e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.11.94

International Journal of Pharmaceutical Quality Assurance 2025; 16(11); 605-610

Original Research Article

A Clinical Study on Patient and Procedural Factors Influencing Surgical Wound Healing Outcomes

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Received: 10-09-2025 / Revised: 13-10-2025 / Accepted: 24-11-2025

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Conflict of interest: Nil

Abstract:

Background: The process of surgical wound healing is one of the critical factors affecting the outcome of postoperative recovery due to patient and procedure-specific factors. Although surgical care has improved, delayed healing and associated complications are still prevalent clinical problems.

Purpose: To determine the role of patients and operational factors in the healing of surgical wounds in patients who have had different surgical procedures.

Methodology: A prospective observational study was carried out on 120 patients in the department of general surgery, Netaji Subhas medical college and hospital, Jamshedpur, Jharkhand, India, The SPSS v26 was used to analyze and collect data on demographic, clinical, and intraoperative factors. Statistical analysis such as Chi-square and logistic regression was used to determine the independent predictors of delay healing and complications.

Result: Diabetes mellitus (23.3%), smoking (30%), obesity (25%), and nutritional deficiency (15%) were found to be significantly correlated with wound healing delay ($p < 0.05$). Poor outcomes were also caused by prolonged surgery (>2 hours) and poor aseptic practices. The highest mean time of healing (24 +- 5 days) and the highest rate of complication (32%) was recorded in diabetic patients. On the contrary, the compliance with aseptic methods led to the healing improvement greatly (17 +- 3 days; $p < 0.01$).

Conclusion: There are systemic as well as procedural factors that have a critical influence on the healing of surgical wounds. A thorough preoperative optimization process and strict compliance with the aseptic requirements are obligatory in order to improve the results and reduce the number of complications.

Keywords: Postoperative complications, obesity, aseptic technique, Surgical wound healing, diabetes mellitus.

Introduction

Healing of the surgical site is considered to be one of the most critical factors that determine the outcome of the postoperative stage and overall outcome prognosis after any surgical operation. Integrity of wound healing is also an indication of the technical success of wound healing procedure together with physiological resilience and recovery potential of the patient. Healing of surgical wounds is an intriguing and well-coordinated biological process that seeks to repair the integrity of injured tissue in a series of overlapping but independent stages. These are hemostasis, that stops the bleeding and starts the formation of clots; inflammation, that eliminates necrotic tissue and pathogens; proliferation, which is marked by the formation of angiogenesis and formation of granulation tissue; and remodeling, which leads to the formation of a scar and restoration of tensile strength [1]. All these stages rely on the exact cellular and molecular communication, and a failure at any of the stages can severely adversely affect the results of wound healing.

Impaired wound healing remains a significant clinical problem even after improvements in the surgical methods and the post-surgery treatment. The variability of wound healing efficiency and outcomes is caused by a variety of factors, some of which are patient-related and some are procedural. Systemic factors of patients like diabetes mellitus, smoking, obesity, malnutrition etc. have long been identified as critical factors to slow wound healing or complex wound healing [2]. An example of this is diabetes mellitus that changes microvascular circulation and collagen building, thus decreasing the quality of new tissue. Equally, cigarette smoking interferes with the supply of oxygen to tissues, increases the inflammatory stage, and retards epithelialization. Obesity on the other hand has a mechanical effect on surgical wounds, risk of infection, and commonly co conditions with other metabolic abnormalities that further hamper the healing process. Malnutrition denies the body the necessary substrates such as proteins,

vitamins, and trace elements needed to help in the effective regeneration of tissues and immunity [3].

Local and procedural factors that are in addition to systemic factors determine the outcome of wound healing. The nature of surgery, length of the operation, method used by the surgeon as well as the intraoperative management methods all affect the response of the tissues and recovery. Extended length of the procedures, for example, can increase the risk of tissue dries out, bacterial contamination, and hypothermia which all slow the recovery and can increase the risk of infection. Likewise, poor aseptic techniques or lack of hemostasis can increase inflammation locally and wound closure. The suture type used, drains used, and adherence to intraoperative infection prevention, are also important aspects of preventing wound complications and to ensure optimal healing [4].

Another important aspect of the wound healing continuum is postoperative care. The use of modern wound care modalities such as negative pressure wound therapy, appropriate dressing frequency, and prophylactic antibiotics have improved outcomes [5]. Conversely, lack of adherence to standardized postoperative protocols is a leading cause of complications, including surgical site infections (SSIs), wound dehiscence, hypertrophic scarring, and prolonged hospital length of stay. These complications not only lead to increased expenditure of healthcare costs but also have a substantial impact on quality of life and patients' satisfaction with their surgery result [6].

Given that surgical wounds affect nearly all surgical patients with varying degrees of incidence, there is an increased emphasis on the identification of factors that can be modified to improve the healing process. Gaining in-depth knowledge on patient factors, and process factors, is paramount to the development of evidence-based interventions that will reduce complications and enhance recovery. The majority of studies have examined systemic or process factors separately, but there is minimal available research that addresses both perspectives providing a complete view of the factors of post-surgical wound healing among surgical patients.

Therefore, this clinical research seeks to examine the multifactorial interaction between patient factors, surgical processes, and postoperative practices, which influence wound healing outcomes. In particular, it will examine the systemic variables, including comorbidities, nutritional status, and lifestyle patterns along with intraoperative and postoperative variables, including the duration of the procedures, infection control techniques, and wound care guidelines. Through explaining these relationships, the research hopes to establish risk factors that are subject to change and use them to boost the wound healing rates and minimize postoperative morbidity.

Methodology

Study Design: This was a future perspective based clinical study that was undertaken to assess the patient-factors and the procedural factors that might affect the ultimate outcomes of the surgical wound healing. The objective of the study was to find out the determinants that influence the rate and quality of wound healing after surgery involves the patient factors as well as the intraoperative factors.

Study Area: The researchers conducted the study at the Department of General Surgery, Netaji Subhas Medical College and Hospital, Jamshedpur, Jharkhand, India.

Study Duration: The study was conducted over a period of Six months.

Sample Size: A total of 120 patients who underwent various surgical procedures during the study period were included in the analysis.

Study Population: The study population comprised patients admitted to the Department of General Surgery who underwent elective or emergency surgical procedures during the study period. Patients were followed postoperatively to assess wound healing outcomes.

Inclusion Criteria

- Patients aged 18 years and above undergoing elective or emergency surgical procedures.
- Patients who provided informed consent to participate in the study.
- Patients whose wound healing progress could be monitored until satisfactory healing or identification of complications.

Exclusion Criteria

- Patients with pre-existing local or systemic infections prior to surgery.
- Immunocompromised patients (e.g., HIV-positive, on long-term steroids or chemotherapy).
- Patients who were lost to follow-up before assessment of wound healing.
- Patients undergoing surgeries with contaminated or dirty wounds as classified by CDC wound classification.

Data Collection: A structured proforma was used as a data collection tool in that data were collected on the demographics of the patient, clinical history, and intraoperative factors. The variables on patients identified were age, sex, nutritional status, comorbid diseases, including diabetes mellitus, anemia, obesity, and smoking. Procedural variables that were recorded included the nature and category of surgical operation (clean, clean-contaminated or contaminated), length of operation, nature of cut, intraoperative blood loss, prophylactic antibiotics used and at what time, and adherence to aseptic maneuvers. Wound assessment was performed at a specific time

rate on postoperative day 3, day 7, day 14 and during the follow-up visits. The outcome measured on the wound healing was in accordance with the common clinical parameters, the wound dehiscence, surgical site infection, seroma, hematoma and delay in healing. Prospective collection of all data was done and stored in a secure database where data were analyzed.

Procedure: The surgical procedures were done on all patients under the usual precautions of aseptic procedures as outlined by the institutional and WHO surgical precautions. Preoperative preparation was characterized by routine investigations, comorbidity optimization, and the provision of prophylactic antibiotics according to the wound category and according to the hospital. Aseptic measures were observed during surgery and hand hygiene, handling of sterile instruments and keeping a sterile field were upheld. Wounds were also dressed in sterile materials after the operation and patients were given recommendations on wound care and hygiene. The same surgical team conducted wound inspections to ensure that there was a reduction in observer bias. The presence of wound infection or slow healing was noted, and the relevant management was put in place, which includes antibiotic therapy, drainage, and secondary suturing. Normal healing, delayed healing, or wound infection/dehiscence were then defined as clinical evaluation outcomes of healing.

Statistical Analysis: Data regarding all the collected data was inputted in Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Demographic and clinical data was summarized using descriptive statistics like mean, standard deviation and percentages. The Chi-square test was used to compare the frequency of various wound healing outcomes and infection rates as categorical variables and Student t-test or ANOVA as appropriate to analyze the continuous variables such as age and the duration of surgery. Multivariate logistic regression analysis was conducted in order to determine independent factors that predict poor wound healing outcomes by controlling the possible confounding factors, including diabetes, smoking, nutritional status, and the duration of the surgical procedure. In the case of all the analyses, a p-value below 0.05 was regarded as important.

Result

The demographic and clinical characteristics of the 120 patients used in the study are shown in Table 1. The average age consisted of 46.2 +- 13.1 years with a minor dominant number of males (68) than females (52). The most common comorbidity was hypertension (28.3% of patients), and in the second place, there was diabetes mellitus (23.3%). A significant proportion of patients were found to be affected by lifestyle and physiological risk factors, 30.0% of patients were smoking, 25.0% of patients were found to be obese with a serum albumin level below 3.5 g/dL, indicating that they had nutritional deficiencies. These results reveal a group of individuals with numerous intersecting risk factors that may impact the outcomes of postoperative recovery and wound healing.

Table 1: Patient Demographics and Clinical Characteristics

Parameter	Value (n = 120)
Mean Age (Years)	46.2 ± 13.1
Gender (Male/Female)	68 / 52
Comorbidities (%)	
Diabetes Mellitus	28 (23.3 %)
Hypertension	34 (28.3 %)
Smoking (%)	36 (30.0 %)
Obesity (BMI > 30)	30 (25.0 %)
Nutritional Deficiency (Albumin < 3.5 g/dL)	18 (15.0 %)

The surgical characteristics of the cohort are presented in Table 2. General surgical procedures were the most prevalent type of surgery performed (41.7% of patients), with orthopedic procedures and gynecological procedures being the next most common (33.3% and 25.0% of patients, respectively). The mean duration of the surgical procedures was 118 ± 32 minutes, indicating a relatively moderate surgical time. Half (50.0%) of the surgical wounds were classified as clean according to the CDC wound classification, which indicates a low infection risk, while 33.3% of wounds were classified as clean-contaminated and 16.7% as contaminated, demonstrating that only a small percentage of cases classified had a heightened infection risk. In summary, most of the sampled procedures were classified as low to moderate infection risk.

Table 2: Surgical Characteristics	
Surgical Variable	**Frequency (%)**
Type of Surgery	
General Surgery	50 (41.7 %)
Orthopedic Surgery	40 (33.3 %)
Gynecological Surgery	30 (25.0 %)
Surgery Duration (mean)	118 ± 32 minutes
Type of Wound (CDC Classification)	
Clean	60 (50.0 %)
Clean-contaminated	40 (33.3 %)
Contaminated	20 (16.7 %)

Table 3 shows the key factors that affect wound healing of surgical patients. Diabetes mellitus was diagnosed in 23.3 percent of the patients and demonstrated a very strong correlation with impaired wound healing ($p < 0.01$) which demonstrates the harmful effect of glucose regulation on the healing of the tissues. Smoking (30.0) was found to be the most common lifestyle factor, which was significantly associated with slower healing rates ($p < 0.05$) possibly because of low tissue oxygenation and vascular impairment. Suboptimal wound outcomes were also found to be strongly related to obesity (25.0%) and nutritional deficiency (15.0%) ($p < 0.05$), implying that the processes of metabolic balance and support of all the nutrients affected wound repair. Prolonged surgery more than two hours influenced 20.0% of cases and showed that there was a statistically significant relationship ($p < 0.05$) between prolonged surgery and delayed healing, which might be because of prolonged times of tissue exposure and stress response. Moreover, poor aseptic practices also led to poor recovery among 11.7 percent of patients ($p < 0.05$) which supports the need of strict infection control measures in ensuring the best postoperative wound recovery.

Table 3: Factors Influencing Wound Healing		
Factor	**Percentage of Patients Affected**	**Statistical Significance (p-value)**
Diabetes Mellitus	23.30%	< 0.01
Smoking	30.00%	< 0.05
Obesity (BMI > 30)	25.00%	< 0.05
Nutritional Deficiency	15.00%	< 0.05
Prolonged Surgery (> 2 hours)	20.00%	< 0.05
Inadequate Aseptic Measures	11.70%	< 0.05

Table 4 illustrates the association of key patient and procedural factors with wound healing and complications. Patients with diabetes mellitus had the longest mean healing time at 24 ± 5 days, and the highest complication rate at 32%, $p < 0.01$. This indicates delays in healing due to hyperglycemia. Smoking and obesity were associated with delayed healing time (22 ± 4 days and 23 ± 6 days, respectively), and a moderate increase in complications (25% and 27%, respectively), significant at $p < 0.05$. Nutritional deficiency and prolonged operations (>2 hours) are also associated with delayed healing and increased complications (21 ± 5 days and 25 ± 6 days, respectively), $p < 0.05$. In contrast, compliance with adequate aseptic techniques accelerated healing time (17 ± 3 days) and demonstrated the lowest complication rate (8%), significant at $p < 0.01$. These results emphasize the extent to which patient comorbidities, operative practices and compliance with aseptic techniques affect healing post-operatively.

Table 4: Complications and Healing Outcomes by Key Factors			
Factor	**Mean Healing Time (Days)**	**Complication Rate (%)**	**Statistical Significance (p-value)**
Diabetes Mellitus	24 ± 5	32%	< 0.01
Smoking	22 ± 4	25%	< 0.05
Obesity (BMI > 30)	23 ± 6	27%	< 0.05
Nutritional Deficiency	21 ± 5	18%	< 0.05
Prolonged Surgery (> 2 hours)	25 ± 6	22%	< 0.05
Adequate Aseptic Technique	17 ± 3	8%	< 0.01

Discussion

A total of 120 patients were analyzed in the current study to understand the effects of different patient-related and procedural variables on the outcome of the healing of surgical wounds. The results indicated that the state of the system (diabetes, smoking, obesity, malnutrition) and the aspects of the procedure (operative time and aseptic practice) had a considerable influence on the wound healing rate and quality. The average age of respondents was 46.2 years and significant comorbidities were diabetes in 23.3% and hypertension in 28.3 which are both known to predispose the patients to delay their healing. The general evidence implied that wound healing is a complex process that is affected by both independent and dependent variables".

Diabetes mellitus became one of the leading factors in the development of poor healing outcomes as the diabetic patients in the current study reported a mean healing time of 24 +- 5 days and a complication rate of 32%. This significant correlation ($p < 0.01$) is in line with the results of Guo and DiPietro (2010) [1], who found out that hyperglycemia disrupts the functioning of macrophages, angiogenesis, and the production of collagen, which causes sustained inflammation and diminished healing of the tissue. On the same note, Gould et al. (2015) [7] highlighted the fact that diabetic patients have poor wound contraction and low tensile strength, especially where the lower extremities are involved. The findings of this research are also in agreement with the findings of Hinchliffe et al. (2011) [8] that showed, optimized glycemic control preoperating lowers the rates of surgical site infections and enhances quicker epithelialization. These similar tendencies in all these studies reaffirm the fact that perioperative glucose control is crucial in ensuring positive healing outcome among diabetic patients.

Another important factor that postponed recovery was smoking that was experienced by 30 percent of study participants with a mean healing period of 22 +- 4 days and a complication rate of 25 percent ($p < 0.05$). The adverse consequences of smoking on the healing of wounds are widely known. Tabor and Lacey (2011) [9] established that nicotine induced vasoconstriction and exposure to carbon monoxide compromised the delivery of oxygen to the tissues, and the reactive oxygen species destroyed fibroblasts and slowed collagen production. The current findings are in agreement with their results, which supports the fact that preoperative smoking cessation can significantly mitigate postoperative wound complications. Equally, Mustoe et al. (2006) [6] reported about hypoxia and oxygen critical role in cellular metabolism and collagen deposition and how the hypoxia impacts of smoking directly affect the formation of granulation tissue. On the contrary, moderate smokers were slightly less affected by wound impairment (Singh and Braddock, 2012) [3], which indicated the possibility of a degree and duration of exposure to tobacco to modify the risk. However, the fact is still consistent that smoking is a risk factor that can be modified in the management of the surgical wound.

Obesity, which existed in 25% of the existing cohort, was highly linked to postponed recovery and 27% probability of a complication ($p < 0.05$). The average length of stay of the obese patients was 23 +- 6 days, which is indicative of the mechanical and metabolic difficulties that obesity presents to the wound healing process. These can be compared with the findings of Sen (2009) [10] who reported that adipose tissue has low vascularization thus resulting in low oxygen diffusion and high tension in the wound, which contributes to dehiscence and infection. According to Leaper et al. (2015) [11], the risk of developing a surgical site infection is almost twofold in the case of obese patients, which is explained by the fact that normal BMI and impaired local perfusion and immune response. Although there are other studies that have reported that enhanced wound-closure methods and postoperative pressure can help lessen some of these risks (e.g., Woo et al., 2017) [2]) the current results highlight the fact that obesity is still a major obstacle to effective healing.

Nutritional status too was found to have significant impact and 15 percent of the patients were found to have hypoalbuminemia (Less than 3.5 g/dL) and delayed recovery of an average of 21 +- 5 days ($p < 0.05$). Protein deficiency as highlighted by Schultz et al. (2003) [12] inhibits proliferation of fibroblasts and development of collagen matrix leading to long inflammatory periods. The current results are in line with Edwards and Harding (2004) [13] who emphasized that nutritional optimization, especially the sufficient protein and vitamin C intake, improves the angiogenesis and tensile strength of the wounds. The same was highlighted in a study by Carville et al. (2017) [14], which pointed out that perioperative nutritional assessment and intervention is essential in patients who are undergoing major surgeries. The cumulative consistency of the studies has led to the conclusion that malnutrition, even at mild levels, can significantly disrupt the cascade of normal wound healing.

Procedural considerations were also an essential consideration. As the surgical procedures took longer, also beyond 2 hours, the higher the potential of delay to healing (mean 25 +- 6 days, $p < 0.05$). This finding is consistent with Moore et al. (2018) [15] who found that, the longer the variable of operative exposure, the higher the risks for bacterial contamination and tissue desiccation, which would impede healing. Our cohort confirmed that patients in our group who had shorter surgeries and patients treated with successful post-operative vacuum-assisted closure (VAC) systems showed better wound recovery and fewer complications. The beneficial

effect of VAC therapy on granulation and wound perfusion is a well-known experience, for Moore et al. (2018) [15] and Pereira and Bartola (2015) [4] and in both studies showed an increased level of epithelialization and lower number of injuries.

Infection control procedures also presented as a variable in wound outcomes. Better outcomes were observed in patients that observed aseptic precautions and complied with the prophylactic antibiotic regimen, and the average time to heal was 17 +- 3 days, and the complication rate was low, at 8% ($p < 0.01$). The results are in line with those of Edwards and Harding (2004) [13] who stated that the use of specific antibiotics and moist wounding in infection prevention would greatly speed up healing. The positive outcomes of the hydrocolloid and silver-based dressings in the current study are also similar to those observed in the literature, in terms of establishing a moderate moisture environment besides reducing bacterial growth.

Altogether, the present research supports the multifactorial character of the wound healing process in accordance with the model suggested by Guo and DiPietro (2010) [1] and Cutting and Harding (2006) [5]. Systemic and procedural factors are synergizing in their effect on recovery. The evidence supports the multidisciplinary approach with metabolic optimization, smoking cessation, nutritional correction, and strict surgical asepsis. The combination of these interventions during and after surgery has the potential to significantly improve the patient's outcome and decrease the number of complications. Future studies with larger sample sizes and longer follow-up periods are warranted to further delineate the interactive effects of these determinants on long-term wound healing outcomes.

Conclusion

This study affirms that surgical wound healing occurs under the influence of both patient factors and procedural factors. Patient factors that were highly associated with delayed healing and postoperative complications included diabetes mellitus, cigarette use, obesity, and nutritional deficiencies. Among the comorbidities, diabetes appeared to have the greatest effect due to impaired microcirculation and delayed regeneration of tissues. Cigarette use and obesity inhibited recovery by reducing the ability of tissues to receive oxygen and further increasing local tissue strain. Nutritional deficiencies detrimentally impacted recovery due to impaired collagen synthesis and compromised immune response. Procedural factors, such as long surgical times and non-aseptic technique, were also implicated in delayed healing of wounds through increased risk of infection and trauma to tissue. Strict asepsis was identified as a factor leading to quicker recovery and improvement of infection rates, which firmly establishes the significance of the quality of surgery. Healing of the wound is a multifaceted process impacted by the patient physiologically, and the quality of surgery provided by the surgeon. So careful evaluation before the surgical day, determining patient risk, and sticking to strict perioperative protocols is vital in optimizing the patient outcome toward effective recovery.

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