Advances of Plastic & Reconstructive Surgery

Chapter 1

Chronic Diabetic Foot Wound Healing: Evaluation and Management

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1. Introduction

Chronic wound refers to the fact that the wound cannot heal normally due to internal and external factors, but enters a continuous pathological inflammatory state. These wounds still cannot be healed after more than one month of regular treatment, or even cannot be healed, which may be related to specific causes such as diabetes, infection, ischemia and so on.

At present, diabetes affects the health of 387 million people around the world. Among patients with diabetes, chronic diabetic foot wounds are very common. The annual incidence rate of diabetic foot wounds is about 2.8%, and the continuous progress of diabetic foot wounds will further lead to amputation of lower limbs [1]. In fact, one lower limb is amputated due to diabetes every 30 seconds in the world, and these amputations will undoubtedly increase patient mortality [2].

The high amputation rate and high mortality rate of patients with diabetic foot wounds have brought huge negative effects on the mental health and daily life of patients, and also brought troubles to the family members who take care of patients. At the same time, diabetic foot wounds can significantly increase the family economic burden of patients and consume huge social medical resources. Chronic diabetic foot wounds have become important problems for patients, family and society. However, the treatment of chronic diabetic wounds has the characteristics of complex pathogenesis, multi-disciplinary coverage, prolonged illness and easy recurrence, which increase the difficulty of treatment. After more than ten years of continuous exploration, there have been many positive developments in the treatment of diabetic foot wounds. In this paper, the evaluation and management of chronic diabetic foot

wounds are reviewed, and the latest treatment methods for chronic diabetic foot wounds are elaborated in detail, so as to provide basis for the treatment scheme of patients with diabetic foot wounds.

2. Evaluation of chronic diabetic foot wounds

The general condition, local condition and psychological condition of patients should be comprehensively evaluated before the treatment of the patients with chronic diabetic foot wounds. The evaluation of patients' general condition mainly includes their demographic characteristics, general nutritional status, metabolic status and complications. Assessment of blood glucose level is the basis of treatment, and controlling blood glucose level in the ideal range is the most critical and effective method. It can be said that good blood glucose level is the premise of good wound healing of diabetic foot wounds. At the same time, the nutritional status of the whole body is also very important for wound healing.

The local evaluation of diabetic foot wounds is the basis for determining the treatment plan, which mainly includes the evaluation of wound characteristics, infection and blood supply. The evaluation of wound characteristics should accurately reflect the location, size, depth, color, tissue necrosis, wound secretion, the range of inflammatory reaction around the ulcer, bone exposure, etc. For the evaluation of wound characteristics, Wagner classification can be used [3]. The ulcer can be graded simply according to the depth of the wound, and the curative effect and amputation rate can be predicted.

The evaluation of wound infection can be based on the clinical manifestations of local swelling or induration, elevated skin temperature, local tenderness or pain, peripheral erythema and purulent secretions, etc. It is also necessary to determine the serum inflammatory markers such as leukocyte count and classification, CRP, erythrocyte sedimentation rate and procalcitonin level. The degree of infection should be comprehensively judged according to multiple inflammatory markers.

Ischemia is recognized as one of the most important risk factors affecting prognosis. It is necessary to fully evaluate the blood supply of the wound, including intermittent claudication history, physical examination, ankle brachial index or lower extremity ultrasound, and if necessary, angiography to check whether the lack of blood supply leads to poor wound healing.

Based on the above three local factors, the WIFI scoring system can be used. The WIFI scoring system combines the wound score, ischemia score and foot infection score to predict the amputation risk and the benefit of revascularization within one year, which can be divided into four grades: very low, low, medium and high. Medical staff can use this classification system to identify early lesions and give corresponding treatment, which can partially reduce the medical burden of patients. It has important application value in guiding the treatment of

patients with diabetic foot ulcers and reducing the rate of minor amputation [4].

In addition, limb pain, fear of amputation, decreased mobility, and degradation of social and family functions seriously affect the mental health of patients with diabetic foot wounds. These aspects also need to be paid attention to and solved, which often affect the quality of life of patients.

According to the evaluation results of diabetic foot wounds, the goal of treatment can be formulated. The overall goal is to prolong the patient's life and improve their quality of life. The content roughly includes: (1) eliminate local necrotic substances; (2) Reduce the impact of odor on patients and surrounding people; (3) Reduce swelling and pain; (4) Improve the whole body nutrition level; (5) Promote the regeneration and reconstruction of local micro blood network; (6) Sealing the wound; (7) Restore function; (8) Improve appearance. The treatment of chronic diabetic foot wounds can not be achieved in one step. It is necessary to adopt a targeted and phased treatment strategy, carry out step by step, and formulate a treatment plan according to the patient's main complaint and the above comprehensive evaluation of the condition.

3. Management of chronic diabetic foot wounds

As a disease, the treatment of chronic diabetic foot wounds involves multiple departments at the same time. The healing mechanism of chronic diabetic foot wounds is complex, there are many influencing factors, and the treatment schemes are different. Therefore, it is necessary to adopt the method of combining multidisciplinary treatment to formulate a comprehensive treatment scheme.

As for the chronic diabetic foot wounds, medical treatment plays an indispensable role, especially in adjusting the general condition of the patient and providing guarantee for wound healing. Firstly, for patients with diabetic foot wounds, it is the most critical and effective to control the blood glucose level in the ideal range. Good blood glucose level is the premise of chronic wound healing. Secondly, the factors that affect the healing of chronic wound should be removed, such as anti-infection treatment, improving systemic nutrition, removing local compression, relieving varicose veins, etc. Moreover, according to the basic condition of diabetes patients, we should also pay attention to the control of blood lipid level, and apply anticoagulants, neurotrophic drugs and drugs to improve micro circulation for over all treatment [5].

3.1 Surgical treatment

3.1.1 Debridement

The chronic foot ulcer is often complicated with infection, resulting in a large number of necrotic tissues in and around the wound of the affected limb, which smells smelly. In this

case, the risk of local infection spreading to the whole body is high. Early debridement plays an important role in controlling wound infection. In the debridement process, the inactivated tissue should be removed as much as possible. Wound edema or unhealthy granulation tissue should be removed as soon as possible. The cavity of sinus wound was fully exposed and completely removed. The source of infection was completely removed from the infected wound, combined with systemic antibiotics and nutritional support. In principle, the necrotic tissue on the surface of the wound should be removed as much as possible during the operation. However, for many patients with severe foot infection, they are often accompanied by systemic inflammatory response syndrome such as high fever, and can not tolerate long-term surgical treatment. Therefore, in this case, the patients can only accept multiple staged debridement. In addition, the application of debridement combined with VSD technology can better control wound infection, improve blood circulation, promote the growth of granulation tissue, and create conditions for secondary skin grafting and skin flap transplantation [6].

3.1.2 Skin grafting and flap transplantation

After the infection of diabetic foot wounds was controlled, the wound with small area could heal by itself, but the healing time was long. However, the wound with large area healed slowly or did not heal, so human intervention was needed to promote its healing. Skin grafting and skin flap transplantation are the most direct and effective surgical methods to cover chronic wounds. Free autologous skin grafting is a commonly used method for the treatment of soft tissue defects of diabetic foot wounds in clinical practice. The commonly used methods in clinical practice are razor-thin skin graft and split thick skin graft. For chronic wounds with large ulcer area, razor-thin skin graft or split thick skin graft can be selected after the fresh flush of wound basal tissue. For the wound with tendon and bone exposure, the skin graft covering the wound often leads to the lack of blood supply of the grafted skin and can not survive, so it needs skin flap transplantation for repair. Skin flap transplantation has great trauma to donor site, great pain to patients, great difficulty in operation, and low survival rate of skin flap after transplantation. Therefore, there is still some controversy about the repair of chronic diabetic foot wounds by skin flap transplantation [7].

3.1.3 Fat transplantation

Fat transplantation can promote chronic wound healing, which may be related to the fact that the stromal vascular fraction (SVF) in the adipose tissue obtained after transplantation can promote the proliferation of fibroblasts and increase the ability of fibroblasts to synthesize collagen. Stromal Vascular Fraction (SVF) is a heterogeneous collection of cells contained within adipose tissue that is traditionally isolated using enzymes such as collagenase. With the removal of adipose cells, connective tissue and blood from lipoaspirate, comes the SVF, a mix including mesenchymal stem cells, endothelial precursor cells, T regulatory cells,

macrophages, smooth muscle cells, pericytes and preadipocytes. Macrophages in stromal vascular fraction participate in inhibiting inflammatory response and play an important role in regulating local inflammation of chronic wound. In addition, a variety of cytokines can be secreted during fat regeneration, creating conditions for local angiogenesis and fibrous connective tissue remodeling [8].

3.1.4 Artificial dermis therapy

The artificial dermis consists of an upper layer of silica gel membrane and a lower layer of spongy collagen scaffold. Silica gel film can prevent water evaporation and microbial invasion. Spongy collagen scaffold layer can promote wound vascularization and create good skin grafting conditions for later skin grafting. Artificial dermis has low immune rejection and good biocompatibility. It provides a good regenerative scaffold for the wound. It has short operation time, low anesthesia risk, reduces the loss of body fluid, reduces the risk of infection, reduces scar formation, has good skin elasticity and flexibility, improves the appearance and function of the skin, and is conducive to the healing of chronic wound of diabetes [9].

3.1.5 Platelet rich plasma (PRP) repair technique

PRP is the concentration of platelet extracted by centrifuging the collected autologous venous blood, and the concentration is at least twice the basic concentration. The effects of PRP on chronic wounds are as follows: (1) PRP as a local dressing can create a moist environment for the wound and supplement the wound growth factor; (2) PRP promotes the proliferation of vascular endothelial cells and fibroblasts, promotes vascular regeneration, and reconstructs local blood circulation; (3) PRP regulates the synthesis of extracellular matrix; (4) PRP has anti-inflammatory and antibacterial effects [10]. PRP can not only accelerate wound healing, but also reduce wound edema, pain and scar hyperplasia in the treatment of chronic diabetic foot wounds. However, there are also disputes about the high price, the use concentration and the difficulty of local fixation.

3.1.6 Skin stretch technique

Patients with chronic diabetic foot wounds often have lower extremity vascular disease, poor blood supply around the wound, and more local secretion caused by wound infection, which leads to necrosis of the transplanted flap. Skin stretch closure device is an auxiliary material that can gradually close the wound under tension reduction. The application of skin stretch closure device technology in the treatment of diabetic foot wounds can avoid the wound edge necrosis caused by poor blood supply of the affected foot. At the same time, it can maintain the maximum traction tension of the skin edge in a progressive way, and stabilize the transcutaneous oxygen partial pressure of the wound edge skin tissue [11]. In addition, the chronic diabetic foot wounds have a gap due to the use of skin retractor closure device,

at this time, the secretion in the wound can be better drained, but the relevant indications and selection criteria need to be further improved.

3.1.7 Interventional therapy

Patients with chronic diabetic foot wounds often have lower limb trunk circulation occlusion. Minimally invasive intervention is widely used to treat this kind of wound. This is a less traumatic operation, which can restore the long-term ischemic limb blood perfusion through the recanalization of intraluminal vessels, so as to restore the peripheral blood supply of the patient's foot wound and promote the wound healing. The goal of interventional surgery is to preserve limb function, reduce amputation level, increase blood perfusion at the edge of the wound, and create conditions for wound granulation tissue regeneration [12]. Interventional therapy is often used in patients with intermittent claudication, resting pain, ischemic ulcer and ineffective conservative medical treatment of diabetic foot wounds. However, because the vascular occlusion of lower limbs usually involves a wide range of vessels, arteriography should be performed to determine the location of vascular lesions before vascular recanalization intervention.

3.1.8 Maggot debridement

Maggot biological debridement refers to the use of maggots to nibble the necrotic tissue of the wound, and maggots can also secrete enzymes to promote wound healing. The advantages of maggot therapy are small trauma and side injury. For patients with serious illness, it can not only completely remove necrotic tissue, reduce toxin absorption, prevent sepsis caused by systemic infection, but also save patients' lives. Maggot therapy is often used in patients with poor general condition, high risk of surgery or difficult to reach the deep part of the wound to clean up necrotic tissue [13].

3.2 Physiotherapy

Extracorporeal shock wave (ESWT) can transform the mechanical biochemical signals produced by cells into biochemical reactions through stress, so as to improve cell functions such as proliferation, differentiation, migration and apoptosis, and improve blood supply by promoting angiogenesis and the expression of related factors. Low and medium energy (0.06-0.25mJ/mm^2) ESWT is mainly used to treat chronic wound in China. Omar's team found in the clinical control experiment on ESWT treatment of diabetes foot patients that the wound healing rate and average healing time of ESWT group were significantly better than those of the control group [14]. The meta-analysis of randomized controlled trials of ESWT in treating patients with type 1 and 2 diabetetes by Huang's team shows that ESWT can effectively improve the complete cure rate of diabetic foot wounds and shorten the cure time of diabetic foot ulcer [15].

At present, laser therapy and infrared therapy are commonly used in the treatment of chronic wound. There are two kinds of lasers for wound treatment: high-intensity laser and low-intensity laser. High-intensity laser mainly destroys and excises necrotic tissue with its high energy. Compared with surgical debridement, it can cause collagen remodeling, cut necrotic substances with high accuracy, and effectively remove biofilm attached to the wound. The disadvantage is that it may cause irreversible re injury to the wound. At present, it is mostly used in chronic wounds with festering tissue and secretions [16]. Low intensity laser, also known as weak laser, directly irradiates the wound without permanent damage. Its main mechanism of promoting wound healing lies in causing a series of biophysical and chemical reactions. The principle of infrared light in treating chronic wound is similar to that of low-power laser. The body absorbs its thermal rays to stimulate the body to produce a series of biological and physical-chemical reactions. The main mechanism may be that it can increase the tissue temperature at the wound irradiation site and then promote the expansion of blood vessels, thus improving the wound circulation. At the same time, the improvement of circulation promotes the increase of wound oxygen partial pressure and the timely removal of inflammatory exudates, Further improved the inflammation of chronic wound [17].

Local tissue hypoxia is also one of the basic reasons for difficult wound healing. The appropriate oxygen partial pressure for wound healing is 50-100mmHg, but the oxygen partial pressure for most chronic wounds is only 10-30mmHg. Hyperbaric oxygen therapy refers to placing the body in pure oxygen greater than 1.4 times the absolute atmospheric pressure. The principle of hyperbaric oxygen therapy for chronic wound is to increase the oxygen partial pressure of blood and local tissues, so as to solve the hypoxia of tissues. At the same time, hyperbaric oxygen can enhance the killing effect of granulocytes on bacteria, promote collagen synthesis and neovascularization, which is commonly used in the treatment of chronic diabetic wounds with secondary infection [18].

Ozone can quickly kill many kinds of microorganisms in vitro. At present, it has been used in the treatment of chronic diabetic wounds. The main reasons for the formation of foot ulcers in diabetics are the decrease of body resistance and local wound infection. Local application of medical ozone has strong sterilization ability, which can clean the wound, promote the growth of wound granulation tissue, and prepare for later skin grafting and skin flap transplantation to repair the wound [19,20].

3.3. new dressings

At present, the dressings used in clinic are mainly gauze block, cotton pad and bandage, which are cheap but easy to impregnate to cause exogenous infection and have no function of promoting wound healing. Therefore, a variety of new dressings that can promote wound healing are emerging more and more. Common clinical dressings include silver ion dressings,

nano silver dressings and new biological dressings. Silver ion dressing denaturates bacterial protein through silver ion to exert bactericidal effect. Nano silver dressing can remove pathogenic bacteria from wound surface by destroying the cell membrane of pathogenic bacteria and blocking the respiratory chain of microorganisms, and rarely produces drug resistance [21]. Xenogeneic acellular dermal matrix dressing can accelerate the formation of wound vascularization and promote healing, but the disadvantage is that it does not contain antibacterial components and is easy to cause infection due to residual effusion [22].

3.4. Vacuum sealing drainage (VSD)

VSD refers to placing the drainage tube connected with a special vacuum pump in a polyimide sponge, sealing the wound with a transparent film, and using the vacuum pump to create a negative pressure environment for wound treatment. VSD has the following advantages in treating chronic diabetic wounds: (1) Increasing blood supply of wound, promoting capillary regeneration, improving wound microcirculation, reducing tissue edema around wound, and promoting wound healing; (2) Timely and effective removal of dead matter, bacteria and exudates from the wound, reduction of wound infection, and beneficial to the growth of granulation tissue; (3) It has excellent histocompatibility and no irritation to tissues; (4)The wound is closed, which can isolate air pollution and effectively prevent pollution and cross infection; (5) It can reduce the times of dressing change and the pain of dressing change. Kim's team found that negative pressure suction is most suitable for complex wounds such as diabetic foot wounds infection, and can be combined with debridement, skin grafting and other surgical treatments [23].

4. References

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