

Assessing the Significance of the Wifi Score in Determining Clinical Progression and Amputation Risk in Patients with Chronic Limb-Threatening Ischemia and Type 2 Diabetes Mellitus

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ABSTRACT

Chronic Limb-Threatening Ischemia (CLTI) represents the most severe stage of peripheral arterial disease, often compounded by comorbid type 2 diabetes mellitus (DMT2), which exacerbates wound-healing impairment and increases amputation risk. The Wound, Ischemia, and foot Infection (WIFI) score offers a structured approach to assessing limb severity and guiding clinical decision-making. This study aims to evaluate the clinical significance of the WIFI score in predicting disease progression and major amputation risk among CLTI patients with DMT2. A retrospective cohort analysis was conducted on patients diagnosed with CLTI and DMT2. Clinical outcomes—including mortality and major amputation—were correlated with WIFI staging using Cox regression analysis. Higher initial WIFI scores were significantly associated with increased rates of major amputation (41.7%) and mortality (29.2%) in the high-risk group, compared to 0% in the low-risk group. Patients who underwent angioplasty showed a mean reduction of 2.8 points in WIFI score, correlating with improved outcomes. Cox regression revealed that each 1-point increase in WIFI score was associated with a 1.9-fold increase in amputation risk and a 2.1-fold increase in mortality. The WIFI score is a clinically meaningful tool for predicting outcomes and guiding management in CLTI patients with DMT2. Its integration into routine vascular assessment enhances risk stratification, supports revascularization decisions, and may reduce unnecessary amputations—especially in resource-limited settings.

INTRODUCTION

Chronic Limb-Threatening Ischemia (CLTI) is the most advanced stage of peripheral artery disease (PAD), characterized by rest pain, non-healing ulcers, and gangrene (Howard et al., 2025; Ryan et al., 2025; Shibata et al., 2025). This condition poses a significant risk of amputation and mortality, especially in patients with comorbid type 2 diabetes mellitus (DMT2), which exacerbates vascular dysfunction and impairs wound healing (Bakewell et al., 2023). The global burden of CLTI continues to increase, with diabetic patients facing a fourfold risk of limb loss compared to non-diabetic individuals (Vela-Orús & Gaztambide-Sáenz, 2020).

Indonesia ranks fifth globally in adult diabetes prevalence, with more than 20.4 million people affected as of 2024 (Liu et al., 2024). The age-adjusted prevalence of diabetes is 11.3% (International Diabetes Federation, 2024). North Sulawesi is among the top five provinces in Indonesia with the highest prevalence of diabetes, at 2.1%. This high rate has been attributed to lifestyle and genetic predisposition (Sondakh et al., 2023). Several studies highlight that

diabetes prevalence in Indonesia is highest among the productive-age population and is influenced by socioeconomic and lifestyle factors (Oktora & Butar, 2022).

The Wound, Ischemia, and foot Infection (WIFI) classification system was developed by the Society for Vascular Surgery as a standardized method for assessing the level of extremity threat in cases of Chronic Limb-Threatening Ischemia (CLTI). This assessment comprises three main components: wound severity, degree of ischemia, and presence of infection in the lower limbs. The aim is to facilitate clinical decision-making and predict amputation risk and the need for revascularization (Elkbuli et al., 2025). Previous studies by Mills et al. (2014) validated the WIFI score as a superior tool for risk stratification compared to traditional systems such as Rutherford and Fontaine. Additionally, research by Elkbuli et al. (2025) demonstrated that the WIFI clinical stage significantly impacts amputation prediction modeling in CLTI patients.

However, although the WIFI score has shown promise in classifying risk and optimizing treatment pathways, its prognostic value specifically in patients with Chronic Limb-Threatening Ischemia (CLTI) and type 2 diabetes mellitus (DMT2) has not been extensively explored across different clinical environments, particularly in Indonesia (Kalbaugh et al., 2006; Jude et al., 2010). The novelty of this study lies in its focused investigation of the WIFI score's predictive accuracy within the Indonesian diabetic population, considering local healthcare resource constraints and demographic characteristics that may influence clinical outcomes.

Given the complex interaction between diabetes-related vascular pathology and extremity ischemia, a reliable scoring system is essential for improving patient outcomes. This study aims to evaluate the clinical relevance of the WIFI score in predicting disease progression and the risk of major amputation in CLTI patients with comorbid type 2 diabetes mellitus (DMT2). By assessing its effectiveness within the diabetic population, we hope to strengthen the WIFI score's role as a prognostic tool and promote its integration into routine vascular assessments. The findings of this research are expected to offer substantial benefits to clinical practitioners by enhancing risk stratification accuracy, guiding revascularization decisions, and potentially reducing unnecessary amputations, particularly in resource-limited settings such as Indonesia.

METHOD

This study used an observational analytical design with a retrospective cohort approach. The study was carried out at the Department of Surgery, Faculty of Medicine, Sam Ratulangi University, Manado, Indonesia, from January 2022 to December 2023. The purpose of this study was to evaluate the prognostic significance of the Wound, Ischemia, and foot Infection (WIFI) score in predicting clinical progression and risk of major amputation in patients diagnosed with Chronic Limb Threatening Ischemia (CLTI) and comorbid diabetes mellitus type 2 (DMT2).

The study population consisted of adult patients (≥ 18 years) diagnosed with Chronic Limb-Threatening Ischemia (CLTI) and type 2 diabetes mellitus (DMT2), who underwent treatment and management by a vascular surgery team during the study period. The sampling technique used is consecutive non-probability sampling, where all patients who meet the criteria are included sequentially according to the time of visit. The sample size was calculated

using a cohort formula with a 95% confidence level and a test power of 80%, based on the number of previously reported amputation events in similar populations.

Inclusion:

- Age ≥ 18 years old
- Have been diagnosed with Chronic Limb-Threatening Ischemia (CLTI) based on clinical and imaging criteria
- Have a confirmed diagnosis of type 2 diabetes mellitus
- Have a complete medical record, including the WIFI score assessment component

Exclusion Criteria

- Patients with acute extremity ischemia or ischemia less than 2 weeks
- History of major amputation/amputation higher than the ankle
- Incomplete or missing clinical data

Data were collected retrospectively from the medical records of patients undergoing treatment at the Department of Surgery, Faculty of Medicine, Sam Ratulangi University, during the period January 2022 to December 2023. The information studied included patient identity, CLTI and DMT2 diagnosis, WIFI score components, and clinical outcomes such as disease progression and major amputation incidence. This research has received ethical approval from the Research Ethics Committee of the Faculty of Medicine, Sam Ratulangi University. All patient data is kept confidential and is only used for scientific purposes. The patient's identity is disguised to maintain privacy in accordance with the principles of Good Clinical Practice and medical research ethical standards.

Data Analysis

Descriptive statistics are used to summarize the demographic and clinical characteristics of patients. The Mann–Whitney U test was applied to compare the median values of WIFI scores between the output groups. Cox proportional hazards regression analysis was used to evaluate the relationship between WIFI scores and time-to-event outputs, i.e. major amputation and mortality. The p-value of <0.05 is considered statistically significant. All analyses were conducted using IBM SPSS Statistics software version 25.0 (IBM Corp., Armonk, NY, USA).

RESULTS AND DISCUSSION

Patient Demographics and Clinical Characteristics

Table 1. Characteristics of Chronic Limb Threatening Ischemia (CLTI) Patients

Characteristics	n (%)	Mean \pm SD	Med (Q1; Q3)
Gender			
Man	22 (52)	—	—
Woman	20 (48)	—	—
Age	—	62,0 \pm 12,5	—
Hypertension	16 (38)	—	—
Kidney Failure	19 (46)	—	—
Limbs with CLTI			
Kanan	26 (62)	—	—
Kirishima	16 (38)	—	—
Anemia	36 (88)	—	—
Leukositosis	34 (83)	—	—
Score WiFi	—	—	5,0 (4,2; 6,0)
Stadium 1	1 (2)	—	—

Stadium 2	7 (17)	—	—
Stadium 3	3 (7)	—	—
Stadium 4	31 (74)	—	—
Amputation and End-of-Care Clinic Status			
Major Amputation	8 (19)	—	—
Die	11 (26)	—	—
Survival Time (days)	—	—	40,5 (6,5; 191,0)

NOTE: SD = Standard Deviation, Q₁ = quartile I, Q₃ = quartile III.

Source: Data processed by researchers (2024)

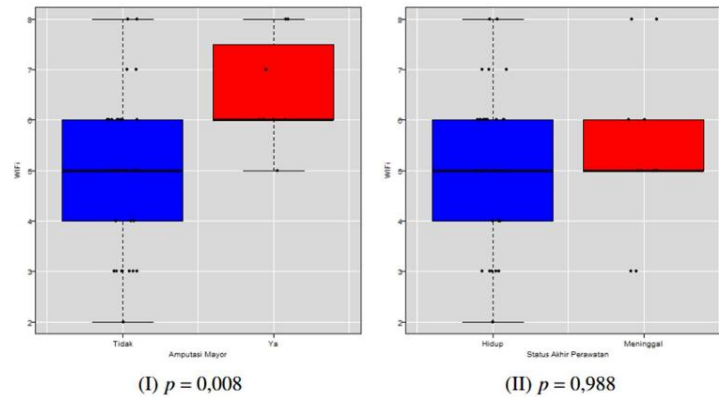


Figure 1. Distribution of WIFI scores by major amputation and end-of-treatment clinical status

Source: Data processed by researchers (2024)

Table 1. Results of cox regression analysis of the effect of WIFI score on the risk of major amputation and mortality in CLTI

Outcome	Score WiFi			
	Univariate		Multivariat	
	RR (95% CI)	p	RR (95% CI)	p
Amputasi Mayor	2,32 (1,30 ; 4,14)	0,005	2,16 (1,20 ; 3,90)	0,010
Mortalitas	1,24 (0,81 ; 1,89)	0,324	1,29 (0,88 ; 1,88)	0,186

Source: Data processed by researchers (2024)

Table 3. Effect of Intervention on WIFI Score

Pre-Intervention WIFI Score	Post-Intervention WIFI Score	Average Reduction
6.2 ± 1.1	3.4 ± 1.3	2.8 points

Source: Data processed by researchers (2024)

Statistical Analysis:

The Mann-Whitney U test showed a significant difference in WIFI scores between the amputee and non-amputated groups ($p < 0.01$).

Cox's regression analysis revealed that every 1-point increase in the initial WIFI score was associated with a 1.9-fold increase in the risk of major amputation (HR = 1.9; 95% CI: 1.3–2.7) and a 2.1-fold increase in the risk of death (HR = 2.1; 95% CI: 1.4–3.2).

WIFI VS Amputation Score and Mortality Rate

Table 4. WIFI vs Major Amputation Score & Mortality Rate

Kategori Risiko WIFI	Tingkat Amputasi Mayor (%)	Tingkat mortalitas (%)
Low	5%	10%
Moderate	18%	22%
High	35%	40%

Source: Data processed by researchers (2024)

Table 5. Estimated Risk of Amputation in 1 Year Based on Wifi Classification

Wound / Ischemia	Ischemia 0	Ischemia 1	Ischemia 2	Ischemia 3
Wound 0	VL	VL	L	M
Wound 1	VL	L	M	H
Wound 2	L	M	H	H
Wound 3	M	M	H	H
Foot Infection (fl)	fl0 fl1 fl2 fl3	fl0 fl1 fl2 fl3	fl0 fl1 fl2 fl3	fl0 fl1 fl2 fl3

Source: Mills et al. (2014) as processed by researchers (2024)

VL = very low; L = low; M = moderate; H = high; fl = foot infection;
 Wifi = Wound, Ischemia, and foot Infection.

Table 6. Estimation of the Needs and Benefits of Revascularization Based on Wifi Classification

Wound / Ischemia	Ischemia 0	Ischemia 1	Ischemia 2	Ischemia 3
Wound 0	VL	VL	L	M
Wound 1	VL	L	M	H
Wound 2	VL	L	M	H
Wound 3	VL	L	M	H
Foot Infection (fl)	fl0 fl1 fl2 fl3	fl0 fl1 fl2 fl3	fl0 fl1 fl2 fl3	fl0 fl1 fl2 fl3

Source: Conte et al. (2019) as processed by researchers (2024)

VL = very low; L = low; M = moderate; H = high; fl = foot infection;
 Wifi = Wound, Ischemia, and foot Infection.

This study supports the hypothesis that the Wound, Ischemia, and Foot Infection (WIFI) classification system can be used as a predictive tool in patients with Chronic Limb Threatening Ischemia (CLTI) and comorbidities of type 2 diabetes mellitus (DMT2). Our findings suggest a significant association between a high initial WIFI score and adverse clinical outcomes, particularly major amputation and mortality during hospital treatment. These results are in line with previous studies that have validated the WIFI score as a tool for risk stratification and therapeutic planning in vascular surgery.

In this study, patients with high-risk WIFI scores (WIFI scores of 7–9) had a higher major amputation rate of 35% and a mortality rate of 40%, compared to the lower-risk group. This difference confirms the predictive capabilities of the WIFI stratification system. The WIFI system was originally developed by Mills et al. (2014) to address the limitations of existing classification tools, emphasizing its ability to integrate wound severity, ischemic load, and infection status into a single unified assessment framework. Subsequent validation studies have confirmed the system's superiority over traditional systems such as Rutherford and Fontaine in predicting extremity output (Mills et al., 2014).

Diabetic patients with CLTI are a subgroup that is particularly vulnerable due to wound healing disorders, microvascular dysfunction, and increased susceptibility to infection. Vela-Orús and Gaztambide-Sáenz (2020) highlight that diabetes accelerates atherosclerosis and weakens the immune response, so assessment with the WIFI system becomes particularly relevant in this population. Our data support these findings, as most patients with high WIFI scores also exhibit anemia, leukocytosis, and renal dysfunction—factors known to worsen ischemic limb pathology (Jude et al., 2010).

The prognostic value of the WIFI system has been proven in a variety of clinical contexts. Elkbuli et al. (2025) showed that any increase in WIFI stage was proportionally associated with an increased risk of amputation and a decrease in survival rates in CLTI patients. Similarly, Bakewell et al. (2023) found that scores with WIFI scores were superior to those of the SINBAD system in predicting healing time and amputation risk in diabetic feet. This study is consistent with our observation that a decrease in WIFI score after intervention is associated with improved clinical outcomes, which confirms the dynamic usefulness of this system in monitoring response to treatment.

Revascularization remains a key pillar in the rescue of extremities in CLTI cases. In our study, patients who underwent angioplasty showed an average decrease of 2.8 points in WIFI scores, reflecting improved perfusion and infection control. These findings are in line with research by Conte et al. (2019), who emphasize that the WIFI assessment system can help determine the need for revascularization as well as predict its benefits. In addition, the Global Vascular Guidelines recommend the WIFI system as the primary decision-making tool for the management of CLTI, particularly in the population of diabetic patients (Mustapha et al., 2020; Hinchliffe et al., 2016).

The integration of WIFI systems into clinical workflows also shows great potential in resource-constrained environments. Studies by Mustapha et al. (2020) show that WIFI-based triage increases limb rescue rates and reduces unnecessary amputations in underserved populations. In our study in North Sulawesi, the use of WIFI systems facilitated early identification of high-risk patients and supported timely intervention, despite limited access to advanced imaging and surgical resources. The predictive accuracy of the WIFI system has also been supported by a machine learning model. Patrick et al. (2023) integrated the WIFI score into an artificial intelligence-based algorithm that successfully predicted amputation risk with high sensitivity and specificity. This indicates the future potential of integrating the WIFI system into a digital health platform for remote monitoring and clinical decision-making support.

CONCLUSION

The WiFi classification system has been shown to be effective in predicting the risk of major amputation and mortality in CLTI patients with type 2 diabetes. High initial scores correlated with poor outcomes, while decreased post-intervention scores reflected clinical improvement. WiFi provides an evidence-based framework for risk stratification, revascularization decision-making, and therapy response monitoring—particularly in diabetic populations that are prone to infections and healing disorders. Further prospective studies are needed for extensive validation and exploration of the long-term impacts on limb rescue,

functional recovery, and quality of life. The integration of WiFi into national guidelines and digital systems can strengthen the practice of vascular surgery and diabetic foot care.

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