



## Original Research Article

# MICROBIOLOGY OF DIABETIC FOOT (DF) INFECTIONS: A RETROSPECTIVE ANALYSIS TO FORMULATE THE ANTIBIOGRAM IN DF SPECIALITY HOSPITAL

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#### ABSTRACT

**Aim:** To describe AntibioGram in tertiary care hospital.

**Objectives:** To describe microbiological profile & antibiotic sensitivity pattern of Diabetic Foot (DF) infections, to compare microbiology of non-DF other infections in diabetics and non-diabetics.

**Material and Methods:** Descriptive retrospective observational study at tertiary care hospital. All Culture Sensitivity (C/S) report of IPD patients during JAN 2023 to FEB 2024 were collected for analysis.

**Results:** Total 238 samples were collected and grouped as diabetic patients 130 (54.62%) and non-diabetic patients 108 (45.37%) Diabetic patients were again sub divided into DF 74 (56.92%) and non-DF 56 (43.07%). Among DF, most common bacteria isolated were Klebsiella 18 (24.32%), E.coli 12 (16.21%), Coagulase negative Staphylococcus 9 (12.16%) & Pseudomonas 6 (8.10%). Most common specimen were Pus 34 (45.95%), Tissue 25 (33.78 %), Bone 13 (17.97 %) followed by Aspiration fluid 2 (2.70 %). Among non-DF, most common bacteria were E. coli 13 (23.21%), Klebsiella 10 (17.85%), Citrobacter freundii 4 (7.14%) & Proteus mirabilis 4 (7.14%). Most common specimens were Urine 37 (66.07%), Respiratory tract specimen (RTS) 7 (12.5%), Blood 6 (10.71%), Pus from abscess 3 (5.35%). Among non DM, most common isolated bacteria were Klebsiella 22 (20.37%), E. coli 20 (18.52%) and Enterobacter 3 (4.63%). Most common specimens were Urine 39 (36.11%), Pus 24 (22.22%), RTS 19 (17.59%) and Blood (14.8%). Most common isolated bacteria were Klebsiella and E.coli among all samples. Pseudomonas was exclusively isolated from Pus. Fluoroquinolones (Ciprofloxacin, Levofloxacin, Gatifloxacin), Carbapenems (Imipenem, Meropenem), B-Lactams with B-Lactamase (Piperacillin+Tazobactam, Cefoperazone+Sulbactam) and Aminoglycosides (Amikacin) were most efficacious among all samples from diabetic as well as non-diabetic patients.

**Conclusion:** Knowing microbiological pattern of infected DF as well all other specimens can give a good idea of starting empirical Antibiotics in DF patient if Institutional AntibioGram is determined. Levofloxacin and Piperacillin+Tazobactam may be used as first line empirical therapy in diabetic foot infection as per antibioGram in given setup.

**Keywords:** antibioGram, diabetic foot, culture sensitivity, antibiotic sensitivity, microorganisms, diabetic foot ulcer, wound.

## INTRODUCTION

Diabetes is a chronic and one of the oldest and major disorders. In report of WHO (World health organization) mentions that, about 422 million people worldwide are diabetic and 1.5 million deaths are directly related to diabetes.

One of the major complications of diabetes is diabetic foot ulcers. One paper published by Michael Edmonds, Chris Manu and Prashanth Vas shows that there were 131.0 million people with lower extremity problems worldwide.<sup>[1]</sup>

To treat these infections, one should have appropriate knowledge about antibiotics based on antibiotic susceptibility. The isolated microorganisms and their antibiotic susceptibility pattern may vary from country to country or in different region of same country.

Multidrug resistant organisms (MDROs) like Methicillin-resistant *S. aureus* (MRSA), Carbapenem-resistant Enterobacteriaceae (CRE) are globally increased in past two decades.<sup>[2]</sup> These leads to serious challenge for physicians to treat diabetic foot infection and to prescribe proper antibiotics. Delay or inappropriate treatment can lead to amputation.

Diabetic foot infections are associated with co morbidities and other diabetic complications frequently required critical care and they may be exposed to hospital bacterial flora depending on other patients even though after taking all aseptic care. It warrants a need to study the microbiological profile of non-diabetic patients and diabetic patients without DF infection and to compare them with DF infection in respect to microorganism and antibiotic sensitivity.

So the present study aimed to study the microbiology of all infection and their antibiotic sensitivity across three major groups Diabetic foot, Non diabetic foot and non-Diabetic.

## MATERIAL AND METHODS

This is a Descriptive retrospective observational study conducted at multispecialty hospital in Western Maharashtra. After permission from institutional ethics committee all C/S report of IPD patients were collected during JAN 2023 to FEB 2024 for analysis.

Once sample received by the microbiology section of diagnostic department, it was processed for the primary stain and then it was inoculated on appropriate culture media which was incubated for 18-20 hours after that it was taken for the anti-susceptibility test on the basis of this, report were prepared.

After collection of reports all reports were divided into three groups based on patient's diagnosis as diabetic and non-diabetic, diabetic group were again sub-divided as diabetic foot and non-diabetic foot

and data were entered in to Microsoft excel for further analysis.

### Statistical Analysis

The collected data were analyzed by using SPSS software. Quantitative variables were expressed as mean with a standard deviation and qualitative variables were expressed as percentages.

### Ethical Approval

The study was approved by institutional ethics committee. Patient's details were kept confidential throughout the study. There was no any kind of financial burden to any patients for this research as all of them received the standard care of treatment.

## RESULTS

Total 238 samples and C/S reports were collected, mean age of patients was  $56.39 \pm 16.08$  years. From which males 154 (64.70%) were predominant over female 84 (35.29 %).

All samples and C/S reports were grouped as diabetic patients 130 (54.62%) and non-diabetic patients 108 (45.37%). Diabetic patients were again sub divided into DF 74 (56.92%) and non-DF 56 (43.07%). [Table 1]

### Diabetic Foot (DF)

Among DF, most common bacteria isolated were *Klebsiella* 18 (24.32%), *E.coli* 12 (16.21%), Coagulase negative *Staphylococcus* 9 (12.16%) & *Pseudomonas* 6 (8.10%). Most common specimen were Pus 34 (45.95%), Tissue 25 (33.78 %), Bone 13 (17.97 %) followed by aspiration fluid 2 (2.70 %). [Table 2]

### Non-Diabetic Foot

Among non-DF, most common bacteria were *E. coli* 13 (23.21%), *Klebsiella* 10 (17.85%), *Citrobacter freundii* 4 (7.14%) & *Proteus mirabilis* 4 (7.14%). Most common specimens were Urine 37 (66.07%), Respiratory Tract Specimen (RTS) 7 (12.5%), Blood 6 (10.71%), Pus from abscess 3 (5.35%). [Table 3]

### Non Diabetic

Among non-DM, most common isolated bacteria were *Klebsiella* 22 (20.37%), *E. coli* 20 (18.52%) and *Enterobacter* 3 (4.63%). Most common specimens were Urine 39 (36.11%), Pus 24 (22.22%), RTS 19 (17.59%) and Blood (14.8%). [Table 4]

### Sensitivity Pattern

Sensitivity pattern of all antibiotics was calculated and tabulated according to the bacteria isolated. Piperacillin+Tazobactam combination was most sensitive among all. [Fig. 1]

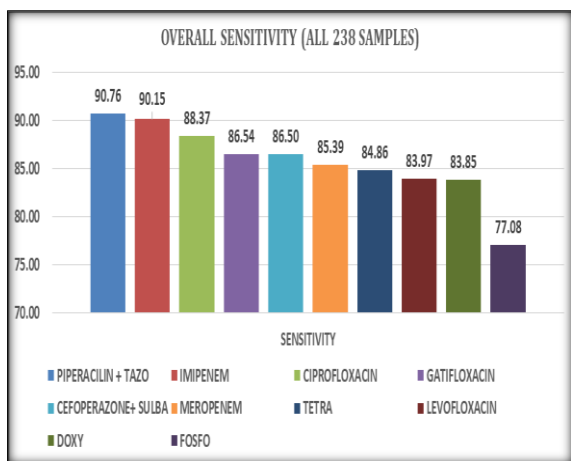


Figure 1: Overall Sensitivity

We have distinguished sensitivity of antibiotics with bacteria in each group i.e., DM (DF&NON DF) & NON DM from which top most antibiotics were tabulated here. [Table 5]

Ciprofloxacin, Imipenem, Meropenem, Levofloxacin, Cefoperazone + Sulbactam, Piperacilin + Tazobactam, Gatifloxacin, Amikacin and Gentamicin were sensitive to all

groups but Ofloxacin, Tetracycline and Fosfomycin found sensitive in DF, Non-DF and Non-DM respectively.

### 1. Diabetic Foot Antibiotics

In the group of DF, Fluroquinolones, Carbapenem, B-Lactam + B-Lactamase Inhibitor and Aminoglycosides were most sensitive groups of antibiotics. Ofloxacin were additionally found to be sensitive among group of DF samples.[Table 6]

### 2. Non-Diabetic Foot Antibiotics

In the group of Non-DF, Fluroquinolones, B-Lactam + B-Lactamase inhibitor, Carbapenem, Aminoglycosides and Tetracycline were most sensitive groups of antibiotics. Tetracyclines were additionally found to be sensitive among group of Non-DF samples.[Table 7]

### 3. Non-Diabetic Antibiotics

In the group of non-diabetics, Fluroquinolones, B-Lactam+B-Lactamase inhibitor, Carbapenem, Aminoglycoside and Fosfomycin were most sensitive groups of antibiotics. Fosfomycin were additionally found to be sensitive among group of Non-DM samples.[Table 8]

Table 1: Patient Demographics and Baseline Characteristics

Age	Total in each age group	Diabetic (130, 54.62%)				Non diabetic (108, 45.37%)	
		Diabetic foot (74, 56.92%)		Non diabetic foot (56, 43.07%)		Male	Female
		Male	Female	Male	Female		
11 to 20	7	0	0	0	1	2	4
21 to 30	14	1	0	0	1	7	5
31 to 40	22	3	0	3	0	9	7
41 to 50	36	8	7	5	2	7	7
51 to 60	50	17	5	5	3	10	10
61 to 70	67	17	4	15	10	11	10
71 to 80	34	10	1	9	1	10	3
81 to 90	8	0	1	0	1	5	1
Total (238, 100%)		56 (23.52%)	18 (7.56%)	37 (15.54%)	19 (7.98%)	61 (25.63%)	47 (19.74%)

Table 2: Microorganisms isolated in Diabetic Foot

Bacteria	Diabetic Foot (74, 56.92%)				
	Pus	Tissue	Bone	Other	Total bacteria
No growth	5 (14.71%)	5 (20%)	5 (38.5%)	2 (100%)	18 (23.0%)
Acinetobacter	0	1 (4%)	1 (7.7%)	0	2 (2.7%)
C. Freundii	0	0	1 (7.7%)	0	1 (1.4%)
C. Koseri	1 (2.94%)	0	0	0	1 (1.4%)
Coag. -ve staph	3 (8.82%)	5 (20%)	1 (7.7%)	0	9 (12.2%)
Coag. + ve staph	1 (2.94%)	3 (12%)	0	0	4 (5.4%)
E.coli	8 (23.53%)	4 (16%)	0	0	12 (16.2%)
Enterobacter	2 (5.88%)	0	0	0	2 (2.7%)
Enterococcus	0	0	0	0	0
Klebsiella	7 (20.59%)	6 (24%)	5 (38.5%)	0	18 (24.3%)
Pro. Vulgaris	1 (2.94%)	1 (4%)	0	0	2 (2.7%)
Pseudomonas	6 (17.65%)	0	0	0	6 (8.1%)
Streptococcus	0	0	0	0	0
Total (238)%	34 (44.15%)	25 (32.46%)	13 (16.88%)	2 (2.59%)	74

Table 3: Microorganisms isolated in Non Diabetic Foot

Bacteria	Non DF (56, 43.07%)					
	Pus	Tissue	Urine	Resp	Blood	Other
No growth	0	0	5 (13.51%)	0	4 (66.6%)	2 (66.7%)
Total (238)%	0	0	5 (13.51%)	0	4 (66.6%)	2 (66.7%)

Acinetobacter	0	0	0	2(28.6%)	1(16.7%)	0	3(5.4%)
C. Freundii	0	0	4(10.81 %)	0	0	0	4(7.1%)
C. Koseri	0	0	3 (8.10 %)	0	0	0	3(5.4%)
Coag. -ve staph	0	0	0	2(28.6%)	0	0	2(3.6%)
Coag. + ve staph	0	0	0	0	0	0	0
E.coli	0	0	12(32.43%)	1(14.3%)	0	0	13(23.2%)
Enterobacter	1(50%)	0	1(2.70%)	0	0	0	2(3.6%)
Enterococcus	0	0	0	0	0	0	0
Klebsiella	1(50%)	1(100%)	5(13.51%)	1(14.3%)	1(16.7%)	1(33.3%)	10(17.9%)
Pro. Mirabilis	0	0	4(10.81%)	0	0	0	4(7.1%)
Pro. Vulgaris	0	0	3(8.10%)	0	0	0	3(5.4%)
Pseudomonas	0	0	0	0	0	0	0
Streptococcus	0	0	0	1(14.3%)	0	0	1(1.8%)
Total (238)	2(3.57%)	1(1.79%)	37(66.07%)	7(12.50%)	6(10.71%)	3(5.36%)	56

**Table 4: Microorganisms isolated in Non Diabetic**

Bacteria	Non dm (108, 45.37%)						
	Pus	Tissue	Urine	Resp	Blood	Other	Total bacteria
No growth	4 (16.7%)	0	13 (33.3 %)	6 (31.6 %)	14 (87.5 %)	4 (44.4 %)	41 (38 %)
Acinetobacter	0	0	0	3 (15.8 %)	0	0	3 (2.8 %)
C. Freundii	0	0	2 (5.1%)	1 (5.3 %)	0	0	3 (2.8 %)
C. Koseri	0	0	3 (7.7%)	0	0	0	3 (2.8 %)
Coag. -ve staph	1 (4.2%)	0	0	1 (5.3 %)	0	1 (11.1 %)	3 (2.8 %)
Coag. + ve staph	0	0	0	0	0	2 (22.2 %)	2 (1.9 %)
E.coli	5 (20.8%)	1 (100%)	11 (28.2 %)	1 (5.3 %)	1 (6.25 %)	1 (11.1 %)	20 (18.5 %)
Enterobacter	1 (4.2%)	0	3 (7.7 %)	0	1 (6.25 %)	0	5 (4.6%)
Enterococcus	0	0	1 (2.6 %)	0	0	0	1 (0.9 %)
Klebsiella	11 (45.8%)	0	3 (7.7 %)	7 (36.8 %)	0	1 (11.1 %)	22 (20.4 %)
Pro. Mirabilis	0	0	2 (5.1 %)	0	0	0	2 (1.9 %)
Pro. Vulgaris	0	0	1 (2.6%)	0	0	0	1 (0.9 %)
Pseudomonas	2 (8.3 %)	0	0	0	0	0	2 (1.9 %)
Streptococcus	0	0	0	0	0	0	0
Total (238)	24 (22.22%)	1 (0.92%)	39 (36.11%)	19(17.59%)	16(14.81%)	9 (8.33%)	108

**Table 5: Top most antibiotics in each group**

Antibiotic sensitivity					
Diabetic 130 (54.62 %)			Non Diabetic (108, 45.37%)		
Diabetic Foot (74, 59.23%)		Non-DF (56, 40.76 %)			
Meropenem	98%	Piperacillin + Tazobactam	100%	Levofloxacin	100%
Levofloxacin	97.5 %	Imipenem	100 %	Piperacillin + Tazobactam	100%
Cefoperazone + sulbactam	96.20%	Meropenem	100%	Imipenem	99.5 %
Piperacillin + Tazobactam	95.7 %	Amikacin	98.2 %	Meropenem	99.5 %
Gatifloxacin	92.9 %	Gentamicin	93.1 %	Cefoperazone + sulbactam	96 %
Amikacin	86.9 %	Ciprofloxacin	90 %	Gentamicin	92.90%
Ofloxacin	85.6 %	Cefoperazone + sulbactam	88.9 %	Fosfomycin	86.2 %
Gentamicin	83.8%	Tetracycline	84.4 %	Amikacin	85.4 %

**Table 6: Antibiotic sensitivity in Diabetic Foot**

Antibiotics	Aci	C. Fr	C. Ko	C. -ve	C. +ve	E. C	E.B	Kleb	P. Mir	P. vul	Pseudo	Sensitivity
<b>Fluroquinolones</b>												
Ciprofloxacin	100	100	100	88.9	100	100	100	94.4	100	100	100	98.5
Levofloxacin	100	100	100	77.8	100	100	100	94.4	100	100	100	97.5
Gatifloxacin	100	100	50	77.8	100	100	100	94.4	100	100	100	92.9
Ofloxacin	100	100	100	55.6	100	91.7	100	77.8	100	50	66.7	85.6
<b>Monobactam</b>												
Imipenem	100	100	100	88.9	100	100	100	88.9	100	100	100	98
Meropenem	100	100	100	88.9	100	100	100	88.9	100	100	100	98
<b>B-Lactam + b-Lactamase inhibitors</b>												
Cefo + Sul	100	100	100	77.8	100	91.7	100	88.9	100	100	100	96.2
Piper + Tazo	100	100	100	66.7	100	91.7	100	94.4	100	100	100	95.7
<b>Amino glycosides</b>												

Amikacin	100	100	100	88.9	50	100	100	83.3	100	50	83.3	86.9
Gentamicin	100	100	100	66.7	25	91.7	100	88.9	100	50	100	83.8

**Table7:** Antibiotic sensitivity in Non Diabetic Foot

Antibiotics	Aci	C.Fr	C.Ko	C.-ve	E.C	E.B	Kleb	P.Mir	P.Vul	Strep	Sensitivity
<b>Fluroquinolones</b>											
Gatifloxacin	100	100	100	100	100	100	100	100	100	100	100
Levofloxacin	100	100	100	100	100	100	100	100	100	100	100
Ciprofloxacin	100	100	100	100	100	100	100	100	100	0	90
<b>B-Lactam + B-Lactamase inhibitors</b>											
Piper + Tazo	100	100	100	100	100	100	100	100	100	100	100
Cefo + Sul	66.7	100	50	100	92.3	100	80	100	100	100	88.9
<b>Monobactam</b>											
Imipenem	100	100	100	100	100	100	100	100	100	100	100
Meropenem	100	100	100	100	100	100	100	100	100	100	100
<b>Amino glycosides</b>											
Amikacin	100	100	100	100	92.3	100	90	100	100	100	98.2
Gentamicin	100	100	100	100	84.6	100	80	66.7	100	100	93.1
<b>Tetracycline</b>											
Tetracycline	66.7	100	100	100	76.9	100	100	0	100	100	84.4

**Table 8:** Antibiotic sensitivity in Non Diabetic

Antibiotics	Aci	C.Fr	C.Ko	C.-ve	C.+ve	E.C	E.B	E.Coc	Kleb	P.Mir	P.vul	Pseudo	Sensitivity
<b>Fluroquinolones</b>													
Gatifloxacin	100	100	100	100	100	100	100	100	100	100	100	100	100
Ciprofloxacin	100	100	100	100	100	100	100	100	100	100	100	100	100
Levofloxacin	100	100	100	100	100	100	100	100	100	100	100	100	100
<b>B-Lactam + b-Lactamase inhibitors</b>													
Piper + Tazo	100	100	100	100	100	100	100	100	100	100	100	100	100
Cefo + Sul	100	100	100	100	100	85	80	90.9	100	100	100	96	96
<b>Monobactam</b>													
Imipenem	100	100	100	100	100	95	100	100	100	100	100	99.5	99.5
Meropenem	100	100	100	100	100	95	100	100	100	100	100	99.5	99.5
<b>Amino glycosides</b>													
Gentamicin	66.7	100	100	100	100	75	80	100	100	100	100	92.9	92.9
Amikacin	66.7	66.7	100	100	100	85	80	90.9	50	100	100	85.4	85.4
<b>Fosfomycin</b>													
Fosfomycin	0	100	66.7	100	100	95	100	86.4	100	100	100	86.2	86.2

\*Aci - Acinetobacter

\*C. Fr- Citrobacter Freundii

\* C. Ko -Citrobacter Koseri

\*C. -ve- Coagulase negative staphylococcus

\*C. +ve- Coagulase positive staphylococcus

\*E.C - E. Coli

\*E.B -Enterobacter

\*E.Coc - Enterococcus

\*Kleb -Klebsiella

\*P. Mir - Proteus Mirabilis

\*P. Vul- Proteus Vulgaris

\*Pseudo - Pseudomonas

\*Strep-Streptococcus

\*Piperacillin+Tazobactam

\*Cefoperazone+Sulbactam

## DISCUSSION

In present study, majority of patients were elderly with an average age of  $56.4 \pm 16.08$  years and with predominance of male over female.

In present study, among the isolated microorganisms, Gram-Negative bacteria were predominant over Gram Positive bacteria. Similarly, a study by Sannathimmappa MB et al at Oman and Kurup R et al at Guyana. [3,4] shows Gram negative bacteria were predominant over Gram positive bacteria.

In the present study, Klebsiella were the most common isolate among Gram negative bacteria followed by E.coli. A study by Jara MC et al, [5] at Brazil also mentioned Klebsiella were most prevalent but in that study, Acinetobacter were 2<sup>nd</sup> most

common and E. coli were 3<sup>rd</sup> most common while Fetni S et al, [6] at Algeria shows that E. Coli were most commonly isolated bacteria and Kande S et al, [7] at India observed E. coli were the most common bacteria isolate among Diabetic patients with UTI

Among Gram positive bacteria, Coagulase negative staphylococcus were most commonly isolated bacteria in our study while Study at Brazil, [5] shows that Enterococcus faecium and Staphylococcus aureus are most common Gram positive bacteria.

However, overall Klebsiella remains the most common isolate in our study.

In the present study, Piperacillin + Tazobactam were most sensitive antibiotic among all. Study by KandeS [7] in India mentioned sensitivity to Nitrofurantoin, Gentamicin and Amikacin while resistant to Cefpodoxime, Cefixime, and Cefadroxil. While study

by Karmaker M et al,<sup>[8]</sup> at Bangladesh mentioned that most of the isolated bacteria were commonly resistant to Cephalosporin and Monobactam.

In the group of Gram-negative bacteria Carbapenem, B-Lactum + B-Lactamase inhibitor, Fluroquinolones shows more sensitivity in our study. Study by Jara MC et al,<sup>[5]</sup> at Brazil observed that among gram negative bacteria, Polypeptides are most sensitive and Penicillin, Quinolones, Cephalosporin were resistant to Gram negative bacteria. In present study Klebsiella shows 98 % sensitivity towards Piperacillin + Tazobactam.

In present study Cephalosporin, Amoxicillin + Clav. Acid, Ampicillin etc shows low susceptibility (less than 60%). In present study, Gram positive bacteria show sensitivity to Tetracycline, Ansamycins, B-Lactum + B-Lactamase inhibitor, Glycopeptides, Fosfomycin, Amino glycosides, Carbapenem, Fluroquinolones (70-100%) while study by JaraMC,<sup>[5]</sup> shows Fusidanes, Glycylcyclines, and Lipopeptides had 100% sensitivity and Macrolides (95.4%); Lincosamides (90.3%) and Penicillin (77%) are resistant to Gram Positive Bacteria.

## CONCLUSION

In DF samples, Pus was most common while in Non-DF as well as Non DM Urine was most common.

Among all samples most common bacteria isolated were Klebsiella followed by E. Coli.

Klebsiella were most common in DF as well as Non-DM samples while E. Coli predominate in Non-DF samples.

For all samples Fluroquinolones, B-Lactam + B-Lactamase inhibitor, Carbapenem and Aminoglycoside were most sensitive.

Among them the group chosen may be -

1. Piperacillin + Tazobactam / Cefoperazone + sulbactam
2. Ciprofloxacin / Gatifloxacin/ levofloxacin
3. Amikacin / Gentamicin
4. Meropenem

Considering Pharmaco-economic profile, Pharmacokinetic profile and Clinical profile of the patients with coexisting diseases especially CKD, most preferred drug may be Piperacillin + Tazobactam and Levofloxacin.

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