RESEARCH ARTICLE

Majalah Kedokteran Bandung (MKB)

pISSN: 0126-074X | eISSN: 2338-6223
https://doi.org/10.15395/mkb.v57.4094
Majalah Kedokteran Bandung. 2025;57(2):148–155

Received: September 2, 2024
Accepted: May 26, 2025
Available online: June 30, 2025

Correlation of Nutritional Status, HbA1c, and Duration of Diabetes Mellitus with Amputation Incidence in Patients with Diabetic Foot Ulcers

Putie Hapsari,[1] Surti Wulan Kharisma,[2] Indra Prasetya Yarman,[1] Ahmad Faried,[3] Teguh Marfen Djajakusumah,[1] Euis Maryani[4]

[1]Division of Vascular and Endovascular Surgery, Department of Surgery, Faculty of Medicine Universitas Padjadjaran/Dr. Hasan Sadikin Hospital Bandung, Indonesia
[2]Department of Surgery, Faculty of Medicine Universitas Padjadjaran/Dr. Hasan Sadikin General Hospital Bandung, Indonesia
[3]Department of Neurosurgery, Faculty of Medicine Universitas Padjadjaran/Dr. Hasan Sadikin Hospital Bandung, Indonesia
[4]Division of Thoracic and Cardiovascular Surgery, Department of Surgery, Faculty of Medicine Universitas Padjadjaran/Dr. Hasan Sadikin Hospital Bandung, Indonesia

Abstract

Diabetic foot ulcer (DFU) is a severe complication of diabetes that significantly impairs quality of life and may often lead to amputation, particularly when infections become extensive. This study investigated the correlation of nutritional status, HbA1c levels, and duration of diabetes exposure with the incidence of amputation in DFU patients. Using an observational analytic study with a retrospective cohort design, data from 47 DFU patients treated at the Vascular and Endovascular Surgery clinic and Emergency Room of a hospital from 2019-2024 were analyzed. The majority of subjects were men aged 40-60 years (59.57%). Among the amputee group, 55.31% experienced neuropathy, primarily classified as Wagner's degree 4. Patients requiring amputation had significantly higher levels of urea, creatinine, and leukocytes compared to those who did not. A significant correlation was observed between the incidence of amputation and nutritional status—specifically, serum albumin ($r = -0.616$) and Body Mass Index (BMI) ($r = 0.823$)—as well as HbA1c levels ($r=0.806$) and duration of diabetes exposure ($r=0.445$) ($p<0.05$). However, the Subjective Global Assessment (SGA) did not show a significant relationship with amputation incidence. The findings of this study suggest that nutritional status, HbA1c levels, and duration of diabetes exposure are significantly correlated with the likelihood of amputation in patients with diabetic foot ulcers (DFU).

Keywords: Amputation, diabetes mellitus, diabetic foot ulcer, HbA1c, nutritional status

Introduction

Diabetic Foot Ulcer (DFU) is a severe complication of Diabetes Mellitus (DM), occurring when a diabetic patient develops a wound. It results from the loss of sensory and motor neuropathy, peripheral vascular disorders, and prolonged infections.[1] Globally, DM affects 9.3% of the population and is among the top 10 deadliest diseases. DFU prevalence is highest in the U.S. (13%), followed by Africa (7.2%), Asia (5.5%), and Europe (5.1%).[2] In Indonesia, there is no specific data on DFU prevalence, but DM cases are expected to increase by 8.2 million by 2020.[3] Amputation is a significant risk for DFU patients, with one limb lost every 30 seconds worldwide, and high mortality rates following amputation (14.3% within a year and 37% within three years).[4]

Around 25% of DM patients may develop DFU, and 16% of those may require amputation if not treated properly.[5] Poor nutritional status and high HbA1c levels (>10%) are major factors affecting wound healing and increasing

Corresponding Author:
Surti Wulan Kharisma
Department of Surgery Faculty of Medicine, Universitas Padjadjaran/Dr. Hasan Sadikin General Hospital Bandung, Indonesia
Email: surtiwulank@gmail.com

amputation risk.[6] Diabetic foot ulcers are one of the common complications in diabetes patients and are a complication of diabetes mellitus that can lead to increased hospital care costs.[7] The high prevalence of DFU among DM patients indicates inadequate prevention and treatment. This is the first study to analyze the significance of nutritional status, HbA1c levels, and duration of DM exposure with risk of amputation in West Java. This study aims to analyze the correlation between nutritional status, HbA1c levels, and the duration of DM exposure with the risk of amputation in patients at Dr. Hasan Sadikin Hospital Bandung, Indonesia.

Methods

This study is an observational analytic study with a retrospective cohort design. All samples that meet the inclusion criteria and are not exposed to the exclusion criteria are included as research subjects. The subjects of this study are patients with diabetic foot ulcers (DFU) who received treatment at the Vascular and Endovascular Surgery Clinic and the Emergency Department of Dr. Hasan Sadikin General Hospital from January 2019 to June 2024. The subjects involved in this study are those who meet the inclusion criteria and are not affected by the exclusion criteria.

Patients included in this study are patients diagnosed with diabetic foot ulcers (DFU), who seek treatment at the Vascular Surgery Clinic and Emergency Department of RSHS, aged above 18 years, and diagnosed with Type 2 Diabetes Mellitus. Patients who are pregnant, patients with incomplete medical records, patients with a history of prior amputation are excluded in this study. Data on the characteristics of the subjects are collected from patient medical records. The sampling process is carried out using the consecutive sampling method.

This study was approved by the Health Research Ethics Committee of Dr. Hasan Sadikin General Hospital, Bandung, under the reference number DP.04.03/D.XIV.6.5/38/2024. The study prioritizes key ethical aspects, particularly the confidentiality of patient medical records.

Data normality was assessed using the Shapiro–Wilk test. Statistical tests were then applied to evaluate relationships between numerical and categorical variables. Correlation strength is evaluated using Guilford's criteria. Correlation direction and p-values determine significance, with $p \le 0.05$ indicating statistical significance. Data are analyzed using SPSS version 24.0 for Windows.

Result

This study is a retrospective cohort study conducted at Dr. Hasan Sadikin General Hospital Bandung, using data from 2019 to 2024. It includes 47 patients who met the inclusion criteria, with no exclusions. Data collected and analyzed include age, gender, neuropathy, Wagner grade, levels of urea, creatinine, leukocytes, and blood. Nutritional status variables assessed include albumin levels, BMI, and SGA scores. The study also evaluates HbA1c levels, duration of diabetes exposure, and amputation occurrences. Table 1 shows that most patients are 40–60 years old and predominantly male. Neuropathy is common, especially in those needing amputation (55.3%) compared to those who don't (14.9%). Most amputations are Wagner grade 4, and patients requiring amputation have higher levels of urea, creatinine, and leukocytes. This study also divides amputations into major and minor categories, with a higher prevalence of major amputations among working-age patients. Major amputation patients have significantly higher urea, creatinine, and leukocyte levels.

Table 1 also indicates that amputated patients have lower serum albumin (1.40 g/dL) compared to non-amputated ones (1.99 g/dL), with major amputation patients having the lowest levels (1.35 g/dL). BMI is higher in the amputated group, with the highest average BMI found in major amputation patients. Most subjects are classified as SGA B, with a consistent distribution of SGA type C across amputation groups.

In this study, nutritional status variables showed a normal distribution and were analyzed using Spearman's correlation. Significant correlations were found: serum albumin had a strong negative correlation with amputation risk ($r=-0.6$, $p<0.001$), while BMI had a very strong positive correlation with amputation risk ($r= 0.8$, $p<0.001$). Chi-Square tests showed that SGA was not significantly related to amputation ($p>0.05$).

Table 3 shows that HbA1C levels are significantly higher in the amputation group compared to the non-amputation group. Within the amputation group, those requiring major amputation have higher average HbA1C levels than those requiring minor amputation. The highest HbA1C level observed was 9.80% in the major amputation group.

The study found that HbA1c levels are normally distributed, with Spearman correlation

Table 1 Subject Characteristics

Variable	Total (n=47)	Not amputated	Amputated	Minor Amputation	Major Amputation
Age (year)					
<40	1 (2.1)	0	1 (2.1)	1 (2.1)	0
40–60	8 (59.6)	12 (25.5)	16 (34.0)	5 (10.6)	11 (23.4)
>60	18 (38.3)	7 (14.9)	11 (23.4)	3 (6.4)	8 (17.0)
Sex					
Male	24 (51.1)	12 (25.5)	12 (25.5)	3 (6.4)	9 (19.1)
Female	23 (48.9)	7 (14.9)	16 (34.0)	6 (12.8)	10 (21.3)
Neuropathy					
Yes	33 (70.2)	7 (14.9)	26 (55.3)	8 (17.0)	18 (38.3)
No	14 (29.8)	12 (25.5)	2 (4.3)	1 (2.1)	1 (2.1)
Wagner Classification					
Grade 1	1 (2.1)	1 (2.1)	0	0	0
Grade 2	4 (8.5)	4 (8.5)	0	0	0
Grade 3	13 (27.7)	10 (21.3)	3 (6.4)	1 (2.1)	2 (4.3)
Grade 4	26 (55.3)	4 (8.5)	22 (46.8)	7 (14.9)	15 (31.9)
Grade 5	3 (6.4)	0	3 (6.4)	1 (2.1)	2 (4.3)
Ureum (mg/dL)					
Mean ± SD	80.3±43.9	40.0±21.3	107.5±32.6	99.8±24.3	111.2±35.9
Median (Range)	80.4 (11.2–177.4)	38.0 (11.2–80.4)	96.3 (64.7–177.4)	98.4 (68.0–133.4)	95.0 (64.7–177.4)
Creatinine (mg/dL)					
Mean ± SD	1.4 ± 0.5	0.9 ± 0.3	1.8 ± 0.3	1.7 ± 0.2	1.8 ± 0.3
Median (Range)	1.5 (0.5–2.4)	0.9 (0.5–1.3)	1.8 (1.3–2.4)	1.8 (1.3–2.1)	1.8 (1.4–2.4)
Leucocyte (mm^3)					
Mean ± SD	23,909.4 ± 10,526.0	14,243.7 ± 5,812.2	30,468.2 ± 7,475.9	22,725.6 ± 2,180.3	34,135.8 ± 6,127.6
Median (Range)	23,980 (7,320–47,050)	13,160 (7,320–33,800)	28,655 (19,300–47,050)	23,340 (19,300–25,220)	34,780 (25,320–47,050)
Serum albumin (g/dL)					
Mean ± SD	1.6 ± 0.5	2.0 ± 0.5	1.4 ± 0.3	1.5 ± 0.3	1.4 ± 0.3
Median (Range)	1.6 (0.9–3.0)	2.0 (1.3–3.0)	1.4 (0.9–1.9)	1.4 (1.2–1.9)	1.3 (0.9–1.9)
BMI (kg/m^2)					
Mean ± SD	24.9 ± 4.4	20.8 ± 2.1	27.7 ± 3.1	28.3 ± 3.3	27.4 ± 3.1
Median (Range)	25.4 (18.2–35.2)	19.8 (18.2–24.7)	26.8 (22.8–35.2)	28.7 (23.5–33.6)	26.7 (22.8–35.2)
Subjective Global Assessment (SGA)					
A (Well Nourished)	10 (21.3)	4 (8.5)	6 (12.8)	2 (4.3)	4 (8.5)
B (Moderate Malnourished)	34 (72.3)	14 (29.8)	20 (42.6)	6 (12.8)	14 (29.8)
C (Severe Malnourished)	3 (6.4)	1 (2.1)	2 (4.3)	1 (2.1)	1 (2.1)

Table 2 Correlation Between Nutritional Status and Amputation Incidence

Variable	Total (n=47)	Not amputated	Amputated	p-value	r value
Serum albumin (g/dL)				<0.001	–0.6
Mean ± SD	1.6 ± 0.5	2.0 ± 0.5	1.4 ± 0.3		
Median (Range)	1.6 (0.9–3.0)	2.0 (1.3–3.0)	1.4 (0.9–1.9)		
BMI (kg/m^2)				< 0.001	0.8
Mean ± SD	24.9 ± 4.4	20.8 ± 2.1	27.7 ± 3.1		
Median (Range)	25.4 (18.2–35.2)	19.8 (18.2–24.7)	26.8 (22.8–35.2)		
SGA				0.071	
A (Well nourished)	10 (21.3)	4 (8.5)	6 (12.8)		
B (Moderate malnourished)	34 (72.3)	14 (29.8)	20 (42.6)		-
C (Severe malnourished)	3 (6.4)	1 (2.1)	2 (4.3)		

Table 3 HbA1c Status Characteristics by Amputation Status

Variable	Total	Not amputated	Amputated	Minor Amputation	Major Amputation
HbA1c (%)					
Mean	7.7	6.4	8.6	8.0	8.8
Standard deviation	1.4	0.5	0.3	0.6	0.7

analysis showing a very strong relationship (r=0.8) between HbA1c levels and amputation incidence (p<0.001). Higher HbA1c levels correlate with a greater likelihood of amputation (Table 4).

Table 5 shows a nearly 3-year difference in diabetes duration between amputated and non-amputated groups. However, minor amputations have a higher average duration of diabetes exposure compared to major amputations. The maximum duration observed is 12 years in the major amputation group.

The analysis of diabetes duration, which is normally distributed, used Spearman's correlation test. Results indicate a significant correlation with a p-value less than 0.05 (p= 0.001) and a moderate correlation coefficient (r=0.4). This suggests that a longer duration of diabetes exposure increases the likelihood of amputation.

Discussion

Diabetes Mellitus (DM) is a chronic condition with rising prevalence, leading to significant morbidity and mortality. Complications like circulatory disorders and neuropathy can cause chronic wounds and infections, potentially resulting in limb amputation. Amputation impacts patients' quality of life and adds economic and psychological burdens. This study

Table 4 Correlation of HbA1c Levels With Amputation Incidence

	Total	Not Amputated	Not amputated	p-value	r value
HbA1c (%)					
Mean ± SD	7.7±1.4	6.4±0.5	8.6±0.3	<0.001	0.8

Table 5 Characteristics of Duration of DM Exposure

Variable	Total	Not amputated	Amputated	Minor Amputation	Major Amputation
Duration of DM (years)					
Mean	6.0	4.5	7.1	7.3	6.9
Standard deviation	2.9	2.6	2.7	2.7	2.8

Table 6 Correlation of DM Duration with Amputation Incidence

Variable	Total (N)	Not amputated	Amputated	p-value	r value
Duration of DM (years)					
Mean ± SD	6.0±2.9	4.5±2.6	7.1±2.7	0.001	0.4

identifies factors influencing amputation risk in DM patients to aid in prevention and early intervention. Data is categorized into major and minor amputations to enhance understanding and improve preventive measures.

The majority of DM patients in this study were within the working-age group (40–60 years), accounting for 59.57% of cases. This finding aligns with research by Abbott et al., which noted that DM tends to manifest at a younger age in Asian populations compared to African and Caucasian groups.[8] Diabetic neuropathy is three times more common in patients requiring amputation compared to those who do not. Neuropathy leads to poor circulation in the feet, causing loss of pain sensation and increasing the risk of infections and ulcers. Perveen's research indicates 50% of DM patients experience neuropathy.[9]

DM can damage small blood vessels in the kidneys, impairing their function and leading to elevated blood urea and creatinine levels, which are markers of kidney function. Higher levels are observed in major amputation cases compared to minor ones, and Gazzaruso et al. research supports these findings.[10] Elevated leukocyte levels, indicating inflammation or infection, are also twice as high in patients needing amputation. Jiang et al. found a link between increased leukocytes and a higher risk of major amputation.[11]

The leukocyte data aligns with findings showing that most amputated subjects have a Wagner grade of 4, indicating localized gangrene due to infection and circulation issues. This mirrors Wang et al.[12] research, which found most surgical patients had Wagner ≥ 3.

Significant differences were found in average serum albumin levels between amputated and non-amputated patients. Non-amputated patients had higher average serum albumin (1.99 g/dL) compared to amputated patients (1.40 g/dL). This suggests that higher serum albumin levels are associated with a lower risk of amputation, as serum albumin is a key indicator of nutritional and overall health status. These findings are consistent with Gulcu et al. in Turkey, which identified a significant relationship between albumin levels and amputation risk in diabetic patients. Lower albumin levels correlate with higher amputation risks ($p < 0.05$).[12]

Low serum albumin may indicate protein metabolism disorders, liver dysfunction, or malnutrition, leading to decreased tissue strength, infection resistance, and wound healing, thereby increasing amputation risk. This study observed that patients requiring major amputations had lower average serum albumin levels than those needing minor amputations. The relationship between serum albumin and amputation risk can be attributed to its role in transporting essential substances and reflecting nutritional and liver health. Low albumin levels may worsen vascular and neuropathic complications in diabetes, increasing amputation risk.[13] Chronic inflammation and underlying health conditions can also elevate amputation risk. Chronic inflammation associated with type 2 diabetes can cause vascular damage, immune system disruption, and delayed wound healing, exacerbating foot ulcers and amputation risk.[14] Therefore, serum albumin is a crucial indicator of general health and complication risk.

There were significant differences in BMI between amputated and non-amputated patients. Non-amputated patients had a lower average BMI (20.77 kg/m^2), while amputated patients had a higher average BMI (27.69 kg/m^2). Surprisingly, minor amputation patients had a higher average BMI than major amputation patients, despite literature suggesting higher BMI is linked to increased amputation risk. This aligns with Costa et al.[15] in Brazil, where a significant relationship between BMI and amputation risk was found. Higher BMI is associated with increased amputation risk due to factors like obesity-related vascular problems and worsened neuropathy.[16] Obesity can exacerbate diabetic complications, affecting wound healing and increasing ulcer risk.[16] Managing weight and preventing obesity are crucial for reducing amputation risk, with interventions focusing on weight loss, diet, and physical activity.

The study found that most patients with diabetic complications had moderate malnutrition (72.3%) based on SGA. Although no significant difference in amputation rates was observed among SGA groups ($p=0.071$), malnutrition is linked to increased amputation risk. Zhu et al.[17] in China also found malnutrition increases amputation risk in diabetic patients ($p<0.05$). Malnutrition affects amputation risk through impaired immune function, delayed wound healing, and worsened diabetic complications. Proper nutritional management is vital for reducing amputation risk and improving clinical outcomes.[18]

Significant differences were observed in average HbA1c levels between amputated (8.6%) and non-amputated patients (6.4%). Higher HbA1c levels were noted in major amputations (8.8%) compared to minor ones (8.0%). This highlights the importance of strict blood glucose control in preventing serious complications like amputation. These findings are consistent with Shatnawi et al.[19], where higher HbA1c levels were associated with increased amputation risk ($p<0.001$). Poor glucose control leads to vascular and neuropathic complications, increasing amputation risk.[19]

High HbA1c indicates chronic hyperglycemia causing vascular and peripheral nerve damage, leading to difficult-to-heal wounds and increased amputation risk. Poor glucose control also exacerbates peripheral vascular disease and reduces oxygen and nutrient supply to the extremities.[20]

The study found that most patients had DM for over 5 years, with amputated patients having a longer exposure (7.07 years) compared to non-amputated ones (4.47 years). Significant differences in amputation rates were noted with different DM durations ($p = 0.001$), showing that longer DM duration affects amputation risk.[18] This is consistent with Nouira et al.[21] and Shatnawi et al.[19] where longer DM duration was significantly associated with higher amputation rates. However, the study's findings showed similar or even longer DM durations in minor amputations, possibly due to limited data.[21]

Long-term DM increases risk through accumulated damage from chronic hyperglycemia, affecting small and large vessels and peripheral nerves. Complications like microangiopathy and neuropathy worsen circulation and wound healing, raising amputation risk.[22] Proper glycemic management is crucial, regardless of DM duration.

The study's limitations include potential selection bias from consecutive sampling, medical records, and lack of differentiation between ischemic and neuropathic causes of complications. Additionally, the use of existing medical data may introduce unrecognized confounding biases affecting the interpretation of amputation risk factors. The secondary data also limits the ability to explore variables that were not initially intended for analysis in this research, potentially reducing the depth and accuracy of findings.

This study concludes that diabetic patients, particularly those in the productive age range (40–60 years), face significant risks of amputation due to complications such as diabetic neuropathy, poor renal function, and malnutrition. Higher levels of HbA1c and longer durations of diabetes are strongly associated with increased amputation risks, underscoring the critical importance of effective glycemic control and early management of diabetes. Additionally, while higher BMI is observed in amputated patients, it does not directly correlate with amputation severity. Overall, the findings highlight the need for proactive intervention and comprehensive care to prevent severe diabetic complications and reduce the risk of amputations.

References

1. Tran MM, Haley MN. Does exercise improve healing of diabetic foot ulcers? A systematic review. J Foot Ankle Res. 2021;14(1):19. doi: 10.1186/s13047-021-00456-w.
2. Zhang P, Lu J, Jing Y, Tang S, Zhu D, Bi Y. Global epidemiology of diabetic foot ulceration: a systematic review and meta-

analysis (†). Ann Med. 2016;49:106–16. doi: 10.1080/07853890.2016.1231932
3. Samidah I, Mirawati, Mariyati D. Faktor-faktor yang berhubungan dengan kejadian ulkus diabetik pada penderita diabetes melitus di Rs Bhayangkara TK III Polda Bengkulu Tahun 2016. J of Nurs and Pub Health. 2018;5:6–10. doi: 10.37676/jnph.v5i1.548
4. Kaka AS, Landsteiner A, Ensrud KE, Logan B, Sowerby C, Ullman K, et al. Risk prediction models for diabetic foot ulcer development or amputation: a review of reviews. J Foot Ankle Res. 2023;16:13. doi: 10.1186/s13047-023-00610-6
5. Atosona A, Larbie C. Prevalence and determinants of diabetic foot ulcers and lower extremity amputations in three selected tertiary hospitals in Ghana. J Diabetes Res. 2019;2019:7132861. doi: 10.1155/2019/7132861
6. Gong H, Ren Y, Li Z, Zha P, Bista R, Li Y, et al. Clinical characteristics and risk factors of lower extremity amputation in the diabetic inpatients with foot ulcers. Front Endocrinol (Lausanne) 2023;14:1144806. doi: 10.3389/fendo.2023.1144806
7. Edmonds M, Manu C, Vas P. The current burden of diabetic foot disease. J Clin Orthop Trauma. 2021;17:88–93. doi: 10.1016/j.jcot.2021.01.017
8. Carmichael J, Fadavi H, Ishibashi F, Shore AC, Tavakoli M. Advances in screening, early diagnosis and accurate staging of diabetic neuropathy. Front Endocrinol (Lausanne). 2021;12:671257. doi:10.3389/fendo.2021.671257.
9. Perveen W, Ahsan H, Shahzad R, Fayyaz S, Zaif A, Paracha MA, et al. Prevalence of peripheral neuropathy, amputation, and quality of life in patients with diabetes mellitus. Sci Rep. 2024;14(1):14430. doi:10.1038/s41598-024-65495-2
10. Gazzaruso C, Gallotti P, Pujia A, Montalcini T, Giustina A, Coppola A. Predictors of healing, ulcer recurrence and persistence, amputation and mortality in type 2 diabetic patients with diabetic foot: a 10-year retrospective cohort study. Endocrine. 2021;71:59–68. doi: 10.1007/s12020-020-02431-0
11. Jiang Y, Ran X, Jia L, Yang C, Wang P, Ma J, et al. Epidemiology of type 2 diabetic foot problems and predictive factors for amputation in China. Int J Low Extrem Wounds. 2015;14(1):19–27. doi: 10.1177/1534734614564867
12. Wang L, Li Q, Chen X, Wang Z. Clinical characteristics and risk factors of lower extremity amputation in patients with diabetic foot. Pak J Med Sci. 2022;38(8):2253–8. doi:10.12669/pjms.38.8.5635
13. Hicks CW, Wang D, Matsushita K, McEvoy JW, Christenson R, Selvin E. Glycated albumin and HbA1c as markers of lower extremity disease inUS adults with and without diabetes. Diabetes Res Clin Pract. 2022;184:109212. doi:10.1016/j.diabres.2022.109212
14. Cheng P, Dong Y, Hu Z, Huang S, Cao X, Wang P, et al. Biomarker prediction of postoperative healing of diabetic foot ulcers: A retrospective observational study of serum albumin. J Wound Ostomy Continence Nurs. 2021;48:339–44. doi: 10.1097/WON.0000000000000780
15. Costa WJT, Penha-Silva N, Bezerra IMP, Paulo Dos Santos I, Ramos JLS, Castro JM de, et al. Analysis of Diabetes mellitus-related amputations in the State of Espírito Santo, Brazil. Medicina (Kaunas). 2020;56(6):287 doi:10.3390/medicina56060287
16. Oh TJ, Lee J-E, Choi SH, Jang HC. Association between body fat and diabetic peripheral neuropathy in middle-aged adults with type 2 diabetes mellitus: A preliminary report. J Obes Metab Syndr. 2019;28:112–7. doi: 10.7570/jomes.2019.28.2.112
17. Zhu Y, Xu H, Wang Y, Feng X, Liang X, Xu L, et al. Risk factor analysis for diabetic foot ulcer-related amputation including controlling nutritional status score and neutrophil-to-lymphocyte ratio. Int Wound J. 2023;20:4050–60. doi: 10.1111/iwj.14296
18. Vural Keskinler M, Feyİzoglu G, Yildiz K, Oguz A. The frequency of malnutrition in patients with type 2 diabetes. Medeni Med J. 2021;36:117–22. doi: 10.5222/MMJ.2021.44270
19. Shatnawi NJ, Al-Zoubi NA, Hawamdeh HM, Khader YS, Garaibeh K, Heis HA. Predictors of major lower limb amputation in type 2 diabetic patients referred for hospital care with diabetic foot syndrome. Diabetes Metab Syndr Obes. 2018;11:313–9. doi:10.2147/DMSO.S165967
20. Casadei G, Filippini M, Brognara L. Glycated hemoglobin (HbA1c) as a biomarker for diabetic foot peripheral neuropathy. Diseases. 2021;9:16. doi: 10.3390/diseases9010016
21. Nouira S, Ach T, Bellazreg F, Ben Abdelkrim A. Predictive factors for lower limb amputation in type 2 diabetics. Cureus. 2023;15:e39987. doi: 10.7759/cureus.39987.

22. Chawla A, Chawla R, Jaggi S. Microvasular and macrovascular complications in diabetes mellitus: Distinct or continuum?. Indian J Endocrinol Metab. 2016;20:546–51. doi: 10.4103/2230-8210.183480