

# Doppler Ultrasound Abnormalities of the Lower Limbs in Patients with Diabetic Foot at the Yopougon University Hospital in Ivory Coast

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## Abstract

**Background:** Diabetic foot is a frequent complication of diabetes, of multifactorial origin, associating nervous and/or circulatory disorders to which infection is often added. Its care is multidisciplinary and requires coordination between different actors. In this context, arterial doppler ultrasound is essential in the diagnosis of diabetic arteriopathy and participates in therapeutic decision-making. The aim of this study was to describe the abnormalities found on Doppler ultrasonography of patients hospitalized for the diabetic foot in the Ivory Coast. **Methods:** We conducted a retrospective descriptive study including 235 patients hospitalized for the diabetic foot in the Endocrinology department of the Yopougon University Hospital from February 2002 to December 2015. All records of patients who performed arterial Doppler ultrasound of the lower limbs were selected and the various abnormalities were described. **Results:** The sex ratio (M/F) was 1.1 (124 men to 111 women). The predominant age group was 61.2 years. Type 2 diabetes was found in 97.4% of cases. The average evolution of diabetes was 8.9 years with extremes of 1 and 32 years. Wet gangrene was the most common type of lesion found in 75.8% of cases. On ultrasonography, 98.7% of the patients had an arterial abnormality of the lower limbs. It was bilateral in 62.2% of cases, dominated by atherosomatous overloads and mediocalcrosis in 46.4% and 43.8% of cases, respectively. Arterial stenosis was lesions hemodynamically found in 76.3% of cases and arterial occlusions in 32.7% of cases. The amputation rate was 72.7%.

**Conclusion:** This study shows the high frequency of arterial abnormalities in patients with the diabetic foot with a predominantly distal involvement. Arterial Doppler ultrasound of the lower limbs remains an essential tool in the care of diabetic foot. This easily accessible, non-invasive examination has a key role in therapeutic decision-making.

## Keywords

Diabetes, Arterial Doppler Ultrasound, Arteriopathy, Ivory Coast

## 1. Introduction

The diabetic foot is the set of trophic manifestations of the foot occurring in diabetic patients due to nerve, arterial, and/or infectious damage [1]. It is a major health problem because of its serious repercussions leading to deterioration in the quality of life of patients. Diabetic foot is the result of a chronic imbalance in diabetes that favors neuropathy, arteriopathy, and infection [2] [3]. Diabetes is the cause of approximately 40% - 60% of non-traumatic amputations and 85% of these are preceded by foot ulceration [4] [5]. Its care is multidisciplinary and requires coordination between different actors.

The presence of arterial disease is a determining factor in the evolution of the diabetic foot, responsible for delayed healing and increasing the risk of amputation. In this context, arterial Doppler ultrasonography is one of the first-line exams, but also an indispensable tool in therapeutic decision-making. It is an easily accessible tool that allows morphological and hemodynamic analysis of the different arteries of the lower limbs [6] [7].

However, assessment of the lower limb's arteries permeability requires a trained investigator and high-performance equipment. In the literature from sub-Saharan Africa, few studies have been reported on Ultrasonography of the lower limb features in patients with diabetic foot wounds. In Ivory Coast, to our knowledge, only two studies reported by Kouamé *et al.* in 2011 [8] and Konin *et al.* in 2014 [9] reported arterial ultrasound lesions of diabetic foot.

The aim of this work is to actualize data by describing the abnormalities of arterial Doppler ultrasonography in patients hospitalized for diabetic foot ulcers in the Endocrinology-Diabetology Department at the University Hospital of Yopougon, in Abidjan, Ivory Coast.

## 2. Methods

### 2.1. Type of Study

We conducted a descriptive retrospective study in the Endocrinology-Diabetology Department (EDD) of the Yopougon University Hospital. This study focused on the records of patients hospitalized for the diabetic foot from January 2002 to December 2015.

All diabetic patients over 18 years of age who had performed lower limbs arterial Doppler ultrasound were included. Were excluded were those who had not performed an arterial Doppler ultrasound of the lower limbs and records that presented unexploitable data.

The patients underwent a complete clinical examination in the department which allowed for classification of the diabetic foot according to Wagner's criteria.

The infected lesions had been deeply swabbed with a catheter to isolate the germs involved. Patients were referred to the Abidjan Heart Institute and to private facilities for arterial Doppler ultrasound.

Ultrasound exploration was globally done using a 7 MHz superficial probe following the anatomy of the arterial network from the abdominal aorta to the pedal arteries. An analysis of the Doppler spectrum and of the morphology of the different axes was carried out.

The descriptions were made following the exploration of the B mode for the appreciation of the arterial wall, mediocalcrosis, and atheromatous plaques. The color mode was used to describe vascular filling, turbulence phenomena (aliasing), and distal vascular tracking. Morphological abnormalities were described during B-mode exploration and the Doppler spectrum with color mode was used to describe the hemodynamic abnormalities: stenosis, arterial occlusion, and collaterals present. According to the degree of stenosis, the stenosis was hemodynamically insignificant when less than 50%; it was insignificant when it was between 50% and 70% and significant when it was above 70%.

## 2.2. Variables and Data Collection

The clinical and paraclinical variables, notably age, sex, laterality of the lesions, type of diabetes, duration of evolution, steady-state of diabetes, and the results of the Doppler ultrasound examination, were listed in an Excel 2010 file.

## 2.3. Statistical Analysis

The calculation of means, standard deviations, extremes, and percentages was performed using IBM SPSS statistics 21<sup>®</sup> software. Quantitative variables were expressed as mean  $\pm$  standard deviation, while qualitative variables as proportions. The student's t-test was used to compare quantitative variables and the Chi-square test for qualitative variables and in both cases, the differences were considered significant at the  $p < 0.05$  threshold.

## 3. Results

In the period from January 2002 to December 2015, 4 204 diabetics were hospitalized in the Department of which 486 patients presented with foot lesions, *i.e.* a diabetic foot prevalence of 11.6%. 235 diabetics met our inclusion criteria.

The mean age of the patients was  $61.2 \pm 11.9$  years with a sex ratio (M/F) of 1.12. All the socio-demographic, clinical, and biological characteristics of the patients are detailed in **Table 1**.

In terms of lesions, gangrene was present in 75% of cases, foot ulcers in 18% of cases, and abscesses in 6% of cases. Wet gangrene was observed in 75.8% of cases against 24.2% of dry gangrene. Right foot involvement predominated in 56% of cases.

On the arterial level, morphological and/or hemodynamic abnormalities of the lower limbs were found in 232 patients, *i.e.* 98.7% of cases (**Table 2**). Arterial involvement was bilateral in 130 patients, *i.e.* 62.2% of cases. Morphological

**Table 1.** Socio-demographic, clinical and biological characteristics of the patients.

Characteristics of patients	Mean ± SD	Number (%)
<b>Age, years</b>	61.2 ± 11.9	
<b>Gender</b>		
Female	-	111 (47.2)
Male	-	124 (52.8)
<b>Type of diabetes</b>		
Type 2 Diabetes	-	209 (97.4)
Type 1 Diabetes	-	26 (2.6)
<b>The mean duration of diabetes</b>	8.9 ± 8.1	-
<b>Current antidiabetic treatment</b>		
Insulin therapy only		178 (75.7)
Insulin therapy + oral antidiabetic drugs		57 (24.3)
<b>Cardiovascular risk factors</b>		
Hypertension		122 (51.9)
Android obesity		18 (7.6)
Smoking		16 (6.8)
Dyslipidemia		11 (4.7)
<b>Fasting Blood Glucose, mg/dl</b>	277 ± 133	
<b>Glycated hemoglobin (HbA1c), %</b>	8.5 ± 2.3	

**Table 2.** Morphological and hemodynamic abnormalities of arterial doppler ultrasound of the lower limbs.

Arterial abnormalities	Number (n)	Percentage (%)
Mediacalcosis	103	43.8
Atheromatous plaques	109	46.4
Arterial thickening	50	21.2
Arterial stenosis	177	76.3
Arterial occlusion	76	32.8
Combinations of several arterial lesions	55	23.7

abnormalities are summarized in **Table 3**.

Of the 103 patients with mediocalcrosis, 30 patients had diffuse tomography (29.1%), with distal involvement in 49 patients (47.6%). Data detailed in **Table 4**.

Of the 109 patients with atherosclerotic plaque, 31 patients had diffuse tomography (39.8%) with predominant distal involvement (43.1%). Data is presented in **Table 5**.

Among the hemodynamic abnormalities found, arterial stenosis was presented predominant with 177 patients (76.3%) of cases and 50 patients (28.3 %) with significant stenosis (**Table 6**).

**Table 3.** Distribution of arterial mediocalcrosis according to the arterial location.

Affected arterial stage	Number (n)	Percentage (%)
Aorto-iliac	10	9.7
Femoro-popliteal	14	13.7
Jambier	39	37.9
Podal	5	4.8
Jambier + Podal	5	4.8
Diffuse damage	30	29.1
<b>Total</b>	<b>103</b>	<b>100</b>

**Table 4.** Distribution of atheromatous plaques according to the arterial location.

Affected arterial stage	Number (n)	Percentage (%)
Aorto-iliac	2	1.8
Femoro-popliteal	29	26.6
Jambier	42	38.5
Podal	2	1.8
Jambier + Podal	3	2.9
Diffuse damage	31	28.4
<b>Total</b>	<b>109</b>	<b>100</b>

**Table 5.** Distribution of arterial stenosis according to the arterial location.

Location	Number (n)	Percentage (%)
Femoro-popliteal	21	11.9
Jambier	94	53.1
Podal	11	6.2
Jambier+ Podal	35	19.8
Diffuse damage	16	9
<b>Total</b>	<b>177</b>	<b>100</b>

**Table 6.** Distribution of patients according to the degree of arterial stenosis.

Quantification of the stenosis lesion	Number (n)	Percentage (%)
Stenosis < 50%	36	20.3
Stenosis between 50% and 70%	91	51.4
Stenosis > 70%	50	28.3
<b>Total</b>	<b>177</b>	<b>100</b>

**Table 7.** Distribution of patients according to the severity of arterial occlusion.

Affected arterial stage	Number (n)	Percentage (%)
Femoro-popliteal	5	6.6
Jambier	39	51.3
Podal	16	21.1
Jambier + Podal	15	19.7
Diffuse damage	1	1.3
<b>Total</b>	<b>76</b>	<b>100</b>

Arterial occlusion was present in 76 patients (32.7%) with 92.1% (70 patients) of distal involvement (**Table 7**).

#### 4. Discussion

Our study described the arterial lesions found in patients hospitalized for the diabetic foot. This retrospective descriptive study involved 486 diabetic foot cases, 235 of which met our inclusion criteria. Our study had a few limitations that are worth mentioning. It is above all about the retrospective nature of the study which resulted in a loss of information for a certain number of patients who were excluded from the study. Then, the performance of arterial Doppler ultrasound in several centers may have led to a loss of homogeneity of the results related to the potential operator and/or center-dependent nature of this examination. However, the sample size was representative compared to the various recent data in the African literature.

The mean age of the patients in our study was  $61.2 \pm 11.9$  years. Dia in Senegal [10] found a similar average age of 62.5 years. On the other hand, the patients in our study were slightly older than those of Kouamé [8] and Monabeka [11], 57.6 and 54.6 years respectively. The slight predominance of the male sex in our study (sex ratio = 1.12/1) was reported by Kouamé [8] in Ivory Coast and, conversely, differs from that described by Dia [10] in Senegal.

Type 2 diabetes predominated in this retrospective cohort in 97.4% of cases. Our results corroborate those of Lokrou [12] who reported 97.6% of type 2 diabetes. The high prevalence of type 2 diabetes in the world could justify this finding. In 89.8% of cases, diabetes was discovered less than 10 years ago. Lokrou reported a mean duration of diabetes of 8.5 years in 2008 [12].

The foot lesions were dominated by gangrene in 75% of cases, of which 75.8% were wet gangrene and 24.2% were dry gangrene. Foot ulcers and abscesses represented 18% and 6% of cases respectively. Tchakonte in Cameroon [13] reported 90% cases of gangrene in his series against 10% of perforating ailments. The predominance of right foot involvement found in our study in 56% of cases is consistent with that of Dia [10] who observed in his series a localization of lesions in the right foot in 45% of cases. This high frequency of gangrene observed is explained by the delay in consulting diabetics in the appropriate foot care centers.

Arterial abnormalities of the lower limbs were found in 98.7% of cases in our series. Arterial involvement was bilateral in 62.2% of patients. Kouamé [8] reported an equally high rate of 89.7% of arterial abnormalities. In his series, Konin [9] found a preferential involvement of the left lower limb of PAD in 67.7% of cases.

PAD in diabetic patients may involve proximal arteries (iliac and femoral) with a comparable prevalence, but arterial damage is more frequent in distal arteries: popliteal artery, tibial-peroneal trunk, anterior tibial arteries, posterior tibial and peroneal arteries [14]. The mechanisms that contribute to atherosclerosis are the same as for coronary or cerebral localization, although glycemia seems to have a more specific deleterious role for the leg arteries [15]. The involvement of the distal arteries is explained, on the one hand, by microangiopathy which is responsible for progressive deterioration of the amplitude and modulation of Doppler tracings [16].

Mediacalcosis was present in 43.8% of cases in our study. It predominated in distality in 46% of cases. Kouamé in his series found a much lower rate of 6% of mediacalcosis. Mediacalcosis is much more frequently observed in diabetes and chronic kidney disease (especially at the hemodialysis stage). It is strongly correlated with the risk of amputation [17] [18] and is frequently associated with PAD [19] [20] but also with vegetative neuropathy [21].

The atherosclerotic plaque was present in 46.4% of cases in our study. It predominated in distality in 43.1% of cases. The leg artery tripod was the most affected in 53.8% of cases, unlike the femoral tripod which is affected in 37.2% of cases. These results corroborate those of Konin [11] who observed that the so-called severe atheromatous lesions were predominant in the tibial arteries compared to the femoral arteries (40% vs 20%).

Arterial stenosis was present in 76.3% of cases in our study. It predominated in distality in 79.5% of cases. The leg artery tripod was the most affected in 58.4% of cases. These results are far superior to those of Kouamé [8] and Dia [10] who reported respectively 43.6% and 21.7% of cases of arterial stenosis. Contrary to the predominant leg tripod involvement, Dia [10] reported more frequent superficial femoral artery stenosis with a rate of 13% and stenosis of the anterior and posterior tibial arteries in 6.5% of cases.

Arterial occlusion was presented in our study in 32.7% of cases. It predomi-

nated in distality in 92.1% of cases. The leg artery tripod was the most affected in 58.4% of cases. These results are superior to those of Kouamé [8] who reported an arterial occlusion rate of 12.8%. Arterial occlusion in our context leads to minor or major amputation due to non-revascularization. In short, these high rates of stenosis and arterial occlusion concomitant with that of clinical gangrene were very decisive for the high amputation rate found in our study.

The collateral circulation was present in twenty-eight patients, i.e. 36.8% of cases. This rate remains low and therefore requires education and early rehabilitation in PAD through a walking training program allowing the development of collateral arteries in arteritis patients.

## 5. Conclusion

This study highlights the high frequency of arterial abnormalities in patients with diabetic foot ulcers with a predominantly distal location. Arterial Doppler ultrasound of the lower limbs remains an essential tool in the management of the diabetic foot. This easily accessible and non-invasive tool has a key role in therapeutic decision-making in diabetic foot ulcers.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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