Original Article

Association between clinical and sonographic patterns of major peripheral arterial occlusion among patients presenting with lower limb dry gangrene at a single center in Western Uganda

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Abstract

Background: Dry gangrene occurs due to a reduced blood supply in body parts, resulting in gradual necrosis. It is among the leading indications for lower limb amputation; however, in situations where timely access of accurate diagnostic and revascularization services are limited, irrational amputations are performed based on mere physical assessment of a specific occluded major arterial segment, consequently preceded with gangrene recurrence on the same limb stump due to physical examination inaccuracies. **Objectives**: We assessed the lower limb dry gangrene patterns and analyzed arterial Doppler reports of these cases to determine the associations between dry gangrene patterns and specific occluded major lower limb arteries to elevate the degree of accuracy of physical assessments. **Methods**: In this cross-sectional study, 36 patients with lower limb dry gangrene were consecutively enrolled. Dry gangrene patterns and Doppler ultrasound reports of the major arteries of the affected lower limbs were assessed. Data were entered in EPIDATA and exported to STATA version 15 for cleaning and analysis. Clinical and sonographic characteristics are summarized as median and frequencies. Odds ratios (ORs) were tabulated and reported relating the dry gangrene patterns and major arterial occlusion levels as a measure of associations; *P* value < 0.05 were considered statistically significant. **Results**: Dry gangrenes demarcated on the toes (61.1%), toes–distal foot 27.8%, and toes–proximal foot and leg (11.1%). Doppler ultrasound revealed femoral arteries (38.9%), popliteal (66.7%), and infra-popliteal (88.9%–100%) arterial occlusions. Association between dry gangrenes demarcating toes–proximal foot and leg with femoral arterial occlusions (ORs: 6.2 and 3.2, respectively), whereas dry gangrene demarcating toes and toes–distal foot with popliteal arterial occlusions (OR, 1.6; *P* value, 0.05). **Conclusion**: Dry gangrene demarcating the toes–proximal foot and leg has a significant association with femoral arterial occlusions, whereas demarcation at the toes and toes–distal foot are more associated with popliteal arterial occlusions.

Keywords: Association, gangrene pattern, occlusion, peripheral arteries, sonography

Introduction

Dry gangrene occurs due to a reduced blood supply in body parts, resulting in gradual necrosis. This condition may arise due to trauma, peripheral arterial disease (PAD), infection, or other health conditions, primarily

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diabetes. It involves gradual tissue necrosis due to chronic ischemia, making the tissue numb, dry, wrinkled, and dead.[1] The Fontaine classifications categorize gangrene of the limbs as a stage IV PAD.

PAD commonly affects the arteries supplying the leg and is mostly caused by atherosclerosis, leading to blood flow restriction due to narrowing or blockage.[2] Often patients initially complain of muscle pain while walking (intermittent claudication), and any further reduction in blood flow causes ischemic pain at rest and later ulceration and/or gangrene may supervene and result in loss of the limb if left untreated.[3]

Patients with lower limb dry gangrene in earlier stages often have skin color and temperature changes of the feet, muscle atrophy from inability to exercise, decreased hair growth and hypertrophied slow-growing nails, muscle rigor, tenderness, and pain on passive movement.[4] There is profound sensory loss, limb is often anesthetic, muscle paralysis, or visible mottled necrotic tissues.[5] The limb changes in cases of dry gangrene are related to the specific arteries that are partially or totally occluded, and this is conventionally diagnosed by digital subtraction angiography, computed tomography angiography, and duplex ultrasonography. Duplex scanning can also provide most of the essential anatomic information, such as lower extremity arterial tree visualization, with the extent and degree of lesions accurately assessed and arterial flow velocities measured.[6]

Although many patients with claudication remain stable, approximately 150–200 per million of the population progress to critical limb ischemia (CLI; Fontaine III or IV) annually, and many of them can undergo revascularization, which has a reasonable chance of saving the limb. The Vascular Surgical Society audit reported a success rate of >70% for these patients, although many patients still require major amputation, with the rate of primary amputation ranging from 10% to 40%; amputations were performed only when no graftable distal vessels were present or in neurologically impaired or hopelessly nonambulatory patients.[7]

Globally, the burden of dry gangrene is not clearly documented. However, a UK-based population study estimated CLI due to large- or small-vessel disease to occur in 0.1/1000 of the population per year and is associated with a high case fatality rate.[8] A United States study reported an annual incidence of CLI of 0.35% and a prevalence rate of 1.33%.[8] In Africa, particularly South-Western Uganda, the burden of this disease has not been fully established, although a single study conducted in 2013 from three hospitals noted that dry gangrene accounted for 49.1% of all gangrene cases seen yearly.[9] A Zambian study reported that dry gangrene was 22% as the second most common indication for amputation.[10]

Transfemoral amputation is negatively associated with quality of life because of increased difficulty in walking with prosthesis.[11]

Revascularization surgery is beneficial for CLI patients when considering limb salvageability and wound healing[12] before the onset of dry gangrene. Increasing the limb salvage rate is anticipated to improve the daily activity and prolong the survival of patients with dry gangrene or CLI.[12] Delayed patient presentation and inaccessibility of diagnostic and therapeutic technologies are presumed to be the underlying circumstances leading to the poor quality of life of patients with this severe form of PAD, especially in poor early health care seeking communities and low resource centers, which lack vascular surgeons and revascularization supplies, making surgical debridement and amputation the mainstay of intervention.

These patients often undergo major amputations merely based on physical assessment of the level of perfusion, due to inaccessibility and unavailability of accurate diagnostic technologies, thereby resulting in nonhealing of the stump wound, progression of gangrene, and reamputation.[13]

We aimed to assess the patterns of lower limb dry gangrene, in relation to sonographic evidence of specific occluded major peripheral arteries, among patients who presented at a single center in Western Uganda, to determine the associations between particular gangrene patterns and specific occluded major arterial segments, providing clinicians and community sensitization about evidence of severe disease, so as to encourage early health care seeking behavior and develop an optimal and rational decision-making process for amputations among clinicians.

Materials and Methods

The study was conducted in accordance with the Declaration of Helsinki and approved by the Faculty of Medicine Research Committee (FREC)/MUST, IRB Number: MUST-22-459, and MRRH prior to data collection. Informed consent was obtained from all study participants.

This cross-sectional descriptive study recruited all patients who presented with dry gangrene at our institution's Department of Surgery from June 2022 to November 2022. The study population included all patients with clinically diagnosed dry gangrene lesions. To assess for any major arterial blockages, routine lower limb arterial Doppler ultrasound scans were performed on both lower limb extremities for each case by a radiologist experienced in vascular imaging, using the same medical equipment. Occlusion was diagnosed

when there was no Doppler or spectral signal in the occluded arterial segment.

Patients were then linked to surgeons on call for a definitive surgical management plan that included pain management, antiplatelet therapy, vasodilator therapy, toe disarticulation, foot amputation, below-knee or above-knee amputation, and revascularization depending on the level of confirmed arterial occlusion.

A structured questionnaire was used to capture all information, including sociodemographic data, clinical history and examination findings, and arterial Doppler examination results. Study variables, such as clinically assessed dry gangrene patterns included demarcation at the toes, toes–foot, and toes–leg and specific occluded lower limb arteries (common femoral, superficial femoral, profunda femoris, popliteal, tibioperoneal trunk, anterior tibial, posterior tibial, peroneal, and dorsalis pedis arteries.

Data Management and Analysis

Data were entered in EPIDATA and exported to STATA version 15 for cleaning and analysis. Patient characteristics were summarized by means, frequencies, and in-depth analyses of qualitative components. Odds ratios (ORs) were tabulated as a measure of association. Clinical and sonographic patterns are summarized by median and frequencies. ORs were tabulated and reported relating the dry gangrene pattern (outcome) and level of arterial occlusion (exposure). A *P* value of 0.05 was considered statistically significant.

Results

Altogether, 38 patients were screened, and 36 participants were eligible for the study. Two participants were excluded because of dry–wet transformation of the gangrene (n = 1), and proximal reamputation (n = 1). The enrolled 36 participants comprised 19 (52.8%) women and 17 (47.2%) men. Their ages were normally distributed with a mean age of 59.5 ± 12.7 (range: 30–85) years.

Clinical patterns of lower limb dry gangrene

The majority of the study patients had dry gangrene demarcating toes (61.1%), toes–distal foot (22.8%), and toes–proximal foot and leg (11.1%) [Table 1].

Among those with isolated toe dry gangrene, involvement of more than one toe was observed in 83.4% of the cases, whereas 16.6% of the cases had only one toe involvement (big toe, 33.3%; small toe, 22.2%).

Table 1: Presentation and pattern of dry gangrene

Dry gangrene pattern	Frequency *N* (%)
Toes: proximal foot and leg	4 (11.1)
Toes–distal foot	10 (27.8)
Toes	22 (61.1)

Table 2: Frequencies of major lower limb arterial occlusions as demonstrated by Doppler ultrasonography

Arterial occlusion	Frequency *N* (%)
Femoral	14 (38.9)
Infra-femoral	22 (61.1%)
Popliteal	24 (66.7)
Posterior tibial	34 (88.9)
Anterior tibial	36 (100)
Fibular/peroneal	35 (97.2)

Table 3: Association between lower limb gangrene pattern and femoral arterial occlusion

Gangrene pattern	Odds ratio (95% CI)	*P* value
Toes–proximal foot and leg	3.2 (1.9–5.3)	0.0078
Toes–distal foot	6.2 (1.6–25.4)	0.0017
Toes	–	0.0001

The toe–proximal foot and leg gangrene have a significant association with femoral arterial occlusions, with an odds ratio of 3.2, whereas toe and toe–distal foot gangrenes were definitely associated, with an odds ratio of 6.2

Sonographic patterns

Doppler ultrasound scan of these cases revealed that the limbs with dry gangrene changes were majorly due to infra-femoral occlusions (61.1%), whereas 38.9% of the cases had occlusion in the femoral arteries. Among the infra-popliteal vessels, the anterior tibial artery was occluded in all participants, the posterior tibial artery in 88.9%, and the peroneal artery in 97.2% of the participants [Table 2].

Association between the gangrene patterns and specific occluded peripheral arteries

The study identified a greater association between demarcated toe–proximal foot and leg dry gangrene and femoral arterial occlusions (OR 3.2), whereas the demarcation at the toes and toe–distal foot dry gangrene was associated with popliteal occlusions (OR 1.6, *P* value of 0.05) [Table 3].

The infra-popliteal association was not included because almost all patients had an infra-popliteal occlusion (anterior tibial, posterior tibial, or peroneal). The tabulation of odd ratios was not significant because there a null figure was included [Table 4].

Table 4: Association of lower limb gangrene pattern with popliteal arterial occlusion

Gangrene pattern	Odds ratio (95% CI)	*P* value
Toes–proximal foot and leg	1.6 (1.2–2.1)	0.1336
Toes–distal foot	1.6 (1.1–2.3)	0.0500
Toes	–	0.0001

The toe and toe–distal foot gangrenes were significantly associated with popliteal arterial occlusions, with an odds ratio of 1.6 (*P* of 0.0001 and 0.05, respectively), compared with toe–proximal foot and leg gangrene (*P* = 0.1336)

Discussion

The present study found a female predominance (52.8%) and mean age of and 59.3 years, reaffirming the findings of other studies showing that women were more likely to have significant femoro-popliteal and multilevel infra-inguinal arterial disease,[14] attributed to the loss of the protective role of estrogen, especially in the postmenopausal age.[15,16]

Clinical patterns

The majority of the study participants had toes and foot dry gangrenes, attributed to early insufficient blood supply to the smaller extreme branches, which supply nutrients and factors for timely wound healing.[17] Furthermore, the arterial branches distally have a smaller lumen; thus, they are easily obstructed due to inflammations because of underlying risk factors (e.g., diabetes, smoking) and presence of small emboli from proximal plaques.[18]

Sonographic patterns

Our study data showed that most participants had popliteal and infra-popliteal arterial occlusions (61.1%), which is similar to the findings of an Illinois university study reporting a 55.5% infra-popliteal occlusion rate.[19] However, these results are contrary to the findings of a previous study that showed that only one-third of their participants had infra-popliteal arterial occlusion, whereas two-thirds had both femoro-popliteal and infra-popliteal diseases.[20] This variation may be attributed to the different diagnostic criteria used, wherein our study only included cases with totally occluded arteries were included, whereas the previous study enrolled even stenotic vaso-occlusion cases.

The anterior tibial, posterior tibial, and peroneal arteries were severely affected (100%, 88.9%, and 97.2%, respectively) in our study participants, which may be attributed to the fact that most of our study participants had diabetes, which has been implicated as responsible for small-vessel vaso-occlusion as opposed to smoking, which is responsible for large-vessel vaso-occlusion.[21]

Association between the gangrene pattern and arterial occlusion

Our study showed that the dry gangrene demarcating toes–proximal foot and leg (OR 3.2) was more associated with femoral arterial occlusions, whereas the demarcations at the toes and distal foot (OR 1.6) were associated with popliteal arterial occlusions. There is a paucity of data on this phenomenon; however, this may be attributed to the femoral artery being more proximal than the popliteal artery, such that its occlusion vastly affects the blood supply to a wider part of the lower limbs, from the level of the toes, feet, and legs. The extent and speed of gangrene formation may also be determined by the degree of arterial occlusion and the rate of collateral blood supply development.[22]

Conclusions

The dry gangrene pattern of any part of the lower limb is associated with a specific segmental peripheral arterial occlusion, which can be confirmed sonographically. Toe–proximal foot and leg dry gangrenes are associated with femoral arterial occlusions, whereas toe and toe–distal foot dry gangrenes are more associated with popliteal arterial occlusions. Gangrene demarcation of the affected lower limb extends proximally in association with distal to proximal progressive segmental arterial occlusions. Our study data demonstrated that early recognition of toes, toe–foot, or toe–leg dry gangrene of the lower limb, with the knowledge on their association with infra-popliteal, popliteal, and femoral arterial occlusion revealed herein, could improve the accuracy of clinician's physical assessments and facilitate optimal therapeutic decision-making, preventing the occurrence of complications from irrational lower limb amputation.

Author contributions

Conceptualization, Emmanuel Barasa, and Alfred Omo; methodology, Emmanuel Barasa; validation, Edson Tayebwa, Emile Ndanga, and Aturinde Mercy; formal analysis, Emmanuel Barasa; investigation, Moses Acan; data curation, Alfred Omo; writing—original draft preparation, Alfred Omo; writing—review and editing, Alfred Omo. All authors have read and agreed to the final version of the manuscript.

Data availability statement

The datasets generated during and/or analyzed during the current study are available with the corresponding author on reasonable request.

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Conflicts of interest

The authors declare no conflict of interest

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