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Effectiveness of Wound Irrigation Using Hypochlorous Acid Liquid on Healing of Diabetic Foot Wounds

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ABSTRACT

Background: Wound cleansing is crucial in wound healing, depending on the method and type of solution used. Hypochlorous Acid is one of the wound irrigation options that can be applied in this process.

Objective: This study aims to evaluate the effectiveness of wound irrigation using Hypochlorous Acid (HOCL) on diabetic foot wound healing.

Methods: This quantitative research employs a quasi-experimental design, involving 13 diabetic foot wound patients selected through total sampling. Interventions were conducted over five weeks, totaling ten sessions. The Bates-Jensen Wound Assessment Tool (BJWAT) was utilized to assess wound healing, and data were analyzed using SPSS 25, applying paired T-tests to evaluate pre-and post-intervention differences.

Results: A statistically significant improvement in diabetic foot wound healing was observed, marked by a p-value = 0.000, highlighting the potential of HOCL in promoting effective wound healing.

Conclusion: HOCL wound irrigation significantly enhances diabetic foot wound healing.

Keywords: Wound Irrigation, Diabetic Foot Wound Healing, Bates-Jensen Wound Assessment Tool (BJWAT)

INTRODUCTION

The International Diabetic Federation reports that 9.1 to 26.1 million people with diabetes mellitus have the potential to develop diabetic foot wounds [1]. Studies have shown that about 30.43% of diabetic foot ulcer patients undergo amputation [2], while the mortality rate reaches 12.3% [3], with 65% recurrence after five years of recovery [4], anxiety and depression at 13.8% & 20% respectively [5], high costs such as hospitalization (45.6%), debridement (14.5%) and hospitalization in the intensive care unit (10.4%) [6]. Wound care aims to promote healing. Wound care management applies three main principles: washing the wound, removing dead tissue and choosing the right dressing [6]. Wound washing is the first stage of wound care and is an absolute necessity. Effective wound cleansing can remove germs [7]. There was a decrease in the number of bacteria after wound washing, which was 2,300 CFU/g. Bacterial infection is the most frequent cause of delayed healing. Bacterial biofilms inhibit proliferation, migration, and cause cell death in several ways [8]. .

Wound irrigation is one of the wounds washing techniques that uses a certain pressure. The pressure in irrigation will increase vasodilation so that the process of forming new tissue will take place properly

[9]. In addition to the utilization of water pressure, the success of irrigation is also influenced by the type of liquid used. *Hypochlorous Acid* or abbreviated as HOCL is one type of acidic wound wash. Chronic wounds generally have a pH range of 7.15 to 8.9, but oxygen from red blood cells will reach the tissue at pH < 7.4 [10]. The acidity or pH < 6 on the wound surface creates an unstable environment for the growth of pathogenic bacteria and also blocks proteolytic enzymes such as elastase and plasmin produced by various bacteria and the wound itself [11].

OBJECTIVE

This study aims to identify the effectiveness of wound irrigation using *Hypochlorous acid* liquid (HOCL) on diabetic foot wound healing.

METHODS

This type of research is quantitative research with a quasi-experiment design. The population in the study were all patients with diabetic foot wounds in the DD Care Wound Care Independent Practice Padang. The sample in this study amounted to 13 people obtained by total sampling technique. Prior to data collection, permission was given and obtained from respondents. The questionnaire used in this study was the Bates Jensen Wound Assessment Tool (BJWAT). Before the intervention, the wound status was assessed with the BJWAT questionnaire and then the intervention was carried out for 5 weeks with 10 meetings or every three days. After the intervention, wound status was reassessed using the BJWAT questionnaire. The BJWAT wound status assessment items consisted of wound size, wound depth, wound edges, caves, necrotizing tissue type, amount of necrotizing tissue, wound edges, amount of exudate, skin colour around the wound, oedematous tissue, edge tissue hardening, granulation and epithelialization. Wound status was scored from 1 to 5. A score of one indicates good wound condition, the higher the score the worse the wound status. The data analysis test used in this study is paired T Test, which compares wound healing before and after intervention using SPSS 25.

RESULTS

Table 1 Characteristics of Diabetic Foot Wound Respondents

Characteristics of Respondents	Frequency (n=13)	Percentage (%)
Age		
22-44	2	15,4
45-60	4	30,8
61-75	7	53,8
76-90	0	0,00
Gender		
Male	6	46,2
Female	7	53,8
Education		
Elementary School	2	15,4
Junior High School	2	15,4
Senior High School	4	30,8
Graduate	5	38,5

Occupation		
Civil Servant / Retired	5	38,5
Self-employed	4	30,8
Housewife	3	23,1
Farmer	1	7,70
Duration of Diabetes		
< 5 Years	2	15,4
5-10 Years	4	30,8
10-15 Years	5	38,5
> 15 Years	2	15,4

Based on table 1, the age of respondents is mostly elderly (53.8%), gender is mostly female (53.8%), education is mostly undergraduate (38.5%), occupation is mostly civil servants/retired (38.5) and the duration of diabetes is mostly 10-15 years (38.5).

Table 2 Mean Differences in BJWAT Total and Item Scores Before and After Intervention (n=13)

BJWAT	Intervention		*p-value*
	Mean ± SD		
	Pre	*Post*	
Total	40,08 ±5,97	22,38±7,99	
Wound size	2,53±1,26	1,69±1,18	0,001
Wound Depth	3,62±0,87	1,92±1.03	0,000
Wound Edge	2,46±0,96	1,46±0,51	0,009
Goa	2,08±1,18	1,15±0,55	0,008
Tissue Type of Necrosis	2,62±1,12	1,23±0,59	0,001
Amount of Necrotizing Tissue	2,54±1,66	1,15±0,37	0,005
Exudate Type	3,15±1,14	1,77±0,72	0,000
Amount of Exudate	3,77±1,16	2,23±1,36	0,000
Skin Color Around the Wound	4,08±1,11	3,08±1,75	0,047
Edematous Tissue	2,08±1,25	1,15±0,37	0,011
Edge Tissue Hardening	2,08±1,70	1,15±0,37	0,046
Granulation	3,08±0,95	1,85±0,80	0,000
Epithelialization	5,00±0,000	2,53±1,71	0,000

Based on table 2 above, it was found that there was a significant difference in the average total and item scores of BJWAT before and after the intervention. The significant difference is indicated by the *p* value <0.005.

DISCUSSION

The results of this study indicate that the age characteristics of respondents are mostly elderly (53.8%). According to [7] in old age there is a decrease in fiber and collagen. Collagen is the main component of connective tissue produced by connective tissue cells called fibroblasts [12]. In aging, changes in capillary walls occur, namely thickening and hardening [13]. This thickening will affect poor blood

circulation especially to the foot area. When blood flow to the feet is reduced, this can lead to wounds [14]. The gender of the respondents was mostly female (53.8%). Protection in women significantly decreases when estrogen levels also decrease. One of the functions of estrogen is to facilitate the presence of insulin and control blood glucose levels [15]. The education of respondents is mostly undergraduate (38.5%). Someone who has a high level of education does not necessarily know about the prevention of diabetic foot wounds.

There are three aspects of behaviour change, namely knowledge, attitude and action. Knowledge is the first level in behaviour change. Someone who already knows the information is expected to change the attitude towards the information, namely accepting or rejecting, then the last stage is action whether the information is carried out or not so that when these three aspects are done well, there will be a change in behaviour. The occupation of a small proportion of civil servants / retirees (38.5%). Civil servants or self-employed people spend more time in the office than doing physical activities. This lack of physical activity is associated with the incidence of diabetic foot wounds. According to [16], physical activity influences the incidence of diabetic foot wounds. The duration of diabetes was mostly 10-15 years (38.5%). The aging process is also followed by aging of the peripheral nervous system characterized by a decrease in sensory and motor nerve conduction, motor amplitude and especially sensory potentials, and changes in proprioceptive sensitivity in almost all cases two-thirds of people over 65 years of age [17]. People over 40 years of age often suffer from neuropathy which will result in loss of pain sensation in the feet making them prone to injury [18].

The results of this study showed that there was a significant difference in wound healing before and after the intervention. This significant difference was also found in all wound healing items, namely wound size, depth, wound edges, caves, necrosis tissue type, necrosis tissue amount, exudate type, exudate amount, skin color around the wound, edematous tissue, edge tissue hardening, granulation, and epithelialization.

Wound size is obtained by using a ruler to measure the longest and widest aspects of the wound surface in centimeters and multiplying the length and width. Wound closure will begin with a change in wound depth. The wound size will decrease from the edges of the wound towards the center if the wound depth has reached the skin surface Before the intervention, a small proportion (30.8%) of the wound area was PxL <16 cm and PxL 36 <80 cm. After the intervention, most of the wound area (61.5%) was PxL <4 cm. The wound depth before the intervention was a small proportion (38.5%) at grade 3 and 4, after the intervention a small proportion (46.2%) was at grade 1. HOCL has a role in the migration of keratinocytes and fibroblasts. Keratinocytes are one of the important substances in the process of forming new skin so that granulation will occur. A study showed that there was a 21% reduction in wound area when washed with HOCl [20].

Before the intervention, most (61.5%) of the wound edges were visible, merging with the wound bed. After the intervention most (53.8%) wound edges were faint, not clearly visible. During wound healing, there must be a change in the shape of the wound. The condition of the wound edges can also be affected by the presence of exudate. If there is a lot of exudates in the wound, it will cause maceration which causes wound edges to be problematic and prolong wound healing. Before the intervention, a small proportion (46.2%) of the respondents did not have wound caves, after the intervention almost all respondents (92.3%) did not have caves. Tissue damage and necrosis can extend lateral to the wound, under the skin, so it is often not visible. Tissue damage can result in the formation of sinuses, cavities,

tracts or fistulas, which can interfere with exudate drainage, potentially leading to infection and impeding wound healing.

In this study, the type and amount of necrotizing tissue before the intervention, *a* small proportion (38.5%) was easily removed and there was no visible necrotizing tissue, after the intervention almost all (84.6%) had no and no visible necrotizing tissue. When tissue death occurs, the wound surface will be covered by a layer of necrotic tissue (eschar) which is often black or brownish in color. HOCL here can act as a debriding agent that can soften the hard eschar. The type of exudate and the amount of exudate before intervention was serosanguineous with a small amount of exudate (38.5%) being moderate. After the intervention, the exudate type of a small proportion (46.2%) was bloody with a small proportion (38.5%) being dry. Chronic wounds generally have a prolonged inflammatory response, providing an ideal environment for bacterial infiltration and proliferation. HOCL is an acidic wound wash. Chronic wounds will generally have a pH range of 7.15 to 8.9 but oxygen from red blood cells will reach the tissue at pH < 7.4 [10]. The skin color around the wound before the intervention was a small proportion (46.2%) dark red/grey and after the intervention a small proportion (30.8%) black/hyperpigmented and pink or normal. Discoloration of the diabetic foot is a result of reduced blood flow intake to the area. Reduced blood flow to the wound area can be caused by reduced physical activity. Physical activity can increase wound healing by 25%.

In the pre-intervention group, a small proportion of foot wounds had oedema (46.2%). After the intervention almost all wounds had no oedema (84.6%). Oedema fluid is mostly water, but protein and cell-rich fluid can accumulate in case of infection or lymphatic obstruction. Prolonged accumulation of fluid in the tissues will affect blood circulation and hinder wound healing. Edema occurs as a sign of inflammation. Inflammation is an inflammatory process caused by bacterial invasion. A study showed a 55% reduction in wound complications on day 14 using HOCL compared to NaCl. Before and after the intervention there was a decrease in edge tissue hardening in the wound, from most (69.2%) to almost all wounds (84.6%) did not experience edge tissue hardening. Edge tissue hardening is formed due to repeated friction or pressure. The accumulation of hard tissue can relieve pressure so that it can cause trauma to the wound.

Before the intervention, a small proportion (38.5%) had no granulation tissue and only 25% had granulation tissue. After the intervention, a small proportion (38.5%) had intact skin or stage 1 and also 100% granulation. Granulation tissue signifies the proliferative phase of wound healing. Healthy granulation tissue is bright, red, shiny and granular. The tissue looks bumpy and may bleed. Granulation tissue formation is complex and requires intricate interactions between cell types at the wound site namely fibroblasts, keratinocytes, endothelial cells, new thin-walled capillaries, and inflammatory cell infiltration of the extracellular matrix [21]. Keratinocyte cell movement is influenced by HOCL fluid [22]. Before treatment all wounds (100%) had <25% epithelialization, after treatment a small proportion (46.2%) had 100% epithelialization. Reepithelialization is the term used to describe the resurfacing of the skin with new epithelium. Re-epithelialization takes place from the surrounding. In chronic wounds protease levels exceed their respective inhibitors, causing destruction of the ECM and degradation of growth factors. HOCL increases re-epithelialization on day four by 14% compared to other fluids. HOCl can convert non-catalytic latent MMP-1 into catalytic MMP-1 and thus can facilitate the movement of keratinocytes during the re-epithelialization process.

CONCLUSIONS

The results showed that there is an effectiveness of wound irrigation using HOCL fluid on diabetic foot wound healing.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest in relation to the research, authorship and/or publication of this article.

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