3-27-2018

Diabetes Mellitus: Prevention and Management of Diabetic Foot Ulcers

Kathleen A. Stevens

Diabetes Mellitus: Prevention and Management of Diabetic Foot Ulcers

Kathleen. A. Stevens

University of North Dakota

Nursing 997 Independent Study

March 22, 2018

PERMISSION

Title Diabetes Mellitus: Prevention and Management of Diabetic Foot Ulcers

Department Nursing

Degree Master of Science

In presenting this independent study in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the College of Nursing of this University shall make it freely available for inspection. I further agree that permission for extensive copying or electronic access for scholarly purposes may be granted by the professor who supervised my independent study work or, in her absence, by the chairperson of the department or the dean of the Graduate School. It is understood that any copying or publication or other use of this independent study or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of North Dakota in any scholarly use which may be made of any material in my independent study.

Signature Kathleen A. Stevens

Date: 03/22/2018

Abstract

Diabetic polyneuropathy (DPN) refers generally to peripheral neural dysfunction as a complication of diabetes mellitus. The Centers for Disease Control and Prevention reported that 29.1 million people or 9.3% of the population of the United States have been diagnosed with diabetes (Allen, Doherty, Rice, & Kimpinski, 2016). Of this group, almost 95% are individuals with type 2 diabetes mellitus. Neuropathy is a common and costly complication of both type 1 and type 2 diabetes and DPN is estimated to occur in at least 20% of diagnosed patients (Allen et al., 2016). Combined with sensory deficits these changes in the motor system can contribute to decreased sensory functional capacity, impaired mobility, altered gait, and increased fall risk (Allen et al., 2016). According to Alexiadou & Doupis (2015), the diabetic foot is one of the most significant and devastating complications of diabetes, and is defined as a foot affected by ulceration that is associated with neuropathy and/or peripheral arterial disease of the limb in a patient with diabetes. The risk of foot ulceration and limb amputation increases with age and duration of diabetes. The prevention of diabetic foot is crucial, considering the negative impact on a patient's quality of life (Alexiadou & Doupis, 2012). The aim of the present review is to summarize the causes and pathogenetic mechanisms leading to diabetic foot and to focus on the management of this important health issue (Alexiadou & Doupis, 2012). The American Diabetes Association recommendations are to perform a comprehensive foot evaluation at least annually to identify risk factors ("Microvascular Complications and Foot Care," 2018).

Diabetes Mellitus: Prevention and Management of Diabetic Foot Ulcers

A pleasant 60-year-old Caucasian female presented to the clinic for a follow-up for her Diabetes Mellitus type II. She had an appointment with the diabetic educator last week, who encouraged the patient to follow-up with the clinic for medical management. She reported that she was diagnosed with diabetes approximately two years ago, but believes the symptoms of DM may have been present approximately one year prior to her diagnosis. She has not received consistent care and has not seen a provider for at least one year. During her visit today, she reported some mild burning and tingling to her feet, however, she has full sensation to her feet bilaterally. Her blood pressure, glycosylated hemoglobin and lipid panel are all elevated today. All of these factors place her at increased risk of diabetic peripheral neuropathy which increases the risk of diabetic foot ulcers.

Several recent studies have implicated poor glycemic control, duration of diabetes, hyperlipidemia, elevated albumin excretion rates and obesity as risk factors for the development of diabetic peripheral neuropathy (DPN) (Tesfaye & Selvarajah, 2012). Diabetic peripheral neuropathy affects up to 50% of patients with diabetes and is a major cause of morbidity and increased mortality (Tesfaye & Selvarajah, 2012). The clinical manifestations include painful neuropathic symptoms and insensitivity, which increases the risk for burns, injuries and foot ulceration (Tesfaye & Selvarajah, 2012). Diabetic foot ulcers (DFU) are the most common complication of diabetes mellitus, they usually fail to heal, and lead to lower limb amputation (Yazdanpanah, Masiri, & Adarvishi, 2015). Yazdanpanah et al. (2015), stated that early effective management of diabetic foot ulcers are as follows: education and blood sugar control, wound debridement, advanced wound care dressings, offloading, advanced therapies and in some cases surgery. Early effective management can reduce the severity of complications and improve the overall quality of life, especially when using a multidisciplinary team approach.

Diabetes is one of the leading causes of chronic disease and limb loss world-wide, currently affecting 382 million people (Hingorani et al., 2016). It is predicted that by 2035, the number of reported diabetes cases will soar to 592 million people (Hingorani et al., 2016). The World Health Organization has projected diabetes will be the seventh leading cause of death in

2030 (Hingorani et al., 2016). In general, the incidence of nontraumatic lower extremity amputations (LEAs) has been reported to be at least 15 times greater in those with diabetes than with any other concomitant medical illness (Margolis et al. 2011). It has been reported annually, approximately 1 to 4 percent of those with diabetes develop a foot ulcer and 10 to 15 percent of those with diabetes will have at least one foot ulcer during their lifetime (Margolis et al. 2011).

Case Report

The patient is a pleasant 60-year-old Caucasian female that was seen in the clinic for a follow-up for DM type II. She is a small woman at 5 feet tall, not significantly overweight, but has mild central obesity. She reported that she does not have any functional limitations. Her current medical diagnosis is diabetes mellitus type II, hyperlipidemia, hypertension, mild neuropathy to her lower extremities and a significant family history of coronary artery disease (CAD). Her current medications are Metformin 500 mg twice a day, Aspirin 81 mg daily, Lisinopril 20 mg daily, Atorvastatin 20 mg daily, and a multivitamin daily. She had a mammogram and pap smear last year that she reported as negative. She is post-menopausal times 10 years. She reported a negative history of tobacco, smokeless tobacco or drug abuse. She reported that she drinks three beers two times weekly. She reported an allergy to penicillin which caused a full body red rash.

Family history (Mom, dad and brother) is significant for DM, coronary artery disease, and hypertension. Her brother and father are both positive for a history of colon cancer. All three first-degree relatives have undergone coronary artery bypass graft surgery. She has a negative surgical history.

Review of systems: she denied any complaints of pain, fatigue, weakness, fever or chills. She denied any changes in vision**.** She denied any issues with chest pain, murmurs, palpitations or dyspnea. She denied and problems with abdominal pain, no nausea or vomiting. She also denied any symptoms frequency, urgency or dysuria. She denied any problems with ambulation, no weakness or dizziness, she did report mild tingling and burning to her feet bilaterally.

Physical examination as follows: Vital Signs: Blood pressure 148/98, Pulse 80, Temperature 98.6, Respirations 20. Eyes: Ophthalmoscope findings: reveal red reflex, no evidence of hemorrhages or nicking. Respiratory: Lungs clear on auscultation anterior and posterior, chest wall expansion is symmetrical and regular. Cardiovascular: regular rate and rhythm, S1/S2 present without murmurs or extra heart sounds. No peripheral edema, varicose veins or discoloration to bilateral lower extremities. Pedal pulses are regular and strong 2+ bilaterally. Microfilament test without any noted deficits. She reported some burning and tingling to areas of her feet, but has full sensation to all areas of bilateral plantar surface on each foot. Abdomen: Bowel sounds active x 4, without tenderness or pain with palpation, to all quadrants. Neurologically, the patient was alert and oriented, to person, place, time and situation. Labs: HbA1C 7.8, Glucose 138, Cholesterol 220, Triglycerides 186, HDL 36, LDL 110, eGFR 53.

Treatment plan: According to the Eighth Joint National Committee (JNC 8), the blood pressure goal for the general population without a diagnosis of diabetes or chronic kidney disease, who are 60 years of age or older is less than 150/90. Patients with a diagnosis of diabetes or chronic kidney disease is less than 140/90 regardless of age. Recommendations from the ADA include: LDL less than 70, HbA1C 6.5, cholesterol less than 199 and Triglycerides less than150. Her eGFR is rated as stage 3 CKD, which is a moderately decreased eGFR. Medical management for this patient, is to increase Metformin to 1000 mg twice a day, Lisinopril to 40 mg daily and increase Atorvastatin to 40 mg daily. Order for complete blood count (CBC), complete metabolic profile (CMP), urinalysis (UA), glycosylated hemoglobin (HbA1C) and Lipid panel. Based on current lab values, I will repeat a renal panel in six months to include electrolytes, bicarbonate, calcium, phosphorus, parathyroid hormone, hemoglobin and albumin. Order for dual-energy x-ray absorptiometry (Dexa scan) to assess for bone loss, ophthalmology for annual eye exam, follow-up appointment with primary care every three months to monitor and manage DM and colonoscopy screening due to family history and age of this patient. Patient Education: Patients with diabetes are at an increased risk for diabetic foot ulcers. Proper foot care includes education on good skin care, nail care, and daily foot inspection. It is important to wear appropriate footwear, which includes wearing shoes in the home to prevent any trauma or injury. Maintaining good glucose control will help slow or delay the progression of neuropathy.

Literature Review

Neuropathy is the main cause that gives rise to diabetic foot ulcers especially the insensate foot. Patients might not be aware of it in the early stages, as they might not feel the pain (Priyadarshini et al., 2018). Furthermore, a neuropathic wound does not heal fast as it is not protected by pain sensation. Optimal glycemic control can reduce the incidence of neuropathy and thereby foot ulcers. Normal glucose level is the first line of defense against chronic complications of diabetes (Priyadarshini et al., 2018). One study in particular has shown that optimal glycemic control may prevent the development of neuropathy. Intensive blood glucose control reduced the development of neuropathy by 40% in patients with type II diabetes and by about 60% in patients with type 1 diabetes (Priyadarshini et al., 2018). Elevated HbA1c levels have been associated with DFU, amputations and peripheral vascular disease. Therefore, it is very important to optimize glycemic control to prevent DFU in the long run (Priyadarshini et al., 2018).

The diabetic foot assessment is a key component in the care of a patient with diabetes. The assessment includes risk factor identification in the patient's history and physical examination, foot care education, treatment, and referrals to other specialties as needed (Johnson, Osbourne, Rispoli, & Verdin, 2018). The foot complications related to diabetes such as peripheral neuropathy, foot ulceration, and amputation can be life altering. The American Diabetes Association recommends a diabetic foot examination and foot care education annually for patients with diabetes (Johnson et al., 2018). Diabetic foot assessment may be recommended more frequently for individuals with risk factors contributing to ulceration, peripheral arterial disease, and peripheral neuropathy (Johnson et al., 2018).

Among the numerous multi-system health consequences of DM, foot ulceration is an all too common problem. Lifetime prevalence estimations of foot ulceration in people with DM are as high as 25% with a yearly incidence rate of 2-4% (Priyadarshini et al., 2018). While both vascular and neuropathic processes contribute to tissue breakdown, the majority of foot ulcers are neuropathic in nature. Importantly, foot ulceration is associated with decreased mobility and quality of life, ulcer recurrence, infection, and subsequent limb amputation (Priyadarshini et al., 2018). Despite these staggering data, many of the adverse sequelae of DM, including neuropathic foot ulceration, are considered preventable (Priyadarshini et al., 2018).

Foot problems are a common complication in people with diabetes. Fortunately, most of these complications can be prevented with careful foot care. If complications do occur, daily attention will ensure that they are detected before they become serious (McCullouch, 2017). Patients who have had a previous foot ulcer are more likely to have future foot complications.

Nerve damage, poor circulation, and chronically high blood sugar levels also increase the likelihood of foot complications (McCullouch, 2017). It is important to wear shoes that fit well. Shoes that are too tight can cause pressure ulcers. Going barefoot, even in the home, should be avoided as this increases the risk of injury to the foot (McCullouch, 2017). People with neuropathy or evidence of increased plantar pressures (e.g., erythema, warmth, or calluses) may be adequately managed with well-fitted walking shoes or athletic shoes that cushion the feet and redistribute pressure ("Microvascular Complications and Foot Care," 2018).

Foot deformities, on the other hand, may also be the cause foot ulcers due to abnormal pressure. In patients with diabetes, deformity due to Charcot neuroarthropathy is increasingly recognized (Priyadarshini et al., 2018). It is important to prevent foot deformity in patients with diabetes with the use of adequate footwear. Similarly, acute Charcot neuroarthropathy should be aggressively treated to maintain the normal architecture of the foot (Priyadarshini et al., 2018). There has been no controlled trial on surgical correction of deformity in the prevention of ulcers but it is worth considering. Recently, surgery to lengthen the Achilles tendon has been shown to be useful in the prevention of ulceration of metatarsal heads (Priyadarshini et al., 2018). If there is recurrence of ulceration over a bony prominence or on an abnormal weight-bearing part, surgical correction may be indicated (Priyadarshini et al., 2018).

Infection is a frequent complication of diabetic foot ulcers, with up to 58% of ulcers being infected at initial presentation at a diabetic foot clinic, increasing to 82% in patients hospitalized for a diabetic foot ulcer ("Predictors of Lower-Extremity Amputation," 2015). Diabetic foot infections (DFIs) are associated with poor clinical outcomes for the patient and high costs for both the patient and the health care system ("Predictors of Lower-Extremity Amputation," 2015). Patients with a DFI have a 50-fold increased risk of hospitalization and

150-fold increased risk of lower-extremity amputation compared with patients with diabetes without a DFI ("Predictors of Lower-Extremity Amputation," 2015). Among patients with a DFI; 5% will undergo a major amputation and 20–30% a minor amputation, with the presence of peripheral arterial disease (PAD) greatly increasing amputation risk ("Predictors of Lower-Extremity Amputation," 2015). Furthermore, lower-limb amputation is associated not only with significant morbidity and mortality but also with major psychosocial and financial consequences. As infection of a diabetic foot wound heralds a poor outcome, early diagnosis and treatment are important ("Predictors of Lower-Extremity Amputation," 2015). Unfortunately, systemic signs of inflammation such as fever and leukocytosis are often absent, even with a serious foot infection. Local signs and symptoms of infection are often diminished due to concomitant peripheral neuropathy and ischemia, diagnosing and defining resolution of infection can be difficult ("Predictors of Lower-Extremity Amputation," 2015).

There are many treatment options available on the market today for treatment and management of DFU's. Treatment of DFU's begins with prevention, debridement of callouses, inspection and appropriate nail care (Yazdanpanah et al., 2015). Debridement is the removal of necrotic and senescent tissues as well as foreign and infected materials from a wound, which is considered as the first and the most important therapeutic step leading to wound closure and a decrease in the possibility of limb amputation in patients with DFU (Yazdanpanah et al., 2015). Debridement seems to decrease bacterial counts and stimulates production of local growth factors. This method also reduces pressure, evaluates the wound bed, and facilitates wound drainage (Yazdanpanah et al., 2015). The gold standard for diabetic foot ulcer treatment includes debridement of the wound, management of any infection, revascularization procedures when indicated, and off-loading of the ulcer (Alexiadou & Doupis, 2012). Other methods have also been suggested as beneficial add-on therapies, such as hyperbaric oxygen, use of advanced wound care products, and negative-pressure wound therapy (NPWT) (Alexiadou & Doupis, 2012).

Debridement should be carried out on all chronic wounds to remove surface debris and necrotic tissues. Debridement improves healing by promoting the production of granulation tissue and can be achieved surgically, enzymatically, biologically, and through autolysis (Alexiadou & Doupis, 2012). Among these methods, surgical debridement has been shown to be more effective in DFU healing (Yazdanpanah et al., 2015). The main purpose of this type of debridement is to turn a chronic ulcer into an acute wound. It has been reported that regular (weekly) sharp debridement is associated with improved healing rates of ulcers, in comparison to ulcers with less frequent debridement's (Yazdanpanah et al., 2015).

Surgical debridement, known also as the ''sharp method,'' is performed with scalpels, and is rapid and effective by removing hyperkeratosis and dead tissue. Particular care should be taken to protect healthy tissue, which has a red or deep pink (granulation tissue) appearance (Alexiadou & Doupis, 2012). Using a scalpel blade with the tip pointed at a 45 angle, all nonviable tissue must be removed until a healthy bleeding ulcer bed is produced with saucerization of the wound edges. If severe ischemia is suspected, aggressive debridement should be postponed until a vascular examination has been completed, and if necessary a revascularization procedure is performed (Alexiadou & Doupis, 2012).

An older debridement type that is categorized as biological debridement is maggot debridement therapy (MDT), which is also known as maggot therapy or larval therapy (Yazdanpanah et al., 2015). In this method, sterile and live forms of the Lucilia sericata larvae are applied to the wound to achieve debridement, disinfection, and ultimately wound healing.

Indeed, larvae secrete a powerful autolytic enzyme that liquefies necrotic tissues, stimulates the healing processes, and destroys bacterial biofilms (Yazdanpanah et al., 2015). This technique is indicated for open wounds and ulcers that contain gangrenous or necrotic tissues with or without infection (Yazdanpanah et al., 2015).

The use of offloading techniques, commonly known as pressure modulation, is considered the most important component for the management of neuropathic ulcers in patients with diabetes (Yazdanpanah et al., 2015). Retrospective and prospective studies have shown that elevated plantar pressures significantly contribute to the development of plantar ulcers in patients with diabetes. In addition, any existing foot deformities may increase the possibility of ulceration, especially in the presence of diabetic peripheral neuropathy and inadequate off-loading (Alexiadou & Doupis, 2012).

Recent studies have provided evidence indicating that proper offloading promotes DFU healing (Yazdanpanah et al., 2015). The most effective offloading technique for the treatment of neuropathic DFU is total contact casts (TCC). TCC is minimally padded and molded carefully to the shape of the foot with a heel for walking (Yazdanpanah et al., 2015). The cast is designed to relieve pressure from the ulcer and distribute pressure over the entire surface of the foot; thus, protecting the site of the wound (Yazdanpanah et al., 2015). The contributory factors to the efficacy of TCC treatment are likely to be due to pressure redistribution and offloading from the ulcer area. In addition, the patient is unable to remove the cast, which thereby forces compliance, reduces activity levels, and consequently improves wound healing (Yazdanpanah et al., 2015). Regardless of the modality selected, patients should not return to an unmodified shoe until complete healing of the ulcer has occurred. Furthermore, any shoe that resulted in the formation of an ulcer should not be worn again (Yazdanpanah et al., 2015).

A major breakthrough for DFU management over the last decades was the demonstration of novel wound dressings. Ideally, wound dressings should confer moisture balance, protease sequestration, growth factor stimulation, antimicrobial activity, oxygen permeability, and the capacity to promote autolytic debridement that facilitates the production of granulation tissues and the re-epithelialization process (Yazdanpanah et al., 2015). In addition, it should have a prolonged time of action, high efficiency, and improved sustained drug release in the case of medicated therapies. Hence, no single dressing fulfills all the requirements of a diabetic foot ulcer (Yazdanpanah et al., 2015). The choice of dressing is largely determined by the causes of DFU, wound location, depth, amount of scar or slough, exudates, condition of wound margins, presence of infection and pain, need for adhesiveness, and conformability of the dressing (Yazdanpanah et al., 2015).

Wound dressing can be categorized as passive, active, or interactive. Passive dressings are used as protective functions and for acute wounds because they absorb reasonable amounts of exudates and ensure good protection (Yazdanpanah et al., 2015). Active and interactive dressings are capable of modifying the physiology of a wound by stimulating cellular activity and growth factors release. In addition, they are normally used for chronic wounds because they adapt to wounds easily and maintain a moist environment that can stimulate the healing process (Yazdanpanah et al., 2015). The main categories of dressings used for DFU are as follows: films, hydrogels, hydrocolloids, alginates, foams, and silver-impregnated (Yazdanpanah et al., 2015). Today, all dressings are commonly used in clinical practice, while the efficacy of these products has been a challenge for researchers and clinicians, and there are controversial results regarding their use (Yazdanpanah et al., 2015). However, dressings are used based on DFU characteristics, hydrogels have been found to be the most popular choice of dressing for all DFU types (Yazdanpanah et al., 2015). Some studies dealing with the incorporation of these products show great potential in the treatment of DFU (Yazdanpanah et al., 2015).

Another available treatment for DFU's is hyperbaric oxygen therapy. Treatment with hyperbaric oxygen therapy involves the intermittent administration of 100% oxygen at a pressure greater than that at sea level (Alexiadou & Doupis, 2012). It is performed in a chamber with the patient breathing 100% oxygen intermittently while the atmospheric pressure is increased to two-three atmospheres for a duration of one-two hours. A full course involves 30–40 sessions (Alexiadou, & Doupis, 2012). A small amount of data suggested a significant reduction of the ulcer area as well as reduction of the risk for major amputation (Alexiadou & Doupis, 2012). Hyperbaric oxygen can be applied as an adjunctive therapy for patients with severe soft-tissue foot infections and osteomyelitis who have not responded to conventional treatment (Alexiadou & Doupis, 2012). Adverse effects include barotrauma to the ears and sinuses, pneumothorax, transient changes in visual acuity, and seizures (Alexiadou & Doupis, 2012).

Negative pressure wound therapy (NPWT) is a non- invasive wound closure system that uses controlled, localized negative pressure to help heal chronic and acute wounds (Yazdanpanah et al., 2015). This system uses latex-free and sterile polyurethane or polyvinyl alcohol foam dressing that is fitted at the bedside to the appropriate size for every wound, and then covered with an adhesive drape to create an airtight seal (Yazdanpanah et al., 2015). Most commonly, 80-125 mmHg of negative pressure is used, either continuously or in cycles. The fluid suctioned from the wound is collected into a container in the control unit (Yazdanpanah et al., 2015). It seems that NPWT removes edema and chronic exudate, reduces bacterial colonization, enhances formation of new blood vessels, increases cellular proliferation, and improves wound oxygenation as the result of applied mechanical force (Yazdanpanah et al., 2015).

Diabetic foot surgery plays an essential role in the prevention and management of DFU, and has been on the increase over the past two decades. Although surgical interventions for patients with DFU are not without risk, the selective correction of persistent foot ulcers can improve outcomes (Yazdanpanah et al., 2015). While the primary goal of DFU management focuses on limb salvage, in some cases amputation may offer a better functional outcome, although this is often not clearly defined. This decision is individualized and multifactorial to match patient lifestyle, medical, physical, and psychological comorbidities (Yazdanpanah et al., 2015). In general, amputation is considered as an urgent or curative surgery and should be the last resort after all other salvage techniques have been explored, and the patient must be in agreement (Yazdanpanah et al., 2015). Indications for an amputation include the removal of infected or gangrenous tissues, control of infection, and creation of a functional foot or stump that can accommodate footwear or prosthesis (Yazdanpanah et al., 2015).

Bio-engineered skin (BES) product cells are seeded into the scaffolds and cultured in vitro (Yazdanpanah et al., 2015). In vitro incubation establishes the cells and allows the cell-secreted extra cellular matrix (ECM) and growth factors to accumulate in the scaffold (Yazdanpanah et al., 2015). The cells within live cell scaffolds are believed to accelerate DFU healing by actively secreting growth factors during the repair process. In addition, it seems that BES can provide the cellular substrate and molecular components necessary to accelerate wound healing and angiogenesis (Yazdanpanah et al., 2015). They act as biologic dressings and as delivery systems for growth factors and ECM components through the activity of live human fibroblasts contained in the dermal elements. Currently, three kinds of BES products approved in the United States are available to use for DFU including Derma graft (Advanced Bio healing Inc., La Jolla, CA), Apligraf (Organogenesis Inc., Canton, Mass), and Oasis (Cook Biotech, West Lafayette, IN) (Yazdanpanah et al., 2015).

DFU have demonstrated the benefit from growth factors (GFs) such as platelet derived growth factor (PDGF), fibroblast growth factor, vascular endothelial growth factor, insulin-like growth factors (IGF1, IGF2), epidermal growth factor, and transforming growth factor b (Yazdanpanah et al., 2015). Among the aforementioned GFs, only recombinant human PDGF (rhPDGF) (Becaplermin or Regranex), which is a hydrogel that contains 0.01% of PDGF-BB (rhPDGF-BB), has demonstrated increased healing rates when compared with controls in a number of clinical trials and has shown sufficient DFU repair efficacy to earn Food and Drug Administration (FDA) approval (Yazdanpanah et al., 2015).

Diabetes is a complex, chronic illness requiring continuous medical care with multifactorial risk-reduction strategies beyond glycemic control. Ongoing patient self-management education and support are critical to preventing acute complications and reducing the risk of long-term complications ("Diabetes care: Standards of Medical Care in Diabetes," 2018). Significant evidence exists that supports a range of interventions to improve diabetes outcomes. A successful medical evaluation depends on beneficial interactions between the patient and the care team. Treatment goals and plans should be created with the patients based on their individual preferences, values, and goals ("Diabetes care: Standards of Medical Care in Diabetes," 2018). Extensive patient education, early assessment, and aggressive treatment by a multidisciplinary team represent the best approach to manage high-risk patients with diabetes. Clinical and economic outcomes demonstrate reduced amputations, length of stay, and costs ("Diabetes care: Standards of Medical Care in Diabetes," 2018).

The care team must continue to become more effective, especially regarding early cost-effective use of appropriate care, interventions, and appropriate consultations to specialized teams (Driver et al., 2010). Early recognition and prevention of diabetic foot disease has been greatly emphasized and proven to be effective in the United States; however, limb preservation services are frequently consulted very late in the disease process, after significant pathology has progressed (Driver et al., 2010). It is quite clear that by using an interdisciplinary team, we can improve function and reduce amputation, but what are the costs? Future clinical research might incorporate specific evidenced-based pathways to reduce amputation while choosing the most cost-effective diagnostic and treatment options (Driver et al., 2010). The next step is to break down silos of care between the various care settings, to improve the continuum of care while realizing more productive and cost-effective methods for saving limbs, and caring for our high-risk population (Driver et al., 2010).

Learning points

- Diabetic foot ulcer (DFU) is the most common complication of diabetes mellitus that usually fail to heal and increase the risk of amputation.
- Early effective management of DFU's can reduce the severity of complications and also can improve overall quality of life of patients especially by using a multidisciplinary team approach to care.
- Diabetic peripheral neuropathy affects up to 50% of all patients with diabetes and is a major cause of morbidity and increased mortality.
- Foot problems in persons with diabetes have been recognized as a major health issue. More than 60% of non-traumatic lower limb amputations occur in diabetic individuals, and at least 80% of amputations are preceded by an ulcer.

- Patients with diabetic peripheral neuropathy (DPN) appear to benefit from exercise programs which improve blood glucose control, weight loss and daily exercise can slow progression of DPN.

References

Alexiadou, K., & Doupis, J. (2012). Management of diabetic foot ulcers. *Diabetes Therapy*, 3(1), 4. doi:10.1007/s13300-012-0004-9

Allen, M.D., Doherty, T.J., Rice, C.L., & Kimpinski, K. (2016). Physiology in medicine: Neuromuscular consequences of diabetic neuropathy. *Journal of Applied Physiology,* 121(1), 1–6. doi:10.1152/japplphysiol.00733.2015

Diabetes Care: Standards of Medical Care in Diabetes-2018. [Supplemental Material]. (2018). *American Diabetes Association*. doi: 10.2337/dc18-SINT01

Driver, V.R., Fabbi, M., Lavery, L.A., & Gibbons, G. (2010). The costs of diabetic foot: The economic case for the limb salvage team. *Journal of Vascular Surgery.* 52(3 Suppl):17S-22S. doi:10.1016/j.jvs.2010.06.003

Hingorani, A., LaMuraglia, G.M., Henke, P., Meissner, M.H., Loretz, L., Zinszer, K.M., ... Murad, M.H., (2016). The management of diabetic foot: A clinical practice guideline by the Society for Vascular Surgery in collaboration with the American Podiatric Medical Association and the Society for Vascular Medicine. 63(2 Suppl):3S-21S doi:10.1016/j.jvs.2015.10.003

Johnson, R., Osbourne, A., Rispoli, J., & Verdin, C. (2018). The diabetic foot assessment, *Orthopedic Nursing*, 37(1) 13–21 doi:10.1097/NOR.0000000000000414

Margolis, D.J., Malay, D.S., Hoffstad, O.J., Leonard, C.E., MaCurdy, T., López de Nava, K., … Siegel, K.L., (2011, February 17) Incidence of diabetic foot ulcer and lower extremity amputation among Medicare beneficiaries, 2006 to 2008: Data Points Publication Series 2. Retrieved from https://www.ncbi.nlm.nih.gov/books/NBK65149/

McCulloch, D.K. (2018). Patient education: Foot care in diabetes mellitus (Beyond the Basics). Retrieved from https://www.uptodate.com/contents/foot-care-in-diabetes-mellitus-beyond-the-basics

Microvascular Complications and Foot Care: Standards of Medical Care in Diabetes-2018. [Supplemental Material]. (2018). *American Diabetes Association*. doi:10.2337/dc18-S010

Pickwell, K., Siersma, V., Kars, M. Apelqvist, J., Bakker, K., Edmonds, M….Schaper, N. (2015). Predictors of lower-extremity amputation in patients with an infected diabetic foot ulcer. *Diabetes Care, 38*(5): 852-857. https://doi.org/10.2337/dc14-1598

Priyadarshini, J., Abdi, S., Metwaly, A., AL Lenjawi, B., Jose, J.S., & Mohamed, H. (2018). Prevention of diabetic foot ulcers at primary care level. *Dermatology Open Journal*, 3(1), 4-9. doi:10.17140/DRMTOJ-3-129

Tesfaye, S., & Selvarajah, D. (2012). Advances in the epidemiology, pathogenesis and management of diabetic peripheral neuropathy. *Diabetes/Metabolism Research and Reviews*, 28(S1), 8-14. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/dmrr.2239/full

Yazdanpanah, L., Nasiri, M. & Adarvishi, S. (2015). Literature review on the management of diabetic foot ulcer. *World Journal of Diabetes*, *6*(1), 37–53. doi:10.4239/wjd.v6.i1.37