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A Prospective Study on Combined Use of Negative Pressure Wound Therapy and Topical Oxygen Therapy on Diabetic Ulcers

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Abstract: ***Aims and Objectives**: To evaluate the efficacy of combined use of negative pressure wound therapy (NPOT) and topical oxygen therapy (TOT) over conventional wound therapy (CWT) in healing of diabetic wounds **Method**: Using a Random number table, a total of thirty patients with diabetic wounds were randomly assigned to the control group (n = 15, receiving Negative pressure wound therapy) and the intervention group (n = 15, receiving Topical oxygen therapy in addition to Negative pressure wound therapy). The patients received continuous treatment for two weeks. Subsequently, the two groups pre - and post - treatment granulation tissue coverage rate, pain, severity, and scores from the pressure ulcer scale for healing (push) were compared. Furthermore, comparisons were made between the two groups' rates of bacterial culture positivity, healing rates, and healing times. **Results**: In both groups, the push scores were considerably lower after treatment compared to pretreatment levels, and the intervention group's scores were lower than the control group's (all p<0.05) From day 3 to day14 posttreatment, both groups' granulation tissue coverage rates increased progressively; nevertheless, at that time, the intervention group's coverage rate was higher than the control group's (all p<0.05). After treatment, the intervention group's bacterial culture positive rate was significantly lesser when compared to before treatment, and it was also significantly lower in the intervention group than it was in the control group (all p<0.05). In all groups, the vas scores showed a substantial drop following treatment when compared to pretreatment values. Notably, the intervention group had greater decreases than the control group (all p<0.05). At the 3 - month follow - up, the intervention group's wound healing rate was higher and its healing duration was shorter than the control group's (all p<0.05). **Conclusion**: Combining topical oxygen therapy with negative pressure wound therapy can significantly accelerate the rate at which granulation tissue covers the wound, speeding up the healing process. Therefore, topical oxygen therapy combined with negative pressure wound therapy is a more successful way to treat diabetic wounds in patients than negative pressure wound therapy alone.***

Keywords: Diabetic Foot Ulcers, topical oxygen therapy, Negative pressure wound therapy, granulation tissue

1. Introduction

Diabetes is the most common cause of non - traumatic lower limb amputations. It has been reported that 1 - 4 percent of diabetics get foot ulcers on an annual basis. Diabetic foot ulcers are chronic and difficult to treat due to the development of microvascular problems and multidrug - resistant pathogens. It is seriously disrupting the daily life and work of patients [1, 2]. Diabetic foot ulcers are frequently treated with negative - pressure wound therapy, which reduces healing time by encouraging tissue growth and speeding up angiogenesis at the wound site. However, removing oxygen from the wounded tissue produces a negative pressure environment that could lead to anaerobic infection and impede the healing process [3 - 5].

As a result, it is suggested that topical oxygen therapy in conjunction with NPWT negative pressure wound care may be able to reduce the incidence of anaerobic infection at the wound site, thus speeding up the healing process [6]. Professor Sen of the Comprehensive Wound Center for Surgery at Ohio State University Medical Center in the United States initially proposed topical oxygen therapy. He demonstrated that this treatment could adequately supply oxygen to the superficial tissue at the wound site, compensating for the hypoxic state. It is a safe, practical treatment that quickens the healing of wounds [7].

Patients with diabetic foot ulcers were chosen as research subjects to examine the effects of topical oxygen therapy and negative pressure wound therapy on the development of granulation tissue and the wound healing process.

2. Materials and Methods

General data

A total of thirty diabetic foot ulcer patients were prospectively selected and randomly assigned, using a random number table method, to the control group (n = 15, receiving negative pressure wound therapy) and the intervention group (n = 15, receiving topical oxygen therapy in addition to negative - pressure wound therapy). The patients were admitted to Kanyakumari government medical college between December 2022 and February 2023. Patients met the eligibility criteria if they had a noticeable diabetic foot ulcer that lasted more than a month if the wound measured more than 5 cm in length or more than 5 cm in area, and if they provided cooperation throughout the study. Patients with peripheral vascular disease (PVD), wounds that bled at the wound site while they were moving, visible major blood vessels or nerves, blood coagulation abnormalities, malignant tumors, or mental illness were eliminated. They declined to give the study's permission. Written informed consent was obtained from all patients, and the ICMR - approved committee approved this study.

Outcome measures
The primary outcome measures of the wound were measured using the push tool both before and after treatment. The wound was scored using the following criteria: the type of wound tissue (0 points), sealed tissue (0 points), epithelial tissue (two points), granulation tissue (three points), slough (four points), and necrotic tissue (five points). Lower scores for the pressure ulcer area and less exudate volume within 24 hours indicate better wound healing [10]. . coverage rate of the granulation tissue: before each dressing, the granulation tissue and wound areas were measured with a ruler. The granulation tissue coverage rate is calculated as granulation tissue area / total wound area * 100%.

The secondary outcome measures
Following treatment, the exudates were dipped into a sterile cotton swab to facilitate the identification and culture of bacteria strains. The number of identified bacterial strains/total bacterial strains * 100% is the cultured positive rate of bacteria.

Degree of pain: using a vernier ruler that was roughly 10 cm long and had 10 tick marks on one side and "0" and "10" at either end, the vas tool measured the degree of pain both before and after therapy [11]. With a zero signifying no pain and a ten signifying unbearable anguish;

Three months of patient follow - up was conducted. The healing rate and the healing time were compared between the two groups. The criteria to determine the wound healing situation were whether the wound was covered with epithelial tissue and whether the result of an oxidation reaction with 3% hydrogen peroxide was negative. The number of patients with healed wounds divided by the total number of patients * 100% is the healing rate.

Statistical analysis
SPSS 20.0 was used for data analyses. Enumeration data were expressed as n (%), and the $\chi 2$ test was used for comparison. Measured data were expressed as mean ± standard deviation (_ x ± sd). A paired t - test was used for comparison between the same group before and after treatment. Independent t - test was used for between - group comparison.

3. Results

Baseline data
The baseline data for the two groups did not differ significantly, and all of the data were comparable (p>0.05). See Table 1.

Table 1: Comparison of Baseline Data between the two groups (n, _ x ± sd)

Measures		Intervention group (n=15)	control group (n=15)	χ2/t	P
Sex (n)	Male	8	6		0.445
	Female	7	9		
Age (year)		42.3±5.3	40.9±6.2	1.374	0.215
BMI (kg/m2)		23.12±1.77	22.77±1.49	0.466	0.659
Duration of the wound (d)		41.2±5.3	42.8±4.7	1.790	0.084
Length of the wound (cm)		7.66±2.15	7.89±1.88	0.614	0.557
Wound area (cm2)		6.95±1.04	7.12±1.22	0.784	0.439
PH of the wound exudates		8.15±0.45	8.27±0.39	1.229	0.235

Note: BMI: Body Mass Index.

Table 2: The scores of items in PUSH in the two groups before and after treatment (_x ± sd)

Group	Time	Wound exudate volume within 24 hours	Pressure ulcer area	Type of the wound tissue
Intervention group (n=15)	Before treatment	2.23±0.44	7.18±1.15	3.22±0.44
	After treatment	1.36±0.40*, #	2.74±1.18*, #	1.49±0.59*, #
Control group (n=15)	Before treatment	2.49±0.50	7.74±1.36	3.46±0.44
	After treatment	1.60±0.42*	4.60±1.29*	2.21±0.40*

Compared with before treatment, *P<0.05

Table 3: The coverage rate of the granulation tissue in the two groups during treatment (_ x ± sd)

Group	Day 3	Day 6	Day 9	Day 12	Day 14
Intervention group (n=15)	10.50±1.84#	19.85±3.38#	35.48±4.30#	43.50±3.88#	55.59±4.57#
Control group (n=15)	8.78±1.73	15.40±3.74	31.03±3.75	37.88±4.57	43.40±4.70

Compared with the control group, P<0.05.

Table 4: Comparison of culture - positive bacterial rate between the two groups (n, %)

Group	Time	Staphylococcus aureus	Pseudomons aeruginosa	Escherichia coli	Other bacteria	Total
Intervention group (n=15)	Before treatment	8 (14.29)	4 (7.14)	2 (3.57)	2 (3.57)	16 (28.57)
	After treatment	3 (5.36)	2 (3.57)	1 (1.79)	0 (0.00)	6 (10.71) *, #
Control group (n=15)	Before treatment	9 (16.07)	5 (8.93)	2 (3.57)	2 (3.57)	18 (32.14)
	After treatment	7 (12.50)	3 (5.36)	3 (5.36)	2 (3.57)	15 (26.79)

Note: Compared with that before surgery, *P<0.05; compared with the control group, #P<0.05.

Wound healing (push)

The two groups' pre - treatment scores on exudate volume within 24 hours, pressure ulcer area, and wound tissue type all showed a substantial decrease after treatment, with the intervention group scoring lower than the control group (all p<0.05). See Table 2.

Coverage rate of the granulation tissue

From day 3 to day 14 post - treatment, both groups' granulation tissue coverage rates increased progressively; during this time, the intervention group's coverage rate was higher than the control group's (all p<0.05). See Table 3.

Culture - positive rate

Before treatment, there was no discernible difference between the two groups' cul - positive rates for the bacteria strains found in the wound exudate (all p>0.05). However, following treatment, the intervention group's culture - positive rate was both lower and less than that of the control group.

Wound healing rate and healing time

The wound healing rate in the intervention group was 89.29% (13/15) at the 3 - month follow - up, which was significantly higher than the 73.21% (11/15) in the control group. Additionally, the intervention group's healing time (27.34±5.68) d was significantly shorter than the control group's (33.47±6.83) d). (all p<0.05)

4. Discussion

The benefits of negative - pressure wound care are indisputable; they include accelerating angiogenesis at the damage site, effectively encouraging tissue proliferation, and reducing the healing time [12]. Nevertheless, recent research has indicated that to create pro - angiogenic hydroxylated collagen, which speeds up the healing process, hydroxylase and collagen must be mixed in an environment with enough oxygen throughout the wound - repairing process [13, 14]. In our investigation, the intervention group's post - treatment push scores for wound area, type of tissues, and exudate volume within 24 hours were all lower than those of the control group. Granulation tissue coverage from day 3 to day 14 was higher in the intervention group than in the control group, indicating that topical oxygen therapy in conjunction with negative - pressure wound therapy may significantly enhance granulation tissue coverage at the traumatic site in patients with chronic traumatic wounds, thereby promoting the healing process. This result supported the finding of Tlapák et al. 's study, which found that topical oxygen therapy in conjunction with negative - pressure wound therapy was more effective in promoting the healing of chronic wounds [15]. It also demonstrated that the combined therapy's efficacy outperformed that of either treatment alone. The results of the 3 - month follow - up demonstrated that the intervention group's healing rate was significantly higher than the control group's (89.29% vs.73.21%) and that the intervention group's healing time was significantly shorter than the control group's (27.34±5.68 d) vs. (33.47±6.83 d)). These findings suggest that topical oxygen therapy combined with negative - pressure wound therapy may effectively speed up and shorten the healing process for diabetic foot ulcers.

Additionally, it has been observed that wound healing requires a suitable level of oxygen partial pressure, which can be achieved by maintaining tcpo2 at 50–100 mmHg [16, 17]. In their investigation into the effects of varying oxygen flow rates on wound healing, Kimmel et al. It discovered that administering oxygen continuously at a rate of 2 to 3 l/min, while maintaining a tcpo2 maintained at 45 - 80 mmHg, might significantly reduce the healing time [18]. As a result, throughout our investigation, oxygen was continuously administered at a rate of 3 l/min. The outcome demonstrated that the intervention group's vas scores were lower than the control group, indicating that topical oxygen therapy in conjunction with negative - pressure wound care may significantly lessen the level of pain experienced by patients with diabetic foot ulcers. This outcome is in line with the findings of Deng et al. [19], who also discovered that topical oxygen therapy might accelerate the healing process of wounds by raising tcpo2 at the site of diabetic foot ulcers.

The two primary bacteria that cause an expanded wound area and a prolonged healing period are Staphylococcus aureus and Pseudomonas aeruginosa [20, 21]. Staphylococcus aureus, pseudomonas aeruginosa, escherichia coli, and other pathogens were found in the exudate of patients in both groups before to treatment in our investigation. Nevertheless, the culture - positive rate was significantly lower in the intervention group following treatment than it was before treatment, and it was also lower in the intervention group following treatment than it was in the control group. This suggests that topical oxygen therapy in conjunction with negative - pressure wound therapy could significantly reduce the number of bacteria in the therapeutic area. This may be due to the adequate oxygen provided during the negative - pressure wound therapy, which inhibited the growth and proliferation of the bacteria [22].

Nevertheless, this is a small sample size, single - center study with a brief follow - up period. Therefore, to confirm the benefits of topical oxygen therapy in conjunction with negative - pressure wound care for patients with persistent traumatic wounds, bigger sample sizes and longer follow - up periods should be planned for future research.

5. Conclusion

Topical oxygen therapy combined with negative - pressure wound therapy can raise the rate of granulation tissue and tcpo2 coverage at the trauma site, facilitating and speeding up the healing process. Compared to negative - pressure wound therapy alone, it is more effective.

References

[1] Alisauskaite N, Spitzbarth I, Baumgärtner W, Dziallas P, Kramer S, Dening R, Stein VM and Tipold A. Chronic post - traumatic intramedullary lesions in dogs, a translational model. PLoS One 2017; 12: e0187746.

[2] Nussbaum SR, Carter MJ, Fife CE, DaVanzo J, Haught R, Nusgart M and Cartwright D. An economic evaluation of the impact, cost, and medicare policy implications of chronic nonhealing wounds. Value Health 2018; 21: 27 - 32.

[3] Sun X, Ni P, Wu M, Huang Y, Ye J and Xie T. A clinicoepidemiological profile of chronic wounds in wound healing department in Shanghai. Int J Low Extreme Wounds 2017; 16: 36 - 44.
[4] Andrade SM and Santos IC. Hyperbaric oxygen therapy for wound care. Rev Gaucha Enferm 2016; 37: e59257
[5] Schreml S, Szeimies RM, Prantl L, Karrer S, Landthaler M and Babilas P. Oxygen in acute and chronic wound healing. Br J Dermatol 2010; 163: 257 - 268.
[6] Günes UY. A prospective study evaluating the pressure ulcer scale for healing (PUSH tool) to assess stage II, stage III, and stage IV pressure ulcers. Ostomy Wound Manage 2009; 55: 48 - 52
[7] Sung YT and Wu JS. The visual analog scale for rating, ranking, and paired - comparison (VAS - RRP): a new technique for psychological measurement. Behav Res Methods 2018; 50: 1694 - 1715.
[8] Anghel EL and Kim PJ. Negative - pressure wound therapy: a comprehensive review of the evidence. Plast Reconstr Surg 2016; 138: 129s - 137s.
[9] de Smet GHJ, Kroese LF, Menon AG, Jeekel J, van Pelt AWJ, Kleinrensink GJ and Lange JF. Oxygen therapies and their effects on wound healing. Wound Repair Regen 2017; 25: 591 - 608.
[10] Gottrup F, Dissemond J, Baines C, Frykberg R, Jensen P, Kot J, Kröger K and Longobardi P. Use of oxygen therapies in wound healing. J Wound Care 2017; 26 Suppl 5: S1 - S43.
[11] Tlapák J, Chmátal P, Oniscenko B, Pavlík V, Dosel P, Páral J and Lochman P. The effect of hyperbaric oxygen therapy on gene expression: microarray analysis on wound healing. Undersea Hyperb Med 2020; 47: 31 - 37.
[12] sea Hyperb Med 2020; 47: 31 - 37. [16] Tejada S, Batle JM, Ferrer MD, Busquets - Cortés C, Monserrat - Mesquida M, Nabavi SM, Del Mar Bibiloni M, Pons A and Sureda A. Therapeutic effects of hyperbaric oxygen in the process of wound healing. Curr Pharm Des 2019; 25: 1682 - 1693.
[13] Jee JP, Pangeni R, Jha SK, Byun Y and Park JW. Preparation and in vivo evaluation of a topical hydrogel system incorporating highly skin - permeable growth factors, quercetin, and oxygen carriers for enhanced diabetic wound - healing therapy. Int J Nanomedicine 2019; 14: 5449 - 5475.
[14] Kimmel HM, Grant A and Ditata J. The presence of oxygen in wound healing. Wounds 2016; 28: 264 - 270.
[15] Deng Z, Chen W, Jin J, Zhao J and Xu H. The neuroprotection effect of oxygen therapy: a systematic review and meta - analysis. Niger J Clin Pract 2018; 21: 401 - 416.
[16] Xu Z and Hsia HC. The impact of microbial communities on wound healing: a review. Ann Plast Surg 2018; 81: 113 - 123.
[17] Mangoni ML, McDermott AM and Zasloff M. Antimicrobial peptides and wound healing: biological and therapeutic considerations. Exp Dermatol 2016; 25: 167 - 173.
[18] Wallace N, Zani A, Abrams E, and Sun Y. The impact of oxygen on bacterial enteric pathogens. Adv Appl Microbiol 2016; 95: 179 - 204.