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Research Article

RESISTANCE PHENOTYPES AND EPIDEMIOLOGICAL PROFILE OF BACTERIA ISOLATED FROM DIABETIC WOUNDS IN THE ENDOCRINOLOGY DEPARTMENT OF THE NATIONAL REFERENCE UNIVERSITY HOSPITAL OF N'DJAMENA, CHAD

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ABSTRACT

Diabetic wound infection and antibiotic resistance remain a major concern for healthcare workers. The objective of this study was to contribute to improving the management of wounds in diabetic patients. This was a prospective, descriptive and analytical study, carried out from February 2022 to February 2023. The isolation and identification of bacteria were carried out according to standard clinical bacteriology techniques. Of the 104 diabetic patients with wounds, 80 cultures were positive, giving a prevalence of infection of 76.9%. The average age of the patients was 50 years with the extremes of 28 and 80 years. The sex ratio was 1.5. Type 2 diabetes predominated at 95%. The average duration of progression of diabetes was 8 years. The sampling site was feet in 77.5%. The predominant germs isolated were *Staphylococcus aureus*, (*Escherichia coli*), *Staphylococcus* spp, *Proteus mirabilis* with a rate of 32.1%, 28.7%, 21.8%, 8.05% respectively. This study made it possible to know the prevalence and frequency of bacteria involved in wound infections in diabetics. It also showed strong resistance of isolated bacterial strains to aminopenicillins and high sensitivities to imipenem and fusidic acid.

Keywords: Diabetic wound, culture, antibiotic resistance, N'Djamena, Chad.

INTRODUCTION

Diabetes is a metabolic disorder characterized by chronic hyperglycemia resulting from a defect in insulin secretion and/or insulin action [1]. It constitutes a real public health problem. Indeed, in 2019 the International Diabetes Federation (IDF) estimated the number of diabetic adults (20-79 years old) in the world at 463 million, representing a prevalence of 9.3% including 19.4 million in Africa and 4.2 million the number of deaths among adults worldwide, or one death every 8 seconds [2]. Diabetes can cause complications that affect several parts of the body and increase the overall risk of premature death. Among the possible complications are wounds which are frequent and formidable, mainly including diabetic feet and necrotizing dermohypodermatitis [3, 4]. The infection of diabetic wounds acts as an aggravating element and increases the risk of complications because it is due to poly-microbial flora [5, 6]. Diabetic foot includes any infection, ulceration or destruction of the deep tissues of the feet associated with neuropathy or arteriopathy of the lower limbs [7]. L'infection d'un pied diabétique peut revêtir plusieurs formes cliniques allant de l'infection superficielle d'une plaie jusqu'à la fasciite nécrosante qui peut engager le pronostic vital et qui relève d'un traitement médicochirurgical urgent [8]. The diabetic environment is particularly favorable to infections. Approximately 15 to 20% of diabetics develop foot ulceration during their lifetime, and 40% to 80% of these feet will become infected [9,10]. Speaking of bacterial dermohypodermatitis and necrotizing fasciitis, these are bacterial skin infections of the dermis and epidermis accompanied by necrosis. These are serious infections, fatal in around 30% of cases, which require surgical treatment in addition to antibiotics [11]. These infections lead to the use of antibiotics against which the bacteria often adapt and find a resistance mechanism [12]. Antibiotics are natural or synthetic substances that can destroy or inhibit the growth of bacteria [13]. In recent years, there has been an increasing prevalence of antibiotic resistance worldwide [14]. This is defined as the ability of a microorganism to grow in the presence of an antimicrobial agent [15]. Antibiotic resistance has been considered a public health priority since 2014 by the WHO [10]. It is the cause of 700,000 deaths per year worldwide [16,17]. This figure will rise to 10 million in 2050, including 4.1 million deaths in Africa if nothing is done [18,19]. In Chad, diabetes is a common pathology with a rural and urban prevalence of 7.36% and 12.9% respectively [20]. Wounds accounted for 21.9% of the main complications and 21% of the main causes of mortality in diabetics [21]. Few studies were devoted to antibiotic resistance in diabetic patients in Chad, hence the importance of this work.

The general objective of this study was to contribute to improving the management of diabetic patients with infected wounds in terms of rational use of antibiotics. The results of this study could serve as an awareness tool for the management of diabetic wounds in terms of rationalization of antibiotics in Chad.

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MATERIAL AND METHODS

Setting, Type and period of study

The following services served as a framework for the study:

The endocrinology department of the National Reference University Hospital Center of N'Djamena (CHURN);The bacteriology unit of the Diagnostic Research and Scientific Expertise Laboratory (LaboReDES) of the Faculty of Human Health Sciences (FSSH) of the University of N'Djamena.

The study was prospective, descriptive and analytical spread over a period of one year from the beginning of February 2022 to the end of February 2023.

Sampling

The study population consisted of any patient of any sex and age, admitted to the endocrinology department of the CHU-RN with a wound. The sample size was proportional to the duration of the study, a minimum of 104 samples were analyzed.

Collection and transport of biological samples

Pus or infected pathological fluids were collected using two sterile swabs and collected in two sterile containers containing sterile physiological water. One of the samples is used for direct examination (gram staining) and the other for culturing. The sample is accompanied by a collection form, and sent quickly to the laboratory with a maximum transport time not exceeding two hours after collection, respecting aseptic conditions.

Microbiological analyzes

Microscopic observations of the smears after GRAM staining made it possible to select the different agars for culturing.

Culture and antibiogram

Solid agar media are used for culture. Chapman agar was used for the search for staphylococci, Hektoen agar for the isolation of Gram-negative bacilli, Chocolate agar + poly vitex + hemoglobin, and fresh blood agar for the search for fastidious bacteria.

The petri dishes containing the solid agars were inoculated and incubated at 37°C, micro-aerobically for Chocolate Agar, and aerobically for Chapman and Hektoen. After 18 to 24 hours, the bacterial colonies were isolated and subjected to biochemical identification.

Biochemical identification of bacteria

The API 20 E, API STREP, API STAPH galleries and other complementary biochemical tests were used to identify germs on the basis of their biochemical characters. Study of the sensitivity of bacteria responsible for wound infections in diabetics to antibiotics

Choice of antibiotics

Antibiotics were chosen based on their prescription for the treatment of wound infections in the endocrinology departments of CHURN.

Table 1: Antibiotics chosen for sensitivity testing

Category	Family	Antibiotic/dose	Diameter (mm)		
			Sensitivity	Intermediate	Resistance
	Fusidic acids	Fusidic acid (10 µg)	>32	26-32	<26
	Betalactams	Oxacillin (5 µg)	>14	8-14	<8
		AMC (20-10 µg)	>24	18-24	<18
		Ceftriaxone (30 µg)	>22	16-22	<16
		Ceftazidime (30 µg)	>31	25-31	<25
		Imipenem (10µg)	>32	17-24	<17
	Fluoroquinolones	Ciprofloxacin (5µg)	>22	19-22	<19
	Macrolides	Erythromycin (15 µg)	>22	19-22	<19
	4 Families	8 antibiotics			

Quality control was carried out using the reference strain *Escherichia coli* ATCC 25922, *Staphylococcus aureus* ATCC 29213; *Streptococcus pneumoniae* ATCC 49619; (CA-SFM, EUCAST; 2016-2022).

AMC: Amoxicillin-clavulanic acid.

Antibiogram

The antibiogram was carried out using the Kirby and Bauer technique which is the method by diffusion of disks impregnated with antibiotics in MH or chocolate agar medium flooded with bacterial inoculum (0.5MacFarland) in suspension and incubated at 37°C for 24 hours. Reading of the diameter of the inhibition zones was carried out following the recommendations of the Antibiogram Committee of the French Society of Microbiology and the European Committee on Antimicrobial Susceptibility Testing (CA-SFM, EUCAST; 2016-2020) table 1 [22].

Data analysis

Microsoft office Excel and Microsoft office Word software were used to analyze the results and write the report. The chi-square test was used to study the correlations between variables with a margin of error of 5%.

Ethical and administrative considerations

The study received prior authorization from the Dean of FSSH and the Director General of CHURN. The verbal consent of each patient or their dependent, the anonymity and confidentiality of the results are respected.

Prevalence of wound infection

The study was carried out on 104 diabetic patients with wounds. Among the 104 samples cultured, 80 (76.92%) cultures were positive for infection and 24 (23.08%) were negative (*p* = 0, 01, significant difference in favor of positive cultures).

Distribution of culture-positive patients by gender

The male gender represented 60% with a number of 48 and the female gender accounted for 32 or 40% (*p* = 0.50, non-significant difference). The sex ratio was 1.5 in favor of men.

Distribution of patients with positive culture according to age group

Depending on the age group, the result is shown in the following figure 1. The most represented patients were those aged 55 to 66. The average age was 50 years with extremes of 28 and 80 years.

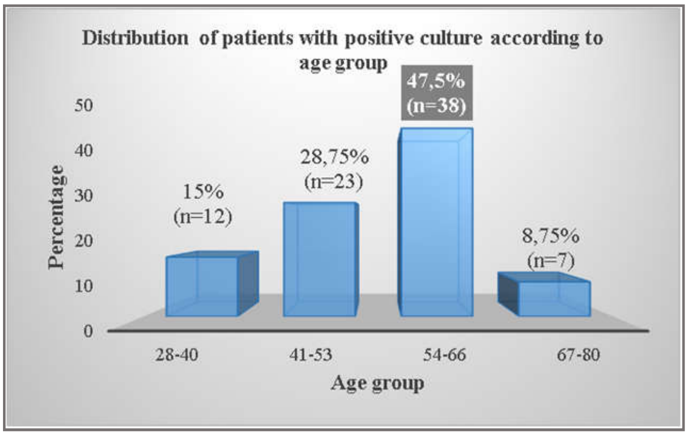

Figure 1: Distribution of patients with positive culture according to group

Distribution of patients with positive culture according to origin

Patients from the urban area were mainly represented 59 (73.75%), compared to 21 (26.25%) from the rural area (*p* = 0.05, significant difference in favor of the predominance of patients coming from the urban area).

Distribution of patients with a positive culture according to schooling

He majority of patients were not in school: 51 (63.75%) compared to 29 (36.25%) in school patients (*p* = 0.50, non-significant difference).

Distribution of patients with positive culture according to follow-up

Among the 80 patients with positive cultures, 57 (71.25%) were hospitalized and monitored and 23 (28.75%) were outpatients.

Distribution of patients with a positive culture according to profession

According to profession, traders predominated with a rate of 36.25% followed by housewives and farmers with 33.75% and 10% respectively.

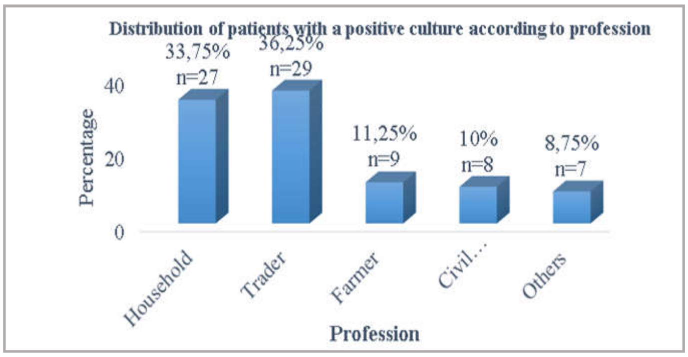

Figure 2: Distribution of patients with a positive culture according to profession

Distribution of culture-positive patients according to type of diabetes

The majority of patients (76) with positive culture had type 2 diabetes, i.e. a prevalence of 95%, and 4 (5%) had type 1 diabetes.

Distribution of culture-positive patients according to duration of diabetes

The most affected group had diabetes dating back 2 to 6 years with a proportion of 36.25%; followed by 7-11 years and 12-16 years with proportions of 31.25% and 17.5% respectively. The average age of development of diabetes was 8 years.

Table 2: Distribution of culture-positive patients according to duration of diabetes

Diabetes duration	Effective	%
0-1 year	7	8.75
2-6 years	29	36.25
7-11years	25	31.25
12-16 years	14	17.5
17-21 years	2	2.5
22-26 years	3	3.75
Total	80	100

Distribution of patients according to antibiotic therapy

Among 104 patients surveyed, 69 patients were under antibiotic therapy on the date of sampling, of whom 75.36% (52/69) were found to be positive for infection and 24.64% (17/69) negative. Thirty-five (35) patients were not on antibiotic therapy on the date of sampling, 80% (28/35) of whom had a positive bacterial test result, and 20% (7/35) were negative for infection.

Distribution of patients with positive culture according to the nature of the sample

Among the 80 infected patients, 68 or 85% had suppurated wounds.

Distribution of culture-positive patients according to collection site

The majority of our samples were from the foot with a rate of 77.5% followed by the hand with 6.25%.

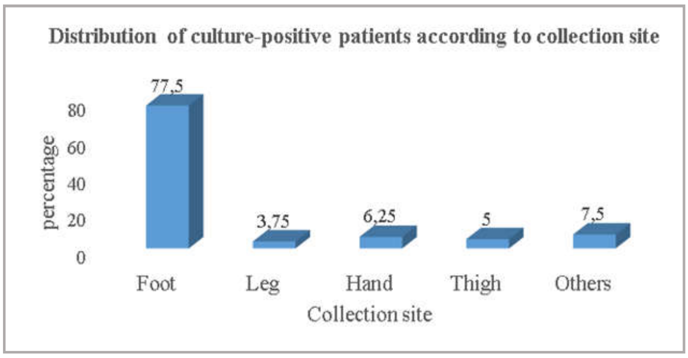

Figure 3: Distribution of patients with positive culture according to sampling siteOthers: neck, buttock, back.

Distribution of the appearance of wounds according to positive or negative culture

The majority of infected wounds suppurated (50%) and 35% were necrotic and suppurated. The suppurating wounds were 50% sterile.

Table 3: Distribution of appearance of wounds according to positive or negative culture

	positive culture		Négative culture	
Wound appearance	Effective	%	Effective	%
Suppurate	40	50	12	50
Suppurate and necrotic	28	35	1	4.17
Necrotic	5	6.25	3	12.5
Red bottom	7	8.75	8	33.33
Total	80	100	24	100

Distribution of wound discharge according to positive or negative culture

In positive cultures, wound discharge was abundant in 39 (48.75%) cases and 66.67% (16) of scanty discharges were culture negative.

Table 4: Distribution of wound discharge according to positive or negative culture

	Positive culture		Negative culture	
Flow	Effective	%	Effective	%
Abundant	39	48.75	4	16.67
Scarce	33	41.25	16	66.67
Non-existent	8	10	4	16.67
Total	80	100	24	100

Distribution of isolated bacterial strains

Among the 80 positive cultures, 7 each had 2 bacterial germs. *Staphylococcus aureus* was the most frequent followed by *Escherichia coli* with the proportions of 32.18% and 28.74 respectively.

Table 5: Distribution of isolated bacterial strains

Bacteria strains	Effective	%
Staphylococcus aureus	28	32.18
Escherichia coli	25	28.74
Staphylococcusspp	19	21.84
Proteus mirabilis	7	8.05
Streptococcus haemolyticus	4	4.60
Pseudomonas aeruginosa	1	1.15
Klebsiella pneumoniae	1	1.15
Serratia marcescens	1	1.15
Clostridium perfringens	1	1.15
Total	87	

Testing strain sensitivity of isolated bacterial strains to antibiotics

Table 6 indicates the evaluation of the effectiveness of 8 antibiotics from 4 families to isolated bacterial strains. Aminopenicillins were almost completely ineffective with an overall resistance rate of 88.2% to strains of *Staphylococcus* isolated from diabetics' wounds. Of the 28 strains of *Staphylococcus aureus* isolated in this study series, 93% were sensitive to imipenem, 71.4% to erythromycin and 100% to fusidic acid.

The highest resistance concerned, oxacillin (86%), ceftriaxone (86%) and ceftazidime (69.4%).In this series, 25 strains of *Escherichia coli* were isolated: 96% were sensitive to imipenem; 56% to ciprofloxacin. The highest resistances concerned, amoxicillin + clavulanic acid (100%); ceftriaxone (68%) and ceftazidime (68%).

In the study, 19 strains of *Staphylococcus* spp were isolated: 84.2% were sensitive to imipenem, 68.2% to ciprofloxacin and 47.37% to erythromycin and 100% to fusidic acid.

The highest resistances concerned, oxacillin (89.5%), erythromycin (53%), ceftazidime (63%) and ceftriaxone (59%).

In this series, 7 strains of Proteus mirabilis were isolated: 100% were sensitive to imipenem; 100% ciprofloxacin; 71.4% to ceftriaxone and ceftazidime each.The highest resistance concerned amoxicillin clavulanic acid (100%).

In the study, 4 strains of *Streptococcus haemolyticus* were isolated: 100% were sensitive to imipenem and 75% to ciprofloxacin.

The highest resistances concerned oxacillin (100%), 57% to erythromycin and ceftazidime each. The *Pseudomonas aeruginosa* strain isolated in this study was sensitive to imipenem and resistant to amoxicillin clavulanic acid, ceftriaxone, ceftazidime and ciprofloxacin.

In this study series, *Klebsiella pneumoniae* was sensitive to imipenem, and resistant to amoxicillin, clavulanic acid, ceftriaxone, ceftazidime and ciprofloxacin.

The Serratia marcescens strain isolated in this study was sensitive to imipenem and resistant to amoxicillin clavulanic acid, ceftriaxone, ceftazidime and ciprofloxacin.

The *Clostridium perfringens* strain isolated in this study was also susceptible to imipenem and resistant to amoxicillin clavulanic acid, ceftriaxone, ceftazidime and ciprofloxacin.

Table 6: Evaluation of the effectiveness of the antibiotics tested against the 87 bacterial agents isolated

Bacterial agents	Nb	Antibiotic															
		OXA		AMC		CRO		CAZ		IMP		ERY		CIP		AF	
		S (%)	I+R (%)	S (%)	I+R (%)	S (%)	I+R (%)	S (%)	I+R (%)	S (%)	I+R(%)	S (%)	I+R (%)	S (%)	I+R(%)	S (%)	I+R(%)
Staphylococcus aureus	28	4(14.3)	24(86)	4(14.3)	24(86)	5(18)	23(82)	8 (28.6)	20(69.4)	26(93)	2(7)	20(71.4)	8(29.6)	10(36)	18(64)	28(100)	0(0)
Escherichia coli	25	NR		0 (0)	25(100)	8 (32)	17 (68)	8 (32)	17(68)	24 (96)	1 (4)	NR		14 (56)	11 (44)	NR	
Staphylococcus spp	19	2(10.5)	17(89.5)	10(53)	9(47)	8(42.1)	11(59)	7 (37)	12 (63)	16(84.2)	3(16)	9(47.4)	10(53)	13(68.2)	6(31.6)	19(100)	0(0)
Proteus mirabilis	7	NR		0 (0)	7 (100)	5 (71.4)	2 (28.6)	5 (71.4)	2 (28.6)	7 (100)	0 (0)	NR		7 (100)	0 (0)	NR	
Str. haemolyticus	4	0 (0)	4 (100)	NR		2(50)	2(50)	1(25)	3(75)	4(100)	0(9)	1(25)	3(75)	3 (75)	1(25)	NR	
P. aeruginosa	1	NR		0 (0)	1 (100)	0 (0)	1 (100)	0 (0)	1 (100)	1(100)	0 (0)	NR		1(100)	0 (0)	NR	
Klebsiella pneumoniae	1	NR		0(0)	1(100)	0(0)	1(100)	0(0)	1(100)	1(100)	0 (0)	1(100)	0 (0)	0 (0)	1 (100)	NR	
Serratia marcescens	1	NR		0 (0)	1 (100)	0 (0)	1 (100)	0 (0)	1 (100)	1(100)	0 (0)	NR		0 (0)	1 (100)	NR	
Clostridium perfringens	1	NR		0 (0)	1 (100)	0 (0)	1 (100)	0 (0)	1 (100)	1(100)	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)	NR	
Total (%)	87	6(12)	45(88.2)	14(17)	69(83)	28(32.2)	59(69.8)	29(33.3)	58(66.6)	81(93.1)	6(7)	31(58.5)	22(41.5)	48(55.2)	39(45)	47(100)	(0)

NR: Not Required, Nb: Number, S: Susceptible, I+R (intermediate + resistant): Resistance, Oxa: Oxacillin, AMC: Amoxicillin-clavulanic acid, CRO: Ceftriaxone, CAZ: Ceftazidime, IMP: Imipenem, ERY: Erythromycin, CIP: Ciprofloxacin, AF: Fusidic Acid, *Str. Haemolyticus*: *Streptococcus haemolyticus*, *P. aeruginosa*: *Pseudomonas*

DISCUSSION

Among 104 samples cultured, 80 were positive for infection, representing a prevalence of 76.9%. This result is similar to that found by Fatima [23] in Morocco in 2017 which was 70%. It is lower than that of Abrogoua et al in Ivory Coast in 2019 who obtained a prevalence of 93.4% [24]. The occurrence of the wound in diabetics is often of mechanical origin, the high prevalence of infection is linked to the alteration of anti-infectious defenses [25] and also to the delay between the appearance of the wound and the consultation. This prevalence reported in these studies show the susceptibility of diabetics to infection. This susceptibility is linked to hyperglycemia which hinders chemotaxis and inhibits the foundation of the phage veil of the polynuclear cell and makes the organism immunodeficient [26].

The study revealed a predominance of the male gender which represented 60% of patients with infected wounds, i.e. a sex ratio of 1.5. This result is superimposable to those obtained by Abrogoua et al in 2019 in Ivory Coast [24] and Awalou et al in 2018 in Togo [5] who obtained a sex ratio of 1.6 and 1.38 respectively in favor men. This male predominance in the study could be explained by the large number of men in the study population, due to their exposure to the occurrence of wounds following occupational accidents. On the other hand, Kokou in Bamako in 2015 obtained a sex ratio of 0.87 in favor of women. This could be explained by the high frequency of diabetes among women in their context [25].

Speaking of age, the group most affected in diabetic wound infections was 54 to 66 years old with a frequency of 47.5% followed by 41 to 53 years old with 28.7%, the average age was 50 years old. This result is similar to that of Kokou who reported in 2015 in Bamako that the age group from 56 to 65 predominated with 30.8% [25]. Furthermore, studies have shown that wounds occur most often in diabetic patients whose average age is 51 years [29, 30].In terms of profession, the patients most concerned were traders with a rate of 36.2%. This result differs from that of Kokou in 2015, which obtained 41.3% of housewives and 17.5% of traders [25]. Occupation being an indicator of a person's socio-economic position and also determines the degree of activity of a person and the environment in which they live. Sedentary lifestyle would be the probable cause of the occurrence of sores among shopkeepers and housewives in this series of studies. Type 2 diabetes represented 95% of cases in this study, Lokrou et al also found type 2 diabetes in 91.3% of cases [25].

Type 2 diabetes remains the most common type of diabetes worldwide [2].

In this study, the most reported duration of diabetes progression ranges from 2 to 6 years with a rate of 36.2%, with an average of 8 years. This result is super imposable to that of Lokrou et al who found in Ivory Coast an average duration of 8.2 (± 3.4) years [25]. It is similar to that of Awalou et al who reported an average duration of progression of diabetes of 11.6 years [5]. These results show that the wound often appears in the first decades of the disease.

The urban population represented 73.7% of patients with infected wounds in the study. This result confirms data from the International Diabetes Federation which reported in 2019 that the prevalence of diabetes is higher in urban areas than in rural areas [2]. This could be explained by a sedentary lifestyle in urban areas and also poor diet rich in sugars and lipids which lead to the progression of obesity. Foot involvement was the majority with a rate of 77.5% in the population with infected wounds. In a study which involved all parts of the body, Kokou reported that foot infection is the most represented with a rate of 57.7% in 2015 in Bamako [25]. The occurrence of sores often on the feet of diabetics could be explained by arteriopathy and neuropathy of the foot.

Among the positive cultures 9 different germs were isolated. *Staphylococcus aureus* predominated with a rate of 32.1% followed by *Escherichia coli* with 28.7%. This result is close to that found by Firomsa et al in Ethiopia in 2020 who obtained a predominance of *Staphylococcus aureus* at 34% and *Escherichia coli* at 20% [26]. Tewahido et al in 2019 in Ethiopia also obtained a predominance of Staphylococci aureus at 59% and *Escherichia coli* at 23.5% [27, 28]. Djahimi et al in Algeria in 2013 obtained Staphylococcus aureus at 30.7% [12]. Kokou in 2015 found *Staphylococcus aureus* in 30.7% of patients followed by *Escherichia coli* and *Klebsiella pneumoniae* which represented 20.1% and 15.3% respectively, or approximately 66.3% of all germs [25]. This could be explained by the fact that *Staphylococcus aureus* and *Escherichia coli* are ubiquitous bacteria and, as the literature highlights, they are often present in samples of this genus. These variations in results could be explained by geographical variations, epidemiological differences, personal hygiene practices, availability and use of antibiotics.In 28 strains of *Staphylococcus aureus* isolated, 92.8% were sensitive to imipenem, 71.4% to erythromycin and 46.4% to gentamicin; 85.7% were resistant to oxacillin; 50% were resistant to ceftriaxone and ceftazidime each; 53.5% were resistant to ciprofloxacin. These results are also comparable to those found by a study carried out in 2021 which noted that *Staphylococcus aureus* is resistant to several families of antibiotics: Betalactams (Oxacillin at 92%), aminoglycosides (Gentamicin at 85%) and fluoroquinolones (Ciprofloxacin at 62%) [29].

In 25 strains of *Escherichia coli* isolated: 93% were sensitive to imipenem; 36% to ciprofloxacin and 18% to ceftriaxone; 100% were resistant to amoxicillin + clavulanic acid. A study carried out in 2016 at the internal medicine department of the Constantine University Hospital in Algeria reported that resistance rates are high to Amoxicillin (84%), to the Amoxicillin/clavulanic acid combination (73%), Cefotaxim (32%), Gentamicin (19%), Ciprofloxacin 76% and Cefazolin (73%) [31]. In 7 strains of *Proteus mirabilis* isolated: 100% were sensitive to imipenem; 100% to ciprofloxacin; 71.4% to ceftriaxone and ceftazidime each; 100% were resistant to amoxicillin + clavulanic acid. Djombera in 2016 in Bamako, found that these bacteria are resistant to Amoxicillin, ticarcillin and Cefazolin with resistance rates of 67.2%, 76.3%, 66.07% respectively [32].

A strain *of Pseudomonas aeruginosa* was isolated during the study; she was: Sensitive to imipenem and ciprofloxacin, resistant to tetracycline and ceftazidime, resistant to ceftriaxone and amoxicillin + clavulanic acid. A study carried out by Tiwari et al in India in 2011 indicates that the resistance rates are: 50% to Gentamicin and Ceftazidime, 51% to Ciprofloxacin [10]. A study carried out in 2016 at Constantine hospital reports that strains of this bacteria are resistant to: 21% to Imipenem, 16% to Gentamicin, 13% to Ceftazidime and 15% to Ciprofloxacin [31].

More than 80% of the isolated organisms each were resistant to oxacillin and amoxicillin + clavulanic acid [33, 34]. The isolated Clostridium perfringens and Serratia marcescens were resistant to almost all molecules tested except sensitive to imipenem. Furthermore, similar studies have shown high rates of resistance of isolated strains to aminopenicillins. This resistance could be linked to the secretion of broad-spectrum beta-lactamases (ESBL) by the bacterial strains in question.

CONCLUSION

Adequate management of diabetic wounds remains one of the major concerns for healthcare workers today. Bacterial infections of these wounds appear to be an aggravating factor because their prevalence is high. In this study the most encountered bacteria were Staphylococcus aureus, *Escherichia coli*, *Staphylococcus*spp and *Proteus mirabilis*. Resistance to the penicillin family was very high and sensitivity to Carbapenems and fusidic acid was high. The appearance of resistance is often due to the uncontrolled use of antibiotics. Antibiotic therapy adapted to the antibiogram is necessary for better management of bacterial infection of the diabetic wound with a view to limiting complications and even reducing amputations.

Declaration of Competing Interests

The authors declare that there is no conflict of interest.

Acknowledgments

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REFERENCES

1. Malone, M., Johani, K., Jensen, SO., Gosbell, B., Dickson, HG., Hu, H., Vickery, K. (2017). Next Generation DNA Sequencing of Tissues from infected Diabetic Foot Ulcers. E Biomed, 21, 142-149. doi: 10.1016/j.ebiom.2017.06.026
2. MacDonald, A., Brodell, J D., Daiss, J L., Schwarz, EM., Oh, I. (2019). Evidence of differential microbiomes in healing versus non-healing diabetic foot ulcers prior to and following foot salvage therapy, J Orthop Res, 37 (2019),1596-1603. doi : 10.1002/jor.24279
3. Centers for Disease Control and Prevention (2020). Combating Antimicrobial Resistance, a global threat. https://www.cdc.gov/drugresistance/index.html, 2020.
4. World Health Organization (2015). Global Action Plan on Antimicrobial Resistance. Geneva. https://www.who.int/publications/i/item/9789241509763.
5. Awalou, MD., Mossi, EK., Djagadou, AK., Balaka, A., Tchamdja, T., Moukaila, R. (2018). Diabetic foot: epidemiological, diagnostic, therapeutic and evolutionary aspects at the medical-surgical clinic of the Sylvanus Olympio University Hospital in Lomé. The pan Afric Med J, 30 (4), 1-5. doi:10.11604/pamj.2018.30.4.14765
6. Verbanic, S., Shen, Y., Lee, J., Deacon, JM., Chen, I A. (2020). Microbial predictors of healing and short-term effect of debridement on the microbiome of chronic wounds, NPJ Biofilms Microbiomes, 6 (1), 1-11. https://doi.org/10.1038/s41522-020-0130-5.
7. Pierre, D (2020). Diabetic foot wound: treatment and prevention.www.podexpert.com.
8. Karen, B., Brigitte, V., Dominique, T., Nadine, B., Charly, B., Juan, R. (2016). Nursing management of the diabetic foot. www.diabetevaud.ch.
9. Kalan, LR., Meise, Ljs., Loesche, MA., Horwinski, J., Soaita, I., Chen, X., Uberoi, A., Gardner, SE., Grice, EA. (2019). Strain- and Species-Level Variation in the Microbiome of Diabetic Wounds Is Associated with clinical outcomes and Therapeutic Efficacy, Cell Host Microbe. 25 (5), 641-655.e5. doi: 10.1016/j.chom.2019.03.006641-655.
10. Tiwari, S., Daliparthy, D., Pratyush., Dwivedi, A., Sajiv, K., Surya, K. (2012). Microbiological and clinical characteristics of diabetic foot infections in northern India. Infect. Dev Countries, 6 (4), 329-332.
11. Zemmouri, A., Tarchouli, M., Benbouha, A., Lamkinsi, T., Bensaghir, M., Elouennass, M., Haimeur, C. (2015). Bacteriological profile of the diabetic foot and its impact on antibiotics. Pan Afri Med. J, 20 (148),1-7. doi: 10.11604/pamj.2015.20.148.5853.
12. Djahmi, N., Messad, N., Nedjai, S., Moussaoui, A., Mazouz, D., Richard, J L A., Sotto, JP. (2013). Molecular epidemiology of Staphylococcus aureus strains isolated from patients with infected diabetic foot ulcers in an Algerian University Hospital. Clin Microbiol Infecter,19 (9), E398-404. doi: 10.1111/1469-0691.12199.
13. http://www.wikipedia.org. (2010). Encyclopédie Wikipédia.
14. Zanella, MC., Benamin, K., Wuarin, L., Bnoit, C., Maitre, S., Domizio, S., Benjamin, A., Lipsky, I. (2016). Microbiology and antibiotic treatment of infected diabetic foot. Rev Medi suisse, 12 (514), 732-737.
15. Swiss Confederation., Swiss Antibiotic Resistance Strategy., Switzerland BBL (2015). https://www. blv.admin.ch/blv/fr/home/das-blv/strategien /nationale-strategies antibiokaresistanzen.html.
16. HAS (High Authority for Health) (2014). How to prevent rehospitalization of a diabetic patient with a foot injury?www.has-sante.fr,2014.
17. Statista Research Department., Deaths from antibiotic resistance worldwide (2015). https://fr.statista.com/statistiques/623506/resistance-antibiotique-decès-dans-le-monde, 2015.

18. O'Neill, J (2016). Tackling drug-resistant infections globally: Final report and recommendations, The review on antimicrobial resistance. https://amr-review.Org/sites /default/files /160518_Final paper with.
19. Tracy, J C., Lalithapriya, J., Matthew, J S., Lucas; F., Christophe, M., Dimitrios, M., Mark; G D. (2020). Contemporary Short-Term Outcomes for Staged or Primary Lower Extremity Amputation in Diabetic Foot Disease. 72 (2), 658-666.e2.doi : 10.1016/j.jvs.2019.10.083 .
20. Dionadji, M., Boy, BO., Mouanodji, M., Batakao, G., Prevalence of diabetes mellitus in rural areas in Chad. Med Trop, 70 (4), 414-5.
21. Mbainguinam, D., Oumar, A., Nodjito, N., Ibrahim, A., Prevalence of medical complications among diabetics hospitalized at HGRN of Ndjamena. Health Sci Dis, 16 (3). 1-4. www.hsd-fmsb.org.
22. CA-SFM/ EUCAST (2016-2020). The new CA-SFM / EUCAST 2015 recommendations are the result of a complete overhaul of methods for studying antibiotic susceptibility by diffusion (heavier bacterial inoculum, load of certain discs modified): www.sfm-microbiologie.org.
23. Fatima, A (2017). Infection du pied diabétique : Aspects bactériologiques et résistance aux antibiotiques. Maroc. https://fac.umc.edu.dz/snv/bibliotheque/biblio/mmf/2020/Microbiologie%20et%20traitement%20antibiotique%20du%20pied%20diab%C3%A9tique%20infect%C3%A9.pdf
24. Abrogoua, DP., Bamba, A., Doffou, E., Lokrou, A. (2019). Economic evaluation of medicinal treatment of diabetic foot at Yopougon/Abidjan University Hospital. Metabolic Dis Med, 13 (1), 91-95.
25. Kokou A (2015). Bacteriology and antibiotic therapy of diabetic wounds in the internal medicine department CHU Point G, Medicine thesis, Bamako 91p https://www.bibliosante.ml/bitstream/handle/123456789/864/15M225.pdf?sequence=1&isAllowed=y
26. Firomsa, B., Legese, C., Ginenus, F., Kumera, B. (2020). Risk factors and outcomes of diabetic foot ulcer among diabetes mellitus patients admitted to Nekemte referral hospital, western Ethiopia: Prospective observational study. An Med Surge, 18 (51), 17-23.
27. Tewahido D., Berhane Y (2017). Self-care practices among diabetes patients in Addis Ababa: a qualitative study. PLoS One, 12(2017) e0169062, https://doi.org/10.1371/journal.pone.0169062.
28. Hanson, KE., Azar MM., Banerjee R., Chou, A., Colgrove, RC., Ginocchio CC. et al. (2020). Molecular testing for acute respiratory tract infections: clinical and diagnostic recommendations from the IDSA's diagnostics committee. Clin Infect Dis, 71 (10), 2744-2751. doi:10.1093/cid/ciaa508.
29. Yin, M., Qiao, Z., Yan, D., Yang, M., Yang, L., Wan, X. et al. (2921). Ciprofloxacin conjugated gold nan rods with pH induced surface charge transformable activities to combat drug resistant bacteria and their biofilms. Mater Sci Eng, 128, 112-292.
30. World Health Organization (2016). Global Action Plan on Antimicrobial Resistance. Geneva. https://www.who.int/publications/i/item/9789241509763, 2015.
31. Benlabed, K., Lezzar, A., Laouar, H., Bentchouala, C., Benkhemissa, M., Khelifa, F., Alleg H. (2016). diabetic foot: epidemiological data, 35th. J Sci of Constantine University Hospital.https://fac.umc.edu.dz/snv/bibliotheque/biblio/mmf/2020/Bact%C3%A9riologie%20du%20pied%20diab%C3%A9tique%20au%20CHU%20de%20Constantine.pdf.
32. Djombera, Z (2018). Monitoring antimicrobial resistance of Proteus strains isolated in the Odolphe Mérieux-Bamako laboratory, Doctoral thesis in pharmacy. https://fac.umc.edu.dz/snv/bibliotheque/biblio/mmf/2020/La%20flore%20bact%C3%A9rienne%20colonisant%20le%20pied%20diab%C3%A9tique%20%20%C3%A9tude%20prospective%20et%20r%C3%A9trospective.pdf.
33. Kostyanev, T., Can, F. (2017). The Global Crisis of Antimicrobial Resistance. Antimicrob Steward, Elsevier, 3–12.
34. Lipsky, BA. (2016). Diabetic foot infections: current treatment and delaying the'post-antibiotic era', Diabetes. Metab Res Rev, 32 (1), 246-253.

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