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RESEARCH ARTICLE (ORIGINAL)

Ankle–Brachial Index: Implications for Leg Ulcer Healing Time

Índice Pressão Tornozelo Braço: Implicação no Tempo de Cicatrização da Úlcera de Perna

Índice Tobillo-Brazo: Implicación en el Tiempo de Cicatrización de las Úlceras en las Piernas

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Abstract

Background: Venous leg ulcers (VLUs) are the most common chronic type of leg ulcer**.** The ankle–brachial index (ABI) is a simple, non-invasive method that can be used to rule out arterial disease, ensuring safe care.

Objective: To determine whether the ABI predicts healing time in individuals with VLUs.

Methodology: A quantitative, descriptive-correlational, cross-sectional, and retrospective study was conducted with a non-randomized convenience sample collected from two complex wound treatment units. Documentary data was collected using a questionnaire between January 2021 and December 2022.

Results: VLUs were the most prevalent (74.5%). The mean ABI value was 1.02. The median healing time for VLUs was 67 days. There was a negative and moderate correlation between healing time and ABI (ρ = -0.34).

Conclusion: The lower the ABI value, the longer the required healing time. Due to the moderate correlation, other clinical variables must be considered when planning nursing interventions.

Keywords: ankle brachial index; leg ulcer; wound healing; nursing

Resumo

Enquadramento: A úlcera de perna venosa é a úlcera crónica mais comum dos membros inferiores. O Índice Pressão Tornozelo Braço (IPTB) é um método simples e não invasivo que permite excluir a doença arterial, garantindo a segurança dos cuidados.

Objetivo: Determinar se o IPTB prediz o tempo de cicatrização em pessoas com úlcera de perna venosa.

Metodologia: Estudo quantitativo, descritivo-correlacional, transversal e retrospetivo. Amostra não aleatória de conveniência em duas unidades de tratamento de feridas complexas. Feita recolha documental através de questionário, entre Janeiro de 2021 e Dezembro de 2022.

Resultados: A patologia venosa foi a mais prevalente (74,5%). O valor médio de IPTB é de 1,02. O tempo mediano de cicatrização da úlcera de perna foi de 67 dias. A correlação entre o tempo de cicatrização e o IPTB é negativa e moderada (ρ = -0,34).

Conclusão: Quanto mais baixo for o IPTB, maior o tempo necessário para a cicatrização. Pela baixa correlação é necessário complementar avaliação com outras variáveis clínicas para planeamento da intervenção da enfermagem.

Palavras-chave: índice tornozelo-braço; úlcera da perna; cicatrização; enfermagem

Resumen

Marco contextual: La úlcera venosa de la pierna es la úlcera crónica más común de las extremidades inferiores. El índice tobillo-brazo (ITB) es un método sencillo y no invasivo que permite descartar la enfermedad arterial, lo que garantiza la seguridad de los cuidados.

Objetivo: Determinar si el ITB predice el tiempo de cicatrización en personas con úlcera venosa en la pierna.

Metodología: Estudio cuantitativo, descriptivo-correlacional, transversal y retrospectivo. Muestra no aleatoria de conveniencia en dos unidades de tratamiento de heridas complejas. Se realizó una recopilación documental mediante cuestionario, entre enero de 2021 y diciembre de 2022.

Resultados: La patología venosa fue la más prevalente (74,5 %). El valor medio del ITB es de 1,02. El tiempo medio de cicatrización de la úlcera de pierna fue de 67 días. La correlación entre el tiempo de cicatrización y el ITB es negativa y moderada (ρ = -0,34).

Conclusión: Cuanto más bajo sea el ITB, mayor será el tiempo necesario para la cicatrización. Debido a la baja correlación, es necesario complementar la evaluación con otras variables clínicas para planificar la intervención de enfermería.

Palabras clave: índice tobillo braquial; úlcera de la pierna; cicatrización de heridas; enfermería

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Introduction

Venous ulcers, which represent 70% to 80% of all leg ulcers (LUs), affect 0.3% to 3% of the global population. Owing to their high prevalence, they constitute the most significant type of LU, impacting patients' quality of life and healthcare services (Gomes et al., 2024).

Initial assessment is the cornerstone of all treatment. Without an adequate evaluation, treatment may not be effective or targeted to the type of wound, potentially resulting in delayed or impaired healing and, consequently, affecting quality of life (Moore et al., 2022, cited by Wounds UK, 2024a).

Despite advances in vascular surgery, the ankle–brachial index (ABI) remains a key component of the initial assessment of individuals with wounds. The ABI is recognized as a non-invasive, accurate, and reliable method, and is recommended by the latest European Society of Cardiology guidelines: "Measurement of the ABI is recommended as the first-line non-invasive test for screening and diagnosis of peripheral arterial disease (PAD)" (Mazzolai et al., 2024, p. 3562), with a sensitivity of 75% and a specificity of 86% for diagnosing PAD.

ABI measurement during patient history-taking is essential for diagnosis and risk stratification, because compression therapy (CT) requires a hemodynamic evaluation in individuals with mixed arterial and venous ulcers. The ABI is the recommended parameter to ensure timely and individualized intervention (Elhomsy et al., 2022). Considering the clinical relevance of the ABI in the care of individuals with wounds and the fact that up to 20% of LUs fail to heal within two years despite appropriate treatment such as CT (Probst et al., 2023), this study aimed to investigate whether ABI can predict healing time in individuals with venous leg ulcers (VLUs).

Background

A VLU is defined as a "break in the skin between the malleolus [...] and the knee, which has not healed within two weeks [and] occurs in the presence of venous disease" (Wounds UK, 2024a, p. 4). Chronic venous insufficiency (CVI) of the lower limbs, resulting from valve incompetence, reflux, venous obstruction, or a combination of these, leading to distal hypertension, is the primary underlying cause. VLUs are the most common LUs, with a significant socioeconomic burden due to slow healing and high recurrence rates (Isoherranen et al., 2023). CT is considered the gold standard for their treatment and is the only therapeutic procedure supported by high-level evidence and a strong recommendation (Grade 1A) in the most recent guidelines and consensus statements (Stanek et al., 2023).

Healing times and recurrence rates vary widely across studies (Probst et al., 2023; Stanek et al., 2023; Wounds UK, 2022), with healing rates ranging from 40% to 70% at 12 weeks (Hannon et al., 2021). High recurrence rates remain a major challenge, with rates between 57% and 78% within 12 months after healing (Gomes et al., 2024). Several risk factors for the development of VLUs have been identified, including, among others, age over 55, elevated body mass index (BMI), family history of CVI, history of pulmonary embolism or superficial/deep venous thrombosis, sedentary lifestyle, lower-limb musculoskeletal disease, multiparity, and advanced stages of chronic venous disease (e.g., lipodermatosclerosis or previous venous ulcers). Poor prognostic indicators for healing include ulcer duration greater than three months, an initial ulcer size ≥10 cm, and the presence of lower-limb arterial disease (Stanek et al., 2023).

Accurate diagnosis of ulcer etiology is essential for appropriate care planning, rather than simply considering that we are dealing with a LU, as ulcers may be arterial, venous, or mixed (Vaz et al., 2021). VLUs represent approximately 70% of all leg ulcers, while 15% are purely arterial and 17–25% have mixed arterial–venous origin (Elhomsy et al., 2022).

The ABI is a well-established, simple, and non-invasive test used to detect lower-limb PAD by comparing systolic blood pressure at the ankle and arm. Although ABI does not diagnose venous disease, it is essential for ruling out significant arterial impairment and determining the safety of applying CT (Wounds UK, 2024b). The National Institute for Health and Care Excellence (NICE) recommends assessing ABI within two weeks of patient admission to avoid treatment delays (Wounds UK, 2024). Although guidelines do not specify exact timing, consensus indicates that ABI should be measured as early as possible, incorporated into the anamnesis, and prior to initiating strong CT (Isoherranen et al., 2023; World Union of Wound Healing Societies [WUWHS], 2024). In healthy individuals, normal ABI values range from 0.9 to 1.4. In individuals with diabetes or end-stage chronic kidney disease, medial artery calcification may lead to ABI values >1.40, reducing sensibility due to incompressible arteries. ABI values < 0.6 indicate severe PAD, in which CT is contraindicated, and vascular referral is required (Isoherranen et al., 2023).

A holistic assessment also includes the patient's anamnesis and objective limb examination, enabling early identification and modification of warning signs for delayed healing or chronicity, such as signs of CVI, comorbidities, lifestyle, and infection risk (Wounds International, 2023). The Clinical Etiological Anatomical and Pathophysiological (CEAP) classification system standardizes diagnosis and facilitates communication among healthcare professionals. It documents venous disease severity across four domains: clinical, etiological, anatomical, and pathophysiological. In practice, the clinical subclassification (C) is most commonly used and provides severity and prognostic information, with CVI typically considered from stage C3 onward (Isoherranen et al., 2023).

Research question

How does ABI influence the healing time of VLUs?

Methodology

A quantitative, descriptive-correlational, cross-sectional, retrospective study was conducted using a non-probability convenience sample of 192 individuals admitted to Casa de Saúde São Mateus (CSSM) and Policlínica Santa Columba between January 2021 and December 2022. These institutions were selected because they host specialized units dedicated to the management of complex wounds. The study was approved by the CSSM Ethics Committee (reference no. 002. CR_2023) and the Ethics Committee of the Polytechnic Institute of Viseu (reference no. 25/SUB/2023), following authorization from the administration of Policlínica Santa Columba and the CSSM Board of Directors. All collected data was anonymized and contained no personally identifiable information to ensure data confidentiality.

Adults (≥ 18 years) with LUs treated with CT or modified CT were included. Exclusion criteria were: individuals with other types of wounds (e.g., diabetic foot, burns, surgical wounds); individuals with diabetes and renal failure; individuals with ABI < 0.6; and individuals who had not completed treatment at the participating health units.

Data were collected through documentary analysis of clinical records (manual and digital). For this purpose, the authors developed a 20-item clinical form comprising two components: demographic and clinical characterization. Researchers Andrade, I. and Cruz, M. accessed the clinical records and extracted data according to the variables of the instrument, subsequently entering all information into Microsoft Excel. Clinical variables included risk factors and indicators of poor prognosis reported in the literature, as well as the clinical signs described in the CEAP classification.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS), version 28. For inferential statistics, the significance level was set at $\alpha = 0.05$. For qualitative variables, absolute (n) and relative (%) frequencies were calculated. For quantitative variables, measures of central tendency (mean, M) and dispersion (standard deviation, SD) were computed, complemented by the median and minimum and maximum values. Spearman's rho (ρ) coefficient was used to assess the association between leg ulcer healing time and ABI. Factors associated with healing time were evaluated using a multiple linear regression model, iteratively adjusted to the data. ANOVA was used to assess model fit. Normality of residuals was examined using the Kolmogorov-Smirnov (K-S) test, appropriate for samples > 50, which rejected the null hypothesis of normality ($p < .001$). Homogeneity of variance – a critical criterion – was tested using the White test and confirmed as constant ($p = .575$). Residual independence was assessed using the Durbin-Watson method, which yielded a value of 2.03. Non-significant predictors were removed sequentially from the intermediate models.

Results

The initial sample consisted of 192 individuals. Of these, 63 were excluded: 15 did not complete treatment, 12 had an ABI < 0.6, 10 had other types of wounds, and 26 had pathologies that were not included in the study. The final sample's age ranged from 26 to 95 years old. There was no statistically significant sex difference (51.6% female; 48.4% male). Most participants (74%) resided within the district where the wound treatment units are located. Before attending these units, 35.4% had been receiving treatment in primary care settings or other locations, including private clinics (4.7%; Table 1).

Table 1

Sociodemographic Profile of Participants

Sociodemographic variables			n (192)		% (100)
Sex	Female (♀) / Male (♂)		♀ = 99 / ♂ = 93		♀ = 51.6 / ♂ =48.4
Marital status	Married		142		74.0
	Widowed		37		19.3
	Single		11		5.7
	Divorced		2		1.0
Area of residence	Rural		123		64.1
	Urbana		69		35.9
Previous treatment location	Home		115		59.9
	Primary care		68		35.4
	Others		9		4.7
	Mean	Standard deviation	Median	Min.	Max.
Age	75.2	11.6	78	26	95

Note. n = Sample; % = Percentage; Min. = Minimum; Max. = Maximum.

Based on the clinical variables analyzed, two distinct etiologies of LUs were identified: venous (74.5%) and mixed (25.5%). Ulcers were predominatly located in the lower (47.4%) or middle (51.0%) segments of the leg. The most common ulcer size was between 5 and 10 cm (over 50% of cases), followed by ulcers smaller than 5 cm (33.3%). Large ulcers exceeding 15 cm were observed in fewer than 4% of participants. Ulcers demonstrated a tendency toward recurrence, with 67.7% of individuals reporting previous episodes. The time from ulcer onset to initiation of treatment varied greatly, ranging from one day to one year and three months, with a median evolution time of 21 days (three weeks). Both the mean and median ABI values in the sample were 1.02, with recorded values ranging from 0.6 to 1.5.

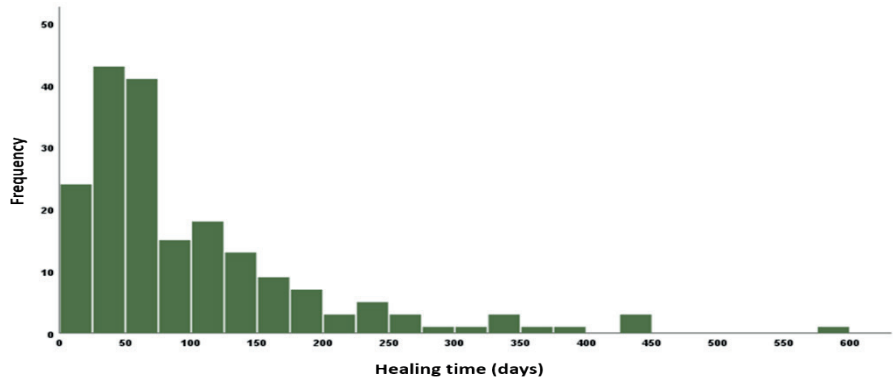
According to the CEAP classification, the observed signs of CVI on visual inspection were edema (approximately 90%), varicose veins (around 70%), and pigmentation or eczema (63.5%). Lipodermatosclerosis or atrophie blanche was identified in only 29.2% of individuals. Antibiotic therapy was required in only 25.52% of cases. The presence of ulcers did not fully restrict mobility in 95% of individuals. Among these individuals, 32.3% required some form of support for ambulation, and only 3.6% relied on a wheelchair (the use of walking aids was not related to the presence of ulcers).

Hypertension (62.5%) and heart disease (28.6%) were the most prevalent comorbidities. Osteoarticular diseases (7.8%), neoplasms (7.3%), and degenerative diseases (2.1%) were less frequent. Beyond these categories, hypercholesterolemia (22.9%) and obesity (14.6%) were noteworthy.

Healing time varied greatly across the sample. The distribution was positively skewed and included multiple extreme values (exceeding 400 days). The median healing time was 67 days, with a very high interquartile range of 93 days, indicating a considerable variability around the median. In fact, for 50% of participants, healing times ranged from 39.3 days (first quartile or 25th percentile) to 132.5 days (third quartile or 75th percentile; Figure 1).

Figure 1

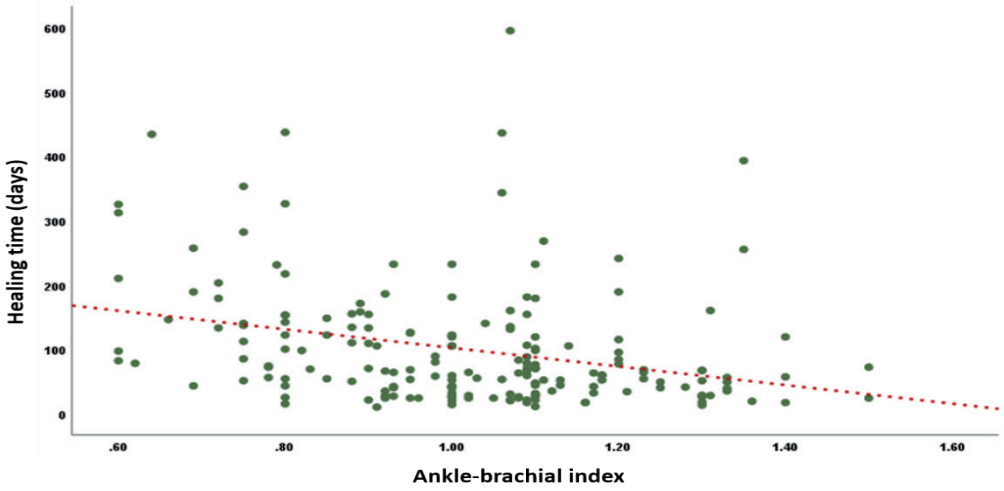
Healing time distribution histogram



Additionally, Spearman's correlation was calculated to assess the association between LU healing time and ABI. A negative correlation coefficient was obtained ($\rho = -0.34$), indicating that lower ABI values are associated with longer healing times ($p < .001$). However, the strength of the correlation is only moderate, suggesting that other factors besides the ABI are associated with healing time. The scatter plot supports the negative correlation between healing time and ABI (downward trending line), as well as the degree of uncertainty represented by the line's weak fit to the points. For each 0.1-point increase in ABI, an estimated reduction of 14.5 days in wound healing time occurs, with the reduction ranging from 21.1 days in the best-case scenario to 7.8 days in the worst-case scenario (95% CI; Figure 2).

Figure 2

Healing time vs. Ankle-brachial index



A multiple linear regression model was used to identify the factors associated with LU healing time, using clinical variables recorded at the beginning of treatment as potential predictors. The final model retained seven predictors, which are presented in Table 2.

Table 2

Multiple linear regression prediction

Independent variables	B (Non-standardized coefficients)	β (Standardized coefficients)	*t*	*p*	95% CI	
					Lower	Upper
(Constant)	25.02		2.28	.02*	3.43	46.62
Mixed ulcer	69.23	0.36	5.75	<.001*	45.48	92.98
Lower limb location	28.78	0.17	2.73	.01*	8.02	49.54
Lipodermatosclerosis/atrofie blanche	24.47	0.13	2.09	.03*	1.40	47.54
Size 5-10 cm	27.17	0.16	2.39	.01*	4.79	49.56
Size 10-15 cm	66.40	0.26	3.76	<.001*	31.57	101.24
Size 15-20 cm	123.18	0.24	3.74	<.001*	58.30	188.06
Number of antibiotics (previous 12 months)	25.29	0.13	2.08	.03*	1.40	49.19

Note. 95% CI = 95% confidence interval.
* Statistical significance.

The relative importance of each predictor of ulcer healing time is indicated by the standardized β coefficient, while the unstandardized B coefficient reflects the estimated change in healing time, in days. All predictors were statistically significant ($p < .05$). Mixed etiology emerged as the strongest predictor (β = 0.36), followed by ulcer size 10–20 cm (β around 0.25). The greatest effect was observed for ulcers measuring 15 and 20 cm, which were associated with an average increase of 123.18 days in healing time ($p < .001$), compared with the reference category (ulcers up to 5 cm). Smaller ulcer sizes showed smaller effects on healing time.

Discussion

This study found substantial variability in LU healing times, ranging from approximately 39 to 132 days, with a median of 67 days. For each 0.1-point increase in ABI, an estimated 14.5-day reduction in healing time was observed. This variation is consistent with previous studies (Hannon et al., 2021; Gomes et al., 2024; Probst et al., 2023), which mostly report healing periods of three to four months. The values obtained in this study fall within that expected range. Cross-analysis of ABI and healing time revealed that ulcer healing potential decreases

as ABI decreases. In practical terms, lower ABI values are associated with a higher risk of developing PAD, which in turn prolongs healing. This finding confirms the negative correlation found in the analysis of the results. However, because the correlation strength was only moderate, additional factors must be considered when predicting healing time. This aligns with the most recent recommendations from the WUWHS and the European Wound Management Association, which emphasize that "ABI should not be used in isolation but as an additive to a combination of the patient anamnesis and objective examination" (Isoherranen et al., 2023, p. 23).

Although ABI does not provide a definitive diagnosis, it remains a fundamental component of clinical assessment. Excluding PAD and determining the ulcer etiology are essential steps as they inform referral pathways and treatment decisions. Regarding etiology, the findings of this study are consistent with the literature (Stanek et al., 2023; WUWHS, 2024). VLUs were the most common (74.5%), followed by mixed ulcers (25.5%). Mixed ulcers demonstrated the greatest negative impact on healing in this sample ($\beta = 0.36$), being associated with an average increase of 69.2 days in healing times. These results further underscore the importance of holistic assessment in detecting other risk factors that may influence ulcer healing.

Although 40% to 70% of individuals achieve healing, 57% to 78% experience a recurrence within 12 months. Using elastic compression stockings is the most effective preventive measure, with higher compression classes associated with lower recurrence rates (Gomes et al., 2024). A systematic review identified 25 recommendations for preventing acute and chronic venous disease and lymphedema; four of which have strong evidence (grade 1a; Vaz et al., 2021). While compression stockings play a key role in preventing recurrence, they should not be used in isolation. A comprehensive understanding of risk factors is essential because recurrence is clearly associated with chronic risk conditions (Gomes et al., 2024).

Most individuals with LUs are older adults and frequently have comorbidities. The sociodemographic profile of this sample reflects this population, with a median age of 78 years. The most prevalent comorbidities were osteoarticular diseases and obesity. Osteoarticular diseases can significantly impair normal ambulation, leading to muscle pump inefficiency and reduced venous output in the leg (Stanek et al., 2023). In this sample, only 7.8% of participants reported osteoarticular diseases, while approximately 36% had mobility impairments. Assessing ankle joint mobility would have provided greater clinical relevance than evaluating gait alone, as the two main determinants of calf muscle pump function are ankle range of motion and muscle strength required for dorsiflexion and plantar flexion. As early as 1990, Schmeller (cited by Cruz, 2011) recognized this issue, concluding that older individuals have reduced ankle range of motion and that individuals with CVI exhibit decreased dorsiflexion compared with healthy adults. Moreover, within the CEAP classification, stage C3 corresponds to edema, present in 90% of the participants of this study, which likely contributes to reduced ankle flexibility, perpetuating a vicious cycle (Stanek et al., 2023).

Obesity directly affects venous hemodynamics by increasing intra-abdominal pressure and is closely associated with higher BMI, sedentary lifestyle, and the development of diseases such as hypertension and hypercholesterolemia, conditions that were among the most prevalent in the studied population (Wounds UK, 2022). Although none of these diseases significantly influenced healing time, they remain established risk factors for future LU development. Furthermore, an ABI outside the normal range is considered an independent risk factor for cardiovascular morbidity and mortality because it reflects the degree of underlying atherosclerosis (Isoherranen et al., 2023).

Timely and accurate diagnosis is essential for evidence-based decision-making and effective LU management. NICE recommends that ABI assessment be performed within two weeks to avoid treatment delays (Wounds UK, 2024b). However, an investigation by Gray et al. (2018; cited in Wounds UK, 2024b) revealed that 40% of individuals with LUs did not undergo ABI assessment, and the existence of a record was unclear. The Burden of Wounds Study, published in 2020, identified major gaps in chronic wound assessment and diagnosis, reporting that 78% of individuals with suspected LUs did not receive a Doppler ultrasound during their initial evaluation (Saghdaoui et al., 2025).

Upon examining the data obtained in this study, it was found that a considerable proportion of individuals (40.1%) had previously received treatment from healthcare professionals before seeking specialized wound care. Although there is insufficient data, it can be assumed that inadequate assessment may have occurred, resulting in care that was not tailored to the specific needs of the wound. Martinho and Gaspar (2012) investigated primary healthcare nurses' knowledge of and practices regarding CT and reported that 79.05% lacked training in ABI assessment, 86.41% did not have access to the necessary equipment, and 92.31% lacked practical experience. In a similar study, Ferreira (2020) found that, although 60.7% of professionals applied CT, 24.8% had no training, and 44.8% lacked practical experience in ABI assessment. Despite some progress between studies, there is still a long way to go regarding professional training, equipment, and hands-on experience. Although ABI measurement is considered an essential component of the assessment process, evidence indicates that it is not widely implemented in clinical practice. This shortfall has significant implications for health systems, patient outcomes, and healthcare costs (Wounds UK, 2024b).

Conclusion

The study allowed addressing the research questions by confirming a median healing time of 67 days for LUs. A moderate negative correlation was identified between ABI values and healing time; that is, the lower the ABI values, the longer the healing time. However, this relationship should not be interpreted in isolation due to the

degree of uncertainty observed. It may be useful when complemented by other indicators, such as ulcer size, wound location, infection status, and clinical signs of lipodermatosclerosis or atrophie blanche.

This study has some limitations. The non-randomized sample and gaps in clinical records (reporting bias) made it impossible to collect relevant data documented in the literature. For future research, we recommend replicating the study with a larger sample to analyze the influence of the examined variables and identified risk factors.

Regarding implications for clinical practice, the study reinforces the need for a paradigm shift in caring for individuals with CVI. Most VLUs are treated by nurses in primary healthcare settings, with a strong focus on local management. The etiology of the wound, determined through ABI assessment, should form the foundation of all care planning. This includes early identification of risk factors and signs of poor prognosis that can be addressed proactively to prevent deterioration. Each etiology requires a distinct therapeutic approach, and treatment depends on differential diagnosis. Without such diagnosis, patients will receive standard care that may delay healing. A thorough assessment of the underlying etiology and its severity is crucial to establishing an appropriate care plan and guiding professionals' decision-making.

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Thesis/Dissertation

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