Original Article
Effect of vacuum sealing drainage in osteofascial compartment syndrome

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Abstract: Objectives: To investigate the effect of vacuum sealing drainage in the patients with osteofascial compartment syndrome in comparison to conventional treatment. Methods: Fifty-two patients diagnosed with osteofascial compartment syndrome were enrolled in this study. They were randomly divided into two groups based on treatments: vacuum sealing drainage and conventional treatment. After operation, the length of hospital stay and antibiotics administration were recorded in the two groups, as well as swelling elimination and wound closure. Results: No significant difference was observed in terms of the baseline characteristics between the two groups. In contrast to conventional treatment group, the time of swelling elimination, wound closure, hospital stay and antibiotics application were reduced significantly in vacuum sealing drainage group. No allergic reactions or other side effects were observed after the application of vacuum sealing drainage material, indicating its safety. Conclusion: Vacuum sealing drainage is effective in treating osteofascial compartment syndrome with better clinical outcomes than conventional therapy.

Keywords: Vacuum sealing drainage, osteofascial compartment syndrome, comparison

Introduction
Osteofascial compartment syndrome (OCS) is a common complication after trauma [1]. The specific compartment pressure in fascial spaces increases after trauma induced by the ischemia of muscle or nerves [2]. After the diagnosis of OCS, the incision and decompression should be immediately applied, otherwise, this condition may lead to gangrene, crush syndrome, ischemic muscle spasm and other life-threatening syndromes [3]. However, the conventional incision and decompression therapy usually leads to excess wound exudation and thus requires frequent dressing change, which can cause lots of pain and discomfort of patients as well as increasing workload for healthcare givers [4]. Therefore, applying a proper decompression method plays an important role in controlling wound healing after the surgery. Vacuum sealing drainage (VSD) is widely used in treating soft tissue defects and preventing ulcerative wound infection. However, the report is limited on the application of VSD in OCS patients [5, 6]. In this study, we evaluated the effect of VSD in treating OCS compared to conventional therapy. As a result, the VSD therapy significantly improved wound healing with less antibiotics usage after surgery.

Patients and methods

Patients

Fifty-two patients diagnosed with OCS were enrolled in this study, hospitalized in the Department of Orthopedics in our hospital from January 2014 to December 2014. At admission, all of the patients suffered progressive pain and swelling in their limbs after trauma. Passive stretch pain and circulation disturbance were also observed. The symptoms were not ameliorated or even aggravated after limb elevation and/or microcirculation improvement [7, 8]. The study was conducted in accordance with the Declaration of Helsinki and approval of the Ethics Committee of the Second People’s Hospital of Nantong.

Patient assessment

Enrolled patients were randomly divided into two groups: Group A, VSD treatment; Group B,
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conventional treatment. In Group A, after the spinal epidural anesthesia, the compartment with OCS symptoms was incised for a thorough decompression. The usage of internal or external fixation at the fracture site was selected to obtain optimal stabilization. The wound was well covered with polyethylene alcohol hydration seaweed salt foam after skin suture. Then a biological semipermeable membrane was covered on top of the foam and the surrounding normal skin for sealing and fixing. After operation, a negative pressure drainage device was connected at the center of the foam material (the pressure was kept in 6.7~26.7 kPa [125~200 mm Hg]). Seven days after the operation, the covered foam material was removed and the incision was sutured or undergone skin grafting [9-11] (Figure 1). In Group B, similar to the operation in the group A, after preliminary debridement and decompression, the osteofascial compartment was open and covered with oil gauze and thick dressing in the conventional manner (Figure 2). And then internal or external fixation was applied to fix the broken bone. The incision was sutured or skin grafting was performed based on the severity of the wound. After surgery, the length of hospital stay and antibiotics administration were recorded in both groups, as well as the time for swelling elimination and wound closure.

Statistical analysis

Data were expressed as mean ± standard deviation (SD) and were analyzed using SPSS 19.0 software package (SPSS, Inc., Chicago, IL, USA). Statistical analysis was performed using Student’s t test for paired samples. The criterion of significance was a p value less than 0.05.

Results

Fifty-two patients were enrolled in this study and divided into two groups randomly (20 males and 6 females in each group). No significant differences existed with respect to the baseline characteristics (i.e. age and the time of occurrence of OCS) between the two groups. For example, in Group A, average age is 37.2 ± 6.1 years while the average age is 36.7 ± 7.9 in Group B (P > 0.05). When evaluated by the Gustilo classification, 12 cases were of Gustilo type II and 14 cases were of type III in Group A. And in Group B, 13 cases were of type II and 13 cases were of type III. Regarding the site of injury, there were 13 cases whose upper limb was injured, 13 cases whose lower limb was injured in Group A. And in Group B, there were 14 cases whose upper limb was injured, 12 cases whose lower limb was injured. The average wound area was 98.4 ± 7.2 cm² in Group A while it was 95.6 ± 8.1 cm² in Group B (P > 0.05) The average time of occurrence of OCS after trauma was 9.3 ± 3.4 hours in Group A while it was 11.2 ± 5.1 hours in Group B (P > 0.05) (Table 1). In this study, patients in both groups received a follow-up checkup one month after healing. No obvious local or systemic complications were found in all cases. Compared to group B, the time of swelling elimination, wound closure, hospital stay and antibiotics application were reduced significantly in group A (Table 2). No allergic reaction or other side effects were observed after the application of VSD material, indicating it is safe to use for this indication.

Discussion

The most effective therapy of osteofascial compartment syndrome is early diagnosis and early treatment. The symptoms of pain and swelling will occur soon after fracture of limbs. Once the “5P” sign appears (5P stands for painless, par-
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**Table 1.** Baseline characteristics of enrolled patients

<table>
<thead>
<tr>
<th></th>
<th>Number of patients</th>
<th>Male/Female</th>
<th>Age (y)</th>
<th>Gustilo classification</th>
<th>Injury Site Limb</th>
<th>Would area (cm²)</th>
<th>The cost of time of operation (h)</th>
<th>The time of occurrence of OCS (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>26</td>
<td>20/6</td>
<td>37.2 ± 6.1</td>
<td>II 12 II 14</td>
<td>13 13</td>
<td>98.4 ± 7.2</td>
<td>2.6 ± 0.7</td>
<td>9.3 ± 3.4</td>
</tr>
<tr>
<td>Group B</td>
<td>26</td>
<td>20/6</td>
<td>36.7 ± 7.9</td>
<td>II 12 II 14</td>
<td>14 12</td>
<td>95.6 ± 8.1</td>
<td>2.3 ± 0.6</td>
<td>11.2 ± 5.1</td>
</tr>
<tr>
<td><em>P value</em></td>
<td>&gt; 0.05</td>
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</table>

**Table 2.** The comparison of the use of time (days) in each index in two groups

<table>
<thead>
<tr>
<th></th>
<th>Wound closure</th>
<th>Hospital stay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>9.0 ± 2.2</td>
<td>11.8 ± 3.6</td>
</tr>
<tr>
<td>Group B</td>
<td>14.2 ± 5.0*</td>
<td>26.2 ± 5.4*</td>
</tr>
</tbody>
</table>

*P < 0.05, Group A vs Group B.

Esthesia, paralysis, no pulse and pale), ischemic muscle spasms are possible to follow, which can be life threatening [12-14]. With respect to early diagnosis, measurement of limb tissue pressure and comparison with the reference pressure are necessary. Under normal circumstances, the forearm tissue pressure is within the range of around 9 mmHg to 15 mm Hg in the shank. Once the tissue pressure reaches more than 20 mm Hg, surgical intervention is required [15, 16].

The principles of vacuum sealing drainage are: (1) continuous negative pressure would alleviate wound exudation in a timely manner to prevent potential lacuna formation. Additionally, negative pressure can improve local microcirculation and stimulate the growth of granulation tissue; (2) the ability to keep the wound closed can prevent infection and help restore skin tissue integrity; (3) the medical foam (VSD material) is able to achieve the thorough wound drainage. Meanwhile, the drainage tube is not easily blocked by the foam material after segmentation and fixation [17-20]. The VSD therapy shows rapid decompression, swelling elimination with improve blood circulation and sterilization of wound. Due to the advantages mentioned above, VSD is widely applied in treating soft tissue defects and preventing ulcerative wound infection [21]. In this study, the effect of VSD was explored in patients with OCS. The time frame for swelling elimination, wound healing, hospital stay and antibiotics application was significantly reduced in OCS patients treated with VSD. In addition, the infection rate in VSD treated group was lower than that in conventional treatment group. Our results are consistent with what have been previously reported, further confirming the applicable value of VSD in treating OCS. In addition, our study also investigated the possible side effects of VSD material. During the treatment period, patients did not show any allergic reactions or any other side effects, indicating that the VSD material is safe for OCS usage.

In our study, the clinical significance of the negative pressure drainage in OCS decompression is obvious. The advantages of the negative pressure drainage are several folds. First, the sealed condition can prevent external bacteria invasion. Second, the continued negative pressure removes the natural culture medium for bacteria and stimulates tissue proliferation and repair. Third, the decrease of the compartmental pressure alleviates the swelling of the limbs and enhances blood circulation. Lastly, the reduced toxin absorption in the wound area can enhance the resistance to infection. The decompression in OCS must be done thoroughly and usually requires big incision, resulting in large wound area and excess exudation. The dressing needs to be changed frequently to prevent infection. Combined with declining patients’ compliance, the healing time is often prolong, not only increasing patients’ discomfort and pain, but also economic burden. The use of negative pressure drainage can rapidly reduce the osteofascial compartmental pressure in the limbs. The formation of negative pressure in the wound area can stimulate granulation tissue growth while reducing local toxin absorption. Meanwhile, the negative pressure also promotes blood circulation surrounding the wound. Overall, swelling of the limbs is reduced and OCS symptoms are alleviated. The conventional OCS treatment only plays a decompressing role without negative pressure formation in the osteofascial compartment. Therefore, the VSD treatment provides OCS patients with additional therapeutic effects by applying negative pressure to the wound area.

Osteofascial compartment syndrome is one of the serious early post-traumatic complications,
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often occurred after bone fracture in the lower legs and forearms. If not treated timely, OCS can lead to limb necrosis and/or other life threatening complications, such as acute kidney failure. Early diagnosis of OCS can be achieved according to injury causes and clinical signs. Surgical decompression is an effective way to treat fascial space syndrome. With complete decompression and appropriate treatment for bone fracture, the symptoms can be successfully relieved. Although mannitol treatment of compartment syndrome is valid, it is not suitable for the long-time observation. Some authors propose an operative time for 6~8 h after the onset. The appropriate and early surgery can, most of the time, restore limb function before circulatory disorder and neurological dysfunction occur.

Medical polymer polyvinyl alcohol hydration salt seaweed foam applied in vacuum sealing drainage (VSD) is used as a temporary skin substitute, which is non-cytotoxic with good biocompatibility and no skin irritation. The material does not degrade and no foam material enters the blood circulation. Combined with biological semipermeable membrane, porous silica tubes were available to the wound drainage. Negative pressure sucks away wound exudate and maintains fluid balance of the wound area, generating a moist environment, which effectively keeps the wound clean and inhibits bacterial growth. In addition, the absorption of toxins can be reduced thus preventing acute renal failure. Early compartment decompression will also prevent neuromuscular ischemic necrosis and permanent tissue damage. The vacuum also improves local microcirculation, promoting blood supply to the wound and removal of edema fluid thus facilitating the repair of damaged tissue. The VSD system serves as an effective and reliable drainage method to treat OCS.

In summary, VSD is effective in treating OCS patients by promoting postoperative wound healing, preventing wound infection and thus shortening the time of hospitalization. It provides a safe and effective therapy to achieve better clinical outcomes in OCS patients.

Disclosure of conflict of interest

None.

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References

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