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Skin-stretching device promotes the treatment effect of vacuum sealing drainage technique on phases III and IV stress-induced injuries in aged patients with chronic critical illness

A retrospective study of 70 patients

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Abstract

Stress-induced injury is a common complication associated with patients with chronic critical illness (CCI). Skin-stretching device (SSD) and vacuum sealing drainage (VSD) technique are 2 approaches that can facilitate wound healing.

In the present study, the effect of the concatenated application of the 2 techniques on the phases III and IV stress-induced injuries in aged patients with CCI was assessed. About 70 patients with CCI with stress-induced injuries were selected from February 2015 to October 2017. The treatment outcomes of the combined method and VSD method were assessed by comparing their clinicopathologic parameters.

The results showed that the combined treatment shortened the average healing duration of wounds. Moreover, the total area of pressure sores, incidence of bleeding, bacteria amount, 28-day cure rate, peripheral C-reactive protein (CRP) level, and the hospitalization duration were all significantly improved in patients treated with SSD and VSD. The overall effective rate (97.14%) of patients treated with VSD and SSD was significantly higher than that (77.14%) in patients treated with VSD.

The present study showed that the combined application of VSD and SSD improved the treatment outcomes of phases III and IV stress-induced injuries in aged patients with CCI.

Abbreviations: CCI = chronic critical illness, ICU = intensive care unit, SSD = skin-stretching device, VSD = vacuum sealing drainage.

Keywords: aged patient, chronic critical illness, skin-stretching device, stress-induced injury, vacuum sealing drainage

1. Introduction

The rapid development of critical care medicine has facilitated the recovery of patients in intensive care unit (ICU) and contributes substantial to the recovery of the patients to their normal lives. However, there are still some cases experiencing changes in diseases from acuteness to chronicity during the stay in ICU, which are characterized by multiple system organ failures or disorders.[1] Those who experiencing such changes always need the support of respirator for their survival and are termed as patients with chronic critical illness (CCI). In 1985, Girard and Raffin inferred that ca 6% to 10% of all the ICU patients would develop into patients with CCI.[2] Worse still, based on the recent investigation, the incidence of CCI has increased substantially,[3] casting great burden to public health system and caregivers. Due to the morbidity, patients with CCI have to stay in bed for quite a long term, which usually results in an incidence of stress-induced injuries as high as 14.9%.[4]

As one of the most commonly occurred injuries, stress-induced injuries are vulnerable to bacterial infection, especially for those in phases III and IV. The injuries are also characterized by the loss of full thickness tissues, and exposure of fascia and muscle, which leads to severe complications,[5] even secondary bleeding infection, and mortality of patients with CCI.[6] Therefore, the effective management of stress-induced injuries will definitely improve the prognosis of patients with CCI. However, simple care of the wounds is rendered less effective due to the complicated mechanisms driving the formation of stress-induced injuries, especially for phases III and IV injuries. Currently, the most widely employed clinical method for the treatment of stress-induced injuries is vacuum sealing drainage (VSD) technique, which has the advantages of controlling wound infections by draining wound excretion and accelerating the growth of

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granulation tissues.[7] Nevertheless, the treatment efficacy of the technique will be impaired by the blocking of tubes by wound tissues and excretion. In addition, VSD technique is also weak in the mechanical stretching of wounds, which will also influence the healing of wounds. To improve the treatment outcomes of VSD technique, numerous approaches have been combined used with the technique to test the potential of the concatenated application of different strategies in handling stress-induced injuries. Of which, skin-stretching device (SSD) is an instrument that can enhance the mechanical stretching of skins and reduce the stretching of scar. The technique has been widely used in surgeries of plastic, burn, and orthopedics. However, few studies have reported the application of SSD in wound healing, not to mention its combined use with VSD technique in the treatment of stress-induced injuries for aged patients with CCI. Fortunately, in our hospital, such combined application has been employed for several years and achieved considerable outcomes in handing stress-induced injuries in aged patients with CCI. In the current study, we selected 35 cases treated with SSD combined with VSD technique and an equal number of patients with CCI treated with VSD technique only. The clinicopathologic and treatment outcome information of patients in both groups was collected and analyzed to evaluate the advantages of the combined method over the simple method. Based on the analysis, it was shown that the combined application of SSD with VSD technique showed an evidently stronger amelioration effect on phases III and IV stress-induced injuries in patients with CCI when compared with strategy using VSD technique only.

2. Methods

2.1. Patients

The clinicopathologic information of patients with ICC with III and IV stress-induced injuries was collected from ICU admissions from February 2015 to October 2017 in the Affiliated Hangzhou First People's Hospital, Zhejiang University School of Medicine. All the patients were diagnosed to be single pressure sore based on the criteria of Kottner et al.[8] Moreover, the sores were developed into muscular and bone layers. The patients with diabetes and unconsciousness were excluded from the final data set. Finally, 70 cases were collected in the present study. Of the 70 cases, 35 ones were treated with the combined application of SSD with VSD technique and were classified as treatment group. The other 35 cases were treated with VSD technique only and were classified as control group. The baseline information regarding the gender, age, wound conditions as well as bacterial infection was collected from the case history of all the patients and used for the analysis of the wound improvement effect between the 2 treatment strategies. All the patients included in the present study signed informed consents for the utilization of their history information. The study was approved by the ethic committee of the Affiliated Hangzhou First People's Hospital, Zhejiang University School of Medicine for the data collection of the patients (approve no: MEC-HFPH-2015-23). All works were undertaken following the provisions of the Declaration of Helsinki.

2.2. Treatment strategy

For patients in good conditions, necrotic tissues around wounds were completely removed, and then treated with SSD and VSD technique sequentially. For patients with bad health conditions, necrotic tissues around wounds were removed for several times, and then treated with SSD and VSD technique sequentially until none bacteria could be detected in the granulation tissues. The application of SSD was performed routinely: scar tissues as well as varus tissues around wounds were resected. Then 3 pairs of SSD were placed 3 cm distance from the both sides of the wounds. Two straight needles were inserted in the dermis of the opposite wound margins. Afterwards, the arms of the SSD were anchored behind these intradermal needles and the healthy skins were stretched for 3 minutes followed by 1 minute relaxation. The stretch-relaxation procedure was reported from 30 minutes and the maximum stretching force should not be stronger than 30 N. Afterwards, polyurethane foams were cut into 5 cm and placed under the SSD to cover the wound surfaces. Then the suction catheter was connected to a bottle that was connected to the adjustable central negative pressure system and the continuous negative pressure mode was set at −125 to −150 mm Hg. The VSD devices were renewed every 5 days and the conditions of wounds were evaluated based on granulation tissue growth and cleanliness. For the wounds with high granulation tissue growth and cleanliness, the stretch force was gradually strengthened to a maximum extent. The wounds were finally closed using subcutaneous absorbable synthetic sutures. For patients exhibiting satisfactory treatment outcomes, the stretching devices were removed 2 to 4 days after the treatment. For patients responding badly to the treatment, the combined treatment or VSD treatment was performed again. After the treatment, all the patients were cared under the same conditions. Both groups were cared by the experienced nurses instead of families and underwent same postsurgery treatments, including wound cleaning, and digestive tract and airway protection. All the patients were given nutrition support by providing 25 to 30 kcal/kg each to prevent anemia.

2.3. Treatment outcome measurement

The treatment outcomes of different strategies were evaluated by comparing the number of maximum healing 30, 60, and 90 days after the surgeries. Moreover, the information regarding the area of pressure sores, incidence of bleeding, bacteria amount, 28-day cure rate, peripheral C-reactive protein (CRP) level as well as the hospitalization duration was also collected and analyzed. The treatment outcome was assessed based on the criteria of NPUAP/EPuap Pressure Ulcer Classification System[9]: "significantly effective" was defined when the wound was completely healed and function exercise was achieved; "effective" was defined when the wound formed strip shape scars and showed normal color as well as blood supply; "ineffective" was defined when the wound was not healed.

2.4. Statistical analysis

Continuous data were expressed as the mean ± standard deviation and analyzed using Student *t* test. Categorical data were represented as frequency distributions or case numbers and analyzed using Chi-squared and Fisher exact tests. Statistical analyses were conducted using SPSS version 19.0 software (IBM, Armonk, NY) with a significant level of 0.05.

3. Results

3.1. Clinicopathologic baseline information

The detail clinicopathologic information of the 2 groups is shown in Table 1. The treatment group included 15 males and 20

Table 1

Baseline values of clinicopathologic information.

	Group (N)		*t*-value	χ^2 value	*P*-value
	Treatment (35)	Control (35)			
Gender, N					
Male	15	13	NA	0.53	.43
Female	20	22			
Age, yr	75.7 ± 7.59	77.5 ± 9.14	−0.906	NA	.36
Total pressure sore area, cm^2	71.22 ± 36.5	69.21 ± 34.26	1.731	NA	.13
Bacterial infection presurgery (N)	28	25	NA	0.951	.35

females, the average age of which was 75.7 ± 7.59 years old (ranging from 64 to 82 years old). The control group contained 13 males and 22 females, the average age of which was 77.5 ± 9.14 years old (range from 65 to 85 years old). No statistically significant difference was detected regarding gender ($P = .426$) and age ($P = .358$) between the 2 groups (Table 1). The average disease duration of treatment group was range from 1 to 13 months, which was similar to that of control group (disease duration: range from 1 to 10 months). The total wound numbers were 42 and 45 for treatment group and control group, respectively.

Regarding the positions of wounds, there were 16 cases having injuries at sacrococcygeal region, 12 cases at greater trochanter of femur, 6 cases at ischial tuberosity, 5 cases at lower back, and 3 cases at lower shoulder in treatment group, with the wound areas ranging from 3.2 × 4.6 cm to 10.3 × 12.4 cm. As for control group, there were 17 cases having injuries at sacrococcygeal region, 15 cases at greater trochanter of femur, 7 cases at ischial tuberosity, 4 cases at lower back, and 2 cases at lower shoulder, with the wound areas ranging from 3.5 × 4.2 cm to 11.1 × 10.4 cm. All the wounds were characterized by necrotic tissues and fascia exposure. A great proportion of the wounds were infected by bacteria and detail information of bacteria identification is shown in Table 1, and no significant difference was detected regarding the incidence of bacterial infection between the 2 groups (Table 1).

3.2. Combined application of SSD and VSD shorten the wound healing duration during a 90-day follow-up

The effect of the combined application of SSD and VSD on the wound healing duration was assessed by comparing the results with those solely treated with VSD technique. As shown in Table 2, the average healing duration of treatment group was shorter than that of control group, and the difference was statistically significant ($P < .05$). Moreover, the stronger effect of the combined strategy to promote wound healing was observed at the 30th day and 60th after the treatment (Table 2), further confirming the advantage of the combined application of SSD and VSD over VSD. For the 90-day follow-up, no significant difference regarding healing duration was detected between the 2 groups.

3.3. Combined application of SSD and VSD improved the prognosis of CCI and increased the rate of effective treatment

The treatment effect of the combined application of SSD and VSD was further evaluated by analyzing the total area of pressure sores, incidence of bleeding, bacteria amount, 28-day cure rate, peripheral CRP level as well as the hospitalization duration. As shown in Table 3, all the parameters in treatment group showed a better improvement when compared with control group. Additionally, based on the criteria of NPUAP/EPuap Pressure Ulcer Classification System, the overall effective rate of treatment group was 97.14%: including 18 "significantly effective" cases, 16 "effective" cases, and 1 "ineffective" case, which was much higher than that of control group (77.14%) ($P < .05$). Taken the above information together, the current results solidly demonstrated the stronger improvement effect on stress-induced injuries by SSD combined with VSD when compared with VSD only.

4. Discussion

Stress-induced injury is one of the most commonly diagnosed complications associated with CCI. The disorder is beyond simply pathologic wounds in skins or subcutaneous tissues. The stress-induced injures, especially III and IV pressure sores, are always characterized by bacteria infection[10,11] and are driven by complicated pathologic mechanisms.[12,13] Thus, the management of stress-induced injures with traditional wound care strategies with wound reconstruction surgeries is rendered less effective. This disadvantage is further enlarged for aged patients with CCI in that aged patients with CCI are always impaired by distinct medical complications, which results in their unsuitability

Table 2

Effect of treatments on wound healing.

	Group (N)		*t*-value	χ^2 value	*P*-value
	Treatment (35)	Control (35)			
Average healing duration, d	41 ± 3.84	60.03 ± 5.52	2.97	NA	.047
Healing no. in 30 d (N)	20	11	NA	5.69	.037
Healing no. in 60 d (N)	29	18	NA	7.84	.012
Healing no. in 90 d (N)	34	28	NA	5.08	.09

NA = not applicable.

Table 3

Effect of the 2 strategies on prognosis.

	Group (N)				
	Treatment (35)	Control (35)	*t*-value	χ^2 value	*P*-value
Total pressure sore area, cm^2	27.23 ± 6.13	45.37 ± 9.24	5.834	NA	.031
Bleeding incidence, %	2.86	5.71	NA	3.25	.045
Bacterial infection postsurgery (N)	10	17	NA	5.37	.037
28-d cure rate, %	57.14	31.43	NA	29.32	.003
Blood CRP, mg/L	9.23 ± 4.23	23.47 ± 6.14	NA	8.72	.027
Hospitalization duration, d	45.00 ± 3.23	63.00 ± 5.67	NA	13.34	.015

NA = not applicable.

for invasive surgeries.[14,15] Worse still, the complex conditions associated with stress-induced injuries also cast substantial obstacles to the reconstruction surgeries, which is devastating for aged patients with CCI and even causes mortality in patients. Due to the limitations of the current treatment methods in handling stress-induced injuries in aged patients with CCI, the development of novel and effective strategies is not only necessary, but also prompting.

The VSD technique can promote the growth of granulation tissues, eliminate necrotic tissues and effusion, and decrease the incidence of bacterial infection around wounds by increasing local blood perfusion. The administration of VSD will reduce edema and inflammation in wounds, which accelerates the healing of wounds. Due to the above advantages, the technique has been widely employed in the treatment of chronic wounds especially those induced by stress.[16–19] However, the effective treatment of VSD depends on the long-term administration and will lead to inaesthetic scars, making the subsequent reconstruction surgeries difficult. To promote the application of VSD technique, clinicians have tested numerous approaches for their potential to improve the treatment outcomes combined with VSD in handling stress-induced injuries in patients with CCI.

The SSD is a technique that can promote the healing of wounds via biologic and mechanical peristalsis. The technique has the advantage over traditional surgeries by healing wounds without subsequent reconstruction surgeries.[20,21] In recent years, SSD has been gradually applied in the fields of plastic, burn, and orthopedics and achieved considerable outcomes.[22] Taken the above information together, the present study combined VSD and SSD for the improvement of wounds in aged patients with CCI with phases III and IV stress-induced injuries. We believed that the concatenated application of the 2 techniques could not only promote the growth of granulation tissues, decrease the incidence of bacterial infection, but also close the wounds gradually, which would improve the treatment outcomes of phases III and IV stress-induced injuries.

The above hypothesis was supported by our investigation of the treatment outcomes of the combined use of the 2 techniques. It was found that the average wound healing time was significantly shorter in patients treated with SSD and VSD together when compared with those treated with VSD only. Regarding the prognosis of the patients in 2 groups: the total area of pressure sores, incidence of bleeding, bacteria amount, 28-day cure rate, peripheral CRP level as well as the hospitalization duration were all significantly lower or shorter in SSD- and VSD-treated groups. Moreover, the overall effective rate of SSD- and VSD-treated groups was 97.14%, which was much higher than that of control group (77.14%). The overall effective rate of the present study was in consistence with the data of the study of Choke et al,[23] further supporting our conclusion that the combined application of SSD and VSD could effectively promote the healing of phases III and IV stress-induced injuries in aged patients with CCI.

Collectively, the present study for the 1st assessed the effect of the combined application of VSD and SSD in the treatment of phases III and IV stress-induced injuries in aged patients with CCI. The analysis results showed that the combined application of the 2 techniques not only promoted the wound healing, but also improved the prognosis of the patients when compared with the treatment using VSD only. The findings outlined in the present study inferred that the concatenated use of the 2 techniques was a promising strategy for handling stress-induced injuries in clinic. However, the effective application SSD depends on the clinical experience of clinician and has no standard guidelines. Thus, to promote the practice application of the strategy, explorations with larger sample should be performed in the future.

Author contributions

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