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ORIGINAL

EFFECT OF NEGATIVE PRESSURE SEALING AND DRAINAGE (VSD) TECHNIQUE ON WOUND INFECTION IN ADULT ORTHOPAEDICS AND ITS INFLUENCE FITNESS INDICATOR

Jingshuang Wang[1]*, Qizan Liu[1], Da He[1], Hongle Xia[1]

[1]Cangzhou Hospital of Integrated TCM-WM.Hebei, Cangzhou Hebei 061000, China
*Corresponding author：Jingshuang Wang
Email: jingshuang1979@163.com

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ABSTRACT

Objective: To investigate the effect of vacuum sealing drainage (VSD) in the healing of adult orthopedic wound infection, and to explore the effect of intervention on white blood cell (WBC) and C-reactive protein (CRP) levels; **Methods:** 80 adult Athlete patients with orthopedic wound infection who were healed in our hospital from January 2020 to January 2022 were retrospectively opted as the research subjects, and were divided into the VSD cluster (n=40, receiving VSD technology) and the control cluster according to their healing methods (CG, n=40, receiving conventional gauze dressing healing), the variations in WBC and CRP between the two clusters before healing, on the 5th day of healing, on the 10th day of healing, and on the 15th day of healing were contrasted between the two clusters, and the wound surfaces of the two clusters of athlete patients were contrasted at the above time points. The variation in appearance, the variation in the bacterial negative rate of the wound surface after the intervention was contrasted, and the wounded limb marks of the two clusters of athlete patients were followed up; **Results:** (1) On the 5th day, 10th day and 15th day of healing, the WBC and CRP levels in the VSD cluster were notably lower than those within the control cluster ($P < 0.05$); (2) On the 5th day, 10th day and 15th day of healing, the wound appearance marks in the VSD cluster were notably upper than those within the control cluster, and the variation between the clusters was notable ($P < 0.05$); (3) The wound bacterial conversion rates within the study cluster were 40.00%, 70.00% and 95.00% at 1 month, 2 months and 3 months after operation, respectively, which were notably upper than 17.50%, 47.50% and 80.00% within the control cluster, and the variation between the clusters was notable ($P < 0.05$); (4) At 1 month, 2 months and 3 months after operation, the Puno limb marks within the study cluster were notably upper than those within the control cluster, and the variation between the clusters was notable ($P < 0.05$); **Conclusion:** VSD technology has a good effect on the healing of adult orthopedic wound infection, can notably enhance the athlete patient's inflammatory state, notably enhance the bacterial negative rate of the patient's wound, help to speed up the patient's recovery process, and has positive sense for the athlete patient's wound recovery.

KEYWORDS: Negative pressure sealing and drainage; Adult orthopedic wound infection; Inflammatory state; Bacterial negative rate; Wound recovery

With the accelerated pace of life of residents in recent years, the advancement of science and technology and the development of transportation, the probability of orthopedic wound infection caused by emergencies and natural disasters has been increasing (Garner, Sethuraman, Schade, & Boateng, 2020). Over the years, trauma researchers have used histopathology, pharmacology, tissue engineering and surgery to carry out research on the mechanism, experiment and clinical healing of wound repair. Although they have achieved certain achievements, adult There are still major problems in the management of orthopaedic wound infection (Tian et al., 2020) (Rupp, Popp, & Alt, 2020). Taking Gustilo III B and Gustilo III C fractures as examples, these fractures are mostly open fractures, with large wounds and serious injuries. Because of the large number of dead spaces, postoperative infection is prone to affect wound healing (Riechelmann, Kaiser, & Arora, 2018).

Negative pressure sealing and drainage technology is a relatively mature intervention in the healing of refractory wounds developed in recent years, especially for open fractures complicated by soft tissue defects or vascular injury (C. Huang, Jia, Gu, Zhao, & Lyu, 2020; Wang, Ma, Wang, Zhang, & Liu, 2021). Many studies have confirmed that VSD technology is effective in the adjuvant healing of various acute and chronic wounds, such as pressure wounds, diabetic foot, etc. It is a simple and economical pure physical therapy to promote wound healing. This study intends to explore the feasibility of VSD technology in the healing of adult orthopedic wound infection by setting up a control cluster, in order to provide a reference for improving the prognosis of such athlete patients (Ataya et al., 2019).

1. MATERIALS AND METHODS

1.1 General data

80 adult athlete patients with orthopedic wound infection who were healed in our hospital from January 2020 to January 2022 were retrospectively opted as the research subjects, and were divided into the VSD cluster (n=40, receiving VSD technology) and the control cluster according to their healing methods (CG, n=40, received routine gauze dressing healing).

Inclusion criteria: (1) Those with a clear history of trauma and diagnosed with orthopaedic wound infection by imaging examination; (2) Those with complete medical records; (3) Those who have been identified as suitable for limb salvage surgery; (4) Age ≥ 18 years old.

Exclusion criteria: (1) Athlete patients with psychiatric disorders; (2) Athlete patients with functional muscle damage resulting in inability to carry out repair and reconstruction; (3) Athlete patients with malignant tumors; (4) Athlete patients who lost the opportunity for limb salvage surgery; (5) Incomplete clinical data.

1.2 Intervention methods

The athlete patients within the control cluster were healed with conventional gauze dressing, and the necrotic tissue in the infected wound was cleaned and disinfected in the emergency room or operating room. Clean; after the wound is cleaned, the fracture is repaired, the wound secretion is collected for bacterial culture, and then antibiotic healing is carried out according to the bacterial culture results. The gauze is cut to an appropriate size and then moistened with saline. The dressing was changed, and then the dressing was changed according to the wound healing of the athlete patient until the second-stage operation could be performed to close the wound.

In VSD cluster, bacterial culture, drug sensitivity test and disinfection were performed before one-stage fracture repair, and then VSD dressing was cut according to the size and shape of the athlete patient 's wound surface to make it sutured and fixed around the wound surface after full contact with the wound surface. At the same time, vacuum sealing drainage dressing and multi-hole drainage tube were pasted to the peri-wound skin using a transparent film with unidirectional air permeability function, central vacuum aspiration and drainage bottle were connected, and negative pressure was set at -125 to -450 mmHg. The drainage fluid was taken 4 – 5 days after operation for bacterial culture again, and the vacuum sealing drainage dressing was removed 7 – 10 days after operation, and then the need for re-debridement and the use of vacuum sealing drainage dressing (flap transposition could be performed for athlete patients with good granulation tissue growth) were decided according to the athlete patient' wound condition, as well as the overall situation (body temperature, blood routine, etc.).

1.3 Observation indicators and evaluation standards

(1) Blood samples were collected from the two clusters before healing, on the 5th day of healing, on the 10th day of healing and on the 15th day of healing, and WBC and CRP levels in plasma (using enzyme-linked immunosorbent assay) were measured; (2), the wound appearance marks were assessed before healing, on the 5th day of healing, on the 10th day

of healing, and on the 15th day of healing in both clusters, with good granulation growth, complete coverage of the wound, bright red color markd as 5 points, good granulation growth, wound coverage more than 75%, bright red color markd as 4 points, good granulation growth, covering more than 50% of the wound, bright red color markd as 3 points, granulation growth, covering 25% – 50% of the wound markd as 2 points, granulation growth, covering 25% – 49% of the wound markd as 1 point, and no granulation growth markd as 0 point (Lin et al., 2021); (3) The wound bacterial conversion rate at 1 month, 2 months and 3 months after operation was followed up and contrasted between the two clusters; (4) Puno criteria (Foote et al., 2021) were used to mark the injured limbs of the two clusters at 1 month, 2 months and 3 months after operation. Puno criteria were divided into 7 aspects: pain, joint range of motion, joint X-ray findings, and muscle strength, with a full mark of 100 points, and the upper the mark represented the better the function of the subjects (Mahajan, Kumar, & Gupta, 2021).

1.4 Statistical methods

T-test was used for the Contrastion of measurement data that obeyed normal distribution and homogeneity of variance, and was described by (mean ± standard deviation), and non-parametric data was used for skewed data or measurement data with unequal variance. The Mann-Whitney test (U test) in the test is described by the median (upper and lower quartiles), and the measurement data is contrasted by the chi-square test, which is expressed as cases (%), and P<0.05 is considered notable.

2. RESULTS

2.1 Contrastion of general data of the two clusters of athlete patients

Table 1. Contrastion of general data of the two clusters of athlete patients ($\overline{x} \pm s$)/[n (%)]

General information		Research cluster (n=40)	Control cluster (n=40)	t/χ^2	*P*
Gender	Male	36	34	0.457	0.499
	Female	4	6		
Mean age (years)		45.90±2.82	45.24±3.05	1.005	0.318
Time between healings (h)		6.24±0.95	6.01±0.47	1.432	0.156
Degree of injury	III A	10	10	0.208	0.648
	III B	23	25		
	III C	7	5		
Cause of injury	Crush injuries	13	15	0.365	0.554
	Car accident injuries	16	14		
	Machine strangulation	10	16		
	Other	1	5		

The general data of the two clusters of athlete patients, such as gender, age, healing interval, degree of injury, and cause of injury, were included and contrasted between the two clusters. The results showed that None notable variation in the above data between the two clusters (P> 0.05), Table 1 and Figure 1.

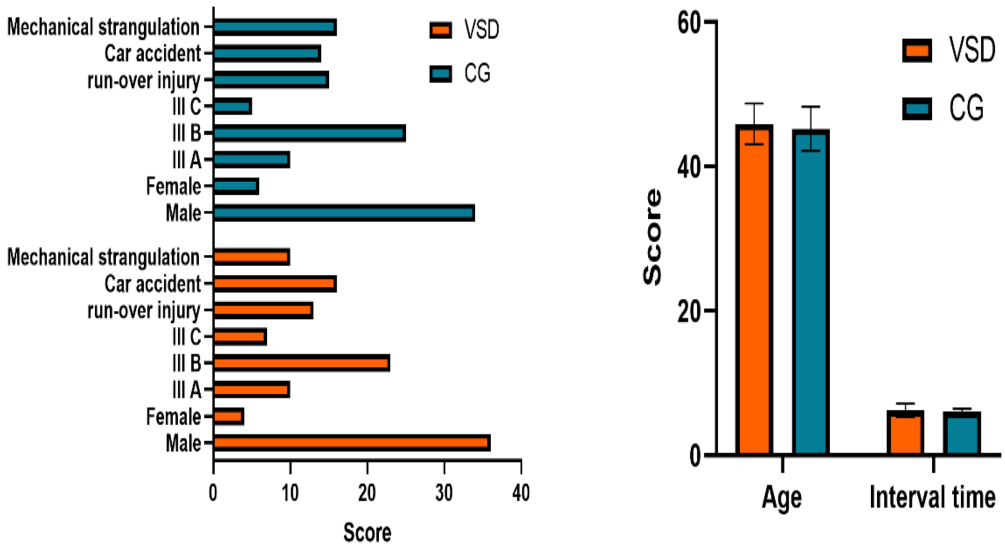

Figure 1. Contrastion of the general information of the two clusters None notable variation between the two clusters in terms of general clinical information such as age, gender and type of injury.

2.2 Analysis of changes in plasma WBC and CRP levels in the two clusters of athlete patients during the intervention

Before healing, none notable variation between the two clusters in WBC and CRP levels (P>0.05). At the 5th, 10th and 15th d of healing, the WBC and CRP levels of patients in the VSD cluster were notably lower than those of the control cluster, and the variation between the clusters was notable (P<0.05), Figure 2 and Figure 3.

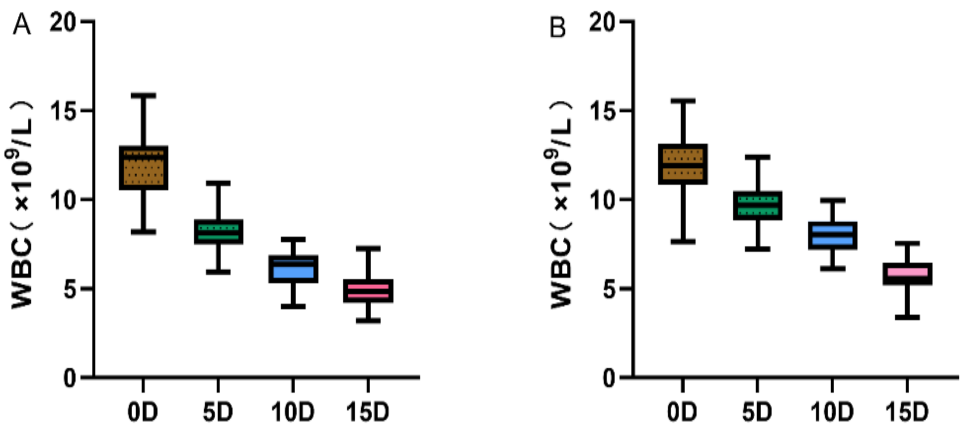

Figure 2. Changes of plasma WBC levels in the two clusters of athlete patients during the intervention On the 5th, 10th and 15th days of healing, the WBC levels of patients in the VSD cluster (Figure A) were notably lower than those within the control cluster (Figure B).

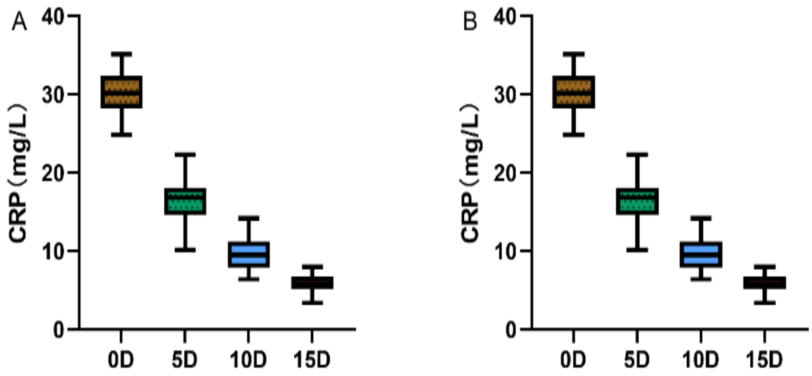

Figure 3. Changes of plasma CRP levels in the two clusters of athlete patients during the intervention On the 5th, 10th and 15th days of healing, the CRP levels of patients in the VSD cluster (Figure A) were notably lower than those within the control cluster (Figure B).

2.3 Contrastion of wound appearance marks between the two clusters of athlete patients after intervention

The contrastion showed that on the 5th day, the 10th day and the 15th day of healing, the wound appearance marks of the athlete patients in the VSD cluster were notably upper than those within the control cluster, and the variation between the clusters was notable (P<0.05), Figure 4.

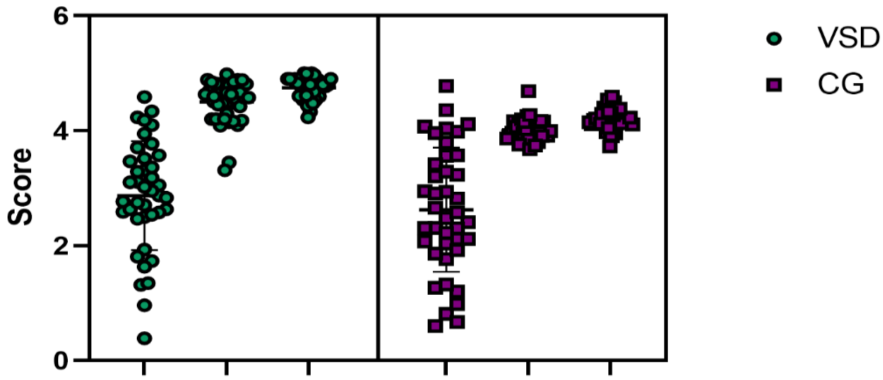

Figure 4. Contrastion of wound appearance marks between the two clusters after intervention On the 5th, 10th and 15th days of healing, the wound appearance marks of the VSD cluster were notably upper than those of the control cluster, and the variation between the clusters was notable (P<0.05).

2.4 variations in the bacterial negative conversion rate of wounds between the two clusters of *athlete* patients after intervention

The bacterial negative conversion rates of the study cluster at 1 month, 2 months and 3 months after the operation were 40.00%, 70.00% and 95.00%

respectively, which were notably upper than 17.50% and 47.50% of the control cluster. and 80.00%, the variation between clusters was notable (P<0.05). Table 2 and Figure 5.

Table 2. Contrastion of the bacterial negative rate of postoperative wounds between the two clusters of athlete patients [n (%)]

Clusters	Cases	1 month	2 months	3 months
VSD cluster	40	16（40.00）	28（70.00）	38（95.00）
Control cluster	40	7（17.50）	19（47.50）	32（80.00）
χ^2	-	4.943	4.178	4.114
P	-	0.026	0.041	0.043

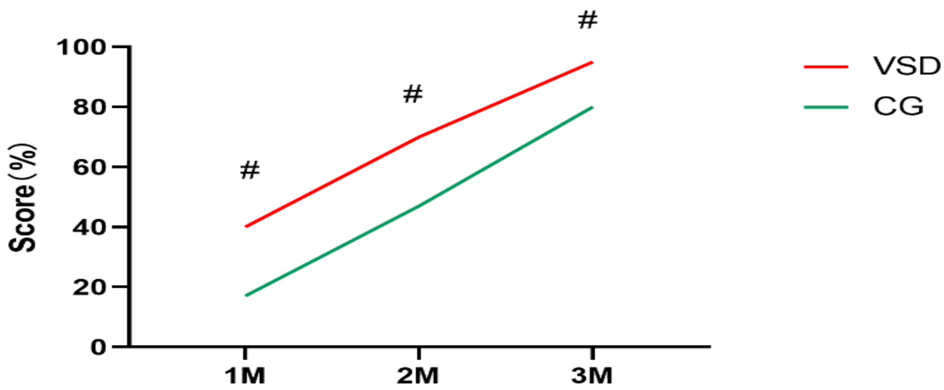

Figure 5. Contrastion of the bacterial negative rate of the wounds between the two clusters of athlete patients. The bacterial negative rates of the VSD cluster at 1 month, 2 months, and 3 months after the operation were 40.00%, 70.00%, and 95.00%, respectively. It was upper than 17.50%, 47.50% and 80.00% of the control cluster, and the variation between the clusters was notable (P<0.05). # indicates that the variation between the same index clusters is notable.

2.5 Follow-up marks of injured limbs in two clusters of athlete patients

The injured limbs of the two clusters of patients were markd at 1 month, 2 months and 3 months after surgery using Puno criteria. The Puno injured limb marks of the patients were notably upper than those of the control cluster, and the variation between the clusters was notable (P<0.05). Table 3 and Figure 6.

Table 3. Contrastion of injured limb marks between the two clusters of patients during follow-up ($\bar{x} \pm s$)

Clusters	Cases	1 month	2 months	3 months
Study cluster	40	66.11±4.33	80.77±4.39	87.68±4.27
Control cluster	40	60.64±4.39	71.56±5.00	80.97±5.32
t	-	5.611	8.754	6.221
P	-	<0.001	<0.001	<0.001

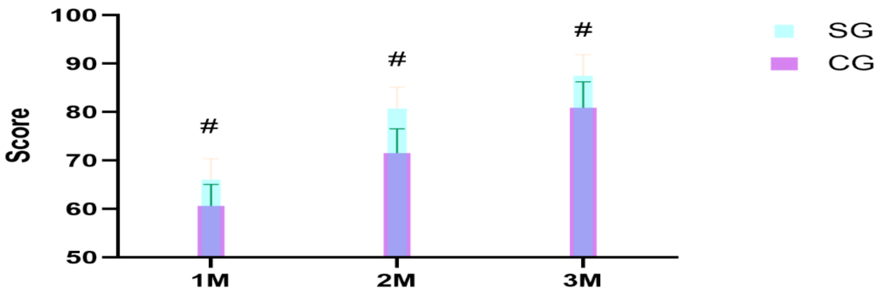

Figure 6. Contrastion of injured limb marks between the two clusters of athlete patients during follow-up At 1 month, 2 months and 3 months after the operation, the Puno injured limb marks of the patients within the study cluster were notably upper than those within the control cluster, and the variation between the clusters was notable (P<0.05). # indicates that the variation between the same index clusters is notable.

3. DISCUSSION

Traumatic fractures are often accompanied by open injuries. Due to the reduction of soft tissue coverage and the destruction of local blood supply, the fracture process will be delayed. At the same time, some athlete patients may experience infection and necrosis due to wound contamination (McMahon, Stranix, Lee, & Levine, 2021). The traditional healing measures for traumatic fracture wounds are dressing change and antibiotic healing. Although this method can protect the wound surface and prevent infection to a certain extent, there are still some athlete patients who do not protect the wound surface in time, which prolongs the healing time and increases the risk of infection (Horton et al., 2021). The bone healing and functional recovery of injured limbs in such patients depend on the healing of their bone and soft tissue injuries. Only by taking into account the early healing of both, can the healing of the athlete patients be facilitated (Ricci et al., 2019). Therefore, the healing points of open fractures also include when and when Covering the wound, how to cover the wound, etc (Sagi & Patzakis, 2021).

The application value of vacuum sealing drainage in athlete patients with orthopedic wound infection was analyzed by establishing a control cluster. The results showed that contrasted with the control cluster athlete patients who used the traditional dressing change method, the plasma WBC and CRP levels of VSD patients who opted vacuum sealing drainage were notably lower on the 5th day after healing, the 10th day after healing, and the 15th day after healing, and the results suggested that the application of VSD notably enhanced the inflammatory status of athlete patients with wound infection. Further studies showed that the wound bacterial conversion rate during follow-up was notably upper in the VSD cluster than within the control cluster. A study on 31 athlete patients with chronic refractory wound infection after Gustilo type Ⅲ open fracture surgery found that after the application of vacuum sealing drainage technique in the healing of wound surface, the wound infection was notably controlled, the edema was notably reduced, the wound area was reduced by 15% -20% after the occurrence of fresh granulation tissue, and the bacterial culture was positive. The wound healed without reinfection after 6-month follow-up after vacuum sealing drainage therapy (Hand, Hand, Welborn, & Zelle, 2020). Another study on 30 athlete patients with Gustilo type IIIB and Gustilo type IIIC fractures found that after vacuum sealing drainage within 8 hours after operation, the wound healing time of 29 patients was 25-40 days, with an average of 27 days. The survival rate of skin grafting was excellent, and the degree of skin recovery was good. Only 1 patient had postoperative infection and bone exposure, which were enhanced after active healing (Higgin, Dean, Qureshi, & Hancock, 2021).

The above studies all suggest that negative pressure sealing and drainage has good application value in patients with orthopedic wound infection. The author of this paper analyzes that negative pressure sealing and drainage technology can create a hypoxic or hypoxic micro-acid environment, thereby inhibiting the growth of wound bacteria (Tan & Kwek, 2020), at the same time, the continuous drainage of necrotic tissue and secretions notably reduces the medium required for bacterial reproduction, so it can quickly enhance the wound infection of patients (Mener et al., 2021). be manifested. In addition, negative pressure sealing drainage also helps to reduce the level of WBC and CRP in local tissues, so as to accumulate neutrophils and accelerate angiogenesis, which helps to enhance the local microcirculation of the wound and provide sufficient nutrient supply for wound repair, and The negative pressure environment can also bring a certain mechanical pulling effect to the tissue, which can induce the proliferation of tissue cells, thereby promoting the growth of granulation tissue on the wound surface, and finally achieving the effect of accelerating wound healing (Duan et al., 2020). Finally, a Contrastion of the wound appearance and limb function of the two clusters of patients was carried out. The results showed that the VSD cluster was notably better than the control cluster in terms of wound appearance and limb function. It can remove the secretions and necrotic tissue in the wound, but in fact, it cannot completely remove all the secretions and necrotic tissue. At the same time, the exudate from the wound will communicate with the outside world, which will affect the healing of the wound and ultimately delay the healing of the wound. The negative pressure drainage technique applied in the VSD cluster can create a good and clean environment for the growth of granulation, which is conducive to the growth of fresh granulation, and provides good conditions for the growth of the wound, which ultimately affects the patient's limb function (Li et al., 2019) (Q. Huang, Huang, & Xue, 2021).

4. CONCLUSION

To sum up, VSD technology has a good effect on the healing of adult orthopedic wound infection, can notably enhance the patient's inflammatory state, notably increase the bacterial negative rate of the athlete patient's wound, help to speed up the patient's recovery process, and has positive sense for the patient's wound recovery.

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