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Original Article

Operative versus non-operative treatment in diabetic dry toe gangrene

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ABSTRACT

Background and aim: Diabetic foot is a major comorbidity of diabetes, with 15–25% of diabetic patients developing diabetic foot ulcer during their lifetime. Other major diabetic foot complications include cellulitis, abscess, wet gangrene, dry gangrene, and necrotizing fasciitis. Dry gangrene involves tissue necrosis due to chronic ischemia whereby the tissue becomes numb, dry, wrinkled, and dead. Although diabetic foot complications have been extensively studied in literature, there is limited data on the management of dry gangrene.
Methods: We report a case series of 12 patients with diabetes-related dry gangrene in the toes, initially planned to be managed conservatively with autoamputation.
Results: One patient had an autoamputation, while eight patients underwent surgical amputations (six major amputations, two minor amputations) for better clinical outcomes. Two patients died, while no change was observed in one patient even after 12 months of follow-up.
Conclusion: Managing diabetic dry toe gangrene by waiting for autoamputation may lead to worse clinical outcomes and should be practiced cautiously on a case-by-case basis. Early surgical intervention should be opted to improve patients' quality of life.

1. Introduction

The International Diabetes Federation (IDF) reported that an estimated 425 million people were suffering from diabetes mellitus in 2017 globally (age range: 20–79 years; prevalence rate: 8.6%), and these numbers are expected to reach 629 million by 2045 [1]. In Saudi Arabia, nearly 20% of the adult population is diabetic, and it ranks among the top ten countries facing a diabetes epidemic [1–3].

Diabetic foot is a major comorbidity of diabetes, with 15–25% of diabetic patients developing diabetic foot ulcer (DFU) during their lifetime [4]; the prevalence is higher in patients with type II diabetes compared to type I diabetes [5]. Apart from DFUs, other major diabetic foot complications include cellulitis, abscess, wet gangrene, dry gangrene, and necrotizing fasciitis [6,7]. In Saudi Arabia, the prevalence of diabetic foot complications has been estimated to be around 3.3%, and include ulcers (2.05%), amputations (1.06%), and gangrenes (0.19%) (based on data from the Saudi National Diabetes Registry, 2015) [8].

Gangrene is of three types, dry, wet and gas gangrene. Dry gangrene involves tissue necrosis due to chronic ischemia whereby the tissue becomes numb, dry, wrinkled, and dead [9]. Although diabetic foot complications have been extensively studied in literature, there is limited data on the management of dry gangrene. As revascularization does not show any benefit in dry gangrene, amputation is the preferred treatment of choice [10]. Amputation can either be achieved through surgical intervention, or patients could await autoamputation. Autoamputation is the spontaneous separation of unviable tissue from viable tissue along a clear line of demarcation [11,12]. In most developing countries, patients with dry gangrene prefer autoamputation because of their cultural beliefs or as an alternative to surgery [13]. Autoamputation is also preferred when the patient is a poor surgical candidate [11,14]. However, waiting for the affected limb to autoamputate could increase chances of infection and prolong patients' pain and discomfort [15].

Surgical amputation offers better outcomes as compared to autoamputation. Moreover, the criteria when patients should wait for autoamputation are not clearly defined [16]. Therefore, the decision to allow autoamputation should be individualized and taken based on patients' lifestyle and the presence of any medical,

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physical, and psychological comorbidities [17]. Here, we report a case series of 12 patients with diabetes-related dry gangrene in the toes, initially planned to be managed conservatively with autoamputation, who eventually underwent surgical amputation in almost all cases.

2. Methods

2.1. Study characteristics

This retrospective, case series included patients from Dr. Sulaiman Al Habib Hospital (Alrayan branch), Riyadh, Saudi Arabia, who presented with diabetic toe dry gangrene between January 2015 till June 2018.

The study was approved by the ethics committee at Dr. Sulaiman Al Habib Hospital (Alrayan branch), Riyadh, Saudi Arabia. Written informed consent was obtained from all patients and included in the study to have their data published.

2.2. Inclusion and exclusion criteria

Patients with type II diabetes and osteomyelitis (confirmed by routine X-ray) were enrolled for the study. All patients had severe peripheral arterial disease (PAD) with absent pedal pulses and ankle brachial index (ABI) < 0.5; they were managed by the same vascular surgeon. Neuropathy was present in all patients; the diagnosis of polyneuropathy was based on assessment of sensory function, temperature measurement, and examination with 10-g monofilament and/or a tuning fork [18]. All patients had severe atherosclerosis (mainly infra-genicular). The patients were either unamenable for or had failed open or endovascular revascularization; therefore, they were initially planned to be managed conservatively with autoamputation.

2.3. Management of diabetes, peripheral arterial disease, infections, and wounds

All patients were followed-up by an endocrinologist to control their blood sugar and given medicines for infection control. Oral 100 mg aspirin and 75 mg clopidogrel (Plavix) were prescribed to every patient. Outpatient daily wound dressing were done with normal saline followed by covering of the toe with betadine gauze, mainly in the line of demarcation. To ensure routine follow-up, each patient was given a follow-up appointment for daily dressing. In addition, appointments were planned once weekly at vascular surgery clinic, and once every 4 weeks at endocrinology and infectious disease medicine clinic. Patients who developed active infection in the form of clinical cellulitis, pus discharge, swelling or conversion to wet gangrene with septicemia underwent surgical amputation.

3. Results

3.1. Patient demographics

Overall, 12 patients (7 male and 5 female) aged between 55 and 73 years (average age: 64.4 years) were included in the study. The average duration since diabetes was first detected in these patients was 22.75 years (range: 15–30 years). Hypertension was the most frequently observed comorbidity, present in seven of 12 patients, followed by coronary artery disease in five patients. Baseline and demographic characteristics of all patients included in the case series are presented in Table 1.

Of the 12 patients, nine had ABI ranging from 0.45 to 0.5, while three had an ABI of 0.3–0.4. Greater toe was affected by dry gangrene in five patients, 2nd toe was affected in four patients, and 5th toe in two patients. While one patient had 4th toe involvement, 3rd toe involvement was not seen in any of the patients. All patients had neuropathy. Of the 12 patients, only seven showed treatment compliance while the rest did not come for daily wound care or for follow-up visits. The clinical characteristics of the patients, compliance, and overall outcomes are presented in Table 2.

3.2. Autoamputation versus surgical amputation: duration and consequences

Overall, only one patient experienced autoamputation and surgical amputation was needed in eight of them. Two patients died during the study while there was no change in the clinical condition of dry gangrene in one patient. Patients' compliance or non-compliance to follow-up visits and wound care did not affect the autoamputation versus surgical amputation rate.

The only patient who had an autoamputation (Case ID: 1) was compliant with treatment; however, she waited for 11 months after her first visit before the affected 2nd toe severed on its own. Moreover, four months into the wait period, she developed dry gangrene of the greater toe as well (Fig. 1). Two patients died awaiting autoamputation; one compliant patient (Case ID: 2) died due to myocardial infarction 2 months after disease presentation and another non-compliant patient (Case ID: 8) died after 3 months due to sepsis following extension of infection and gangrene. Apart from Case ID: 8, sepsis was also observed in another non-compliant patient, Case ID: 5. Infection was seen in a non-compliant patient, Case ID: 10, and in two compliant patients, Case IDs: 4 and 11 (Fig. 2A, B, C). Case ID: 11 also had to undergo a below knee amputation (BKA), and his case is discussed in Fig. 2D.

Surgical intervention was needed in eight patients. Midtarsal amputation had to be performed in two compliant patients (Case IDs: 3, 9), at 2 and 8 months, respectively. BKA was performed within 6 months of disease presentation in four patients (Case IDs: 4, 5, 7, 11) (all were compliant except Case ID: 5), while above knee amputation (AKA) was carried out on two patients (Case IDs: 10, 12) at 7 and 1 months, respectively. Five patients had a greater toe necrosis (Case IDs: 2, 3, 6, 7, and 12). Of these, Case ID: 2 died, Case ID: 3 needed a midtarsal amputation, Case ID: 7 needed a BKA, while Case ID: 12 needed AKA; no change was observed in Case ID: 12. Two patients who were non-compliant to treatment also tried cauterization; however, their condition deteriorated further (Fig. 3). One compliant patient did not show any change in the dry gangrene even after 12 months of follow-up (Case ID: 6).

4. Discussion

All the 12 patients with diabetic toe dry gangrene included in this case series were planned to be managed conservatively by waiting for them to have an autoamputation; however, only one patient had an autoamputation, while eight patients underwent surgical amputations (six major amputations, two minor amputations) for better clinical outcomes. Two patients died, while no change was observed in one patient even after 12 months of follow-up.

There are very few studies reporting the success of autoamputation in diabetic dry toe gangrene management. The most recent one is a 2011 retrospective cohort study with 11 patients having diabetic dry toe gangrene. The study reported successful autoamputation in 6 (55%) patients within 2–6 months of disease presentation. However, one patient died awaiting autoamputation while the remaining four had to be surgically amputated within 3–6.5 months (two Ray and two midatarsal). Also, nine patients subsequently developed infections which required antibiotics and

Table 1
Baseline and demographic characteristics.

Case ID	Age (years)	Gender	Years since detection of DM	Concomitant comorbidities
1	60	F	20	Hypertension
2	72	M	30	Hypertension, Hyperlipidemia
3	64	M	22	ESRD, Hypertension
4	59	M	18	Hyperlipidemia, CAD
5	70	F	30	CAD
6	58	F	20	Hypertension
7	69	M	25	Hyperlipidemia
8	60	M	21	CAD, Hypertension
9	67	M	23	CAD
10	73	M	28	CAD, Hypertension
11	66	F	21	ESRD, CAD
12	55	F	15	Hypertension

F = Female; M = Male.
DM: Diabetes mellitus; CAD: Coronary artery disease; ESRD: End-stage renal disease.

Table 2
Clinical characteristics, compliance and patient outcomes.

Case ID	ABI	Toe with dry gangrene (1 indicates greater toe; 2, second toe, etc.)	Compliant/Wound care in outpatient setting	Non-compliant/Used traditional treatments	Outcomes/Duration (in months)
1	0.5	2	Yes	No	Autoamputation/11M
2	0.45	1	No	Yes	Death, MI/2M
3	0.5	1	Yes	No	Midtarsal amputation/2M
4	0.5	4	Yes	No	BKA/5M
5	0.35	5	No	Yes	Sepsis, BKA/3M
6	0.45	1	Yes	No	No change/12M
7	0.4	1	Yes	No	BKA/3M
8	0.5	2	No	Yes	Death, Sepsis/3M
9	0.5	5	Yes	No	Midtarsal amputation/8M
10	0.3	2	No	Yes	AKA/7M
11	0.5	2	Yes	No	BKA/4M
12	0.45	1	No	Yes	AKA/1M

ABI: Ankle brachial index; AKA: Above knee amputation; BKA: Below knee amputation; M: Month; MI: Myocardial infarction.

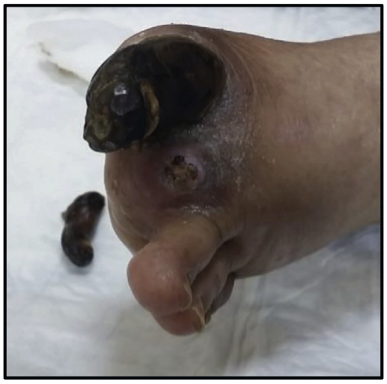

Fig. 1. Patient with autoamputation. Case ID 1: A 60-year-old woman presented with a diabetic 2nd toe dry gangrene. She was compliant with management. 4 months after starting management she developed 1st toe dry gangrene. Then she had autoamputation of the 2nd toe after 11 months.

significant pain was reported in three subjects (two had undergone surgical amputation and one had successful autoamputation) [11].

Surgical amputation has shown to help in faster recovery and reducing the discomfort associated with dry gangrene. In a case series that analyzed toe necrosis resulting from different etiologies, two patients with dry gangrene preferred surgical amputation over autoamputation; both patients recovered well enough to walk with the help of special shoes [19]. Early surgical amputation may also help to reduce rates of major amputations. In a Saudi Arabian study by Elsharawy et al., aggressive attempts at foot salvage before AKA/BKA were justified in patients with diabetes and advanced foot gangrene. In their study, midtarsal amputations, the primary management strategy of advanced gangrene achieved functional ambulation in 20/30 (67%) limbs analyzed [20]. This is in line with this study where two patients underwent successful midtarsal amputation and were able to walk with the help of special shoes. However, despite our best efforts, 4 patients had to undergo BKA (2 compliant and two non-compliant), while another 2 non-compliant patients underwent AKA.

It is well known that ischemia, neuropathy, and infection are the three pathological components in the etiology of diabetic foot complications [16]. Chronic ischemia (indicated by ABI ≤ 0.5) and neuropathy were present at baseline in all patients included in our study. During the study, six patients also developed infections and/or sepsis. Earlier surgical intervention could have possibly reduced the chances of infection in these patients. Low ABI values ($\leq$0.9) have been previously shown to be predictors of major lower extremity amputations (LEAs) in patients with DFUs [21]. In addition, low ABI values have also been reported to be independent risk factors for survival in patients with diabetes and foot ulcers, regardless of the status of LEA [22,23].

Two deaths were observed in our study (one due to myocardial infarction and the other due to sepsis). Previously, it has been shown that the mortality rate is more than two times higher among DFU patients when compared to the nondiabetic group, and

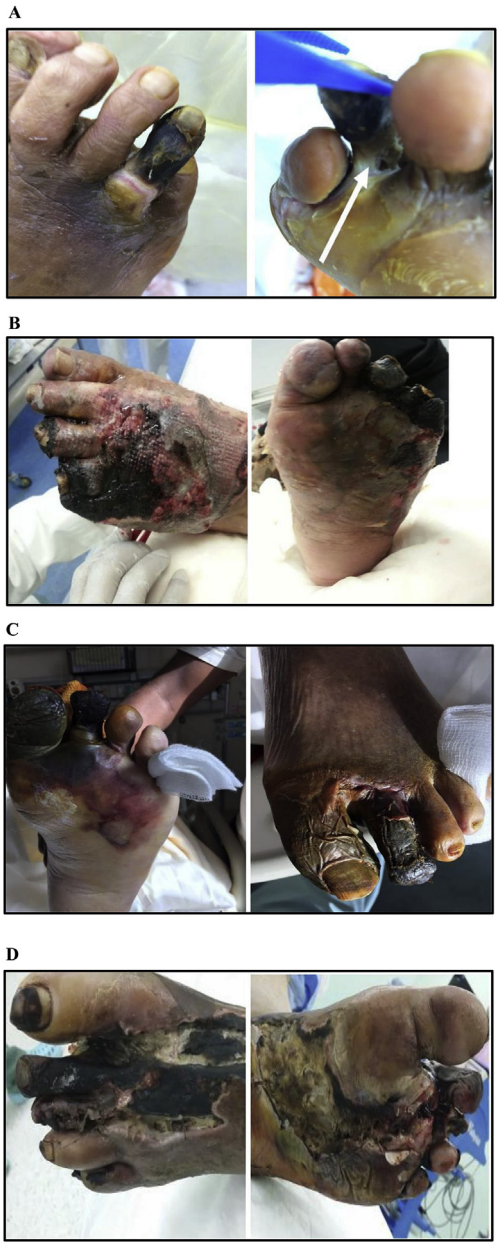

Fig. 2. Description of a few patients (both compliant and non-compliant) who had infection and/or sepsis. **A: Case ID 4**: Dry gangrene of 4th toe with compliant patient; developed infection (white arrow). The patient underwent a BKA after 5 months. **B. Case ID 8:** Non-compliant patient with 2nd toe dry gangrene; lost follow up and presented with sepsis and extension of infection and gangrene. He died after 3 months due to sepsis. **C. Case ID 10:** Non-compliant patient with 2nd toe dry gangrene; lost follow up for 3 months then presented with sepsis and extension of infection and gangrene. He had to undergo an AKA after 7 months of disease presentation. **D. Case ID 11**: A 71-year-old male with diabetes presented with dry gangrene of the 2nd toe. His medical history included sensory neuropathy and peripheral vascular disease. He had absent pedal pulses with an ABI <0.4. Endovascular surgery failed to recanalize the tibial vessels which were heavily calcified. He was followed with the autoamputation strategy. However, after one month of follow up, the patient failed to attend the clinic. He came back 2 months later with extension of gangrene, severe infection, and sepsis. He was admitted and treated for sepsis; however, he refused amputation till 1 month. He agreed to undergo BKA 4 months after disease presentation.

patients with a history of DFU have almost 40% higher mortality than diabetic patients without a history of DFU [24,25]. Also, most of the reported deaths were due to myocardial infarction and fatal stroke [26].

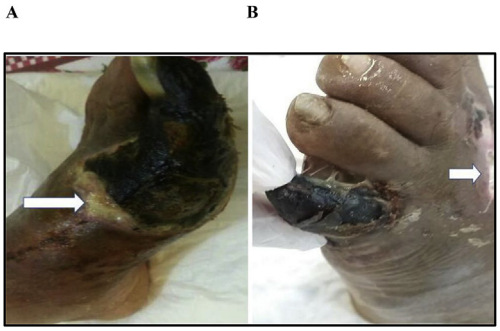

Fig. 3. Patients with worse outcomes due to cauterization. A: **Case ID: 7:** Dry gangrene of the 1st toe. Lost follow-up for 2 months and then presented with extension of the gangrene of the same toe. He tried cautery (white arrow). Finally, he underwent BKA after 3 months of disease presentation. **B: Case ID: 9:** Dry gangrene of the 5th toe lost follow-up for 1 month and then presented with wet gangrene of the same toe. He tried cautery (white arrow). Finally, he had to undergo midtarsal amputation after 8 months.

In this study, of the five patients with greater toe necrosis, major complications were observed in three patients; one of them died, one had to undergo an AKA, and one of them needed a BKA. A previous study has shown that greater toe necrosis is associated with significantly higher rates of total toe loss and major amputation compared to other toes [27]. In our study, we observed that dry gangrenes of the second toe were also associated with complications similar to those observed with the greater toe. Of the four patients with the second toe affected, major complications were observed in three patients; one patient died, one needed an AKA, and another needed a BKA. Thus, the initial location of necrosis may be predictive of limb prognosis, as observed in our study.

Our study included only patients with type II diabetes. It has been shown that the etiology of diabetic neuropathy differs in type I and type II diabetes. Compared to type I diabetes, the initial structural defects in type II diabetes are reversible and milder, despite similar hyperglycemic exposure. However, this phase is progressively replaced by structural degeneration that leads to nerve fiber loss [28]. This accompanied by the long duration of diabetes observed in our study (22.75 years) and high rates of chronic complications (such as coronary artery disease, end-stage renal disease, hypertension, etc.) may explain the severity of dry gangrenes observed in our study, and the consequent need for surgical amputation in most of the patients.

The rate of amputation in the lower limbs is inversely related to the prevention and management of foot ulcers, and hence are important indicators of patient and healthcare awareness. Overall, a high incidence of amputation may be reflective of a higher prevalence of diabetes, late referral, limited resources, or an outcome of using a particular approach towards gangrene management. In Saudi Arabia and other Middle-East countries, poverty, lack of education, unhygienic living environment, along with cultural, social and individual patient factors play a critical role in the decision-making process for amputations. Most patients present with advanced diabetic foot complications, which delays proper management, whereby toe or foot amputations are inevitable [29–31]. Moreover, the home healthcare system is still underdeveloped in Saudi Arabia, and patients are required to visit an outpatient care clinic for daily dressing, as was needed for our study. This may be one of the factors that led to patients' non-compliance to follow-up treatments, which further worsened their prognosis.

In our study two non-compliant patients also tried cauterization. In Arab countries, herbal and traditional medicine in the form

of cautery is widely used, often as a last resort, for the treatment of many diseases including diabetic foot. This is also an important cause of delays in the presentation of patients to the specialist, which is eventually associated with poor patient outcomes. Local healers use heated (glowing red) iron rods of various sizes and shapes, which usually have sharp/pointed ends, and are applied to the affected site using either a fine touch or firm pressure. The site of the application varies with different disease. In the diabetic foot, it is commonly observed in the dorsum of the foot or the lateral aspect of the lower leg [31].

Early effective management of diabetic foot complications using a multidisciplinary team consisting of a general practitioner, a nurse, an educator, an orthotic specialist, a podiatrist, and consultations with other specialists such as vascular surgeons, infectious disease specialists, dermatologists, radiologists, endocrinologists, dieticians, and orthopedic specialists can decrease the risks associated with DFUs by 50–85% [32–34]. Therefore, it is important to educate people about diabetes, diabetes control, and foot care in order to overcome challenges in diabetic foot management, especially in rural Arabic countries [35–38].

5. Conclusion

This case series does not suggest a correlation between autoamputation rate and patients' compliance to follow-up visits and wound care regimen, disease severity, or degree of comorbidities. Both compliant and non-compliant patients initially awaiting autoamputation did not end up with autoamputation, except one. Patients in both groups had to undergo major surgical amputations. Interestingly, AKA and deaths were reported only in the non-compliant group.

Overall, autoamputation strategy of managing diabetic dry toe gangrene should be practiced cautiously and treatment should be individualized, especially for patients with limited resources, lower education level, and those dwelling in poverty and unhygienic living conditions. Early surgical intervention should be opted to improve patients' quality of life. Waiting for autoamputation may lead to worse clinical outcomes if patients do not receive definitive and timely management. Patient and health care personnel's awareness, early management, and meticulous follow-up can lead to prevention of complications associated with clinical outcomes of diabetic patients with dry gangrene awaiting autoamputation.

Conflicts of interest

None.

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