

Factors Contributing to Foot Amputation Risk in Patients with Diabetic Foot Infection

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Abstract:

Introduction: Diabetic foot complications pose a significant health burden globally, particularly among specific ethnic populations. Understanding the contributing elements of diabetic foot ulcers and amputations is critical for tailored preventive strategies. The goal of the research is to understand the risks involved in foot amputation in the cases of Diabetic foot ulcers.

Methods: The study was conducted at Balangir Medical College and Hospital Bhima Bhoi Medical College. The entire investigation and research followed the medical procedure and ethics of the Helsinki Declaration. Medical records of 150 participants were reviewed, evaluating variables such as foot ulcer location, size, chronic kidney disease, eGFR, and sarcopenia index. Statistical analysis was conducted for each variable.

Results: While comparing both the categories it was observed that the ankle-brachial index (ABI) showed a substantial difference, with the amputation group displaying a lower mean ABI (1.0 ± 0.1 vs. 1.9 ± 0.6 , $p = 0.028$). Previous amputation history, $ABI < 0.9$ prevalence, and chronic kidney disease were notably higher in the amputation group. Moreover, the amputation category had a significantly lower eGFR (66.2 ± 26.0 vs. 64.1 ± 29.8 , $p = 0.039$). These findings suggest ABI, past amputation, kidney health, and eGFR as crucial amputation risk factors in diabetic patients.

Conclusion: Analysis revealed forefoot ulcers as higher risk factors for amputation due to compromised blood supply in the distal foot area. Larger ulcer sizes and lower eGFR significantly increased amputation risk, emphasizing the role of chronic kidney disease. The study underlines the necessity for early identification and targets prevention strategies for diabetic foot complications among the Indian population.

Keywords: Diabetic foot, ulcers, ankle-brachial index, amputation, sarcopenia index.

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Introduction

Diabetic foot disease refers to a group of conditions affecting the feet of individuals with diabetes mellitus. It encompasses a spectrum of complications including peripheral neuropathy (nerve damage), peripheral vascular disease (blood vessel damage), foot ulcers, and infections [1]. In diabetes, prolonged high blood sugar levels can lead to nerve damage (neuropathy), impairing sensation in the feet. This loss of sensation makes it difficult for individuals to perceive injuries, such as cuts or blisters, which can develop into ulcers [1, 2]. Additionally, diabetes can lead to poor blood circulation in the feet due to damage to the blood

vessels (peripheral vascular disease), impairing the body's ability to heal wounds and fight infections [2].

Diabetic patients face a heightened risk of developing foot ulcers, with estimates suggesting that approximately 25% of individuals with diabetes will experience a foot ulcer at some point in their lives [2]. Several contributing factors increase this risk, including peripheral neuropathy, impaired blood circulation, foot deformities, a history of ulcers, and previous amputations. Amputations due to diabetic foot complications occur at alarming rates [2]. On a global scale, a limb reportedly

undergoes amputation every 30 seconds due to “diabetes” related foot issues [3]. The impact of diabetic foot complications is a global concern, affecting millions of individuals and placing a strain on healthcare systems worldwide [3]. Efforts aimed at education, early intervention, and comprehensive foot care programs are vital in addressing the high rates of diabetic foot ulcers and amputations, aiming to improve outcomes and alleviate the burden associated with this debilitating complication of diabetes [3].

The expenses linked to treating diabetic foot complications make up roughly a quarter of a diabetic patient's overall hospital expenditures [4]. To alleviate this financial burden, healthcare providers should emphasize both prevention and treatment of diabetic foot conditions. Undoubtedly, amputation in individuals grappling with Diabetic foot complications hampers their ability to engage in daily activities, significantly impacting their life quality [4, 5]. Hence, understanding the risk elements associated with diabetic foot amputation is a critical concern [5]. Thorough study and proactive measures for individuals at an elevated risk of diabetic issues, along with early identification of foot problems, have the potential to diminish the incidence of ulcers and amputation [5].

Diabetic foot ulcers arise from a combination of factors intricately linked to the complications of diabetes mellitus. Primarily, peripheral neuropathy, characterized by nerve damage, diminishes sensation in the feet, making it challenging to detect injuries that could evolve into ulcers [6]. Additionally, compromised blood circulation due to peripheral vascular disease impairs the healing process, exacerbating the risk of ulceration [7]. Deformities in the feet, previous foot trauma, inadequate foot care practices, and compromised immune function further contribute to ulcer formation [7]. Understanding these factors is pivotal in preventing diabetic foot ulcers, necessitating proactive foot care practices, regular inspections, optimal blood sugar control, appropriate footwear, and immediate attention to any foot-related concerns. Therefore, the goal of the study the risks and factors that increases the chances of amputation in Indian Diabetic patients who have been subjected to general treatment in a medical institute.

Materials and Methods

The study was conducted at Balangir Medical College and Hospital Bhima Bhoi Medical College in Balangir, Odisha, India during the study period from January 2021 to December 2022. The entire investigation and research followed the medical procedure and ethics of the Helsinki Declaration. A total of 150 participants were taken into the research. All the patients signed the consent form before admitting them to the research and were made aware

of the procedures to be conducted during the investigation. The personal details of each patient were not shared with the researchers.

Researchers reviewed medical records which comprised of admission notes and initial laboratory findings, providing critical patient information for this study. The selection of independent variables aligns with previous research on diabetic foot risk factors, aiming to comprehend amputation occurrences. “Hypertension” was identified by prior documented diagnoses. “Ankle-brachial index” calculations involved the ratio of “ankle systolic blood pressure” to “upper arm systolic blood pressure”, with an ABI below 0.9 considered abnormal. “Diabetic retinopathy” determination involved ophthalmologic records. “Chronic kidney disease” was defined using estimated GFR calculated through a specific formula. Skeletal muscle mass was estimated via the sarcopenia index. Ulcer size assessment relied on endocrinologist evaluations at admission. Foot ulcer location classifications were forefoot, midfoot, and hindfoot. Information on procedures like “percutaneous transluminal angioplasty” (PTA) and diagnostic scans for osteomyelitis was collected from relevant departmental records.

Quantitative variables of both groups underwent statistical analysis using a t-test, while categorical variables were examined using a chi-square test. Statistical significance was established for p-values below 0.05.

Result

Table 1 represents the comparison between the amputation and non-amputation groups. While age, BMI, and duration of diabetes showed no statistically significant variations, distinct disparities were observed in other parameters. Notably, the “ankle-brachial index” (ABI) displayed a considerable discrepancy between the groups, with the amputation group recording a notably lower mean ABI of 1.0 ± 0.1 in contrast to 1.9 ± 0.6 in the non-amputation group ($p = 0.028$). Additionally, a higher prevalence of previous amputation history was evident in the amputation group, accounting for 6.6% compared to 11.1% in the non-amputation group ($p = 0.043$). Moreover, occurrences of an ABI less than 0.9 were notably more frequent in the amputation group (21.1% vs. 35.7%, $p = 0.005$), as was the prevalence of chronic kidney disease (27.1% vs. 36.4%, $p = 0.019$). Furthermore, the (eGFR) was significantly lower in the amputation group (66.2 ± 26.0 mL/min/1.73 m²) compared to the non-amputation group (64.1 ± 29.8 mL/min/1.73 m², $p = 0.039$). These findings highlight the potential significance of ABI, previous amputation history, chronic kidney disease, and eGFR as crucial risk factors contributing to the likelihood of amputation among diabetic patients.

Table 1: Comparison between the amputation and non-amputation groups

Variables	Amputation	Non-Amputation	P-value
Age	60.5±10.3	64.9±10.1	0.603
BMI	22.9±3.9	23.0±3.6	0.682
Diabetes Duration	14.9±9.9	14.8±19.1	0.81
ABI	1.0±0.1	1.9±0.6	0.028
Diastolic BP	79.1±10.1	76.9±13.1	0.161
Systolic BP	131.2±18.1	134.3±21.2	0.901
Previous amputation history	6.6	21 (11.1)	0.043
ABI (ABI<0.9)	21.1	35.7	0.005
Diabetic peripheral polyneuropathy	68.1	55.7	0.091
Chronic kidney disease	27.1	36.4	0.019
Sarcopenia index	103.3±13.1	99.9±91.1	0.870
Hemoglobin (g/dL)	65.1	60.1	0.714
Total cholesterol (mg/dL)	159.0±56.3	159.1±60.1	0.729
Triglyceride (mg/dL)	140.9±101.1	163.1±174.1	0.169
Creatinine (mg/dL)	2.5±5.0	1.4±2.6	0.59.7
eGFR (mL/min/1.73 m ²)	66.2±26.0	64.1±29.8	0.039
Ulcers	2.7±2.2	3.6±2.6	0.0001

Discussion

The ankle-brachial index (ABI) emerged as a crucial factor, displaying a statistically significant discrepancy between the amputation and non-amputation groups. Higher ABI was found in the amputation group indicates compromised peripheral vascular status in individuals who underwent amputation due to diabetic foot issues. Higher ABI is linked to higher risk of amputation. However, researchers demonstrated that a higher ABI was linked to the risk of amputation in Wagner grade 3 wounds [10]. This finding accentuates the critical importance of assessing and monitoring peripheral vascular health in diabetic patients, as a lower ABI could signify impaired blood flow, contributing to the development of complications and the potential need for amputation [11].

Ulcers situated in the forefoot region emerged as a heightened risk factor for diabetic foot amputation when compared to those located in the midfoot or hindfoot areas. Given its distal location, the forefoot region is presumed to have comparatively inadequate blood supply within the foot, potentially leading to a deficiency in oxygen, white blood cells, and essential nutrients. The prevalence of previous amputation history showcased a substantial difference between the two groups [12, 13]. Previous research findings have consistently indicated that larger foot ulcers and those displaying greater severity significantly elevate the risk of amputation among diabetic individuals [12-14].

The incidence of ABI values falling below 0.9 was notably greater for the amputation group. This observation underscores the significance of ABI as a diagnostic tool for identifying peripheral arterial disease and vascular compromise, which are

contributory factors in diabetic foot complications and amputation.

Chronic kidney disease (CKD) also emerged as a substantial factor associated with amputation risk among diabetic patients. The higher prevalence of CKD in the amputation group suggests a potential correlation between renal function and the likelihood of amputation [15, 16]. This finding emphasizes the need for comprehensive diabetic care that includes monitoring and managing renal function to potentially mitigate the risk of amputation. "Diabetic kidney disease" is also one of the complications that can arise, and it is known as a vital indicator for the general vascular condition of diabetic patients. Additionally, patients with "nephropathy" are also prone to developing "peripheral vascular disease" [17].

The presence of chronic kidney disease and lower (eGFR) emerged as crucial risk factors associated with a heightened likelihood of diabetic foot amputation. This underlines the significant impact of renal function on the risk of diabetic feet and major amputation, corroborating recent findings linking eGFR and chronic kidney disease to an increased risk of amputation in diabetic individuals [18, 19]. Moreover, recent studies have highlighted sarcopenia as another critical contributing element for "diabetic foot disease", significantly influencing its outlook [18-20]. However, the assessment of skeletal muscle mass often requires expensive and complex imaging techniques like body structure analysis or computed tomography [19, 20,21].

Strengths and Limitations

This study's strength lies in its focus on a specific ethnic group, fostering a shared cultural and dietary

background among the participants. Additionally, the standardized treatment procedures administered to all subjects, stemming from a single center-based recruitment, minimized biases associated with heterogeneous subject characteristics and diverse treatment protocols seen in multicenter studies. Scaling up this research on a larger scope could pave the way for developing a risk stratification system tailored to diabetic foot complications.

However, several limitations need consideration. The study's single-center, hospital-based design might introduce selection biases and limit the representation of the broader local population. Consequently, further multicenter investigations are necessary for a more comprehensive understanding. Moreover, the retrospective nature of this study restricted a thorough assessment of independent variables and prevented the definitive establishment of causality between factors and outcomes.

Conclusion

Analysis revealed forefoot ulcers as higher risk factors for amputation due to compromised blood supply in the distal foot area. Larger ulcer sizes and lower eGFR significantly increased amputation risk, emphasizing the role of chronic kidney disease. The study underlines the necessity for early identification and targets prevention strategies for diabetic foot complications among Indian population.

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