Research Article

A Microbiological Study of Diabetic Foot Ulcer in a South Indian Tertiary Care Hospital

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ABSTRACT

Diabetic foot ulcer is an important complication among diabetic patients and is a significant risk factor for lower extremity amputation. Knowledge of microbes that cause infections will be helpful to determine proper empirical antibiotic therapy. Thus, this retrospective study was undertaken in 150 diabetic patients with foot ulcers who were admitted in the Department of Endocrinology. Patient data relevant to the study was collected using a standard data collection form. Details of organisms isolated and susceptibility pattern were collected from microbiology department. A total of 273 pathogens were identified from 150 patients with an average of 1.8 organisms per patient. Among 150 cases, 65 (43.3%) had monomicrobial infection and 85 (56.7%) had polymicrobial infection. Both gram positive and gram negative organisms caused diabetic foot infections and this study showed a preponderance of gram negative organisms. Among the 273 pathogens, 150 (54.9%) were gram negative bacteria, 104 (38.1%) were gram positive bacteria and 19 (7.0%) were fungi. *Enterococcus faecalis* and *Escherichia coli* (12.1% each) were the most common pathogens isolated. Vancomycin, teicoplanin, tigecycline and linezolid were found to be the highly effective against gram positive organisms, whereas amikacin and colistin were most effective against gram negative organisms. The high prevalence of polymicrobial infection highlights the need for combined antimicrobial therapy for initial management. Effective planning of therapy is very essential for preventing the emergence of drug resistant organisms.

Keywords: Diabetic foot, infection, microbiology, antibiotic susceptibility, polymicrobial.

INTRODUCTION

Diabetes is rapidly emerging as the new global epidemic, especially in developing countries, where the number of people living with diabetes is increasing at an alarming rate compared with the developed world. According to International Diabetes Federation, the number of people with diabetes in the world in 2013 was 382 million, which is going to increase to almost 592 million by 2035. It has been predicted that the prevalence of diabetes in the adult population in India will be nearly 6% by the year 2025. Diabetic foot ulcer is the most costly and devastating complication of diabetes mellitus, which affects 15% of diabetic patients during their lifetime and accounts for nearly 35% of all hospital admissions in diabetic clinics. It also accounts for nearly 80% of all nontraumatic amputations of the lower limb. About 50% of patients with diabetic foot infections who have foot amputations die within five years.[1-6]

In developing countries like India, there are specific causes and risk factors that increase the burden of diabetic foot infections, for example, barefoot walking, using improper footwear, poor knowledge of foot care practices, lack of adequate and timely access to podiatry services, and poor health care resources.[6] Proper management of these infections requires appropriate antibiotic selection based on culture and antibiotic susceptibility results. Thus, the present study was designed to determine the microbiological profile and antibiotic susceptibility pattern of organisms isolated from patients with diabetic foot ulcers.

MATERIALS AND METHODS

This was a retrospective study conducted in the Department of Endocrinology during the period 2013-2014. The study was approved by the Institutional Research and Ethics Committee. All type 2 diabetic patients with diabetic foot ulcer were included. Type 1 diabetic patients and also out patients with diabetic foot ulcer were excluded. Patient data relevant to the study was collected using standard data collection form. Details regarding the age, sex, co-morbid conditions, duration of diabetes, culture and antibiotic susceptibility were collected. Culture specimens were obtained at the time of admission. Antibiotic susceptibility testing was done by standard disc diffusion method as recommended by Clinical Laboratory Standards Institute guidelines.

RESULTS AND DISCUSSION

Diabetic foot infections are a frequent clinical problem and a leading cause of hospitalization for patients with diabetes. Prompt treatment is essential to prevent amputation of the infected foot. This study comprised of data from 150 diabetic foot ulcer patients who were admitted during the study period.

Males were predominant (73.3%) in the study subjects. The age ranged from 25 to 93 years with mean age being 63.6 years. Diabetic foot ulcers were observed more frequently in the age group of 61-80 years, followed by 40-60 years. The duration of diabetes ranged from 1 year to 40 years with a mean duration of 16.2 years. Most of the patients (41.3%) had a diabetic history of 11-20 years.

It is believed that hyperglycemia may contribute to the development of infection. In our study, the mean blood sugar value was 143.9 mg/dl. Data on glycated hemoglobin was available for 113 patients and the mean value was 9.7% suggestive of poor control of blood sugar levels for past three months. Briefly, there is a vicious cycle that the infections can worsen the glycemic control of the diabetic patient and vice versa, the poor glycemic control or other factors associated with diabetes can facilitate or aggravate the development of the infections. Hence, hyperglycemia should be monitored closely and controlled because it may increase the virulence of microorganisms.

In the present study, out of 150 patients, 22 (14.7%) patients had gangrene, 8 (5.3%) patients had cellulitis and 6 (4%) patients had abscess. Osteomyelitis and necrotizing fasciitis were observed in 24 (16%) and 3 (2%) patients, respectively. Nine patients had a past history of amputation. Eighty nine patients underwent amputation during their present admission.

In the present study, co-morbid condition was found in 146 patients. Twenty six patients (17.3%) suffered from a single co-morbid condition and 120 patients (80%) suffered from more than one co-morbid condition. Majority of the patients (27.3%) suffered from three co-morbid conditions. Hypertension (74.7%) was the most common co-morbid condition. Peripheral neuropathy and peripheral occlusive vascular disease were present in 109 and 51 patients, respectively.

Diabetic foot infections are predominantly polymicrobial with the ability to form biofilm, which is an important virulence factor and results in treatment failure. Polymicrobial infections are also associated with an increased risk of amputations, prolonged hospital stay, increased expenses and higher infection-related mortality. In the present study, a total of 273 pathogens were identified from 150 patients with an average of 1.8 organisms per patient. Among 150 cases, 65 (43.3%) had monomicrobial infection and 85 (56.7%) had polymicrobial infection. Our results are consistent with earlier published literature.[7-10] No patient had sterile culture. Nearly 37% patients were infected by two pathogens.

There has been a changing trend in the microorganisms causing diabetic foot infections, with gram negative bacteria replacing gram positive bacteria.[7,10-13] In the present study, among the 273 pathogens, 150 (54.9%) were gram negative bacteria, 104 (38.1%) were gram positive bacteria and 19 (7.0%) were fungi. Gram positive organisms were found as the only isolate in 40 patients (26.7%), while 53 patients (35.3%) had only gram negative organisms. In four patients only fungal isolates were found. Thirty nine patients had both gram positive and gram negative organisms.

In the present study, most of the isolated pathogens belonged to the genus *Staphylococcus* (20.1%),

Enterococcus (14.3%) and *Pseudomonas* (13.6%). Table 1 depicts the organisms isolated from infected diabetic foot ulcers. Among the *Staphylococcus* species, *Staphylococcus aureus* and *Coagulase negative staphylococci* constituted 9.2% and 7.0% of the isolates, respectively. Among *Enterococcus* and *Pseudomonas* species, *Enterococcus faecalis* and *Pseudomonas aeruginosa* constituted 12.1% and 11.4% of the isolates, respectively. Other commonly isolated organisms were *Escherichia coli* (12.1%) and *Klebsiella pneumoniae* (10.2%). The *Candida* species isolated included *Candida albicans* (2.6%), *Candida parapsilosis* and *Candida tropicalis* (0.7% each); and *Candida famata* and *Candida haemulonii* (0.4% each). Other organisms isolated included *Proteus mirabilis* (3.3%), *Acinetobacter baumannii* (1.8%), *beta haemolytic streptococci* (1.1%) and *Proteus vulgaris* (0.7%).

Table 1: Organisms isolated from infected foot ulcers in diabetic patients

Type of organism	Number of isolates (%)
Staphylococcus species	55 (20.1)
Enterococcus species	39 (14.3)
Pseudomonas species	37 (13.6)
Klebsiella species	35 (12.8)
Escherichia coli	33 (12.1)
Candida species	13 (4.8)
Proteus species	11 (4.0)
Acinetobacter species	10 (3.7)
Streptococcus species	9 (3.3)
Morganella morganii	8 (2.9)
Enterobacter species	4 (1.5)
Fungal species	4 (1.5)
Gram negative bacilli	4 (1.5)
Burkholderia cepacia	3 (1.1)
Citrobacter species	2 (0.7)
Kodamaea ohmerii	2 (0.7)
Gram positive diptheroids	1 (0.4)
Providencia rettgeri	1 (0.4)
Serratia marcescens	1 (0.4)
Stenotrophomonas maltophilia	1 (0.4)

Few studies from India have reported *Staphylococcus aureus* as the most common isolate.[11,13,14] However, in the present study, *Enterococcus faecalis* and *Escherichia coli* (12.1% each) were the most common pathogens isolated. In another study from northern India also, *Escherichia coli* was the most common isolate.[15]

Knowledge about the antibiotic susceptibility pattern of the isolates is also essential for proper management of diabetic foot infections. Against gram positive organisms,

linezolid, teicoplanin, tigecycline and vancomycin showed >90% susceptibility. In the present study, all *Staphylococcus* species isolated were susceptible to vancomycin, tigecycline, teicoplanin and linezolid and all of *Enterococcus* species susceptible to vancomycin. These antibiotics are highly effective against gram positive organisms isolated from this study and these antibiotics seem to be appropriate for empirical treatment of diabetic foot infections. *Coagulase negative staphylococcus* also showed 100% susceptibility to levofloxacin. Most of the gram positive organisms showed low susceptibility to erythromycin and Penicillin G.

The antibiotic susceptibility pattern of the gram positive bacteria isolated from diabetic ulcers is shown in Table 2.

Table 2: Antibiotic susceptibility of gram positive isolates from infected foot ulcers

Antibiotic	*Enterococcus* species (n=39)	*Staphylococcus* species (n=36)	*Coagulase negative staphylococci* (n=19)
Ampicillin/amoxicillin	56.7	-	-
Chloramphenicol	77.4	-	-
Clindamycin	-	65.4	44.4
Co-trimoxazole	-	62.5	63.2
Doxycycline	57.1	-	-
Erythromycin	25	50	27.3
Levofloxacin	-	77.8	100
Linezolid	97	100	100
Penicillin G	48.5	6.1	5.3
Teicoplanin	-	100	100
Tigecycline	92.3	100	100
Vancomycin	100	100	100

Table 3: Antibiotic susceptibility of gram negative isolates from infected foot ulcers

Antibiotic	*Pseudomonas* species (n=37)	*Klebsiella* species (n=35)	*E. coli* (n=33)	*Proteus* species (n=11)	*Acinetobacter* species (n=10)
Amikacin	75.9	58.1	83.3	100	40
Amoxicillin clavulanate	-	15.6	3.3	81.8	-
Cefoperazone sulbactam	-	31.8	45.4	85.7	25
Colistin	83.3	100	100	-	100
Co-trimoxazole	-	35.7	24	27.3	20
Levofloxacin	44.4	39.3	32	100	0
Meropenem	42.8	55	89.5	-	16.7
Piperacillin tazobactam	41.7	26.1	27.8	-	28.6

In the present study, **a**gainst *Pseudomonas* species, colistin and amikacin showed good susceptibility. However, against *Klebsiella* species, amikacin showed only 58% susceptibility. *Klebsiella*, *Escherichia coli* and *Acinetobacter* isolates were susceptible to colistin. Majority of the *Klebsiella* and *Acinetobacter* isolates were resistant to cefoperazone sulbactam, co-trimoxazole, and piperacillin tazobactam. Against *Escherichia coli*, meropenem and amikacin showed >80% susceptibility. *Proteus* species showed 100% susceptibility to amikacin and levofloxacin. *Acinetobacter* species showed complete resistance to levofloxacin. Management of gram negative infections is extremely challenging. Future studies should aim at identifying the risk factors for the development of these infections, so that appropriate treatment can be implemented early and can hence prevent fatal outcomes. The antibiotic susceptibility pattern of the gram negative bacteria isolated from diabetic ulcers is shown in Table 3.

Against *Candida* species, amphotericin and fluconazole showed 83.3% and 90.9% susceptibility, respectively.

Thus, our study demonstrates that a variety of organisms can be isolated from diabetic foot ulcers. Knowledge of the usual causative organisms in these infections and their antibiotic susceptibilities will allow clinicians to make informed choices. Since most of the infections were polymicrobial, empirical therapy should be relatively broad spectrum, especially for patients with severe infections and those who are immunocompromised. Once

the probable pathogen(s) are isolated, deescalation of empiric therapy can be guided by relevant culture results.

However, the present study has its own limitations. Firstly, the data presented originates from a single center. Secondly, the anaerobic organisms were not studied. Hence, larger multicentric studies are warranted in the near future to better understand the causative agents and develop an antibiotic policy for empirical treatment.

CONCLUSION

Both gram positive and gram negative organisms caused diabetic foot infections and this study showed a preponderance of gram negative organisms. Majority of the diabetic foot infections were polymicrobial, hence necessitating the need for combined antimicrobial therapy for initial management. Effective planning of therapy is very essential for preventing the emergence of drug resistant organisms.

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