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Original article

Profile of Clinical and Bacteriological Findings in Diabetic Foot Infections at a Tertiary Care Centre, 2025

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A B S T R A C T

Diabetic foot infections are a serious global health concern and a common occurrence in daily life. One of the primary reasons why diabetes individuals experience morbidity is diabetic foot infections (DFIs), which frequently necessitate hospitalization and may even result in amputation. The objective of this study was to identify the most frequent cause of diabetic foot infections and ulcers, treat them with the appropriate antibiotic, and reduce the need for amputation. Additionally, depending on sensitivity and culture, we should establish guidelines for the administration of an empirical antibiotic regimen in our area. Fifty-two individuals with diabetes have been selected using a convenience sampling strategy from the emergency room (ER) and clinics. The diagnosis of type 2 diabetes can be detected in patients with elevated HbA1c (> 7%), elevated blood glucose levels (fasting blood glucose > 100 mg/dl and random blood glucose > 180 mg/dl), and presenting with infection according to Wegener grade 2–5,13 wounds, and have not yet received systemic antibiotic therapy within a week. Both aerobic and anaerobic microbiological methods were used to collect and cultivate the culture specimens. The isolates' sensitivity to widely used antibiotic treatment was examined. The most sensitive antibiotics to the Klebsiella organism were ciprofloxacin, azithromycin, chloramphenicol, and meropenem. The most sensitive antibiotics to Staphylococcus organisms included amikacin, imipenem, rifampin, cefoxitin, doxycycline, nitrocefin, and levofloxacin. The antibiotics that are most sensitive to the Escherichia coli organism were Ciprofloxacin, Levofloxacin, Tetracycline, Gentamicin, Cephalexin, Vancomycin, and Meropenem. The antibiotic that was most sensitive to Serratia organisms was chloramphenicol. Gram-positive bacteria like Staphylococcus aureus or polymicrobial infections were the primary causes of diabetic foot infections.

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent [1]. Poorly controlled diabetes significantly increases the risk of both macrovascular and microvascular complications, including neuropathy, retinopathy, and pedal ulcers with or without gangrene. Approximately 15% of individuals with diabetes develop foot ulcers, which may progress to osteomyelitis [2]. The progression of these wounds from superficial lesions to severe, debilitating infections is facilitated by the patient's compromised immune response and delays in initiating appropriate treatment. Infections involving subcutaneous tissues can extend to deeper structures, potentially resulting in gangrene and, in severe cases, the need for amputation [3].

Diabetic foot infections (DFIs) are complex, prevalent, and costly complications of diabetes, representing a leading cause of non-traumatic amputations and accounting for the majority of diabetes-related hospitalizations. Few studies have examined the relationship between the diversity of causative organisms and the severity or type of infection [4]. Frykberg (2003) reported that most mild infections are monomicrobial, commonly involving Gram-positive cocci such as Streptococcus species and Staphylococcus aureus [5]. In contrast, severe DFIs are typically polymicrobial, with pathogens including Gram-negative bacilli (e.g., Klebsiella species, Proteus species, Escherichia coli, Pseudomonas species), aerobic Gram-positive cocci, and anaerobes [6].

Early initiation of optimal therapy for diabetic foot infections (DFIs) plays a critical role in reducing the morbidities associated with these infections. Timely and effective management can significantly lower the frequency and duration of hospitalizations, as well as decrease the risk of major limb amputation. Achieving

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favorable clinical outcomes depends on several factors, including prompt detection of lesions, modification of underlying host risk factors, early initiation of appropriate antibiotic therapy, and timely surgical intervention—such as debridement of necrotic bone and soft tissue. Many DFIs are real emergencies; hence, prompt antibiotic therapy should be undertaken to increase limb survival chances [7].
To improve patient care, local data on the bacteriological profile and clinical presentation of DFIs must be produced immediately. This data is going to encourage antibiotic management initiatives that aim to lower resistance rates in addition to assisting clinicians in choosing efficacious empirical antimicrobial regimens. Additionally, defining the clinical range of these illnesses in a tertiary care setting can help with risk assessment, early identification, and focused preventative measures. This study has the potential to significantly lower amputation rates, shorten hospital stays, and enhance the quality of life for diabetic patients by bridging the gap between empirical treatment and actual pathogen prevalence.
Therefore, the study aims to know the most common causative agent of diabetic foot infection and ulcer, and treat it with proper antibiotics to decrease the need for amputation, and to make guidelines to use an empiric antibiotic regimen for our locality based on culture and sensitivity.

Methods

Study design and setting

A prospective study was carried out using diabetic foot infection (DFI) samples collected between 2021 and 2022. Specimens were processed using optimal culture techniques and antibiotics. The Clinical and Laboratory Standards Institute (CLSI) recommendations were followed for conducting susceptibility testing. The study was conducted at the diabetic clinic and Albieda Medical Center.

Population and sampling

After informed consent,52 diabetic adult patients were selected by convenience sampling techniques from the clinics and emergency room Diabetic clinic, and Albieda Medical Center. Type 2 DM cases based on a raised HbA1c (> 7%) and raised blood glucose levels Patients with fasting blood glucose levels > 100 mg/dl and random blood glucose levels > 180 mg/dl, presenting with infected wounds classified as Wagner grade 2–5, and who had not received systemic antibiotic therapy within the preceding week were included in the study. Patients with other types of foot ulcers or foot infections not associated with diabetes were excluded.

Methods for data collection

Clinical history

A detailed clinical history was obtained, including the demographic profile of persons with diabetes (PWD), the duration of their diabetes and foot-related problems, previous treatments received for diabetes, and the presence of other systemic conditions. All patients underwent thorough clinical evaluation, and their foot lesions were graded using established diabetic foot infection (DFI) severity classification methods, including the Wagner Classification System, which was as follows: Grade 0: No open lesion; may have deformity or cellulitis in a high-risk foot. Grade 1: Superficial ulcer involving the full thickness of the skin but not extending to underlying tissues. Grade 2: Deep ulcer extending to ligaments and muscles, without bone involvement or abscess formation. Grade 3: Deep ulcer with cellulitis or abscess formation, often associated with osteomyelitis. Grade 4: Localized gangrene of the forefoot or heel. Grade 5: Extensive gangrene involving the entire foot.

Bacterial Isolation

After cleansing the wound surface with normal saline and debriding superficial exudates, culture specimens were collected. Samples were obtained by scraping the ulcer base or the deeper margin of the wound edge using a sterile curette. Both aerobic and anaerobic culture techniques were utilized. Specimens underwent Gram staining and were inoculated onto selective and non-selective media, including MacConkey agar (Oxoid), blood agar (BA; Oxoid, Basingstoke, UK), chocolate agar, and 5% (v/v) BA supplemented with vitamin K1 (1 µg/ml), gentamicin (75 µg/ml) (GBA), and haemin (5 µg/ml). The inoculated plates were incubated under appropriate atmospheric conditions for 24–48 hours to promote bacterial growth. Identification of isolated organisms was performed using standard microbiological procedures.

Antibiotic Susceptibility Patterns

To achieve the 0.5 McFarland turbidity criterion, bacterial colonies were suspended in sterile distilled water. Mueller–Hinton agar plates were uniformly inoculated using a sterile swab that had been submerged in the suspension. A 1 µg oxacillin disc was used to screen Staphylococcus aureus isolates for methicillin resistance. Reference strains of Escherichia coli, Staphylococcus aureus, and Enterococcus faecalis served

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as Gram-positive control strains. Antimicrobial susceptibility testing was performed against commonly used antibiotics to determine the sensitivity profile of each isolate.

Statistical analysis

Version 20.0 of the IBM SPSS software suite was used to analyze the data. (IBM Corp., Armonk, NY) Numbers and percentages were used to describe the qualitative data.

RESULTS

(Table1) showed the Distribution of the studied cases according to organism (n=52). Klebsiella was found in 12 (23.1%) of cases, Staphylococcus was found in 22 (42.3%) of cases, Escherichia coli was found in 6 (11.5%) of cases, and Serratia was found in 4 (7.7 %) of cases.

Table 1. Distribution of the studied cases according to organism (n= 52)

Organism	No.	%
N/A	4	7.7
No	4	7.7
Klebsiella	12	23.1
Staphylococcus	22	42.3
Escherichia coli	6	11.5
Serratia	4	7.7

Table 2 showed resistance and sensitivity patterns for various antibiotic classes. Klebsiella revealed moderate resistance to Augmentin (33.3%) and high resistance to Amoxicillin (75.0%), whereas Staphylococcus indicated high resistance to both Amoxicillin (80.0%) and Dicloxacillin (100.0%). Klebsiella and Escherichia coli showed total resistance to Cefotaxime in some cases, whereas Serratia was completely resistant to Ceftriaxone and Cefuroxime. Notably, Staphylococcus showed considerable resistance to Cefixime (68.4%) and Ceftazidime (75.0%). The carbapenems had a better profile, with Klebsiella being entirely susceptible to Meropenem (100.0%) despite full resistance to Imipenem, and Staphylococcus being very sensitive to both Imipenem (100.0%) and Meropenem (86.7%). Overall, carbapenems and certain cephalosporins remained effective, although penicillin demonstrated greater resistance rates, particularly against Staphylococcus and Klebsiella.

Table (2). Antibiotic Resistance and Sensitivity Patterns of Penicillin, Cephalosporins, and Carbapenems Among Bacterial Isolates

Antibiotic	Klebsiella		Staphylococcus		Escherichia coli		Serratia	
	Resistant	Sensitive	Resistant	Sensitive	Resistant	Sensitive	Resistant	Sensitive
Penicillins								
Augmentin (AMC)	4/12 (33.3%)	8/12 (66.7%)	10/19 (52.6%)	9/19 (47.4%)	2/6 (33.3%)	4/6 (66.7%)	4/4 (100.0%)	0/4 (0.0%)
Amoxicillin	6/8 (75.0%)	2/8 (25.0%)	4/5 (80.0%)	1/5 (20.0%)	2/2 (100.0%)	0/2 (0.0%)	-	-
Ampicillin (AMP)	-	-	2/2 (100.0%)	-	-	-	-	-
Dicloxacillin (DCX)	-	-	2/2 (100.0%)	-	-	-	-	-
Cephalosporins								
Ceftriaxone (CRO)	4/12 (33.3%)	8/12 (66.7%)	8/17 (47.1%)	9/17 (52.9%)	4/6 (66.7%)	2/6 (33.3%)	4/4 (100.0%)	0/4 (0.0%)
Cefuroxime (CXM)	-	-	-	-	-	-	4/4 (100.0%)	-
Cephalexin (CL)	-	-	2/2 (100.0%)	0/2 (0.0%)	0/2 (0.0%)	2/2 (100.0%)	-	-
Cefixime (CFM)	8/12 (66.7%)	4/12 (33.3%)	13/19 (68.4%)	6/19 (31.6%)	6/6 (100.0%)	0/6 (0.0%)	2/2 (100.0%)	0/2 (0.0%)
Cefotaxime (CTX)	4/4 (100.0%)	0/4 (0.0%)	8/19 (42.1%)	9/19 (47.4%)	2/4 (50.0%)	2/4 (50.0%)	-	-
Cefoxitin (FOX)	-	-	-	2/2 (100.0%)	-	-	-	-
Ceftazidime	-	-	6/8 (75.0%)	0/8 (0.0%)	2/2 (100.0%)	0/2 (0.0%)	2/4 (50.0%)	2/4 (50.0%)
Carbapenems								
Imipenem (IMP)	-	-	-	4/4 (100.0%)	-	-	-	4/4 (100.0%)
Meropenem (MRP)	0/10 (0.0%)	10/10 (100.0%)	2/15 (13.3%)	13/15 (86.7%)	0/6 (0.0%)	6/6 (100.0%)	-	-

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The findings indicated that fluoroquinolones demonstrated high sensitivity in *Klebsiella* and *Escherichia coli*, with Ciprofloxacin and Levofloxacin showing 100% sensitivity in *Klebsiella* and *E. coli*. *Staphylococcus* exhibited moderate resistance to Ciprofloxacin (50.0%) and Moxifloxacin (26.7%), while *Serratia* was generally highly sensitive except for complete resistance to Ciprofloxacin. Nitrofurantoin retained strong activity against *Klebsiella* (83.3%) and *Staphylococcus* (86.7%), though *E. coli* showed moderate sensitivity (66.7%).

Within the tetracyclines, both Doxycycline and Tetracycline were highly effective against *Staphylococcus* (88.2% and 73.3% sensitivity, respectively) and *E. coli* (66.7–100%), while *Klebsiella* displayed moderate resistance. Macrolides revealed mixed results: *Klebsiella* remained fully sensitive to Azithromycin (100%), whereas *Staphylococcus* showed high resistance (84.6%).

For aminoglycosides, Amikacin showed total sensitivity in all tested organisms, but Gentamicin showed lower activity against Staphylococcus (33.3% sensitivity), and great effectiveness against E. coli (100%). Among the other antibiotics, Septrin was extremely effective against Klebsiella (66.7%) but was highly resistant in E. coli (100%). Chloramphenicol remained effective in Klebsiella (100%) and Serratia (100%), although Staphylococcus demonstrated significant resistance (71.4%). Vancomycin exhibited complete resistance in Klebsiella and moderate sensitivity in Staphylococcus (44.4%). Rifampin was tested only against Staphylococcus and demonstrated perfect sensitivity (100%).

Table (3). Resistance and Sensitivity Patterns of Fluoroquinolones, Nitrofurans, Tetracyclines, Macrolides, Aminoglycosides, and Other Antibiotics

Antibiotic	Klebsiella		Staphylococcus		Escherichia coli		Serratia	
	Resistant	Sensitive	Resistant	Sensitive	Resistant	Sensitive	Resistant	Sensitive
Fluoroquinolones								
Ciprofloxacin	0/12 (0.0%)	12/12 (100.0%)	9/18 (50.0%)	9/18 (50.0%)	0/6 (0.0%)	6/6 (100.0%)	4/4 (100.0%)	0/4 (0.0%)
Norfloxacin	-	-	2/2 (100.0%)	-	-	-	-	-
Levofloxacin (LEV)	0/12 (0.0%)	12/12 (100.0%)	4/17 (23.5%)	13/17 (76.5%)	0/6 (0.0%)	6/6 (100.0%)	4/4 (100.0%)	0/4 (0.0%)
Nalidixic acid (NA)	-	-	1/1 (100.0%)	-	-	-	-	-
Moxifloxacin (MXF)	-	-	4/15 (26.7%)	11/15 (73.3%)	2/4 (50.0%)	2/4 (50.0%)	-	-
Nitrofurans	2/12 (16.7%)	10/12 (83.3%)	2/15 (13.3%)	13/15 (86.7%)	2/6 (33.3%)	4/6 (66.7%)	-	-
Tetracyclines								
Doxycycline (DO)	4/12 (33.3%)	8/12 (66.7%)	2/17 (11.8%)	15/17 (88.2%)	2/6 (33.3%)	4/6 (66.7%)	4/4 (100.0%)	0/4 (0.0%)
Tetracycline (TE)	4/10 (40.0%)	6/10 (60.0%)	4/15 (26.7%)	11/15 (73.3%)	0/6 (0.0%)	6/6 (100.0%)	2/2 (100.0%)	0/2 (0.0%)
Macrolides								
Azithromycin (AZM)	0/6 (0.0%)	6/6 (100.0%)	11/13 (84.6%)	2/13 (15.4%)	4/6 (66.7%)	2/6 (33.3%)	-	-
Clarithromycin (CLR)	-	-	2/4 (50.0%)	2/4 (50.0%)	2/2 (100.0%)	0/2 (0.0%)	-	-
Aminoglycosides								
Amikacin (AK)	-	2/2 (100.0%)	-	6/6 (100.0%)	-	-	-	4/4 (100.0%)
Gentamicin (CN)	-	-	2/3 (66.7%)	1/3 (33.3%)	0/2 (0.0%)	2/2 (100.0%)	-	-
Others								
Septrin (SXT)	4/12 (33.3%)	8/12 (66.7%)	11/19 (57.9%)	8/19 (42.1%)	6/6 (100.0%)	0/6 (0.0%)	4/4 (100.0%)	0/4 (0.0%)
Chloramphenicol (C)	0/6 (0.0%)	6/6 (100.0%)	5/7 (71.4%)	2/7 (28.6%)	2/6 (33.3%)	4/6 (66.7%)	0/2 (0.0%)	2/2 (100.0%)
Vancomycin	6/6 (100.0%)	0/6 (0.0%)	5/9 (55.6%)	4/9 (44.4%)	0/2 (0.0%)	2/2 (100.0%)	-	-
Rifampin	-	-	-	1/1 (100.0%)	-	-	-	-

Discussion

Any inframalleolar infection in a diabetic is referred to as a diabetic foot infection. These include tendinitis, osteomyelitis, septic arthritis, paronychia, cellulitis, myositis, abscesses, and necrotizing fasciitis. On the other hand, an infected diabetic "mal-perforans" foot ulcer is the most common and conventional lesion.

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(89) Foot infections are common in people with diabetes and can be expensive and complex [5]. People with diabetes may develop chronic, non-healing foot ulcers for several reasons, such as peripheral artery disease, neuropathy, and high plantar pressures [8]. Long-term, chronic ulcers are more likely to become infected, which hinders the healing of the lesion. These patients can be infected by a wide range of germs. E. coli, Klebsiella, and Staphylococcus aureus were the most isolated organisms.

Gram-positive bacteria, as evidenced by earlier research showing that DFP was more likely to isolate Gram-positive strains [9 -11]. Gram-negative bacteria, such as Proteus species, E. coli, and Pseudomonas aeruginosa, were the most common strains, according to Gadepalli et al. (11). The most prevalent etiological agent in the current study was Staphylococcus aureus, which is followed by Klebsiella. Twenty-two (42.3%) of cases had Staphylococcus, twelve (23.1%) had Klebsiella, six (11.5%) had Escherichia coli, and four (7.7%) had Serratia. Numerous studies have established that the primary causal agent is Staphylococcus aureus. [12-16]. Similarly, in two recent studies, gram-negative bacteria were the most common agents. [11,17]. However, previous investigations have identified gram-positive bacteria as the most common species associated with diabetic foot infections [16,17].

Although our findings are consistent with prior research indicating that Gram-positive bacteria were predominant in diabetic foot infections [18-21], other investigations have found that Gram-negative bacteria were predominant in specific locations [11, 22]. In terms of Staphylococcus isolates, 100.0, 100.0, 100.0, and 84.6% were resistant to Norfloxacin, Ampicillin, Nalidixic acid, Cephalexin, and Azithromycin, respectively. Amikacin, Imipenem, Rifampin, Cefoxitin, Doxycycline, Nitrofurantoin, and Levofloxacin are the most sensitive antibiotics against Staphylococcus organisms. In terms of Klebsiella isolates, 100.0, 100.0, and 75.0, 66.7% were resistant to cefotaxime (CTX), vancomycin, amoxicillin, and cephalexin. Ciprofloxacin, azithromycin, chloramphenicol, and Meropenem are the most sensitive antibiotics for Klebsiella organisms. In terms of Escherichia coli isolates, 100.0, 100.0, 100.0, and 100.0% were resistant to amoxicillin, clarithromycin, septrin, cefixime, and ceftazidime, respectively. Ciprofloxacin, Levofloxacin, Tetracycline, Gentamicin, Cephalexin, Vancomycin, and Meropenem are the most sensitive antibiotics for the Escherichia coli pathogen. In terms of Serratia isolates, 100 percent were resistant to Augmentin, Ciprofloxacin, Levofloxacin, Doxycycline, Ceftriaxone, Cefuroxime, Septrin, and Cefixime. Chloramphenicol is the most sensitive antibiotic for the Serratia bacterium.

Most Enterococcus spp. were solely responsive to vancomycin, with varied susceptibility to other antibiotics. Similarly, in another investigation, all enterococcal isolates were found to be equally sensitive to vancomycin and linezolid. Meropenem was shown to be the most efficient antibiotic against all organisms (12) and was additionally found to be effective against DFU in another investigation. The next was Amikacin [22, 23]. As a result, Amikacin, Imipenem, Rifampin, Cefoxitin, Doxycycline, Nitrofurantoin, and Levofloxacin might be regarded as key drugs in the empirical regimen for treating diabetic foot infections, particularly in situations with considerable resistance to other antibiotics.

Another investigation revealed that all enterococcal isolates were similarly susceptible to linezolid and vancomycin [12]. Consequently, vancomycin can be regarded as a crucial medication in the empirical regimen for the treatment of diabetic foot infections, especially in settings where there is a high level of antibiotic resistance. A single antimicrobial treatment is unlikely to be effective against all of the potential species collected from diabetic foot infections because DFIs are caused by many microbes. The most prevalent organism in diabetic foot ulcer in the cited 2016 study in Pakistan was Staphylococcus aureus, with E. coli and Klebsiella also common. The bacteria showed the most sensitivity to meropenem and resistance to cotrimoxazole [24].

Antimicrobial treatment for diabetic foot infections should be guided by validated culture and sensitivity data to guarantee the use of the most effective drugs while minimizing resistance development. Given the complexity and potential complications of the illness, diabetic foot surgeons are most suited to manage these infections. Physicians participating in patient care should have extensive experience performing diabetic foot examinations in order to diagnose the condition early and intervene promptly. Furthermore, patient education is critical; diabetics should be informed about the early signs and symptoms of diabetic foot infections, allowing them to seek prompt medical attention and lowering the risk of severe complications such as ulceration, deep tissue infection, and amputation [25].

Strengths and limitations

This study presented a detailed clinical and bacteriological profile of diabetic foot infections in a tertiary care context, allowing for the identification of the most common causing organisms and their antibiotic susceptibility patterns. The study provides therapeutically relevant findings by incorporating both Gram-positive and Gram-negative bacteria and testing a wide range of drugs. The implementation of standardized culture and sensitivity tests in accordance with CLSI criteria improves the reliability and comparability of results. Furthermore, focusing on both resistance and sensitivity rates provides a more balanced picture of antibiotic efficacy, which is critical for creating localized treatment regimens and antibiotic stewardship

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measures.
The study's small sample size (n=52) and use of convenience sampling may restrict the findings' applicability to the larger diabetes population. Because the study was undertaken in a single tertiary care center, the bacterial composition and resistance trends found may not be representative of other areas or healthcare settings. The removal of patients who received systemic antibiotics within a week of sampling may have limited the representation of specific clinical circumstances. Furthermore, the cross-sectional approach further limits the capacity to evaluate treatment outcomes or long-term recurrence rates

Conclusion

It may be inferred that the selection of the most effective antibiotics depends on the culture specimens for the proper treatment of diabetic foot infections and the understanding of antimicrobial drug susceptibility. Gram-positive bacteria like Staphylococcus aureus or polymicrobial infections were the main causes of diabetic foot infections. Culture specimens are essential in the proper therapy of diabetic foot infections because they provide significant information on the pathogenic bacteria and their antimicrobial susceptibility patterns, allowing for the selection of the most appropriate and effective medications. Accurate pathogen identification ensures focused therapy, maximizes treatment efficacy, and lowers the chance of resistance. According to the current findings, diabetic foot infections are primarily caused by Gram-positive bacteria, particularly Staphylococcus aureus, but many cases are polymicrobial in nature, involving a combination of aerobic and anaerobic organisms, emphasizing the importance of a thorough microbiological evaluation before beginning antimicrobial treatment.

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Conflicts of Interest

The authors declare there is no conflict of interest related to the publication of this study.

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