ORIGINAL RESEARCH

The Value of Continuous Closed Negative Pressure Drainage Combined with Antibacterial Biofilm Dressing in Postoperative Wound Healing for Severe Pancreatitis

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ABSTRACT

Objective • To investigate the application value of continuous vacuum sealing drainage (VSD) combined with antibacterial biofilm hydraulic fiber dressing in wound healing after surgery for severe acute pancreatitis (SAP).

Methods • A total of 82 SAP patients who underwent minimally invasive surgery in our hospital from March 2021 to September 2022 were randomly divided into two groups using a random number table method. Each group consisted of 41 cases. Both groups received surgical treatment, with the control group receiving VSD treatment and the observation group receiving VSD treatment combined with antibacterial biofilm hydraulic fiber dressing. The postoperative recovery efficiency, preoperative and postoperative wound area reduction rate, pressure ulcer healing score (PUSH), serum biological indicators (white blood cell count (WBC), C-reactive protein (CRP), procalcitonin (PCT)), and the rate of wound-related adverse reactions were compared between the two groups.

Results • There was no statistical difference between the two groups in the time to resume eating ($P > .05$). However, the wound healing time and hospitalization days in the observation group were significantly shorter than those in the control group ($P < .05$). After 7 and 14 days of treatment, the wound area reduction rate in the observation group was significantly higher than in the control group, and the PUSH score was significantly lower than in the control group ($P < .05$). WBC, CRP, and PCT levels in the observation group were lower than in the control group ($P < .05$). The incidence of wound-related adverse reactions in the observation group (12.20%) was significantly lower than that in the control group (34.15%) ($P < .05$).

Conclusions • The application of VSD combined with antibacterial biofilm hydraulic fiber dressing in the postoperative wound healing of SAP has a significant effect. It improves wound healing efficiency, reduces pressure ulcer scores, decreases inflammation indicators, and lowers the incidence of adverse reactions. While further research is needed to determine its impact on infection and inflammation prevention, this treatment approach shows promise for clinical application. (*Altern Ther Health Med.* 2023;29(5):375-379).

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INTRODUCTION

Acute pancreatitis (AP) is a common acute abdominal disease of the digestive system, with severe acute pancreatitis (SAP) accounting for 20% of AP cases.[1] Once the disease progresses, it can lead to persistent organ damage, local or systemic complications, and a high mortality risk.[1,2] Immediate implementation of appropriate treatment strategies is crucial for SAP patients. Surgery serves as the primary treatment modality, effectively addressing pathological conditions.[3] However, surgical intervention is inherently traumatic, causing disruption of wound tissue integrity and increasing the risk of postoperative infection and wound dehiscence. These factors can impede proper wound healing, prolong hospitalization, and contribute to unfavorable outcomes.[1-3]

Currently, vacuum sealing drainage (VSD) is widely utilized in the clinical management of infected wounds. VSD foam is applied to the abdominal fascia or skin, creating a sealed environment that facilitates wound healing and enhances drainage efficiency.[4,5] Nonetheless, the limited antibacterial capabilities of negative pressure materials necessitate further improvement in strategies to promote wound healing. Hu et al.[6] suggest using intelligent hydrogels incorporating antibacterial films and anti-virulence activities, which can effectively reduce bacterial pathogenicity, prevent biofilm infection, and mitigate chronic wound infection.

However, clinical reports on the application of VSD combined with an antibacterial biofilm hydraulic fiber dressing strategy are scarce, warranting additional trials for validation.

Based on these considerations, this study aims to analyze the efficacy of VSD combined with an antibacterial biofilm hydraulic fiber dressing in promoting postoperative healing in SAP. The objective is to offer more dependable and safe healing strategies for SAP patients.

PATIENTS AND METHODS

Study Design

This study employed a prospective randomized controlled design to investigate the application value of vacuum sealing drainage combined with an antibacterial biofilm hydraulic fiber dressing in postoperative healing of severe acute pancreatitis patients.

Study Participants

A total of 82 SAP patients who underwent elective minimally invasive surgery at our hospital from March 2021 to September 2022 were selected. Using a random number table method, they were divided into two groups, with 41 patients in each group. In the observation group, there were 24 males and 17 females, aged 23-69 years (mean age: 43.19 ± 6.24 years), with a wound area ranging from 3.25-10.67 cm^2 (mean: 5.11 ± 1.63 cm^2). The control group consisted of 25 males and 16 females, aged 24-67 years (mean age: 43.52 ± 6.08 years), with a wound area ranging from 3.64-10.25 cm^2 (mean: 5.19 ± 1.44 cm^2). There were no significant differences in baseline data of SAP patients between the two groups ($P > .05$).

Inclusion and Exclusion Criteria

Inclusion criteria were as follows, (1) Patients met SAP diagnostic criteria[7]: The patient presented with persistent upper abdominal pain of varying degrees, dysfunction of one or more organs (such as respiratory function and renal function impairment), accompanied by abdominal distention, nausea, vomiting, and other clinical symptoms; (2) Laboratory tests confirmed the elevated serum lipase and signs of changes in abdominal imaging were found; (3) The improved Marshall score system was used to evaluate, and any organ score ≥2 points; (4) Patients who conformed to the indications of VSD technology application; (5) Informed consent signed by the patient's family members.

Exclusion criteria set as follows, (1) Patients allergic to dressings and negative pressure materials in this study; (2) Patients with systemic infection complicated by a malignant tumor and secondary infection; (3) Patients complicated with pancreatic or peripancreatic necrotic tissue infection.

The study followed ethical principles and was reviewed by an institutional review board or ethics committee. Informed consent was obtained from all participants.

Surgical Procedure and Wound-Healing Strategies

Both groups underwent surgical treatment with different wound-healing strategies. The control group received vacuum sealing drainage using the VSD treatment instrument (Henan Huibo Medical Co., LTD., Registration Number: Yousang Injection Registration 20172540896). The procedure involved the removal of necrotic tissue around the pancreas, placing an irrigation tube into the omentum sac, and inserting two medical foam sponges in the direction of the tail and head of the pancreas to ensure full coverage. The incision was then sutured on both sides, and a sealing film was applied to seal the wound. Postoperatively, the abdominal cavity was irrigated with 20,000 ml/day of normal saline, and the dressing was changed every 48-72 hours. The swelling of the wound, pancreas, and surrounding organs was monitored, and the intervention continued for a duration of 14 days.

Based on the control group, the observation group received additional treatment with an anti-bacterial biofilm hydraulic fiber dressing (manufacturer: Lanke Hengye Medical Technology (Changchun) Co., LTD., Approval No.: Jixian Zhuizun 20182140152). Following VSD treatment, the dressing was applied to the wound surface using a standard sterile technique. It was carefully cut to match the size and shape of the wound and gently pressed onto the wound bed to ensure proper contact. Adhesive strips or a secondary dressing were used to secure the dressing in place. The negative pressure material and a thin cushion layer of bacterial biofilm hydraulic fiber dressing were combined with a negative pressure drainage device to create a sealed environment for the wound. Other procedures remained the same as described above, and continuous low negative pressure drainage was maintained.

Observation Indicators

Comparison of Postoperative Rehabilitation Efficiency. The postoperative rehabilitation efficiency of the two groups was compared. The recovery feeding time, wound healing time, and hospitalization days were recorded.

Comparison of Wound Area Reduction Rate. The wound area reduction rate and pressure ulcer healing score were compared between the two groups. The evaluation measured the wound area before surgery at 7 days post-surgery and 14 days post-surgery. Using a universal wound-measuring ruler, the length, width, and depth of the wounds were measured, and the wound volume was calculated. The wound volume reduction rate was determined by subtracting the postoperative volume from the preoperative volume, dividing it by the preoperative volume, and multiplying it by 100%.

Pressure Ulcer Healing Scale (PUSH). The pressure ulcer healing scale (Pressure Ulcer Healing Scale, PUSH) was utilized to assess ulcer healing.[8] For assessment, the scale included wound area (0 to 10, followed by 0 and < 0.3 $cm)^2$, 0.3 (excluding) -0.6 cm^2, 0.6 (excluding) -1.0 cm^2, 1.0 (excluding) -2.0 cm^2 2.1-3.0 cm^2, 3.0 (excluding) -4.0 cm^2, 4.0 (excluding) -8.0 cm^2, 8.0 (excluding) -12.0 cm^2 12.0 (excluding) -24 cm^2, >24 cm^2), the amount of exosmotic fluid (0-3 points were none, a small amount (<5 ml/24 h), medium amount (5 (excluding -10 ml/24 h), large amount (>10 ml/24 h)), and tissue type (0-4 points were closed, epithelial tissue,

granulation tissue, rotting flesh, and necrotic tissue). The wound area was categorized into different ranges, and points were assigned based on the amount of exosmotic fluid and tissue type. The total score ranged from 0 to 17 points, with a higher score indicating poorer wound healing.

Comparison of Serum Biological Indicators between the Two Groups. Serum biological indicators of the two groups were compared: A 5 ml sample of early morning fasting venous blood was collected from patients before and after surgery at 3 days. The blood samples were then subjected to centrifugation (3500 r/min, 10 cm, 10 min) to obtain the upper serum. The white blood cell count (WBC) was detected using an automatic hematology analyzer (Model: Sysmex SE-9000), while the levels of c-reactive protein (CRP) and procalcitonin (PCT) were detected using an ELISA kit (Shanghai Hengyuan Biotechnology Co., LTD., Shanghai, China).

Comparison of Incidence of Wound-Related Adverse Reactions. Following the methodology by Metcalf et al,[9] adverse reactions related to bacterial biofilm were assessed, including delayed wound healing, excessive exudation, chronic inflammation/redness, and recurrent infection/worsening. The incidence of these adverse reactions was calculated to determine the overall occurrence rate.

Statistical Analysis

The data were analyzed using Statistical Product and Service Solutions (SPSS) 23.0 software (IBM, Armonk, NY, USA). Continuous variables, such as gastric mucosa-associated factors and gastrointestinal hormone levels, were expressed as mean ± standard deviation ($\bar{x} \pm s$) if they followed a normal distribution. Within-group and between-group comparisons were performed using independent/paired sample *t* tests. Categorical variables, including the Hp eradication rate, CAG improvement rate, and adverse reaction rate, were analyzed using the χ^2 test and presented as percentages (%). A *P* value of less than .05 ($P < .05$) was considered statistically significant.

RESULTS

Comparison of Postoperative Rehabilitation Efficiency

There was no significant difference in the recovery time of eating between the two groups ($P > .05$). However, the observation group exhibited significantly shorter wound healing time and hospitalization days compared to the control group ($P < .05$). Please refer to Table 1 for detailed results.

Comparison of Wound Area Reduction Rate and Pressure Ulcer Healing Score

There was no statistically significant difference in the pressure ulcer healing score (PUSH score) between the two groups before surgery ($P > .05$). However, after 7 days and 14 days of treatment, the observation group exhibited a significantly higher wound area reduction rate compared to the control group. Additionally, the PUSH score in the observation group was significantly lower than in the control group ($P < .05$). Please refer to Table 2 for detailed results.

Comparison of Serum Biological Indices

There were no significant differences in WBC, CRP, and PCT levels between the two groups before surgery ($P > .05$). However, after surgery, these indexes showed a significant decrease in both groups. Furthermore, the observation group exhibited lower WBC, CRP, and PCT levels compared to the control group ($P < .05$). Please refer to Table 3 for detailed results.

Comparison of Wound-Related Adverse Reactions

The incidence of wound-related adverse reactions was significantly lower in the observation group (12.20%) compared to the control group (34.15%) ($P < .05$). See Table 4 for detailed results.

DISCUSSION

Surgical treatment is the preferred strategy for managing SAP,[10-11] but it can lead to fibrosis and interfere with wound healing. This effect is more pronounced in severe SAP cases, which are associated with chronic inflammation, complications, and compromised immunity.[10] Vacuum sealing drainage is a commonly employed technique in clinical practice for managing complex wounds and promoting postoperative tissue healing.[11]

Table 1. Comparison Of Postoperative Rehabilitation Efficiency Between the Two Groups ($\bar{x} \pm s$, d)

Group	Number of Cases	Recovery Time	Wound Healing Time	Length Of Stay
Observation Group	41	3.47 ± 0.45	11.15 ± 2.11	12.65 ± 2.41
Control Group	41	3.56 ± 0.32	14.67 ± 2.13	15.13 ± 2.46
t	-	1.044	7.518	4.611
P value	-	.300	<.001	<.001

Note: Data is presented as Mean ± Standard Deviation; The *t* values: are the results of the independent sample *t* test; the *P* values: are the level of statistical significance.

Table 2. Comparison of wound area reduction rate and pressure ulcer healing score between the two groups ($\bar{x} \pm s$)

Group	Number 0f Cases	Wound Area Reduction Rate (%)		Pressure Ulcer Healing Score (Score)		
		7 Days After Surgery	14 Days After Surgery	Preoperatively	7 Days After Surgery	14 Days After Surgery
Observation Group	41	36.47 ± 3.45	58.15 ± 4.11	11.65 ± 2.41	9.53 ± 1.68[a]	8.95 ± 1.68[a]
Control Group	41	21.56 ± 2.32	47.67 ± 4.13	11.13 ± 2.46	10.67 ± 2.74[a]	9.89 ± 1.14[a]
t	-	22.963	11.517	0.967	2.271	2.964
P value	-	<.001	<.001	.337	.026	.004

[a]*P* is compared with preoperative; $P < .05$.

Table 3. Comparison of Serum Biological Indexes Between the Two Groups ($\bar{x} \pm S$)

Group	No of Cases	WBC Times (10^9/L)		CRP (Mg/L)		PCT (Mg/L)	
		Preoperatively	Postoperatively	Preoperatively	Postoperatively	Preoperatively	Postoperatively
Observation Group	41	10.41 ± 2.16	3.27 ± 1.06[a]	17.58 ± 2.45	5.45 ± 1.34[a]	9.47 ± 0.89	2.85 ± 0.21[a]
Control Group	41	10.65 ± 2.21	4.35 ± 1.01[a]	17.20 ± 2.59	8.62 ± 1.25[a]	9.39 ± 0.86	4.19 ± 0.36[a]
t	-	0.497	4.723	0.683	11.077	0.414	20.587
P value	-	.620	<.001	.497	<.001	.680	<.001

[a]*P* is compared with preoperative, $P < .05$.

Table 4. Comparison of Wound-Related Adverse Reactions Between the Two Groups [n, (%)]

Group	Number of Cases	Delayed Wound Healing	Massive Seepage	Chronic Inflammation/ Redness	Recurrent Infection/ Deterioration	Incidence Rate
Observation Group	41	2 (4.88)	1 (2.44)	1 (2.44)	1 (2.44)	5 (12.20)
Control Group	41	8 (19.51)	3 (7.32)	2 (4.88)	1 (2.44)	14 (34.15)
χ^2	-	-	-	-	-	5.549
P value	-	-	-	-	-	.018

The application of VSD in heavily contaminated or infected abdominal surgical sites offers several benefits, including infection prevention and treatment, maintenance of clean abscesses, promotion of abscess collapse, acceleration of secondary incision closure, reduction in hospital stay, and mitigation of local complications.[12] The mechanism of action of VSD is multifaceted. Firstly, the continuous vacuum negative pressure, coupled with the dilution and scouring effects of the rinse solution, minimizes the stimulation of pancreatic fluid and enhances drainage efficiency. The spatial contraction induced by VSD stimulates cell proliferation and matrix synthesis and facilitates faster healing. Secondly, the negative pressure indirectly decreases the hydrostatic pressure of local tissue edema, reduces leakage, prevents the accumulation of cells and inflammatory mediators in the abdominal cavity, promotes the regression of edema and blood perfusion, facilitates blood vessel formation and improves local circulation. Additionally, the hypoxic environment created by the continuous negative pressure inhibits bacterial proliferation, eliminates bacterial colonization, and suppresses the growth of bacteria.[12] However, further improvement is required to understand the effect of VSD alone on wound healing fully.

Due to the involvement of pathogenic bacteria biofilms in 70% of chronic infections, their colonization, multiplication, and growth on wounds pose significant challenges, particularly in the context of increasing clinical antibiotic resistance. As a result, novel hydrogel healing agents have been proposed as potential dressings for chronic wounds.[13] Compared to traditional silver-containing dressings, antibacterial biofilm hydraulic fiber dressings exhibit greater biofilm resistance potential and biocompatibility. These dressings can reduce the active biofilm by approximately 90% and decrease the height of the biofilm by around 65%. Additionally, their higher porosity promotes wound fluid absorption and cell migration, thereby accelerating wound healing.[14]

Tavakolian et al.[15] demonstrated that antibacterial hydrogels can effectively eliminate approximately 99% of exposed bacteria within 3 hours of exposure. Consistent with these findings, the present study revealed that the observation group exhibited significantly shorter wound healing time and hospitalization days compared to the control group ($P < .05$). Moreover, the observation group exhibited significantly higher wound area reduction rates after 7 and 14 days of treatment, along with lower PUSH scores compared to the control group ($P < .05$). Additionally, the WBC, CRP, and PCT levels in the observation group were significantly lower than those in the control group ($P < .05$).

The incidence of wound-related adverse reactions was found to be significantly lower in the observation group (12.20%) compared to the control group (34.15%) ($P < .05$). This difference can be attributed to the presence of bacterial biofilm, which is a major factor influencing wound healing. Bacterial biofilm has the ability to disrupt normal tissues, proteins, and immune cells, thereby compromising the body's immune recovery capacity. It sustains a chronic inflammatory state in the wound, making it difficult to eliminate bacteria and impeding the natural healing process. It can eventually lead to recurrent chronic infections and inflammation.

While VSD combination therapy can partially disrupt the biofilm on the wound surface, it does not effectively address the underlying symptoms. On the other hand, using anti-bacterial biofilm hydraulic fiber dressing demonstrates superior efficacy. This dressing prevents the formation of bacterial proteins, inhibits bacterial replication, and induces the destruction of bacterial cell walls, membranes, and leakage. Additionally, the hydraulic fiber dressing maintains excellent water retention, permeability, tensile strength, and elastic modulus, creating an optimal environment for wound healing. It enhances the defensive properties against bacterial biofilms, exhibits potent bactericidal effects, reduces wound

inflammation, and lowers WBC, CRP, and PCT levels. Furthermore, it accelerates wound area reduction and promotes rapid wound healing. However, there is a lack of comprehensive clinical studies on the application of antibacterial biofilm hydraulic fiber dressings, and further research is warranted to validate their practical use.

Study Limitations

The limitations of this study include a relatively small sample size, which may affect the generalizability of the findings. The follow-up duration was also limited to 14 days, and longer-term outcomes were not assessed. Further studies with larger sample sizes and longer follow-up periods are needed to validate the results and provide a more comprehensive understanding of the effectiveness of the interventions.

CONCLUSION

The findings of this study support the effectiveness of VSD combined with anti-bacterial biofilm hydraulic fiber dressing in promoting postoperative wound healing in SAP patients. The combination therapy demonstrated improved wound healing outcomes, reduced pressure ulcer scores, prevented infection and inflammation and decreased incidence of wound-related adverse reactions. However, due to the small sample size in this study, further validation through large-scale randomized, multicenter, double-blind studies are necessary to confirm and apply these findings in clinical practice.

CONFLICT OF INTERESTS

The authors declared no conflict of interest.

AUTHORS' CONTRIBUTIONS

XS, LL, and JS designed the study and performed the experiments; XS and LL collected the data; JY and JS analyzed the data; and XS, LL, and JS prepared the manuscript. All authors read and approved the final manuscript.

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