International Journal of Clinical Dermatology
2025, Vol. 8, No. 2, pp. 63-68
https://doi.org/10.11648/j.ijcd.20250802.14

Research Article

Application of Skin Protective Film Combined with Negative Pressure Regulation to Prevent Skin Injury After Chronic Wound VSD

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Abstract

Objective: To evaluate the efficacy of skin protective film combined with negative pressure adjustment in preventing periwound skin injury after vacuum sealing drainage (VSD) surgery for chronic wounds. *Methods:* From September 2022 to December 2023, 200 patients with chronic wounds undergoing VSD surgery were randomly divided into four groups (A, B, C, D) of 50 each. Group A used low negative pressure (-120 to -70 mmHg), Group B used traditional negative pressure (-450 to -125 mmHg), Group C combined skin protective film with low negative pressure, and Group D combined skin protective film with traditional negative pressure. Outcomes included skin injury incidence, granulation tissue growth, and pain and comfort scores on postoperative days 1, 3, and 5. *Results:* Group C showed a significantly lower skin injury rate (12.2%) than Group B (37.5%) ($P<0.008$). No significant differences were found in granulation tissue growth among the groups ($P>0.05$). Pain scores were significantly lower in low negative pressure groups (A and C) on postoperative days 1 and 3 ($P<0.05$), with no differences on day 5 ($P>0.05$). Comfort scores were significantly higher in skin protective film groups (C and D) on postoperative day 5 ($P<0.05$). *Conclusion:* Skin protective film combined with low negative pressure effectively reduces skin injury incidence, alleviates early postoperative pain, and enhances late postoperative comfort, offering practical clinical benefits.

Keywords

Chronic Wound, Vacuum Sealing Drainage, Skin Injury, Skin Protection Film, Negative Pressure Regulation

1. Introduction

Chronic wounds are defined as wounds that fail to proceed through the normal phases of wound healing in an orderly and timely manner, such as vascular ulcers, diabetic ulcers, and pressure injuries [1]. Statistics show that about 30 million chronic wound cases occur annually in China [2]. Vacuum sealing drainage (VSD), a technique using foam material and biosemipermeable membrane to cover the wound and apply negative pressure to drain exudate, promotes healing and is widely used in chronic wounds [3]. However, prolonged use of VSD can cause periwound skin injuries like blisters and maceration, reducing patient satisfaction and compliance, and potentially leading to increased costs, longer hospital stays, and medical disputes [4]. This study aims to explore the preventive effect of skin protective film combined with negative pressure adjustment on periwound skin injury after VSD surgery.

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Received: 2 September 2025; **Accepted:** 11 September 2025; **Published:** 26 September 2025

2. Subjects and Methods

2.1. Research Subjects

We selected patients with chronic wounds undergoing VSD surgery in our hospital. Inclusion criteria: wounds meeting chronic wound diagnostic criteria [5]; first-time VSD surgery; age over 18 with good cognitive and communication abilities. Exclusion criteria: pre-existing periwound skin issues; severe neurovascular injuries; long-term steroid use; uncontrolled systemic diseases; alcohol allergy. Exclusion criteria: early tube removal due to bleeding, blockage, or non-plan removal. Based on the primary outcome (skin injury incidence), using the sample size formula for multiple sample rate comparisons, with α=0.05, β=0.1, P_{max}=0.40, P_{min}=0.08, and ν=3, the calculated sample size per group was 45. Considering a 10% dropout rate, each group needed at least 50 patients, totaling 200.

2.2. Study Methods

A computer-generated random sequence determined group allocation, with sealed envelopes containing assignment cards. Patients were assigned to groups sequentially upon enrollment. All patients received routine preoperative education and psychological support. Intraoperatively, after debridement and hemostasis, foam dressings were applied and fixed with skin staples. A semi-permeable membrane was then applied beyond the wound edge (3-5cm), and the wound was dressed with gauze for observation [6]. Postoperatively, patients were connected to a central negative pressure device, with settings based on wound conditions [7].

2.3. Intervention Measures

Negative pressure: Groups A and C used low negative pressure (-120 to -70 mmHg), while Groups B and D used traditional negative pressure (-450 to -125 mmHg).

Skin protective film: Groups C and D applied skin protective film intraoperatively, using alcohol swabs to clean the periwound skin, then applying the film outward from the wound center, covering an area 1-2cm beyond the semi-permeable membrane.

2.4. Observation Indicators

2.4.1. Skin Injury Incidence

Assessed twice daily and after tube removal, categorized into types like tension blisters and maceration.

2.4.2. Granulation Growth

Evaluated using a 0-4 scoring system based on color and filling rate.

2.4.3. Pain Score [8]

Measured using VAS on postoperative days 1, 3, and 5.

2.4.4. Comfort Score [8]

Assessed using VAS on postoperative days 1, 3, and 5.

3. Statistical Methods

Data were analyzed using SPSS 26.0. Measurement data were analyzed by ANOVA or non-parametric tests, and count data by chi-square or Fisher's exact tests. Repeated measures ANOVA was used for pain and comfort scores, with Bonferroni correction for multiple comparisons (corrected P=0.00833). P<0.05 was considered statistically significant.

4. Results

4.1. Comparison of General Data Among Four Groups

A total of 200 patients were enrolled, with 5 dropouts, leaving 195 for analysis. No significant differences were found in general or wound characteristics among the four groups (P>0.05), ensuring comparability, Table 1 and Table 2.

Table 1. *Baseline characteristics.*

	Group A (n=49)	Group B (n=48)	Group C (n=49)	Group D (n=49)	*P*-value
Gender					0.244
Male, n	27 (55.1)	24 (50)	34 (69.4)	27 (55.1)	
Female, n	22 (44.9)	24 (50)	15 (30.6)	22 (44.9)	
Age (years, mean ±SD)	65.27±13.2	62.2±13.33	61.6±12.49	62.1±14.24	0.531
Degree of education					0.856
Primary school, n	33 (67.3)	33 (68.8)	31 (63.3)	34 (69.4)	
Middle school, n	10 (20.4)	4 (8.3)	10 (20.4)	10 (20.4)	

	Group A (n=49)	Group B (n=48)	Group C (n=49)	Group D (n=49)	*P*-value
High school, n	2 (4.1)	6 (12.5)	3 (6.1)	5 (10.2)	
College or above, n	4 (8.2)	5 (10.4)	5 (10.2)	0 (0)	
BMI (mean ±SD) ($\bar{X}$±s)	23.42±3.01	23.34±3.21	23.46±3.60	24.35±3.71	0.418
Hemoglobin (g/L, mean±SD)	122.33±17.89	126.40±15.95	127.14±17.02	126.22±21.39	0.556
Serum albumin (g/L, mean±SD)	38.30±4.87	38.80±5.06	38.64±5.10	38.17±5.03	0.920

Table 2. *Comparison of wound data.*

	Group A (n=49)	Group B (n=48)	Group C (n=49)	Group D (n=49)	*P*-value
Wound types, n					0.695
Trauma wounds	18 (36.7)	17 (35.4)	21 (42.9)	20 (40.8)	
Arteriovenous ulcers	11 (22.4)	9 (18.8)	12 (24.5)	12 (24.5)	
Incision does not heal	5 (10.2)	8 (16.7)	7 (14.3)	3 (6.1)	
Diabetic Foot ulcers	7 (14.3)	4 (8.3)	2 (4.1)	8 (16.3)	
Others	8 (16.3)	10 (20.8)	7 (14.2)	6 (12.2)	
Wound sites, n					0.346
Lower limbs	39 (79.6)	34 (70.8)	39 (79.6)	44 (89.8)	
trunk	5 (10.2)	9 (18.8)	6 (12.2)	4 (8.2)	
Others	5 (10.2)	5 (10.4)	4 (8.2)	1 (2)	
Wound duration					0.911
≤3 months	39 (79.6)	37 (77.1)	36 (73.5)	38 (77.6)	
>3 months	10 (20.4)	11 (22.9)	13 (26.5)	11 (22.4)	
Wound area (cm^2, $M(P_{25}, P_{75})$)	17.50 (7.50, 25.0)	13.50 (8.25, 23.25)	12.0 (6.0, 20.0)	12.0 (7.25, 26.0)	0.421

4.2. Comparison of Skin Injury Incidence

Table 3. *Incidence of skin injury.*

	N	Skin injury		*P*-value
		n	rate (%)	
Group A	49	15	30.6%	0.022
Group B	48	18	37.5%	
Group C	49	6	12.2%	
Group D	49	10	20.4%	

Significant differences were found in skin injury incidence among the four groups (P<0.05), Table 3. Specifically, Group C had a significantly lower incidence than Group B (P<0.008), with no other significant between-group differences.

4.3. Comparison of Granulation Growth

No significant differences were found in granulation growth scores among the four groups (P>0.05), Table 4.

Table 4. *The comparison of granulation growth between the four groups.*

	N	granulation growth	*Z*-value	*P*-value
Group A	49	3 (3, 4)	1.523	0.677
Group B	48	3 (3, 4)		
Group C	49	4 (3, 4)		
Group D	49	3 (3, 4)		

4.4. Comparison of Postoperative Pain Scores

On postoperative days 1 and 3, Groups B and D had higher pain scores than Groups A and C (P<0.05). No significant differences were found on postoperative day 5 (P>0.05), Table 5.

Table 5. *The comparison of pain intensity between the four groups.*

	N	Day 1	Day 3	Day 5
Group A	49	4.06±0.88[2)4)]	2.16±0.62[2)4)]	1.04±0.71
Group B	48	4.88±0.98[1)3)]	2.98±0.64[1)3)]	1.15±0.74
Group C	49	4.04±0.93[2)4)]	2.10±0.65[2)4)]	1.06±0.63
Group D	49	4.76±0.92[1)3)]	2.96±0.71[1)3)]	1.08±0.79
F-value		11.098	26.532	0.194
P-value		<0.001	<0.001	0.900

Notes: 1) compared with Group A, P<0.05; 2) Compared with Group B, P<0.05; 3) Compared with Group C, P<0.05.

4.5. Comparison of Postoperative Comfort Scores

No significant differences were found on postoperative day 1 (P>0.05). On postoperative day 5, Groups C and D had higher comfort scores than Groups A and B (P<0.05), Table 6.

Table 6. *The comparison of comfort between the four group.*

	N	Day 1	Day 3	Day 5
Group A	49	8.55±1.04	6.82±1.07	5.24±1.38[3)4)]
Group B	48	8.29±1.05	6.5±1.09[3)]	5.17±1.46[3)4)]
Group C	49	8.57±0.96	7.12±1.22[2)]	6.33±1.34[1)2)]
Group D	49	8.22±1.07	6.92±1.11	6.12±1.45[1)2)]

N	Day 1	Day 3	Day 5
F-value	1.449	2.572	8.670
P-value	0.230	0.055	<0.001

Notes: 1) compared with Group A, P<0.05; 2) Compared with Group B, P<0.05; 3) Compared with Group C, P<0.05; 4) Compared with Group D, P<0.05.

5. Discussion

5.1. Skin Protective Film and Low Negative Pressure Reduce Skin Injury

In this study, the incidence of skin injury in group B was the highest, reaching 37.5%, while that in group C was only 12.2%. A meta-analysis showed that negative pressure may be an important reason for the formation of post-VSD tension blisters [9]. Group C adopts small negative pressure, and the skin protective film can quickly form a colorless and breathable film on the skin surface to prevent the damage of various liquids and viscose products to the skin [10], so the occurrence of skin damage can be significantly reduced. In the course of this study, it was found that the high incidence of tension blisters in the first and second days after surgery was analyzed, which may be caused by mechanical pulling related to postoperative negative pressure, suggesting that medical staff should pay more attention to the skin conditions around the wound on the first and second days after VSD surgery, and educate patients about skin damage. Low negative pressure reduces mechanical traction, while the film forms a protective barrier, preventing skin damage from adhesives and exudate.

5.2. Effect of Negative Pressure on Granulation Growth

The results showed that there was no significant difference in the growth of wound granulation tissue among the four groups (P > 0.05). A study showed [11] that the wound is more contracted during NPWT treatment at a high level of negative pressure or when using a small foam. Conversely, the wound is less contracted during NPWT treatment at a low level of negative pressure or when using gauze or a large foam filler. At the same time, Torbrand et al. [12] observed that when the negative pressure value was -120 mmHg, the contraction deformation and stress around the wound were the maximum, which had a positive effect on promoting wound healing. It can be seen that the conclusions drawn by different researchers on the effects of different negative pressure values on the growth of granulation tissue are not all consistent, and the existing evidence has not yet reached a consensus. Although the research results showed that there was no statistically significant difference in the growth of granulation tissue, the median of the four groups reached more than 3 points, that is, most of the granulation tissue grew well and the coverage rate was more than 50% [13]. Therefore, further research is needed to explore optimal negative pressure levels.

5.3. Low Negative Pressure Alleviates Early Postoperative Pain

The results of this study showed that the degree of early postoperative pain was related to the value of negative pressure. Previous study has showed that negative pressure closed drainage technology can shorten the patient's healing course and reduce the duration of treatment, reduce the pain of dressing changes, improve prognosis, and have satisfactory therapeutic effect [14]. According to the high pain scores obtained in the early postoperative period and the traditional negative pressure group, the analysis results are as follows: in the early postoperative period, in addition to the pain related to the wound itself and the postoperative incision, the negative pressure suction will aggravate the irritation pain of the wound. On the third day after the operation, the tissue enters the repair state, and the effect of negative pressure suction on wound stimulation is gradually reduced, so that the pain is gradually reduced [13]. This suggests that medical staff should pay attention to the pain of patients after negative pressure therapy, especially in the early stage, and try to use small negative pressure on the premise of ensuring effective drainage of negative pressure [15]. Higher negative pressure levels were associated with increased pain, especially in the early postoperative period. This suggests that using lower negative pressure can reduce pain while maintaining effective drainage.

5.4. Skin Protective Film Enhances Late Postoperative Comfort

The results of this study show that the use of a skin protective film can improve comfort in the later period after VSD. It isolates the wound from the outside by means of the semi-permeable biofilm sealing, reducing the risk of external bacterial infections [14, 16]. Some patients continue to scratches and scratches due to the itching caused by the VSD film after the operation, which leads to the film's air leakage and negative pressure failure. Some patients require the use of

drugs to stop itching or early extubation because of the unbearable itching, which reduces patient compliance and satisfaction, and even affects the treatment process. Therefore, in the clinical treatment and nursing, we should pay attention to the comfort of patients in the process of catheterization. When patients have discomfort such as dryness, tightness, itching, timely evaluation and take measures, can be given gently pat and cold compress first, if it is not relieved, report to the doctor, and use antihistamine drugs according to the doctor's advice.

6. Conclusion

In conclusion, combining skin protective film with low negative pressure effectively reduces skin injury incidence after VSD surgery, alleviates early pain, and improves late comfort, offering a practical clinical approach.

Abbreviations

BMI	Body Mass Index
VSD	Vacuum Sealing Drainage
VAS	Visual Analogue Scale

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Miao Aimei: Resources, Supervision, Validation

Funding

Wenzhou Scientific Research Project (Y20220540); Zhejiang Province Traditional Chinese Medicine Clinical Research Plan Project (2024035573).

Conflicts of Interest

The authors declare no conflicts of interest.

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