Diabetes Case Reports
ISSN: 2572-5629

Sindhu, Diabetes Case Rep 2018, 3:1
DOI: 10.4172/2572-5629.1000134

Mini Review Open Access

An Overview on Diabetic Foot Ulcer (DFU): Mini Review

Sindhu S*

Department of Biotechnology, Karunya University, Coimbatore, India

Abstract

Diabetes is a major disease which is widespread throughout the world. It is a condition in which the glucose level in the blood increases. The increase in blood glucose level is due to insufficient secretion of insulin in body. Insulin is a protein secreted by pancreas into the body, it makes use of sugar from carbohydrates in the food and store glucose for future. There are three types of diabetes, type 1 and type 2 and gestational diabetes. In type 1 diabetes insulin is not produced, in type 2 diabetes insulin is produced by not effectively used and gestational diabetes occurs during pregnancy, the hormones block the insulin. The cause of diabetes is not known exactly till now, it may be due to some factors like obesity, lack of exercise, genetic factors etc. Some of the signs of diabetes include frequent urination, fatigue, excessive hunger and thirst, blurry vision, slow healing wounds etc. The other complications of diabetes include nephropathy, retinopathy, neuropathy, heart disease and limb amputations. There is no cure for diabetes but can be controlled by proper diet and regular exercise. In this review we are going to discuss about diabetic foot ulcer (DFU), which is a major threat to diabetic patients. DFU is mainly caused due to vascular and neuropathic complications. The neuropathic complications lead to complete loss of sensation in foot and leg, this condition is known as diabetic neuropathy. The improper blood flow leads to ulceration. The diabetic foot ulcers are difficult to heal as the wound does not get enough nutrients or oxygen from blood, leading to the risk of lower limb amputation. Both gram-positive and gram-negative organisms play a vital role in DFU. Let us now see in detail about diabetic foot ulcer.

Keywords: Diabetic foot ulcer; Causative organisms; Biofilm formation; Management

Introduction

DFU

Diabetes is more in developing countries compared to developed countries, moreover India is considered as the home for more number of diabetic individuals. The increase in diabetes mellitus leads to many infections, especially foot ulcer infections [1]. DFU is the result of various factors like peripheral vascular disease, peripheral neuropathy, trauma, foot deformities, arterial insufficiency and impaired resistance to infection. It can be caused by both type 1 and type 2 diabetes. 25% of the patients with diabetes are at a risk of developing foot ulcers [2]. DFU causes longer hospitalization than any other complications of diabetes. It influences a person's quality of life, resulting to a decline to social, physical and psychological functions [3]. It frequently leads to amputation of the leg and increases the rate of mortality and morbidity [4]. The diabetic foot ulcer commences with a small ulcer or surgical wound and results in loss of limb. The diabetic foot occurs in the areas of higher pressure, especially on the plantar aspect of the foot. Some other common areas of infection include medial first metatarsal phalangeal joint, posterior calcaneus and lateral aspect of the fifth metatarsal phalangeal joint. Moreover the diabetic foot ulcer is classified into ischemic, neuropathic or decubitus wounds. The healing potential of ulcer directly depends on its size and duration [5]. The foot ulcer is diagnosed by secretion of pus from infected wound and some physical factors like tenderness, edema, erythema and pain [2].

Causative organisms

The DFU mostly appears to be polymicrobial in nature [6]. Both gram-positive (*Staphylococcus aureus*, *Enterococcus*) and gram-negative (*Pseudomonas aeruginosa, E. coli, Klebsiella species, Proteus species*, etc.) are involved in DFU. These different organisms combine together and form micro-communities within a matrix of EPS (Extra cellular Polymeric Substances) and this is termed as biofilm [7]. The percentage of dominance for biofilm formation by each organism varies in different reports. According to the report by Carla et al, (2015) the biofilm formation was dominated by Pseudomonas which was then followed by *Corynebacterium*, *Acetinobacter, Staphylococcus* and then *Enterococcus*. A study by Semedo-Lemsaddek et al. reveals that *enterococcal* strains are a part of complex diabetic foot ulcer microbiota.

On a study among the gram-negative bacteria in biofilm formation it was found that *E. coli* represented the most common isolate (42.2%), followed by *P. aeruginosa*, *K. oxytoca*, *K. pneumonia*, *Proteus vulgaris*, *Acinetobacter species*, *Proteus mirabilis* and *Morganella morgani* [6]. In 2015, Banu et al. reported that the predominant biofilm former was *Staphylococcus aureus* followed by *Pseudomonas aeruginosa*, *Citrobacter species*, *E. coli*, *Proteus species* and then *Klebsiella oxytoca*. It was found that polymicrobial communities was able to produce higher biofilm formation than individual species [8]. Kirsner also stated that majority of infections in diabetic wounds are polymicrobial. He reported that most of the bacteria are aerobic gram-positive *cocci* especially *Staphylococcus aureus* and *haemolytic Streptococci*. Moreover an infection relays on the type and number of bacteria in a wound.

Biofilm formation

Biofilms are nothing but communities of microorganisms within extracellular polymeric matrix which comprises of lipids, proteins, polysaccharides and nucleic acids, they attach to a biotic or abiotic surface in the solid-liquid interface. Moreover the organisms in the biofilm are provided with essential nutrients supply and water for their growth [9,10]. The biofilm formation is the major cause of many

***Corresponding author:** Sindhu S, Department of Biotechnology, Karunya University, Coimbatore, India, Tel: +91 4222614300; E-mail: sasidharsindhu@gmail.com

Received: February 23, 2018; **Accepted:** April 11, 2018; **Published**: April 16, 2018

Citation: Sindhu S (2018) An Overview on Diabetic Foot Ulcer (DFU): Mini Review. Diabetes Case Rep 3: 134. doi: 10.4172/2572-5629.1000134

chronic infections. Moreover they are multidrug-resistant and cause failure of the treatment. The eradication of biofilm is not possible using conventional antibiotics [7]. Elizabeth Alvarado-Gomez et al. stated that the biofilm formation is a resistant mechanism utilised by bacteria against immune system or antibiotics. He also reported that compared to the biofilm formed by mono-species organisms the biofilm formed by multi-species organisms is structurally and chemically more complex. Moreover the adhesion forces vary between mono-species and multi-species biofilms. The biofilm formation depends on certain factors like a) availability of key nutrients, b) motility of bacteria, c) chemotaxis towards surface, d) surface adhesion and e) presence of surfactants. Biofilms are the site of quorum sensing [6].

DFU being polymicrobial in nature forms biofilm which makes it difficult for treatment. The abuse and misuse of antibiotics for treatment of DFU resulted in multidrug resistance and failure of treatment causing health issue [9]. The polymicrobial ecology forms multilayer biofilm [10]. This multilayer biofilm is highly resistant to antibiotics. This is mainly due to close cell-cell contact in the biofilm which permits the easy transfer of plasmids which contains multidrug resistance genes from one organism to another [7].

Literature Review

Management

DFU can be reduced by proper management. The management of DFU includes:

- Control of blood sugar
- Awareness
- Debridement
- Advanced dressing
- Offloading [11]

Control of blood sugar: The blood sugar level is a major factor to be considered by patients affected by diabetes, as it has been found that the inappropriate control of blood sugar is the foremost cause of DFU. It has been reported that improper maintenance of blood sugar elevated the consequences of Peripheral Arterial Disease, which is considered as a primary cause of diabetic foot ulcer [11].

Awareness

It has been reported that over 50% of DFU can be prevented by proper awareness. People must be provided with sufficient knowledge on self-management of foot. They must be given proper information on the importance of foot care, about the risk factors owing to DFU. Awareness about foot hygiene, use of appropriate footwear and blood sugar control must be provided to the public to avoid major consequences of DFU [12].

Debridement

Debridement is the elimination of devitalized and necrotic tissue from the wound, it is considered as a foremost step which helps in the closure of wound and prevents the amputation of the limb in DFU. It alters the wound from chronic to acute. It declines the counts of bacteria and accelerates the production of local growth factors. Methods of debridement include use of scalpel (standard technique), ultrasound, pulsed lavage, topical and autolytic enzymatic ointments. It is reported that frequent debridement has lead to higher rates of DFU healing [13].

Advanced dressing

Novel dressing is very important in diabetic foot ulcer management. The ideal characteristics of a novel dressing includes:

- Moisture balance
- Protease sequestration
- Stimulation of growth factors
- Antimicrobial activity
- Oxygen permeability
- Ability to promote autolytic debridement.

The other major factors include prolonged time of action, higher efficiency and in the case of medicated treatment sustained drug release. The wound dressing depends on certain factors like location of the wound, depth of the wound, amount of slough, wound margins, presence of pain and infection, dressing conformability and need for adhesiveness. Wound dressing is divided into two categories:

- Passive
- Active or interactive.

Passive: This is mainly suited for acute infections as they absorb adequate amount of exudates and provides good protection.

Active or interactive: This type of dressing is capable of altering the physiology of wound by promoting growth factors release and cellular activity. It is suited for chronic wounds and provides moist environment that stimulates healing process.

The different categories of dressings used for DFU includes: films, hydrogels, hydrocolloids, alginates, foams and silver-impregnated dressing. The dressings depend mainly on the characterisation of DFU. It has been reported that hydrogels has found to be the frequently used dressing for all types of DFU [11].

Offloading

Offloading in other words in also known as the pressure relieving method, used for DFU healing. Here the patients are provided with custom-made orthotic devices and fibre casts to allow them to partially mobilise [4]. It includes crutches, wheel chairs, specialised footwear like boots, surgical shoes etc. Other devices like RCW (Removable Cast Walker) and TCC (Total Contact Casting) are also used for patience convenience. It has been reported that it should not be used by patients with infected or ischemic wounds [13].

Discussion

Therefore, diabetes mellitus must be taken care starting from the earlier stage, otherwise it leads to complications like diabetic foot ulcer. DFU causes complications like lower limb amputation if left untreated. The treatment of DFU also seems to be costly. In many cases DFU has resulted fatal due to inappropriate treatment and its multidrug resistance due to its polymicrobial nature, leads to failure of treatment. Prevention and management of diabetes is very important to avoid such conditions.

Conclusion

Therefore, further researches must be carried out for the treatment of DFU, as it is drug resistant. Further studies on the inhibition of biofilm formation and bacterial adhesion can be carried out for the effect treatment of diabetic foot ulcer.

References

1. Malik A, Mohammad Z, Ahmad J (2013) The diabetic foot infections: Biofilms and antimicrobial resistance. Clin Res Rev 7: 101-107.

2. Noor S, Mohammad Z, Ahmad J (2015) Diabetic foot ulcer- A review on pathophysiology classification and microbial etiology. Clin Res Rev 9: 190-199.
3. Robert K, Lisa M, Stephen C (2006) The diabetic foot: The importance of biofilms and wound bed preparation. Curr Diab Rep 6: 439-445.
4. Jeffcoate WJ, Harding KG (2003) Diabetic foot ulcers. The Lancet 361: 1545-1551.
5. Kim J, Steinberg S (2013) Complications of the diabetic foot. Endocrinol Metab Clin N Am 42: 833-847.
6. Mohammad Z, Malik A, Ahmad J, Rizvi M, Jamal K, et al. (2010) A study of biofilm production by gram-negative organisms isolated from diabetic foot ulcer patients. Front Life Sci: Basics and Applied 3: 147-157.
7. Banu A, Noorul Hassan MM, Rajkumar J, Srinivasa S (2015) Spectrum of bacteria associated with diabetic foot ulcer and biofilm formation: A prospective study. Australas Med J 8: 280-285.
8. Carla M, Mendes J, Cristino M, Cavaco-Silva P, Tavares L, et al. (2015) Polymicrobial biofilms by diabetic foot clinical isolates. Folia Microbiol 61: 35-43.
9. Semedo-Lemsaddek T, Carla M, Alves-Barroco C, Cavaco-Silva P, Tavares L, et al. (2015) Characterization of multidrug-resistant diabetic foot ulcer enterococci. Enferm Infecc Microbiol Clin 34: 114-116.
10. Alvarado-Gomez E, Perez-Diaz M, Valdez-Perez D, Ruiz-Garcia J, Magaña-Aquino M, et al. (2017) Adhesion forces of biofilms developed *in vitro* from clinical strains of skin wounds. Mater Sci Eng C 82: 336-344.
11. Yazdanpanah L, Nasiri M, Adarvishi S (2015) Literature review on the management of diabetic foot ulcer. World J Diabetes 6: 37-53.
12. Faglia E, Favales F, Morabito A (2001) New ulceration, new major amputation, and survival rates in diabetic subjects hospitalized for foot ulceration from 1990 to 1993: a 6.5-year follow-up. Diabetes care 24: 78-83.
13. Jhamb S, Vangaveti VN, Malabu UH (2016) Genetic and molecular basis of diabetic foot ulcers: Clinical review. J Tissue Viability 4: 229-236.