Journal of Cardiovascular Disease Research
ISSN: 0975-3583,0976-2833 VOL 13, ISSUE 2, 2022

GLYCAEMIC CONTROL AND SURGICAL SITE INFECTION RATES IN TYPE 2 DIABETIC PATIENTS UNDERGOING ELECTIVE ABDOMINAL SURGERY: A PROSPECTIVE OBSERVATIONAL STUDY IN RURAL TAMIL NADU

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ABSTRACT

Background: Surgical site infections (SSIs) constitute a major postoperative complication in patients with Type 2 diabetes mellitus (T2DM), with glycaemic dysregulation recognised as a pivotal predisposing factor. In the rural healthcare setting of Tamil Nadu, where diabetes prevalence is high and perioperative glycaemic optimisation is frequently suboptimal, the burden of SSI is a pressing yet incompletely characterised problem. This study aimed to determine the association between preoperative and perioperative glycaemic control and the incidence of SSI in T2DM patients undergoing elective abdominal surgery. **Methods:** A hospital-based prospective observational study was conducted from January 2021 to December 2021 at a tertiary care centre in rural Tamil Nadu. A total of 120 adult T2DM patients (aged 30–70 years) scheduled for elective abdominal surgery were enrolled. Preoperative HbA1c, fasting blood glucose, serum albumin, and body mass index were recorded. SSI was defined and classified per Centers for Disease Control and Prevention (CDC) criteria and assessed at 30-day follow-up. Statistical analyses included Chi-square tests and binary logistic regression; $p \leq 0.05$ was considered significant. **Results:** The overall SSI rate was 24.17% (29/120). Patients with HbA1c > 8.5% had an SSI rate of 53.57%, compared to 20.37% for HbA1c 7.0–8.5% and 7.89% for HbA1c < 7.0% ($p < 0.001$). Prolonged operative duration (≥ 120 minutes), use of surgical drains, and hypoalbuminaemia were independently associated with SSI. Colonic resection and anastomosis carried the highest procedure-specific SSI rate (64.29%). Staphylococcus aureus was the predominant isolate, with all strains demonstrating penicillin resistance. **Conclusions:** Poor glycaemic control, as reflected by elevated HbA1c, is a strong and modifiable predictor of SSI in diabetic patients undergoing elective abdominal surgery in rural Tamil Nadu. Structured

preoperative optimisation of glycaemia, nutritional status, and judicious use of drains are essential preventive strategies. Targeted interventions addressing these risk factors could significantly reduce the morbidity and economic burden of SSI in resource-limited settings.

Key-words: Diabetes mellitus, Elective abdominal surgery, Glycaemic control, HbA1c, Rural Tamil Nadu, Surgical site infection.

INTRODUCTION

Surgical site infections (SSIs) are among the most prevalent and consequential healthcare-associated infections, accounting for approximately 15% of all nosocomial infections globally [1]. Defined by the Centers for Disease Control and Prevention (CDC) as infections occurring within 30 days of surgery — or within one year in patients with implants — SSIs encompass superficial incisional, deep incisional, and organ or space infections [2]. Their clinical significance lies not only in prolonged hospital stays and increased healthcare expenditure, but also in the associated rise in morbidity, readmission rates, and, in some cases, mortality [3].

Type 2 diabetes mellitus (T2DM) represents one of the most well-established patient-level risk factors for SSI. The pathophysiology is complex and includes impaired neutrophil chemotaxis and phagocytic function, microvascular compromise, delayed wound healing secondary to reduced collagen synthesis, and a state of chronic low-grade inflammation [4,5]. Hyperglycaemia, even in the perioperative period, has been shown to impair host immune responses and potentiate bacterial adherence to surgical wound tissues [6]. The degree of chronic glycaemic dysregulation, as measured by glycated haemoglobin (HbA1c), further compounds this risk by reflecting the cumulative metabolic burden on tissue vascularity and immunological competence [7].

India harbours the second-largest diabetic population in the world, with a significant proportion residing in semi-urban and rural areas [8]. Tamil Nadu, a state with a disproportionately high prevalence of T2DM, faces particular challenges in the perioperative management of diabetic surgical patients, including limited preoperative optimisation services, delayed presentation, and suboptimal glycaemic monitoring at rural tertiary referral centres [9]. These systemic gaps translate into a highrisk environment for postoperative infectious complications.

Despite the considerable burden of diabetes in the surgical population, prospective data examining the granular relationship between perioperative glycaemic control and SSI incidence in the rural Indian context are scarce. Most existing studies originate from urban tertiary centres or high-income settings, limiting the generalisability of their findings [10]. This study was therefore undertaken to characterise the association between preoperative glycaemic status (HbA1c) and the incidence and microbial profile of SSI in T2DM patients undergoing elective abdominal surgery at a rural referral hospital in Tamil Nadu, with the aim of informing locally relevant prevention protocols.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based prospective observational study was conducted from January 2021 to December 2021 in the Sree Balaji Medical College & Hospital, Tamil Nadu — a rural tertiary care teaching hospital serving a predominantly agrarian population with a high prevalence of metabolic comorbidities.

Sample Size and Eligibility

A total of 120 patients with established T2DM aged between 30 and 70 years, scheduled to undergo elective abdominal surgery under general or regional anaesthesia, were consecutively enrolled following written informed consent. The sample size was calculated using the formula $N = Z^2(1-\alpha/2) \times p \times q / d^2$, assuming an SSI prevalence of 20% in diabetic surgical patients (derived from published Indian literature), a confidence level of 95%, and an absolute precision of 7%.

Inclusion Criteria

Adult T2DM patients (aged 30–70 years) undergoing elective abdominal surgery and able to provide informed consent for a 30-day postoperative follow-up were included.

Exclusion Criteria

Patients with Type 1 diabetes mellitus, active systemic infections, immunosuppressive therapy, concurrent malignancy on chemotherapy, chronic kidney disease (eGFR < 30 mL/min/1.73m²),

ischaemic heart disease with left ventricular dysfunction, emergency surgeries, and those lost to follow-up were excluded.

Data Collection and Perioperative Protocol

Preoperative data collected included demographics (age, sex, BMI), duration of T2DM, comorbidities (hypertension, dyslipidaemia), HbA1c, fasting blood glucose on the day of surgery, serum albumin, and total leucocyte count. Intraoperative variables included surgery type, classification (clean or cleancontaminated per Altemeier criteria), operative duration, estimated blood loss, and use of drains.

Antibiotic prophylaxis was administered as per institutional protocol: a single preoperative intravenous dose of Cefazolin 1 g (or Ceftriaxone 1 g for clean-contaminated procedures), with additional Metronidazole 500 mg for bowel-related surgeries. Perioperative blood glucose was maintained between 140 and 180 mg/dL using an insulin infusion protocol in all patients.

Outcome Definition and Assessment

The primary outcome was SSI, defined and classified according to CDC/NHSN 2021 criteria [2]. Wounds were assessed in the outpatient department at one week, two weeks, and 30 days postoperatively by a blinded surgical resident. Culture and sensitivity of wound exudate were performed for all clinically suspected SSI cases.

Statistical Analysis

Data were entered and managed in Microsoft Excel 2019 and analysed using IBM SPSS Statistics version 25. Descriptive statistics were expressed as mean ± standard deviation for continuous variables and as frequencies and percentages for categorical variables. The Chi-square test or Fisher's exact test was used to assess associations between SSI and categorical predictor variables. Binary logistic regression was performed to identify independent predictors of SSI. A two-tailed p-value ≤ 0.05 was considered statistically significant.

Ethical Approval

The study was approved by the Institutional Ethics Committee, Sree Balaji Medical College & Hospital (Approval No. SBMCH/IEC/2021/087, dated 10 December 2021). Written informed consent was obtained from all participants prior to enrolment.

RESULTS

Patient Demographics

Of 120 enrolled patients, 72 (60.0%) were male and 48 (40.0%) were female. The mean age was 52.4 ± 9.7 years. The mean duration of T2DM was 8.6 ± 4.3 years. Hypertension was present in 68 (56.7%) patients and dyslipidaemia in 41 (34.2%). The mean preoperative HbA1c was 8.1 ± 1.6% and the mean serum albumin was 3.6 ± 0.5 g/dL. Hypoalbuminaemia (albumin < 3.5 g/dL) was identified in 31 (25.8%) patients.

SSI Rate by Glycaemic Control (Table 1)

The overall SSI rate was 24.17% (29 of 120 patients). Stratification by preoperative HbA1c revealed a stepwise increase in SSI rates with worsening glycaemic control. Patients with HbA1c > 8.5% had an SSI rate of 53.57%, compared to 20.37% in those with HbA1c 7.0–8.5% and 7.89% in those with HbA1c < 7.0%. This gradient was highly statistically significant ($p < 0.001$).

Table 1: SSI Rates Stratified by Preoperative HbA1c

HbA1c Category	No. of Patients	SSI Cases	SSI Rate (%)
< 7.0% (Controlled)	38	3	7.89
7.0–8.5% (Moderate)	54	11	20.37
> 8.5% (Poor)	28	15	53.57
Total	120	29	24.17

SSI Rate by Surgery Type (Table 2)

Among the surgical procedures performed, colonic resection and anastomosis carried the highest SSI rate (64.29%), followed by small bowel resection (40.00%) and open cholecystectomy (37.50%).

Laparoscopic procedures, including laparoscopic cholecystectomy, were associated with substantially lower infection rates (9.09%), underscoring the protective effect of minimally invasive techniques.

Table 2: SSI Rates by Surgical Procedure

Surgery Type	Patients (n)	SSI Cases (n)	SSI Rate (%)
Open appendicectomy	18	3	16.67
Laparoscopic cholecystectomy	22	2	9.09
Open cholecystectomy	8	3	37.50
Colonic resection & anastomosis	14	9	64.29
Inguinal hernia repair (open)	20	2	10.00
Small bowel resection	10	4	40.00
Gastrojejunostomy / bypass	12	4	33.33
Exploratory laparotomy	16	2	12.50
Total	120	29	24.17

Risk Factor Analysis (Table 3)

On univariate analysis, HbA1c > 7.0%, operative duration ≥ 120 minutes, use of surgical drains, and hypoalbuminaemia were significantly associated with SSI. BMI > 30 kg/m² and age > 55 years did not reach statistical significance. On binary logistic regression, HbA1c > 7.0% (OR 5.4; 95% CI 2.1– 13.9; $p < 0.001$), operative duration ≥ 120 minutes (OR 3.8; 95% CI 1.5–9.6; $p = 0.002$), and the use of surgical drains (OR 3.2; 95% CI 1.3–8.1; $p = 0.011$) emerged as independent predictors of SSI.

Table 3: Univariate Analysis of Risk Factors for SSI

Risk Factor	SSI (n=29)	No SSI (n=91)	p-value
HbA1c > 7.0%	26 (89.7%)	56 (61.5%)	< 0.001
Surgery > 120 min	19 (65.5%)	29 (31.9%)	0.002
Use of surgical drain	17 (58.6%)	22 (24.2%)	0.001
Hypoalbuminaemia (< 3.5 g/dL)	13 (44.8%)	18 (19.8%)	0.009
BMI > 30 kg/m2	11 (37.9%)	21 (23.1%)	0.12
Age > 55 years	16 (55.2%)	41 (45.1%)	0.34

Microbiological Profile (Table 4)

Culture reports were available for all 29 SSI cases. Three wounds yielded no growth on standard culture media. Among the remaining 26, Staphylococcus aureus was the most frequently isolated pathogen (n = 12), followed by Klebsiella pneumoniae (n = 7), Escherichia coli (n = 4), and Pseudomonas aeruginosa (n = 3). All S. aureus isolates demonstrated penicillin resistance, with four strains (33%) also demonstrating methicillin resistance (MRSA). All isolates remained sensitive to vancomycin and linezolid.

Table 4: Microbiological Profile of SSI Cases

Organism	Isolates (n)	Penicillin R	Cefazolin R	Sensitive To
S. aureus (MSSA/MRSA)	12	100%	33%	Vancomycin, Linezolid
Klebsiella pneumoniae	7	—	57%	Carbapenems
E. coli	4	—	50%	Piperacillintazobactam

Pseudomonas aeruginosa	3	—	—	Carbapenems
Negative culture	3	—	—	—
Total	29			

DISCUSSION

This prospective observational study demonstrates a clear and statistically robust association between poor preoperative glycaemic control and the incidence of SSI in Type 2 diabetic patients undergoing elective abdominal surgery in a rural Tamil Nadu setting. With an overall SSI rate of 24.17%, this cohort exhibited rates considerably higher than the 9–15% range reported in mixed surgical populations, a finding consistent with the known immunological vulnerabilities of the diabetic host [11].

The most compelling finding of this study was the stepwise escalation of SSI rates with increasing HbA1c. At HbA1c values exceeding 8.5%, more than half of patients developed SSI — a figure that underscores the magnitude of risk imposed by chronic hyperglycaemia. This aligns closely with the systematic review by Martin et al., which reported a near doubling of SSI risk in diabetic patients, with the association strengthening proportionally with glycaemic disarray [12]. The biological underpinnings are well characterised: sustained hyperglycaemia impairs polymorphonuclear leucocyte function, disrupts complement activation, and reduces opsonisation efficiency, collectively creating a wound microenvironment that is permissive to microbial colonisation and invasion [5,6].

Among surgical procedures, colonic resection and anastomosis for malignancy carried the highest SSI burden (64.29%), a finding consistent with established data on the microbiota-laden environment of the large bowel and the complexity of anastomotic surgery [13]. Conversely, laparoscopic cholecystectomy was associated with a substantially lower rate (9.09%), reinforcing the infectionprotective role of minimally invasive approaches through reduced tissue trauma, shorter operative times, and smaller incisions [14]. The finding that open cholecystectomy carried a fourfold higher SSI rate compared to its laparoscopic equivalent provides granular support for encouraging laparoscopic conversion wherever technically and resource-contextually feasible.

The independent association between operative duration of ≥ 120 minutes and SSI (OR 3.8; p = 0.002) mirrors observations from multiple prospective studies, wherein prolonged surgery correlates with greater tissue devitalisation, hypothermia, and bacterial count accumulation at the wound site [15]. Similarly, the use of surgical drains was a significant and modifiable risk factor (OR 3.2; p = 0.011). While drains serve important haemostatic and fluid management purposes, they represent a bidirectional conduit that permits both retrograde bacterial ingress and wound contamination [16]. Their use should therefore be rationalised and, where feasible, replaced by closed-suction systems with early removal protocols.

Hypoalbuminaemia, present in approximately one-quarter of the cohort, was significantly associated with SSI on univariate analysis. Low serum albumin is a surrogate for poor nutritional status and reflects impaired synthesis of immunoglobulins, acute-phase proteins, and collagen precursors that are integral to wound defence and repair [17]. In the rural Indian context, where protein-caloric malnutrition frequently coexists with diabetes, preoperative nutritional supplementation — including high-protein oral supplements and, where indicated, enteral feeding — should be systematically incorporated into surgical preparation pathways.

The microbiological profile observed in this study is comparable to national antibiogram trends. S. aureus predominance in SSI is consistent with the primary role of commensal skin flora in wound colonisation during incision and closure [18]. The identification of MRSA in 33% of S. aureus isolates is of serious clinical concern, as MRSA infections are associated with prolonged hospital stays, higher treatment costs, and elevated mortality. The complete penicillin resistance of all S. aureus isolates argues against beta-lactam monotherapy as empirical treatment for SSI in this population and supports the need for locally derived antibiogram-guided policies incorporating vancomycin or linezolid for confirmed or suspected MRSA infections [19].

This study is strengthened by its prospective design, 30-day follow-up protocol, and systematic microbiological characterisation. However, several limitations must be acknowledged. The singlecentre design in a rural Tamil Nadu hospital limits generalisability to diverse healthcare settings. The relatively small sample size may have reduced the power to detect associations for secondary outcomes such as BMI and age. Furthermore, perioperative blood glucose variability, which may be a more dynamic predictor than HbA1c alone, was not systematically characterised in this study and

warrants evaluation in future work. Multicentre studies across Tamil Nadu's rural district hospitals are needed to validate these findings and develop regionally tailored SSI prevention bundles.

CONCLUSION

This study provides compelling prospective evidence that poor preoperative glycaemic control, as measured by HbA1c, is the most significant and modifiable risk factor for SSI in Type 2 diabetic patients undergoing elective abdominal surgery in rural Tamil Nadu. A structured perioperative management bundle — encompassing preoperative HbA1c optimisation ideally to below 7.0%, correction of hypoalbuminaemia, selective and early drain removal, and minimisation of operative time through skilled surgical techniques — has the potential to substantially reduce SSI incidence in this vulnerable population. The predominance of penicillin-resistant and MRSA strains further mandates institution-specific antibiograms to guide empirical antibiotic therapy. Implementing these evidence-based preventive strategies in resource-limited settings will require coordinated efforts across surgical, endocrinological, and nutritional care pathways.

ACKNOWLEDGMENT:

The all authors wish to express gratitude to the Sree Balaji Medical College & Hospital, Chennai, for supporting this work.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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