blood glucose management affects the infection rate in patients with diabetes mellitus. Postoperative blood glucose levels above 200 mg/dl are associated with a higher incidence of SSI, underscoring the importance of maintaining strict postoperative blood glucose control.*
Key Word*:* ***Surgical Site Infection; Bacteriology; Diabetes Mellitus; Wound Healing; Hospital Stay***

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I. Introduction

Despite extensive research on best practices, improvements in surgical techniques, technological progress, and the use of preoperative antibiotics, surgical-site infection remains among the most common complications for hospitalized patients. Infections at the wound site are a significant cause of postoperative illness and can sometimes lead to death in surgical patients. They represent roughly a quarter of all nosocomial infections. [1]

The surgical site includes infections that develop after surgery in deep organ spaces beneath the skin and soft tissue, such as the peritoneum and bone. [2] An infection must occur within 30 days post-surgery to qualify as an SSI. If an implanted device or prosthesis is involved, this period extends up to 1 year. The definition of surgical site infection also requires evidence of pus, cellulitis, or the need for incision and drainage of the surgical site. [3] This study aims to examine the patterns of organisms isolated from SSIs, their antibiotic susceptibilities, and the effectiveness of preoperative antibiotic prophylactic regimens used in various surgeries at the Department of Surgery, ZMC Hospital, especially among diabetic patients.

II. Materials and Methods

The prospective study was conducted on 70 known diabetic patients (DM Type 1 & 2) who underwent various elective surgical procedures from August 2021 to July 2024 at the Department of General Surgery, ZMC, Aizawl, Mizoram. A bacteriological profile (anaerobic) and antimicrobial susceptibility pattern of Surgical Site Infection cases were also studied during this period.

Study Design: Prospective open-label observational study

Study Location: This was a tertiary care teaching hospital-based study done in the Department of General Surgery at Zoram Medical College and Hospital, Falkawn, Aizawl, Mizoram.

Study Duration: August 2022 to July 2024

Sample size: 70 diabetic patients.

Inclusion criteria:

1. Diabetic patients (fasting blood glucose ≥ 126 mg/dL [7.0mmol/L]) who underwent various elective surgical procedures at the Department of General Surgery, ZMC, Aizawl, Mizoram.
2. Either sex
3. Aged ≥ 18 years,

Exclusion criteria:

1. Contaminated wounds (C-III)
2. Dirty wounds (C-IV) of the CDC Wound Classification
3. Emergency operative procedures
4. Minor operations under local anaesthesia
5. Laparoscopic procedures.

Procedure methodology

The prospective study was conducted on 70 known diabetic patients (DM Type 1 & 2). A bacteriological profile (anaerobic) and antimicrobial susceptibility pattern of Surgical Site Infection cases were also studied during this period.

1. Prior approval for conducting the research work was obtained from the Institute Ethical Committee (IEC) of RIMS before commencing the study.

3. Informed Consent was taken for each study using a standard proforma of informed consent issued by the IEC of ZMC

4. Clinico-bacteriological study, detailed history, thorough physical examination, and follow-up for evidence of surgical site infection were undertaken. Age, sex, duration, type of operation, length of pre- and post-operative hospital stay, and overall length of hospital stay (LOS) were recorded.

5. Preoperative estimation of blood sugar level (fasting and post-prandial), complete haemogram, urinalysis, serum urea, serum creatinine, serum electrolytes, electrocardiography, and radiological investigation were included in routine investigations, along with the specific investigations for each type of operation. SSI (superficial) was diagnosed according to the Centers for Disease Control and Prevention guidelines. [3]

6. Blood glucose level was monitored and controlled intraoperatively if the duration of the procedure exceeded 60 minutes. Post-operative blood sugar level (capillary) was estimated within 24 hours of the procedure for each case. A neutralizing glucose-insulin infusion was given to each patient, and hyperglycemia was controlled with a sliding scale regimen.

7. SSI (superficial) was diagnosed as per the guidelines issued by the Centers for Disease Control and Prevention.

8. Pus or exudates from the wound were collected by two sterile swabs (with the sterile container) if SSI was suspected. The specimen was sent immediately to the Microbiology Department at ZMC. Gram's staining was done from 1 of the swabs. The other swab was inoculated into the blood agar and MacConkey's agar. The inoculated plates were incubated at 37 °C overnight. Further identification was done by examining the colony characteristics, Gram's staining, Hanging-drop preparation, and other relevant biochemical tests.

9. The antimicrobial sensitivities of the commonly used antibiotics in the hospital were tested by using the Kirby-Bauer disc diffusion method as per the standard recommended. [58] [59]

Statistical analysis
Statistical analyses were performed using SPSS 20 for Windows (SPSS Inc., Chicago, IL, USA) and Epi Info™ software. A 'P' value of <0.05 was considered significant.
Data were analyzed, and post-operative outcomes were determined.

III. Result

Out of 70 consecutive patients with diabetes mellitus, 11 developed surgical site infections, resulting in a crude SSI rate of 15.7%. The wound classification affects the SSI rate, with 5.5% in clean wounds and 19.2% in clean-contaminated wounds.

The relation of wound infection to the type of wound
SSI rates between men and women were very similar. The SSI rate in men was 15.6%, compared with 15.1% in women. Seroma/serous discharge formation was seen exclusively in female patients (n=5); 4 post-cholecystectomy (open) and one urological surgery patient.

This study showed that, in diabetic patients, the rate of SSI increases with age, especially above 60 years of age. The age range was 29 to 79 years, with a median age of 55. The highest SSI rate occurred in the 60-year-old and older age group.
The link between the SSI rate and preoperative blood sugar levels was not assessed because all patients had preoperative fasting and postprandial blood glucose values controlled at ≤125 and ≤150 mg/dl, respectively. Capillary blood glucose levels in mg/dL were recorded within 24 hours after surgery for all patients (see Table 4).

Table: 4
Postoperative glucose level and infection rate

Blood glucose postoperative (mg/dl)	Total no. of patients	No. of patients infected	Percentage (%)
≤150	47	2	4.2%
151-200	21	8	38.1%
≥201	2	1	50%

Most patients received a neutralizing dose of glucose-insulin infusion after surgery. Poor glycemic control, defined as a mean 24-hour capillary blood sugar≥ 200 mg/dL (per current Canadian and American guidelines for perioperative management of patients with DM), was observed in 2 patients, with 1 developing SSI (50%). Postoperative hyperglycemia was managed using a sliding scale, but current endocrinology guidelines recommend scheduled doses of longer-acting insulin for better control.
Hospital stay/length of stay (LOS) ranged from 6 to 63 days, with a median of 22 days. This study identified a positive correlation between postoperative blood glucose levels (hyperglycemia) and LOS.
The most extended preoperative hospital stay was 45 days. There is a linear increase in SSI rates with increasing preoperative stay length. The above findings suggest that the duration of the preoperative stay is directly related to the SSI rate.

Duration of operation and SSI
Operative durations exceeding 151 minutes had the highest SSI rate at 100%, while durations between 31 and 60 minutes had the lowest at 5.2%. There were no SSI cases in procedures that lasted less than 30 minutes. These data clearly indicate that longer operative times are associated with increased SSI rates.
All SSIs developed within two weeks of the procedure and were identified during the in-hospital stay. There was a high detection rate of SSIs during postoperative wound dressings, most commonly on postoperative day 3. Three of the SSIs were identified on POD 10, two on POD 4, and one case each at POD 7 and POD 12.
If signs of SSI, such as erythema, serosanguineous discharge, and wound gaping, were observed postoperatively, clips or sutures were removed or loosened to promote drainage of the inflammatory fluid. Pus was sent to the Microbiology Department of ZMC for culture and antibiotic sensitivity testing in all SSI cases. Antibiotic treatments were adjusted based on the sensitivity results. All patients were monitored with routine dressing changes and wound evaluation for at least 2 weeks after the procedure. Some patients required secondary wound closure.

Organisms: Positive cultures from infected wounds were obtained in 81.8% of cases, and all isolates underwent standard antibiotic sensitivity testing. The most common organisms identified were S. aureus (n=4) and Escherichia coli (n=4). Other microorganisms included Coagulase-negative Staphylococcus (n=1) and Klebsiella pneumoniae (n=1). One MRSA was isolated among the 11 SSIs. In patients with diabetes, SSIs are caused by the same organisms as those in healthy hosts.

Antimicrobial resistance/susceptibilities of SSI organisms:
In this study, the infecting organisms were most sensitive to carbapenems (imipenem, meropenem, and etrapenem), followed by third- and fourth-generation cephalosporins and glycopeptides (vancomycin).

IV. Discussion

Koch (Professor of Hygiene and Microbiology, Berlin, 1843-1910) first identified infective foci as secondary to microbial growth in his 19th-century postulates. In the mid-1800s, Semmelweis (Austrian obstetrician, 1822-1895) demonstrated a fivefold reduction in puerperal sepsis by implementing handwashing between postmortem examinations and entering the delivery room. Joseph Lister (Professor of Surgery, London, 1827-1912) and Louis Pasteur (French bacteriologist, 1822-1895) revolutionized the understanding of wound infections. [4]

Today, surgical practitioners face infection issues daily. Even with 20th-century innovations such as antimicrobial chemotherapy, surgeons still need to drain abscesses, debride infected wounds, and treat patients with various acute infectious diseases. Surgeons often view infection as an unwanted outcome of surgical procedures. It was estimated that over 290,000 surgical infections occurred in hospitalized surgical patients in the U.S. in 2002, leading to 8205 deaths. These SSIs accounted for about 20% of the more than 1,700,000 healthcare-associated infections estimated for that year, many, if not most, of which developed in surgical patients.[5]

The 1964 National Academy of Sciences-National Research Council Cooperative Study found a similar age-adjusted rate of surgical wound infection in 354 diabetic subjects (7.2%) compared with non-diabetic subjects (7.1%).[6]

Conversely, in a study of 23,649 surgical wounds from various procedures performed at two Calgary hospitals in 1970, Cruse PJE et al. [7] found that, compared to the overall clean wound infection rate in non-diabetics, patients with diabetes experienced a higher infection rate.

Hjortrup A et al. [8] in 1985 reported that among 224 matched diabetic and non-diabetic cases who underwent vascular or abdominal surgery, there was no difference in wound infection rates between the two groups.

McConnell YJ et al. [9] found that, in a cohort of 149 patients, 24% had poor postoperative glycemic control (defined as a mean 48-hour postoperative capillary glucose [MCG] >200 mg/dL). These patients experienced a significantly higher rate of SSI compared to those with a 48-hour MCG<200 mg/dl. In conclusion, a 48-hour MCG >200 mg/dl was independently associated with increased SSI following colorectal resection in patients with diabetes mellitus.

A study by Kune GA et al. [10] in 2007 found that perioperative wound contamination significantly contributed to the development of SSI. In clean surgeries, the infection rate was 5.9%. Usually, wound contamination and infection were caused by Gram-positive organisms, specifically Staphylococcus aureus. After opening the gastrointestinal or biliary tract, the infection rate increased to 28%. The typical contaminating and infecting organisms were enteric, and Staphylococcus aureus was isolated only occasionally. They concluded that better methods are needed to minimize preoperative wound contamination.

However, a study conducted by Kamat US et al [11] on 144 patients between June and July 2005 at Goa Medical College found that, among patients with surgical site infections, 79% of the isolated organisms were Gram-negative bacteria; Pseudomonas (22.9%) being the most common, followed by Staphylococcus pyogenes (19.7%).

SSI incidence in DM and non-DM

The findings in this study align with several earlier studies on general surgery and most cardiothoracic and spinal surgeries, where the SSI rate was higher in diabetic patients. In the original 5-year study by Cruse PJE [7], the clean wound infection rate was 10.7% for people with diabetes, compared to an overall rate of 1.8%. However, contrary to these findings, the 1964 National Academy of Sciences-National Research Council Cooperative study reported a similar age-adjusted rate of surgical wound infection- 7.2% in 354 diabetic patients versus 7.2% in non-diabetics.[6] Hjortrup A et al. [8] also found no difference in wound infection rates between 124 matched diabetic and non-diabetic patients who underwent vascular or abdominal procedures.

Postoperative capillary blood sugar level and rate of SSI in people with diabetes:
In this study, significant increases in SSI incidence were observed when postoperative 24-hour capillary glucose levels exceeded 200 mg/dl (50%). It was also commonly observed at 151-200 mg/dl (38.1%). However, in patients with postoperative capillary blood glucose levels below 150 mg/dl, the SSI incidence did not change much from that of the non-diabetics.

Postoperative blood glucose level and length of hospital stay:

The length of hospital stay ranged from 6 to 63 days, with a median of 22 days. The extended LOS was linked to the diabetic status of the patients. There was a positive correlation between postoperative blood glucose levels and hospital stay duration in this study. Among patients with postoperative blood glucose levels of 150 mg/dl or below, those with SSI had an average LOS of 29.5 days, compared to 14.1 days for those without SSI. Similarly, patients with wound infections in the 151-200 mg/dl glucose group had an average LOS of 37.4 days, versus 18 days for patients without SSI. Vriesendorp TM et al. [11] concluded that high postoperative glucose levels were associated with more extended hospital stays. However, they found that postoperative glucose concentration was not an independent risk factor for extended in-hospital stay in their multivariate analysis of post-esophagectomy patients with diabetes mellitus.

Bacteriological survey

Positive cultures were obtained in 81.8% of the infected cases. The culture was sterile in 2 patients. In this study, the most common etiological agent among Gram-positive organisms was Staphylococcus aureus (40%), consistent with the report by Giacometti A et al. [12], who found Staphylococcus aureus (28.2%) to be the most frequently isolated agent from SSI. Staphylococcus aureus was also the most common agent identified from SSI by Kune GA et al. [10]

Among Gram-negative organisms, Escherichia coli was the most frequently isolated at 40%. The high prevalence of Escherichia coli may be related to surgical procedures that compromised the GIT, leading to contamination of the wound edges. These findings align with reports by Nichols et al. [1] and Cruse and Foord [13], which indicated that Staphylococcus aureus is the most common cause of post-operative wound infections.

V. Conclusion

The rate of superficial SSI was 15.7% among diabetic patients who underwent clean and clean-contaminated elective surgeries. The level of blood glucose management affects the infection rate in patients with diabetes mellitus. Postoperative blood glucose levels above 200 mg/dl are associated with a higher incidence of SSI, underscoring the importance of maintaining strict postoperative blood glucose control.

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