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"CLINICAL, BACTERIOLOGICAL PROFILE AND ANTIMICROBIAL SUSCEPTIBILITY PATTERNS IN DIABETIC FOOT INFECTIONS: A HOSPITAL-BASED STUDY"

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ABSTRACT
Diabetic foot infections (DFIs) remain one of the most serious complications of diabetes mellitus, often resulting in prolonged hospitalization, amputations, and significant morbidity. This observational study was conducted on 100 hospitalized patients with clinically infected diabetic foot ulcers to determine the demographic profile, bacteriological spectrum, antimicrobial susceptibility patterns, and treatment outcomes. A male predominance (65%) was noted, with the majority of cases (44%) occurring between 41–60 years of age. Poor glycemic control was common, with a mean HbA1c of 8.9%. The predominant bacterial isolate was *Staphylococcus aureus* (26%), followed by *Pseudomonas aeruginosa* (18%) and *Klebsiella pneumoniae* (15%). Antimicrobial susceptibility testing revealed high resistance to ampicillin (73%), ceftriaxone (60%), and ciprofloxacin (57%), while colistin (100%), linezolid (92%), vancomycin (82%), and meropenem (76%) showed excellent activity. Clinically, debridement was the most frequent intervention (46%), followed by amputations (21%). Outcomes included cure in 52% of cases, improvement in 33%, poor outcome in 12%, and mortality in 3%. The findings underscore the importance of early diagnosis, stringent glycemic control, and judicious use of antibiotics guided by culture and sensitivity testing. Strengthening preventive foot care and multidisciplinary management approaches is crucial to reducing the burden of DFIs.

Keywords: Diabetic foot infections, Staphylococcus aureus, antimicrobial resistance, amputation, glycemic control, bacteriological profile, wound management.

INTRODUCTION

Diabetes mellitus is one of the most challenging public health problems worldwide, with an alarming rise in prevalence, particularly in low- and middle-income countries. According to the International Diabetes Federation, more than 537 million people are living with diabetes globally, and this number is projected to reach 783 million by 2045【1】. Among the chronic complications of diabetes, diabetic foot infections (DFIs) represent a significant cause of morbidity, prolonged hospitalization, and even mortality【2】. It is estimated that approximately 15–25% of individuals with diabetes will develop a foot ulcer during their lifetime, of which nearly 50–60% progress to infection, and up to 20% require amputation【3】. DFIs not only affect the patient's quality of life but also impose a substantial economic burden on healthcare systems, particularly in resource-limited settings【4】.

The development of DFIs is multifactorial, arising from the interplay between peripheral neuropathy, peripheral arterial disease, and impaired host immunity【5】. Neuropathy results in loss of protective sensation, motor dysfunction causing abnormal foot biomechanics, and autonomic neuropathy leading to dry skin and fissures【6】. These changes predispose patient to ulceration following minor trauma. Peripheral arterial disease reduces perfusion, impairing oxygen and nutrient delivery to the wound bed, thereby delaying healing and reducing antibiotic penetration【7】. Furthermore, hyperglycemia impairs neutrophil function, chemotaxis, and phagocytosis, resulting in compromised host defense mechanisms【8】. The presence of biofilms and multidrug-resistant organisms further complicates the pathogenesis of infection【9】.

The microbiological spectrum of DFIs is diverse and influenced by geographic, socioeconomic, and healthcare factors. In developed countries, Gram-positive cocci such as Staphylococcus aureus and Streptococcus spp. are the predominant pathogens【10】. In contrast, studies from developing countries, including India, report a higher prevalence of Gram-negative bacilli such as Pseudomonas aeruginosa, Escherichia coli, and Klebsiella pneumoniae【11】. Anaerobes and polymicrobial infections are frequently seen in deep and chronic ulcers【12】. Methicillin-resistant Staphylococcus aureus (MRSA) and multidrug-resistant Gram-negative organisms are increasingly reported, reflecting the growing concern of antimicrobial resistance【13】. This variation underscores the importance of regional microbiological surveillance to guide empirical therapy.

Antibiotic resistance is a major global health threat and poses significant challenges in managing DFIs. Empirical use of broad-spectrum antibiotics, often without culture sensitivity guidance, has accelerated resistance rates【14】. Several studies have documented high resistance to commonly prescribed antibiotics such as ampicillin, third-generation cephalosporins, and fluoroquinolones【15】. In contrast, last-line agents such as linezolid, vancomycin, carbapenems, and colistin have retained high sensitivity【11,14】. However, their inappropriate use raises concerns about emerging resistance even to these critical drugs. Judicious antibiotic use, guided by culture and susceptibility patterns, is therefore essential.

Patients with DFIs often present with poorly controlled diabetes, hypertension, or other comorbidities. Late presentation, lack of awareness, and poor access to specialized foot care contribute to the severity of infection【16】. Amputation rates remain high in developing nations, ranging between 15–30%, compared to 5–10% in developed countries【17】. Amputation not only increases mortality risk but also severely compromises mobility, independence, and quality of life【18】. Studies have shown that mortality after a major amputation may reach 39–80% within five years【19】. Thus, early diagnosis, appropriate antimicrobial therapy, and timely surgical intervention are vital to improving outcomes.

The heterogeneity in clinical presentation, microbial spectrum, and resistance patterns across different regions necessitates local hospital-based studies. Such studies provide vital data for formulating effective empirical treatment policies and infection-control measures. They also help identify emerging resistance trends and guide antimicrobial stewardship programs 【20】. Moreover, understanding the clinical and bacteriological profiles of DFIs in a given population aids in developing multidisciplinary strategies for prevention, early detection, and treatment.

Given the rising burden of diabetes in India and the increasing incidence of DFIs, it is crucial to generate local data on microbial profiles and drug resistance. The present study was undertaken to assess the demographic and clinical features, bacterial spectrum, antimicrobial susceptibility, and treatment outcomes among hospitalized patients with diabetic foot infections. By providing hospital-specific evidence, this research aims to contribute to better clinical decision-making, rational antibiotic usage, and ultimately, improved patient outcomes.

Diabetic foot infections (DFIs) represent one of the most severe complications of diabetes mellitus, contributing significantly to morbidity, prolonged hospitalization, and increased risk of amputation. The combination of neuropathy, peripheral vascular disease, and impaired immunity predisposes diabetic patients to chronic non-healing ulcers and recurrent infections. Globally, it is estimated that 15–25% of diabetic patients will develop a foot ulcer during their lifetime, and a substantial proportion will progress to infection requiring surgical intervention or even amputation.

The microbiology of diabetic foot infections is diverse, commonly involving Gram-positive cocci such as *Staphylococcus aureus,* Gram-negative bacilli including *Pseudomonas aeruginosa* and *Escherichia coli*, and less frequently, anaerobes and multidrug-resistant organisms. The rising trend of antimicrobial resistance further complicates management, necessitating region-specific surveillance to guide empirical therapy.

The present study was conducted to determine the clinical profile, bacteriological spectrum, and antimicrobial susceptibility pattern of isolates from diabetic foot infections in hospitalized patients, along with treatment outcomes.

MATERIALS AND METHODS

This observational study was conducted on 100 patients admitted with diabetic foot infections.

Aim and Objectives

1. To study the demographic and clinical profile of patients with diabetic foot infections
2. To identify the spectrum of bacterial pathogens isolated from infected diabetic foot cases.
3. To evaluate the antimicrobial susceptibility patterns of the isolates
4. To assess treatment outcomes and complications associated with diabetic foot infections.

Inclusion criteria

1. Diabetic patients with clinically infected foot ulcers.

Exclusion criteria

1. Patients with non-infected ulcers or with recent antibiotic use were excluded.

Clinical Data Collection: Demographic details, comorbidities, duration of symptoms, grade of ulcer, treatment modality, and discharge outcomes were recorded. Laboratory investigations included random blood sugar (RBS), HbA1c, complete blood count, ankle-brachial index (ABI), and other relevant parameters.

Microbiological Methods: Samples were collected under aseptic precautions and cultured on standard media. Bacterial isolates were identified using conventional biochemical tests. Antimicrobial susceptibility testing (AST) was performed using the Kirby–Bauer disk diffusion method according to CLSI guidelines. Antibiotics tested included aminoglycosides, cephalosporins, carbapenems, fluoroquinolones, glycopeptides, and polymyxins.

Statistical Analysis: Data were analyzed in terms of frequencies, percentages, and mean ± standard deviation.

Demographic Distribution:
Out of 100 cases, 65% were males and 35% females, showing a clear male predominance. Age distribution revealed that most cases occurred in the age group of 41–60 years (44%), reflecting the higher risk of complications in middle-aged and older diabetics.

Bacteriological Profile:
A total of 100 isolates were obtained. The predominant pathogen was Staphylococcus aureus (26%), followed by Pseudomonas aeruginosa (18%), Klebsiella pneumoniae (15%), and Escherichia coli (14%). Less frequent isolates included Enterococcus spp., Acinetobacter baumannii, Proteus spp., and multidrug-resistant organisms such as MRSA (2%) and MRCONS (2%).

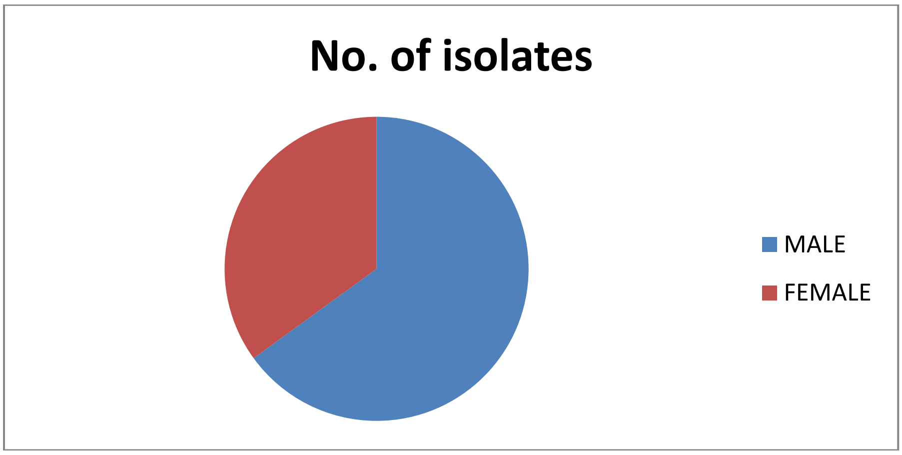
Antimicrobial Susceptibility Pattern:
AST revealed high resistance to ampicillin (73%), ceftriaxone (60%), and ceftazidime (55%). Moderate resistance was observed against ciprofloxacin (57%), gentamicin (34%), and tetracycline (60%). In contrast, high sensitivity was noted with colistin (100%), linezolid (92%), vancomycin (82%), polymyxin B (95%), and meropenem (76%), indicating their effectiveness in severe and resistant cases.

RESULTS

Clinical Characteristics and Outcomes:
In the present study it was observed that that Mean RBS was 238.7 mg/dL and mean HbA1c was 8.9%, indicating poor glycemic control in most patients.
Average duration of symptoms was 32.6 days, with mean hospital stay of 11.1 days.
Hypertension was present in 61% of cases.
Ulcer grading showed maximum cases in Grade II (41%), followed by Grade III (29%).
Oral hypoglycemic drugs were being used by 55% and insulin therapy by 24%.
Leucocytosis was seen in 48% of patients. ABI values showed peripheral vascular compromise in 41%.
Treatment involved debridement (46%), amputation (21%), conservative management (14%), IV antibiotics only (15%), and drainage (4%).
Discharge outcomes: 52% cured, 33% improved, 12% poor outcome, and 3% mortality.

Genderwise	No. of isolates	Percentage
Male	65	65%
Female	35	35%

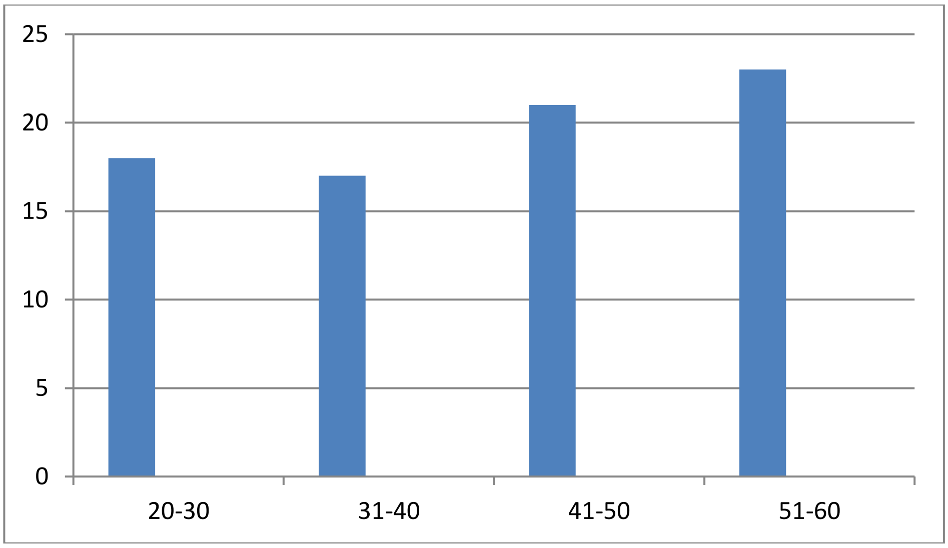
Table No. 1: Genderwise distribution of the cases



Graph No. 1: Graphical Representation of No. of isolates

Age wise Distribution of the cases	No. of cases	Percentage
20-30	18	18%
31-40	17	17%
41-50	21	21%
51-60	23	23%
61-70	13	13%
≥71	8	8%

Table No. 2: Agewise distribution of the cases



Graph No. 2: Graphical Representation of Agewise Distribution of cases

Type of organisms	No. of cases	Percentage
Pseudomonas aeruginosa	18	18%
MSSA	26	26%
E.coli	14	14%
Klebsiella pneumoniae	15	15%
M.morganii	3	3%
A.baumannii	2	2%
C.freundii	2	2%
Proteus mirabilis	1	1%
K.oxytoca	2	2%

P.rettegeri	2	2%
E.cloacae	2	2%
E.faecalis	3	3%
Proteus vulgaris	3	3%
E.faecium	3	3%
MRSA	2	2%
MRCONS	2	2%

Table No. 3: Type of organisms distribution of the cases

The antimicrobial susceptibility testing (AST) results with antibiotics listed across the columns (AK, CA, G, CIP, TET, CFS, CTR, MEM, ATM, PIT, POM, AMP, C, CC, DOXY, LE, VAN, TEC, LNZ, COL etc.) and organisms or isolates in the rows. The results were marked as S (Sensitive), R (Resistant), and sometimes MS (maybe Moderately Sensitive or Intermediate).

Table No. 4A : Antimicrobial Susceptibility Testing (AST) for Gram Negative Bacterial isolates

Antibiotic	Sensitive (n, %)	Resistant (n, %)	Intermediate (n, %)	Total (n)
Amikacin (AK)	78 (78%)	20 (20%)	2 (2%)	100
Ceftazidime (CA)	42 (42%)	55 (55%)	3 (3%)	100
Gentamicin (G)	60 (60%)	34 (34%)	6 (6%)	100
Ciprofloxacin (CIP)	39 (39%)	57 (57%)	4 (4%)	100
Ampicillin (AMP)	22 (22%)	73 (73%)	5 (5%)	100
Cefoperazone-Sulbactam (CFS)	56 (56%)	38 (38%)	6 (6%)	100
Ceftriaxone (CTR)	37 (37%)	60 (60%)	3 (3%)	100
Meropenem (MEM)	76 (76%)	21 (21%)	3 (3%)	100
Aztreonam (ATM)	28 (28%)	69 (69%)	3 (3%)	100
Piperacillin-Tazobactam (PIT)	63 (63%)	32 (32%)	5 (5%)	100
Polymyxin B (POM)	95 (95%)	5 (5%)	0 (0%)	100

Antibiotic	Sensitive (n, %)	Resistant (n, %)	Intermediate (n, %)	Total (n)
Levofloxacin (LE)	49 (49%)	46 (46%)	5 (5%)	100
Tetracycline (TET)	35 (35%)	60 (60%)	5 (5%)	100
Chloramphenicol (C)	52 (52%)	40 (40%)	8 (8%)	100
Vancomycin (VAN)	82 (82%)	12 (12%)	6 (6%)	100
Teicoplanin (TEC)	80 (80%)	14 (14%)	6 (6%)	100
Linezolid (LNZ)	92 (92%)	6 (6%)	2 (2%)	100
Clindamycin (CC)	44 (44%)	48 (48%)	8 (8%)	100
Doxycycline (DOXY)	57 (57%)	38 (38%)	5 (5%)	100

Table No. 4B : Antimicrobial Susceptibility Testing (AST) for Gram Positive Bacterial Isolates

In the present study it was observed that High resistance to Ampicillin, Ceftriaxone, Ceftazidime.
Moderate resistance was observed for Ciprofloxacin, Gentamicin, Tetracycline.
High sensitivity to Colistin, Linezolid, Vancomycin, Polymyxin B, Meropenem.

Parameter (n=100)	Categories / Mean ± SD	Frequency
RBS (mg/dL)	238.7 ± 55.4	–
HbA1c (%)	8.9 ± 1.7	–
WBC (×10⁹/L)	11.4 ± 3.2	–
Duration of Symptoms (days)	32.6 ± 20.4	–
Length of Stay (days)	11.1 ± 5.6	–
HTN	YES	61
	NO	39
Grade	I	18
	II	41
	III	29
	IV	12
Hypoglycemic Drugs	Oral	55
	Insulin	24
	Both	14
	None	7
ABI	Normal	59
	Low	41
Leucocytosis	YES	48
	NO	52
Discharge Status (6 weeks)	Cured	52
	Improved	33
	Poor	12
	Death	3
Treatment	Debridement	46
	Amputation	21
	Conservative	14
	IV antibiotics only	15
	Drainage	4
Cause of Fever	None	39
	Cellulitis	22
	Ulcer infection	18
	UTI	10
	Pneumonia	6
	TB	5

Table No. 5: Different Parameters

DISCUSSION

The present study demonstrates that diabetic foot infections are more prevalent in middle-aged and elderly males, consistent with findings by Shanmugam et al. (2011) [21] and Banu et al. (2015) [22], who also reported male predominance and poor glycemic control as key risk factors.

Our bacteriological profile showed Staphylococcus aureus as the leading pathogen, followed by Pseudomonas and Klebsiella. Similar patterns were reported by Citron et al. (2007) [23] and Zubair et al. (2010) [24] , though some studies have shown higher isolation of Gram-negative organisms, reflecting regional variations.

Antimicrobial resistance remains a major challenge. We observed high resistance to commonly used antibiotics such as ampicillin, cephalosporins, and fluoroquinolones, in agreement with earlier studies by Tentolouris et al. (2014) [25] and Lipsky et al. (2016) [26]. The excellent activity of colistin, polymyxin B, vancomycin, and linezolid underscores their role as last-resort drugs, though their routine use must be restricted to prevent further resistance.
Clinically, most patients had uncontrolled diabetes (mean HbA1c = 8.9%), supporting the association of poor glycemic control with infection severity as highlighted by Ndosi et al. (2018) [27] . The amputation rate of 21% in our series is comparable to studies from India and other developing countries, but higher than reports from developed nations, indicating the need for better preventive and early intervention strategies.
Overall, our findings emphasize the importance of strict glycemic control, early detection of infection, and judicious antibiotic use guided by culture sensitivity.

CONCLUSION

Diabetic foot infections are common in middle-aged diabetic males with poor glycemic control and hypertension as frequent comorbidities. The predominant bacterial isolates were Staphylococcus aureus and Gram-negative bacilli such as Pseudomonas and Klebsiella. High resistance was observed to ampicillin, cephalosporins, and fluoroquinolones, while colistin, linezolid, vancomycin, and carbapenems remained highly effective. Surgical interventions including debridement and amputation were required in a substantial proportion of cases.
Strengthening diabetic foot care through patient education, early diagnosis, multidisciplinary management, and rational antibiotic policies is essential to reduce morbidity, amputations, and mortality.

DECLARATIONS:

Conflicts of interest: There is no any conflict of interest associated with this study
Consent to participate: There is consent to participate.
Consent for publication: There is consent for the publication of this paper.
Authors contributions: Author equally contributed the work.

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