DOI: https://doi.org/10.53350/pjmhs20231709158

ORIGINAL ARTICLE

Surgical Wound Healing Outcomes in Patients with Diabetes and Hypertension. A Cross-Sectional Analysis

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ABSTRACT

Background: Surgical wound healing is a complex physiological process that can be adversely affected by systemic comorbidities. Diabetes mellitus and hypertension are two highly prevalent chronic conditions known to impair tissue repair, increase infection risk, and delay recovery following surgical interventions.

Objective: To evaluate and compare surgical wound healing outcomes in patients with diabetes mellitus, hypertension, both conditions combined, and those without either, in a tertiary care setting in Pakistan.

Methods: A cross-sectional study was conducted at Aziz Bhatti Shaheed Teaching Hospital, Gujrat, and Mayo Hospital, Lahore, from March 2022 to April 2023. A total of 100 adult patients who underwent clean or clean-contaminated surgeries were included and divided into four groups: Group A (diabetic only), Group B (hypertensive only), Group C (both diabetic and hypertensive), and Group D (controls). Patients were followed on postoperative days 3, 7, and 14 for wound healing assessment. Outcomes measured included time to complete wound healing, incidence of delayed healing, surgical site infections (SSIs), and need for debridement. Data were analyzed using SPSS version 26.0.

Results: Group C exhibited the poorest outcomes with the longest mean healing time (15.4 ± 3.1 days), highest delayed healing rate (60%), highest SSI incidence (52%), and greatest need for debridement (40%). Group A and B showed moderate impairment, while Group D had the most favorable healing profile. All differences were statistically significant ($p < 0.05$).

Conclusion: Diabetes and hypertension, particularly in combination, significantly impair surgical wound healing. Preoperative optimization and postoperative vigilance are essential for improving outcomes in these high-risk patients.

Keywords: Surgical wound healing, diabetes mellitus, hypertension, wound infection, delayed healing, comorbidities.

INTRODUCTION

Surgical wound healing is a complex and tightly regulated physiological process that plays a pivotal role in patient recovery and the overall success of surgical interventions. It encompasses four overlapping phases hemostasis, inflammation, proliferation, and remodeling each of which must occur in a controlled and sequential manner for optimal tissue repair[1]. Any disruption or delay in these phases can result in poor wound healing, increased susceptibility to infections, wound dehiscence, chronic wound formation, and prolonged hospital stays. Among the many factors known to influence surgical wound healing, systemic comorbidities such as diabetes mellitus and hypertension are particularly significant due to their high prevalence and profound effects on vascular, immune, and metabolic functions[2].

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia, which impairs wound healing through multiple mechanisms. It leads to microvascular and macrovascular complications that compromise tissue perfusion, reduces leukocyte chemotaxis and phagocytosis, and delays fibroblast proliferation and collagen synthesis[3]. These pathophysiological changes collectively delay granulation tissue formation and epithelialization, while also increasing the risk of surgical site infections and wound breakdown. In addition, diabetic patients often present with peripheral neuropathy, which can mask early signs of wound complications, further exacerbating the clinical course[4].

Hypertension, although not traditionally considered a direct impediment to wound healing, contributes significantly to poor outcomes through its effects on the vascular endothelium. Chronic elevated blood pressure induces arterial wall thickening, reduces capillary density, and impairs tissue oxygenation[5]. These vascular alterations hinder nutrient delivery to the surgical site, delay angiogenesis, and may contribute to the formation of ischemic or necrotic tissue, particularly in wounds with high tension or compromised blood supply. Furthermore, in hypertensive patients undergoing surgery, there is a higher risk of hematoma formation and wound edema due to altered vascular integrity and increased hydrostatic pressure[6].

When diabetes mellitus and hypertension coexist, their combined pathophysiological burden exerts a synergistic negative effect on surgical wound healing. The compounded microvascular dysfunction, oxidative stress, and immune dysregulation in such patients lead to a higher incidence of postoperative complications, including infections, wound dehiscence, abscess formation, and delayed closure. Despite improvements in surgical techniques and perioperative care, these comorbidities remain persistent obstacles to achieving favorable healing outcomes, particularly in resource-constrained settings[7].

In Pakistan, the burden of non-communicable diseases like diabetes and hypertension has been steadily increasing, particularly in the adult population. This epidemiological shift has important implications for surgical practice, where clinicians are frequently managing patients with multiple comorbidities. However, local studies evaluating the direct impact of these conditions on surgical wound healing remain scarce. Most existing data are either extrapolated from Western populations or lack clinical specificity regarding wound-related outcomes. There is a clear need for regional evidence to guide clinicians in identifying at-risk patients, implementing targeted perioperative management strategies, and improving surgical outcomes[8].

Therefore, this cross-sectional study was designed to assess the outcomes of surgical wound healing among patients with diabetes, hypertension, both conditions combined, and those without these comorbidities. By analyzing clinical data from a diverse surgical population, this study aims to provide insight into the extent to which these systemic diseases affect healing dynamics, infection rates, and the need for secondary wound interventions. The ultimate goal is to inform risk stratification models, enhance postoperative monitoring protocols, and contribute to the development of evidence-based strategies

Received on 10-05-2023
Accepted on 11-08-2023

tailored to the needs of patients in the Pakistani healthcare system[9].

MATERIALS AND METHODS

This cross-sectional analytical study was carried out at two major tertiary care public sector hospitals in Punjab, Pakistan: Aziz Bhatti Shaheed Teaching Hospital, Gujrat, and Mayo Hospital, Lahore. The study duration extended from March 2022 to April 2023, covering a period of thirteen months. Ethical approval was obtained from the respective Institutional Review Boards prior to the commencement of data collection. All participants provided written informed consent after being briefed on the purpose of the study, their right to confidentiality, and the voluntary nature of participation.

A total of n=100 adult patients who underwent clean or clean-contaminated elective or emergency surgical procedures during the study period were enrolled using non-probability consecutive sampling. Patients were stratified into four groups based on their comorbid status: Group A included patients with type 2 diabetes mellitus only; Group B consisted of patients with hypertension only; Group C included those with both diabetes mellitus and hypertension; and Group D served as the control group, comprising patients without either condition. The diagnoses of diabetes and hypertension were confirmed through clinical records and the use of antidiabetic or antihypertensive medications.

Patients aged 18 years or older, of either gender, and undergoing any clean or clean-contaminated surgery under general or regional anesthesia were eligible for inclusion. Exclusion criteria involved patients with chronic systemic conditions such as chronic kidney disease, chronic liver disease, malignancies, autoimmune disorders, or immunodeficiency states such as HIV/AIDS. Also excluded were individuals on long-term immunosuppressive drugs or corticosteroids, patients with existing chronic ulcers, infected wounds at the time of surgery, or those undergoing contaminated or dirty procedures. Pregnant women and patients with incomplete follow-up data were also excluded to reduce confounding variables.

Demographic and clinical data were collected through patient interviews, physical examinations, and hospital records. Parameters included age, sex, body mass index (BMI), duration and classification of comorbidities, type of surgery, wound classification according to CDC guidelines (clean or clean-contaminated), surgical duration, and anesthesia type. Baseline fasting blood glucose levels and blood pressure readings were recorded preoperatively. All patients were followed prospectively for postoperative wound healing assessment.

Wound healing outcomes were assessed clinically by trained surgical residents under senior supervision on postoperative day 3, day 7, and day 14. Wound condition was evaluated based on erythema, local warmth, edema, discharge, gaping, formation of granulation tissue, and time to complete epithelial closure. Delayed wound healing was defined as failure of the wound to close within 10 postoperative days in the absence of infection. The presence of surgical site infection (SSI) was determined by clinical signs such as purulent discharge, erythema, tenderness, local swelling, and systemic signs such as fever, along with laboratory confirmation if wound swab cultures were taken. Any patient requiring further intervention such as wound debridement, drainage, or re-suturing was recorded separately.

All patients were instructed to return for follow-up visits on specified days unless urgent evaluation was needed earlier due to wound-related complications. Those who exhibited infection or delayed healing received appropriate medical or surgical intervention. Antibiotic therapy was administered empirically and adjusted based on wound culture sensitivity if indicated.

Data were entered and analyzed using IBM SPSS Statistics version 26.0. Continuous variables such as age, BMI, and wound healing time were expressed as mean ± standard deviation (SD), while categorical variables including gender distribution, presence of infection, and requirement for secondary intervention were presented as frequencies and percentages. One-way Analysis of Variance (ANOVA) was used to compare means across the four groups for continuous variables, while the Chi-square test was employed for categorical comparisons. A post-hoc Tukey's HSD test was conducted to further analyze intergroup differences where ANOVA results were significant. A p-value less than 0.05 was considered statistically significant.

To ensure reliability and minimize observer bias, the same surgical team followed a standardized protocol for wound assessment throughout the study. Inter-observer discrepancies were minimized by joint evaluations, and data completeness was maintained with no cases lost to follow-up during the observation period. This methodological approach ensured the generation of consistent and reliable data to evaluate the impact of diabetes and hypertension on surgical wound healing outcomes.

RESULTS

A total of 100 patients who underwent clean or clean-contaminated surgical procedures were included in the final analysis. Among them, 58 were male and 42 were female, with an overall male-to-female ratio of approximately 1.4:1. Gender distribution across the groups showed no statistically significant difference, indicating balanced representation. Males were slightly predominant in all groups except Group D, where the gender distribution was more even. This distribution allowed for an unbiased assessment of wound healing outcomes in relation to diabetes and hypertension, without confounding gender bias.

Patients were divided equally into four groups: Group A (diabetic only), Group B (hypertensive only), Group C (both diabetic and hypertensive), and Group D (controls with neither condition). The mean age across all participants was 53.7 ± 9.8 years, with Group C comprising older patients on average. Obesity, measured by BMI, was slightly more prevalent in the comorbid group, which may further contribute to impaired healing. The type of surgeries performed was similar across all groups, with a majority being abdominal and soft tissue procedures under general anesthesia.

Table 1: Baseline Demographic and Clinical Characteristics of the Study Population

Variable	Group A (Diabetic)	Group B (Hypertensive)	Group C (Both)	Group D (Control)	p-value
Mean Age (years)	55.2 ± 7.6	54.8 ± 8.3	58.1 ± 6.7	46.6 ± 9.1	<0.001
Gender (Male)	15 (60%)	14 (56%)	16 (64%)	13 (52%)	0.680
Gender (Female)	10 (40%)	11 (44%)	9 (36%)	12 (48%)	
BMI (kg/m²)	28.2 ± 3.3	27.6 ± 2.9	29.0 ± 3.1	26.8 ± 2.5	0.041
Clean surgeries (%)	16 (64%)	17 (68%)	15 (60%)	18 (72%)	0.778
Clean-contaminated (%)	9 (36%)	8 (32%)	10 (40%)	7 (28%)	

Table 2: Comparison of Wound Healing Outcomes Across Study Groups

Outcome	Group A	Group B	Group C	Group D	p-value
Mean Healing Time (days)	12.1 ± 2.5	11.3 ± 2.2	15.4 ± 3.1	8.5 ± 1.9	<0.001
Delayed Healing (%)	9 (36%)	7 (28%)	15 (60%)	3 (12%)	0.002
Surgical Site Infection (%)	6 (24%)	5 (20%)	13 (52%)	2 (8%)	<0.001
Need for Debridement (%)	3 (12%)	2 (8%)	10 (40%)	0 (0%)	<0.001

As seen in Table 1, the groups were comparable in terms of gender distribution ($p = 0.680$), while a significant difference was observed in mean age ($p < 0.001$), with the control group being relatively younger. A statistically significant variation in BMI was also noted across the groups ($p = 0.041$), with Group C having the highest mean BMI, which may have contributed to their poor wound healing outcomes.

In evaluating wound healing outcomes, the most critical indicators assessed included the average time required for complete wound closure, the incidence of delayed wound healing, surgical site infections (SSIs), and the need for secondary surgical interventions such as debridement. Patients were followed on postoperative days 3, 7, and 14. Delayed healing was defined as failure to achieve epithelial closure within 10 days in the absence of infection. SSIs were diagnosed based on clinical signs and, where possible, microbiological confirmation.

Group C (patients with both diabetes and hypertension) exhibited the poorest wound healing outcomes, with significantly delayed closure, higher infection rates, and the highest requirement for wound debridement. Group A (diabetics) showed moderate impairment, while Group B (hypertensives) showed mild delay. Group D (control group) demonstrated optimal healing and the lowest complication rate.

As illustrated in Table 2, the mean healing time was significantly prolonged in Group C (15.4 ± 3.1 days), which also had the highest percentage of delayed wound healing (60%). The control group (Group D) showed the shortest healing time (8.5 ± 1.9 days) and the lowest incidence of delayed healing (12%), highlighting the adverse impact of systemic diseases on wound recovery. The rate of surgical site infection was markedly elevated in Group C (52%) compared to the other groups, further corroborating the influence of combined metabolic and vascular comorbidity on wound vulnerability. Similarly, the need for surgical wound debridement was most frequent in Group C (40%), while none of the patients in the control group required additional intervention.

The overall pattern demonstrates that the presence of both diabetes and hypertension is strongly associated with poor wound healing outcomes. These patients not only heal slower but are more prone to infections and complications requiring surgical reintervention. This trend was statistically significant across all primary outcomes, emphasizing the critical need for targeted perioperative optimization, infection control strategies, and closer postoperative surveillance in comorbid populations.

DISCUSSION

The findings of this cross-sectional analysis provide compelling evidence that systemic comorbidities, specifically diabetes mellitus and hypertension, have a profound and statistically significant impact on surgical wound healing outcomes[10]. Patients harboring both conditions exhibited the worst healing profiles, including prolonged time to epithelial closure, a markedly higher incidence of surgical site infections (SSIs), and an increased need for secondary interventions such as wound debridement. These results support the long-standing clinical observation that chronic metabolic and vascular disorders disrupt the normal physiological cascade of wound repair[11].

Diabetes mellitus contributes to impaired wound healing through multiple interlinked mechanisms. Chronic hyperglycemia promotes the formation of advanced glycation end-products (AGEs), which disrupt collagen synthesis and delay tissue regeneration. Microvascular dysfunction, a hallmark of diabetic pathology, limits oxygen and nutrient delivery to the wound bed. Additionally, impaired leukocyte chemotaxis and phagocytosis reduce the host's ability to control microbial contamination, thereby increasing infection susceptibility. This aligns with our study's results, where patients in Group A (diabetes only) had a 36% rate of delayed healing and a 24% incidence of SSIs [12].

Hypertension, while often underappreciated in wound pathology, also interferes with normal healing. Prolonged high blood pressure damages the endothelial lining, leads to vascular rigidity, and reduces tissue perfusion. In this study, patients with isolated hypertension (Group B) exhibited a 28% rate of delayed healing and a 20% infection rate higher than the control group but lower than the diabetic and comorbid groups suggesting a contributory but lesser role in wound healing impairment compared to diabetes [13].

The most notable observation was in Group C, where the coexistence of diabetes and hypertension resulted in compounded deleterious effects. These patients had the highest rate of delayed healing (60%), the highest infection rate (52%), and the greatest need for debridement (40%). These findings indicate a synergistic pathological interaction between impaired glucose metabolism and chronic vascular compromise. Not only is angiogenesis inhibited, but inflammatory responses are dysregulated, and oxidative stress is heightened, creating a highly unfavorable environment for tissue repair [14, 15].

Our results are consistent with existing literature. Several international studies have reported delayed wound healing in diabetic and hypertensive populations, though few have explored the combined effect as rigorously as done in this setting. The present study adds to the limited data from South Asia, particularly Pakistan, and emphasizes the real-world challenges in managing surgical patients with chronic illnesses in resource-constrained environments. In a healthcare system where follow-up compliance is often poor and perioperative optimization is inconsistently applied; such comorbidities can significantly elevate morbidity and prolong hospitalization[16].

The clinical implications of these findings are substantial. First, preoperative risk stratification protocols must rigorously incorporate glycemic and blood pressure control as essential components of surgical planning. Secondly, patients with diabetes and/or hypertension should be flagged for intensive postoperative monitoring, including more frequent wound inspections and lower thresholds for initiating antibiotic therapy or surgical review. Third, interdepartmental collaboration with endocrinology and internal medicine teams should be encouraged in surgical wards to optimize comorbid disease management and enhance outcomes[17, 18].

There are limitations to this study. As a cross-sectional design, causal relationships cannot be definitively established, and long-term wound outcomes beyond the initial two-week follow-up were not assessed. In addition, laboratory confirmation of infections was not uniformly performed due to resource limitations, and microbial sensitivity patterns were not explored. Despite these limitations, the uniform methodology, equal group distribution, and standardized wound assessment provide strong internal validity and contribute significantly to the evidence base on this subject[19].

CONCLUSION

This study clearly demonstrates that diabetes mellitus and hypertension, both independently and in combination, are associated with significantly poorer surgical wound healing outcomes. Patients with both conditions exhibited the longest healing durations, highest rates of surgical site infections, and greatest need for wound-related interventions. These findings highlight the importance of meticulous perioperative control of blood glucose and blood pressure, careful surgical site management, and targeted follow-up in patients with chronic comorbidities. Integration of comorbidity screening into surgical protocols and multidisciplinary patient management can lead to improved outcomes and reduced postoperative complications, particularly in resource-limited healthcare settings like Pakistan. Future prospective studies with longer follow-up periods and microbiological profiling of infected wounds are recommended to build on these findings and guide evidence-based surgical care.

Funding: No funding was received for this study.

Conflicts of Interest: The authors declare no conflicts of interest.
Ethical Approval: Ethical approval was obtained from the relevant Institutional Review Board.
Informed Consent: Written informed consent was obtained from all participants involved in the study.
Authors' Contributions:
R.A: contributed to the study conception, design, and manuscript drafting.
F.H: was responsible for data collection and literature review.
Q.A. L: performed data analysis and interpretation.
S.M: contributed to literature review and referencing.
M.S. F: critically revised the manuscript and provided supervision.
M.I.: conducted the final review and approved the manuscript for publication.
Acknowledgements: The authors express their gratitude to the participants and supporting staff for their cooperation throughout the study.

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This article may be cited as: Ashraf R, Hameed F, Laghari QA, Memon S, Farooq MS, Iqbal M: Surgical Wound Healing Outcomes in Patients with Diabetes and Hypertension. A Cross-Sectional Analysis. Pak J Med Health Sci, 2023;18(9): 158-161.