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Closure Techniques and Postoperative Outcomes of Major Lower Limb Amputation in Acute Limb Ischemia

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Abstract

Amputation, derived from the Latin "amputare," refers to the removal of a body part covered by skin, often necessitated by acute limb ischemia (ALI). Effective wound closure is critical for minimizing complications, length of stay, costs, and the risk of re-amputation. This study compared postoperative outcomes of major lower limb amputation in ALI patients with primary versus delayed wound closure. A descriptive analytic study was conducted at Dr. Hasan Sadikin Hospital, Bandung, Indonesia, from January 2020 to December 2023, analyzing medical records of 46 patients aged 19–85 years, with a predominance of female patients. Thrombosis was the leading cause of ALI (76.1%), and hypertension was the most frequent comorbidity. Significant differences were observed in stump complications and revision surgery rates between primary and delayed wound closure groups ($p<0.05$), while length of stay and mortality did not show statistically significant differencesy. In conclusion, the study highlights a significant relationship between different wound closure methods and complications, suggesting that choice of closure technique may influence the postoperative outcomes in ALI patients.

Keywords: Acute limb ischemia (ALI), delayed wound closure, major amputation, primary wound closure

Introduction

Amputation, derived from the Latin word *amputare* (to cut), is defined as the removal of part or all of a body part covered by skin. Amputation involves the process of removing a limb or its part by cutting through one or more bones. Lower limb amputation, defined as the surgical removal of part or all of a limb, remains a major global health concern. Peripheral artery disease (PAD) is the leading cause, followed by trauma, infection, and malignancy. Epidemiological data show that trauma predominates in younger populations and in developing countries, whereas PAD is increasingly responsible for amputations in older adults. Common comorbidities such as hypertension and sepsis further complicate the clinical course and may adversely affect outcomes. Despite advances in surgical techniques and perioperative care, the incidence of lower limb amputation remains substantial, highlighting the need for preventive strategies and comprehensive postoperative management. For upper limb amputations, trauma is the primary cause, accounting for 80% of all amputations.[1] It usually occurs in men aged 15 to 45 years. The second most common causes are cancer/tumors and complications from vascular diseases.

Amputation has significant economic, social, and psychological impacts. Upper limb amputation cases have a higher level of disability compared to lower limb amputations. Different levels of amputation result in varying quality of life outcomes. The more distal the level of amputation, the lower the patient's morbidity rate. It is estimated that 185,000 people undergo amputation in the United States each year, with 45 percent caused by trauma. Other causes include diabetes, vascular diseases, and malignancies. In many low- and middle-income countries, trauma is the leading mechanism for limb amputation. In Indonesia, general epidemiological data on amputation is not yet available; a recent study at RSCM reported that out of 111 DM patients hospitalized due to diabetic foot problems, 35% underwent amputation.[4–7]

Several factors are considered in determining the level of amputation, including local infection at the amputation site, systemic infection,

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contamination of the wound, and the extent of tissue damage around the wound. Therefore, in the management process, a surgeon may choose between two types of techniques for wound closure after amputation: primary wound closure and delayed wound closure. Delayed closure is sometimes preferred over primary closure to reduce the risk of surgical wound infection. In primary closure, the skin is sutured immediately after surgery, whereas in delayed closure, the incision is left open and sutured after 2-5 days.[2,3,8,9]

Amputation with wound closure requires timely intervention to save the life of the patient or prevent life-threatening systemic complications. Moreover, choosing the appropriate wound closure method can reduce complications in amputation cases, length of hospital stays, treatment costs, or the need for re-amputation at a higher level.[6,10]

Meanwhile, at Dr. Hasan Sadikin General Hospital (RSHS), amputation management and wound closure procedures are performed quite frequently. However, precise data on the number and characteristics of patients have never been published, nor has any research been conducted. Furthermore, data on postoperative outcomes comparing primary versus delayed closure have not been found in the Indonesian or West Java population. Therefore, his study aims to evaluate the postoperative outcomes of patients with acute limb ischemia (ALI) undergoing major lower limb amputation, with a focus on differences between primary and delayed wound closure at RSHS.

Methods

This analytical study employed a retrospective, cross-sectional design, with data collected between January 2020 and December 2023. The inclusion criteria were: (1) patients with ALI who underwent major lower limb amputation at RSHS between January 2020 and December 2023; and (2) complete medical records covering all amputations at or proximal to the ankle, including supporting data as required by the variables (including identity, examination findings, supporting examinations, risk factor history, surgical reports). The exclusion criteria were: (1) incomplete medical records that do not meet the required variables; (2) patients under the age of 18 at the time of amputation; and (3) patients who underwent amputation at other hospitals and came to RSHS for follow-up or complication management. Patients were categorized into two groups: (1) patients who underwent amputation with primary wound closure (immediately after amputation); and (2) patients who underwent amputation with delayed wound closure (2-5 days after amputation).

Based on the unpaired comparative analysis formula, the minimum required sample size was 23 patients per group, for a total of 46 patients. Secondary data from medical records served as the primary study instrument, recorded by attending physicians during patient care. This study has obtained ethical approval from the Health Research Ethics Committee of Dr. Hasan Sadikin Hospital Bandung (approval number DP.04.03/D.XIV.6.5/345/2024).

Descriptive analysis was performed to summarize patient characteristics. Categorical variables were presented as frequency (n) and percentage (%), while continuous variables were expressed as median (range). A comparative test will be conducted to examine differences between the two groups. Statistical analysis will begin with a comparison test of the characteristics. Statistical analysis for categorical data will be tested using the Chi-square test if the Chi-square assumptions are met; otherwise, Fisher's exact will be used for 2x2 tables and Kolmogorov-Smirnov tests test for tables other than 2x2. Binary logistic regression was applied when potential confounders were identified. Statistical significance was set at $p \leq 0.05$. Data were analyzed using SPSS version 25.0 for Windows.

Results

This study examines differences in postoperative infection rates, length of stay, and the need for revision surgery based on wound closure techniques, as well as the influence of factors such as age and comorbidities (diabetes, hypertension, sepsis, heart dysfunction, and exposure to COVID-19 cases) on these outcomes. The data analyzed include demographic and clinical information from 46 patients, divided into two groups: those who underwent primary wound closure and those with delayed closure, with ages ranging from 19 to 85 years. Patient characteristics are summarized in Table 1.

Since the data were not normally distributed, a non-parametric test such as the Mann-Whitney U test was used. A p-value of 0.276 was greater than 0.05, which means there was no statistically

Table 1 Subject Characteristics

Variable	Total (n=46)	Group I (primary closure)	Group II (delayed closure)	p-value
Age	57 (22-28)	59 (25-88)	55 (23-86)	0.178
Gender				
Male	19 (41.3%)	10 (43.5%)	9 (39.1%)	0.118
Female	27 (58.7%)	13 (56.5%)	14 (60.9%)	
Cause of ALI				
Trombosis	35 (76.1%)	18 (78.3%)	17 (73.9%)	0.256
Emboli	11 (23.9%)	5 (21.7%)	6 (26.1%)	
Comorbid				
Diabetes mellitus	8 (17.4%)	5 (21.7%)	3 (13%)	
Hypertension	35 (76.1%)	18 (78.3%)	17 (73.9%)	
Sepsis	21 (45.7%)	14 (60.9%)	7 (30.4%)	0.231
Heart problem	14 (30.4%)	8 (34.8%)	6 (26.1%)	
COVID-19	8 (17.4%)	3 (13%)	5 (21.7%)	
Amputation Duration				
<48 hours	4 (8.7%)	2 (8.7%)	2 (8.7%)	
48 hours-1 weeks	39 (84.8%)	19 (82.6%)	20 (87%)	0.123
>1week	3 (6.5%)	2 (8.7%)	1 (4.3%)	

significant difference in the length of stay between Group I and II. The difference between these two groups was not statistically significant at the 5% significance level (p=0.276). Therefore, it can be concluded that there was no significant difference in the length of stay between Group I and II.

The analysis of revision surgery showed a significant difference based on the type of procedure (p=0.016). Based on cross-tabulation

Table 2 Association between Wound Closure Type and Main Outcomes

Variables	Total Data (n=46)	Group I (primary closure)	Group II (delayed closure)	p-value
Duration of stay				
Mean ± SD	17.15	20.96	13.35	
Median	12.50	13.00	12.00	0.276*
Range	66	66	37	
Stump complication				
Yes	16 (34.8%)	12 (52.2%)	4 (17.4%)	0.013**
No	30 (65.2%)	11 (47.8%)	19 (82.6%)	
Mortality				
Lives	17 (37%)	9 (39.2%)	8 (34.8%)	0.760**
Death	29 (63%)	14 (60.8%)	15 (65.2%)	
Amputation Stump Revision				
Yes	11 (23.9%)	9 (39.1%)	2 (8.7%)	0.016**
No	35 (76.1%)	14 (60.9%)	21 (91.3%)	

*Mann-Whitney U Test; **Chi-Square Test

Table 3 Postoperative Outcomes of Major Amputation in Acute Limb Ischemia

Variable	Odds Ratio (Exp(B))	95% CI for Exp(B)	p-value
Stump operation complication	5.182	(1.35–19.84)	0.017
Amputation revision	6.750	(1.30–35.10)	0.025
Mortality	1.205	(0.38–3.85)	0.760
Length of stay	1.105	(0.18–2.85)	0.840

results, primary wound closure (group I) was associated with higher rates of infection (p=0.013). Also, patients in Group I showed a higher rate of revision surgery compared to Group II.

No significant difference was found between the type of procedure (p=0.760) and the mortality rate. Statistical test results showed that the difference in mortality between primary and delayed wound closure groups was not statistically significant, so it can be concluded that the type of procedure does not have a substantial impact on patient mortality.

Normality tests for variables such as surgical wound infection, stump revision, and mortality were conducted using the Shapiro-Wilk test due to the sample size being less than 50, which showed that the data were not normally distributed.

The analysis results highlighted several key findings. First, there was a significant multivariate effect of the procedure type (primary vs. delayed) on overall postoperative outcomes (p=0.024). Second, further univariate analysis revealed that the procedure type significantly affected postoperative stump complications (p=0.032) and revision surgery rates (p=0.006).

Among comorbidities, diabetes was significantly associated with revision surgery (p=0.028), though not with infection rates. Sepsis showed a significant overall effect (p=0.004), but no specific association with individual outcomes. Age, hypertension, heart disease, and COVID-19 exposure were not significantly associated with postoperative outcomes.

Discussion

This study compared postoperative complications of primary versus delayed wound closure in patients undergoing major lower limb amputation for acute limb ischemia (ALI), with particular focus on surgical site infections (SSIs), revision surgery, length of stay, and mortality. Patient-related factors such as age and comorbidities were also evaluated.

Key findings include a statistically significant difference in infection rates between the two groups. Group I (primary closure) had a higher risk of complications compared to Group II (delayed closure), as supported by Chi-square tests (p=0.013) and binary logistic regression (odds ratio=5.182). The higher rate of stump complications in Group I may be attributed to higher prevalence of risk factors such as sepsis and diabetes within this group. Multivariate analysis confirmed that treatment group, sepsis, and diabetes were significant predictors of postoperative complications.

These results are consistent with previous studies. Silva et al. reported that delayed closure reduced infection risk in patients with non-traumatic causes of amputation, particularly those prone to impaired wound healing, such as ALI patients.[11] Katiyar et al. reported that in-hospital infections were detected in 23.3% of cases with primary closure and 27.3% of cases with delayed closure, although this difference was not statistically significant. However, it should be noted that the study conducted by Katiyar et al. focused on subjects with a trauma mechanism, such as injuries from a train collision.[9] The reduced infection rate in delayed closure may be attributed to the strategy of leaving the wound temporarily open, which reduces the chance of infection by preventing bacteria from being trapped under the closed skin flap.[10,12,13]

This study found that patients in the delayed closure group required more revision surgeries compared to the primary closure group. Katiyar et al.[9] found additional surgical procedures such as debridement and amputation revision after stump complications were not statistically significant (20% vs 15.2%; p 0.4). Similarly, the need for amputation revision was also not statistically different (10% vs 12%; p 0.1). The need for additional surgery in the delayed closure group may be related to the nature of the procedure itself, where the initial surgery

is followed by secondary surgery to close the wound. While this approach helps to reduce infection, it also increases the overall number of surgical interventions, potentially increasing morbidity.[6,8,9,14]

This study found no statistically significant difference in the length of hospital stay between the two groups, although the trend showed a longer hospital stay for the delayed closure group. This is in line with the findings of Silva et al,11 who also noted a longer hospital stay for delayed closure (25 vs 16 days, although not statistically significant), possibly due to the need for a second surgery. Katiyar et al.9 also found no statistically significant difference in the length of hospital stay between the groups (10.3 vs 11 days; p 0.78). Although the length of hospital stay was not significantly different, the financial implications of additional surgeries and longer hospital stays need to be considered, especially in hospitals with limited resources.9,15,16

This study found no significant difference in mortality rates between the two groups, despite differences in infection and revision rates. This suggests that while the choice of wound closure technique may affect immediate postoperative complications such as infection and the need for further surgery, they may not have a significant impact on overall survival. However, the study by Silva et al.11 found a lower perioperative mortality rate in patients who underwent delayed wound closure 10.9% vs. primary 20.7%, (p=0.0247) and a lower 30-day mortality rate (12.2% vs. primary 23.8%, p=0.022) despite more cases with Rutherford grades 5 and 6, diabetes, and infection..

The findings of this study have important implications for clinical practice. The higher infection rate associated with primary closure, coupled with the increased need for revision surgery with delayed closure, suggests that the choice of wound closure technique should be tailored to the patient's specific condition. For patients at high risk of infection, such as those with severe ALI or multiple comorbidities, delayed closure may be preferable despite the need for additional surgery. Conversely, in patients who require minimal surgical intervention, primary closure may be considered, with careful monitoring for possible infection.[15–18]

This study has limitations. The relatively small sample size (n=46) limits generalizability, and the retrospective, single-center design carries potential for selection bias. Lack of randomization between groups may also confound results, while unmeasured variables such as severity of ischemia, preoperative optimization, and variations in surgical expertise could influence outcomes. Finally, variations in surgical expertise were not considered, which could significantly impact the results. To enhance the applicability of findings, future multicenter, randomized controlled trials with larger sample sizes and longer follow-up periods are recommended.

In conclusion, the study highlights a significant relationship between wound closure method and complications, suggesting that choice of closure technique can impact postoperative outcomes in ALI patients. While delayed closure may reduce the risk of postoperative infection, this technique also comes with its own challenges, including the need for additional surgery and the possibility of longer hospitalization. Further studies with larger sample sizes and more diverse patient populations are needed to refine these findings and optimize postoperative care in patients undergoing major lower limb amputation due to ALI.

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