Wounds with complicated shapes tend to develop infection during negative pressure wound therapy

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Abstract

Introduction: While negative pressure wound therapy (NPWP) has been shown to be useful, we felt that patients with wounds of complicated shapes were likely to develop infection during performing NPWT. We conducted an investigation to determine the factors of wound shape responsible for the occurrence of infection. **Materials and Methods:** A total of 55 patients with wounds were treated using NPWT in our unit in 2011. Eight whose wounds formed a pocket, 7 whose wounds were deep, and 40 whose wounds did not come under the above 2 types were eligible for this retrospective study. **Results:** Fifteen patients (27.3%) with NPWT showed a relapse of local infection. Six of the 8 patients (75.0%) in the wound with pocket group, 5 of the 7 (71.4%) in the deep wound group, and 4 of the 40 (10.0%) in the other wounds developed infection. The wound infection development ratio of the wound with pocket and deep wound groups was significantly higher than that of the other wound group. **Conclusion:** Wounds with complicated shapes are more likely to develop infectious complications during the management of NPWT. More careful observation is required when negative pressure therapy is used for wounds with a complicated shape.

Highlights: Wounds with complicated shapes are likely to develop infection during NPWT.

Key words: Wounds with complicated shapes, wound infection, negative pressure wound therapy, vacuum-assisted closure therapy, wound geometry

Abbreviations :

Negative pressure wound therapy, NPWT

Acknowlegments:none.

Running head: Complicated wound geometry develop infection during NPWT

Introduction

Negative pressure wound therapy (NPWT) of infected wounds has recently gained popularity among various surgical specialties [1-3]. This system is based on the application of negative pressure by controlled suction to the wound surface. The effectiveness of the NPWT for microcirculation and the promotion of granulation tissue proliferation owing to removing excessive exudates, increasing blood flow, and decreasing bacterial colonization has been verified. Thus, it has allowed uncomplicated wounds to heal quickly [4]. However, it sometimes leads to local wound infection, including: erythema, swelling, increased pain, exudates or pus, and fever, which can cause long-term distress for the patient, increase the hospitalization time, and, consequently, decrease the quality of life. In our experience, we have seen an increased tendency of wounds with complicated shapes to develop infection during NPWT.

The present study investigates this by comparing patients who underwent NPWT with deep wounds, wounds with large pockets, and shallow wounds without pockets.

Patients and Methods

NPWT has been employed in our department since 2011 as a device to bridge the period between debridement and definite surgical closure in full-thickness wounds. A total of 575 patients with wounds (acute wounds: 345, chronic wounds: 230) were treated in the Department of Plastic and Reconstructive Surgery, National Organization Nagasaki Medical Center, in 2011. Of these patients, 55 underwent negative pressure wound therapy using the Vacume-Assisted Closure

System (V.A.C.ATS®, KCI Inc. San Antonio,TX, USA). Wound diagnoses of patients who received NPWT are shown in Figure 1. All participants received surgical debridement, as well as nutrition and hemodynamic support. After debridement, cleansing and wet-to-dry dressing or continuous irrigation were performed for several days. After recognizing symptoms of infection disappeared, subatmospheric pressure (125 mmHg below ambient) was applied and transmitted to the wound continuously using a pump. We used black foam. In cases wounds formed a pocket with over-hanging skin, the form was not inserted to the pocket, but laid over the area of ulcer to stick the inner wall of pocket firmly each other.

The dressing foam was usually changed every 48 hours; however, this varied depending on the presence of infection. As no wounds showed inflammatory signs at the initiation of NPWT, no patients were administered antibiotics during NPWT use. The diagnosis of wound infection was based on the clinical signs and symptoms of the patient, including: erythema or skin discoloration, edema, warmth, induration, increased pain, purulent wound exudate, elevated temperature, and elevated white blood cell count.

Of these patients, 8 whose wounds formed a pocket with more than 1 cm of over-hanging skin (wound with pocket group), 7 whose wounds were deep, extending to the bone or penetrating into the muscle (deep wound group), and 40 whose shallow wounds were without a pockets (other group) were eligible for this retrospective study (Figure 2). In this study, wound with pocket group was defined as having a more than 1 cm of over-hanging skin to differentiate wounds with pocket

from those with thick rolled wound margin, but without undermining pocket.. All information was obtained from patients' medical records, examination, and interview at the first examination.

Results

Fifteen of the 55 patients (27.3%) with NPWT showed a relapse of local infection. Patients developing infection ranged in age from 31 to 84 years (mean age, 57.5 years), and patients without infection ranged in age from 8 to 95 years (mean age, 51.5 years) (no significant difference, Wilcoxon rank sum test). The etiology of wounds in patients with and without wound infection is shown in Table 1. There was no significant difference between the groups for each cause of wound ($p>0.05$, Chi-square test). The locations of wounds in patients with and without wound infection are shown in Table 2. There was no significant difference between the groups in each wound location ($p>0.05$, Chi-square test). Complications which may influence the development of infection, such as diabetes mellitus, renal failure, collagen disease, cancer, and steroid usage, in patients with and without wound infection are shown in Table 3. There was no significant difference between the groups for each complication ($p>0.05$, Chi-square test).

Six of the 8 patients (75.0%) in the wound with pocket group, 5 of the 7 (71.4%) in the deep wound group, and 4 of the 40 (10.0%) in the other group developed infection. The patients' sex, age, characters of wounds, location, and the interval between the start of NPWT and the development of infection are shown in the Table 4. The mean number of negative pressure wound therapy treatment days was 10 (range: 1 to 19). The wound infection development ratio of the wound with

pocket and other group revealed a significant difference ($p<0.01$, chi-square test). That of the deep wound and other group also revealed a significant difference ($p<0.05$, chi-square test).

Discussion

NPWT has become a widely accepted device to assist in optimizing the management of open wounds [1-3, 5]. The application of controlled subatmospheric pressure promotes wound healing by removing excessive exudates, increasing blood flow, and decreasing bacterial colonization [4, 6]. However, with the widespread use of this technique, some related complications after and during NPWT have been described, including: wound infection due to sponge retention, massive bleeding, infectious erosion of aorta, and severe soft tissue infection [17-10]. Our study showed that 27.3% of patients with NPWT had relapsed local infection. According to the wound shapes, wounds with complicated shapes were significantly more likely to develop infection compared to those with a simple shape.

Generally, all open wounds have bacteria and many wounds involve colonization, and the amount of bacteria can be minimized through adequate cleaning of the wound, absorption of drainage, and debridement if necessary [11]. Mouës et al. performed a clinical trial to compare the efficacy of vacuum therapy with conventional moist gauze therapy, and concluded that vacuum therapy does not decrease the number of bacteria colonizing the wound.[4] When a bacterial colony develops in an open wound during NPWT, it can be controlled by the removal of exdate, improvement of blood supply, and stimulation of the cellular proliferation of reparative granulation tissue [12]. However, these benefits of NPWT may cause the growth of a bacterial colony, resulting in the wound infection

in cases involving complicated shapes. The proliferation of granulation and tight contact owing to the negative pressure facilitate early wound adhesion, especially, in the inner wall of a pocket and narrow fistulae of a deep wound. This phenomenon may confine the bacterial colony to the granulation, which can represent a focus of infection, because an entrapped bacterial colony cannot be cleansed and exudate cannot be drained. Consequently, wound infection develops as the bacterial colony worsens to the critical colonization level (Figure 3). The same mechanism is thought to be a cause of deep wound infection. When early closure of the superficial layer of a deep wound occurs due to insufficient insertion of the sponge, the entrapped bacterial colony will induce wound infection (Figure 4). Citak et al. reported a case of necrotizing fasciitis in a patient who underwent NPWT for the treatment of a deep pressure ulcer, and concluded that the use of NPWT for grade four sores may have deleterious consequences for the patient [10]. This complication also developed in a case with a deep wound. The sponge should be inserted into the pocket while not allowing the walls to adhere to reduce the risk of wound infection. Besides, if foam removal is not performed properly, a retained piece of sponge may also result in a focus of wound infection (Figure 4) [4]. Careful washing and observation are required at dressing change.

We believe that only careful inspection on dressing change and the clinical monitoring of patients' conditions may prevent such local infection. We are not of the opinion that NPWT should never be applied for wounds with complicated shapes. However, when infectious signs are noted, cleansing, wet-to-dry dressing or irrigation, and surgical debridement if necessary should be performed

following discontinuation of NPWT. Negative pressure wound therapy with continuous irrigation should be recommended for the treatment of wounds with complicated shapes at first.

Conclusion

NPWT technique is a straightforward and effective means of wound management. However, complicated shapes of wound are more likely to develop infectious complications during the management of NPWT. More careful wound observation is required to discover the signs of infection in an early stage.

Disclosures: This manuscript has not benefited from any source of funding support or grant, and the authors have no conflicting financial interest.

Ethical Considerations: The procedures were in accordance with the Ethical Standards and Internal Review Board of our institutional committee (National Hospital Organization Nagasaki Medical Center) on human experimentation in 2011.

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Legends

Table 1: The cause of wounds in patients with and without wound infection

Table 2: The location of wounds in patients with and without wound infection

Table 3: The complications which influence on development of infection in patients with and without wound infection

Table 4: Cases of wound infection development during NPWT

Figure 1: Wound diagnosis in patients who received NPWT (N=55)

Figure 2: Wound shape in patients who received NPWT

Figure 3: Mechanism of infection development in wounds with a pocket during NPWT

Figure 4: Mechanism of infection development in deep wounds during NPWT

Table 1.
The cause of wounds in patients with and without wound infection

	Pressure ulcer	Infection	Trauma	Ischemia	Chronic ulcer
Infection (15)	6	6	1	1	1
Non-infection (40)	9	14	11	3	3

Table 2.
The location of wounds in patients with and without wound infection

	Buttock	Extrimities	Trunk
Infection (15)	7	6	2
Non-infection (40)	7	26	6

Table 3.
The complications which influence on development of infection in patients with and without wound infection

	Diabetes mellitus	Renal failure	Collagen disease	Cancer	Steroid usage
Infection (15)	8	1	1	3	1
Non-infection (40)	17	2	4	8	4

Table 4.
Cases of wound infection development during NPWT

Case	Shape of wound	Sex	Age	Wound	Location	NPWT duration (days)
1	Pocket	M	75	Pressure ulcer	Sacrum	15
2	Pocket	M	31	Pressure ulcer	Ischial tuberosity	19
3	Pocket	M	57	Pressure ulcer	Ischial tuberosity	14
4	Pocket	F	78	Sacral pressure ulcer	Sacrum	11
5	Pocket	M	43	Abscess	Iliopsoas	8
6	Pocket	M	54	Pressure ulcer	Sacrum	12
7	Deep	F	40	Oteomyelitis	Trochanter	10
8	Deep	F	72	Post-surgical wound infection	Abdomen	1
9	Deep	F	74	Oteomyelitis	Foot	11
10	Deep	M	61	Intra-muscular abscess	Thigh	10
11	Deep	F	54	Gas gangrene	Leg	3
12	Others	M	8	Laceration	Knee	14
13	Others	F	88	Ischemic necrosis	Toe	11
14	Others	M	70	Chronic ulcer	Leg	8
15	Others	M	65	Pressure ulcer	Heel	12

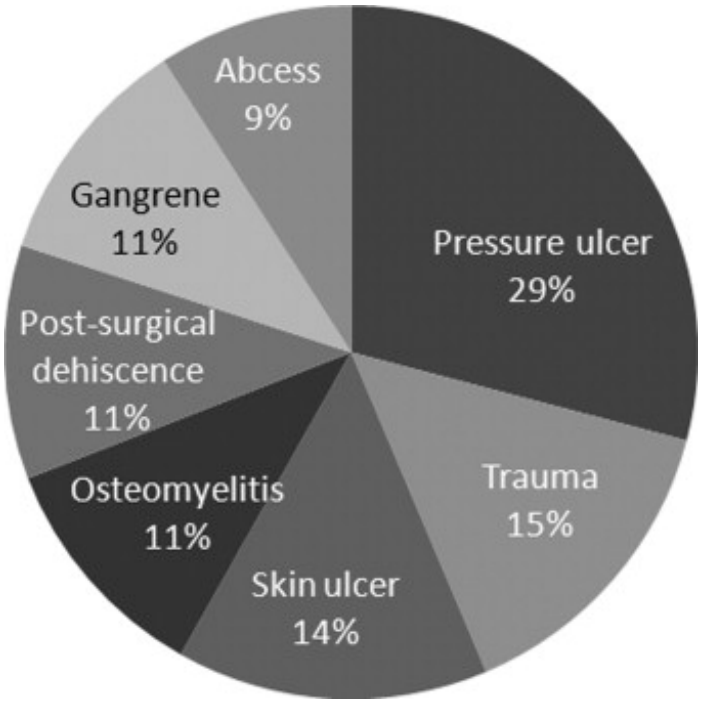

Figure 1: Wound diagnosis in patients who received NPWT (N=55)

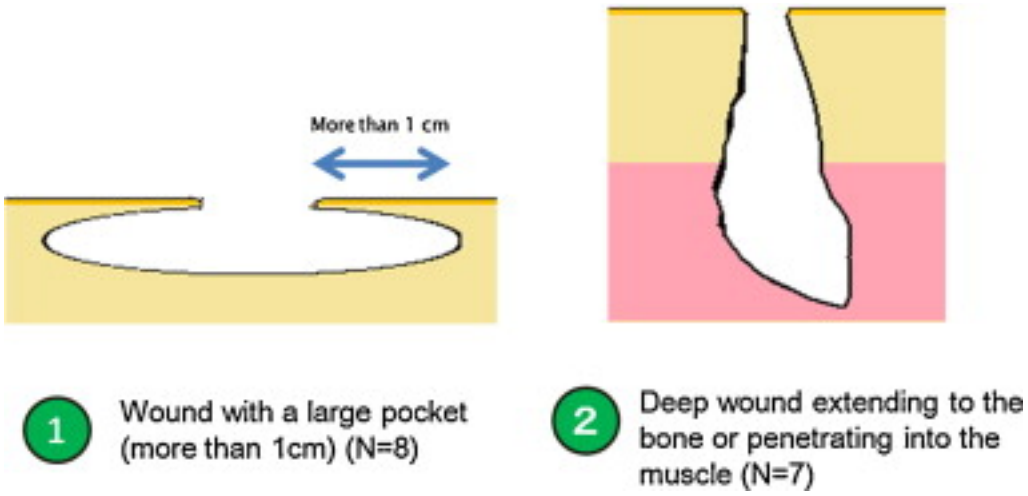

Figure 2: Wound shape in patients who received NPWT

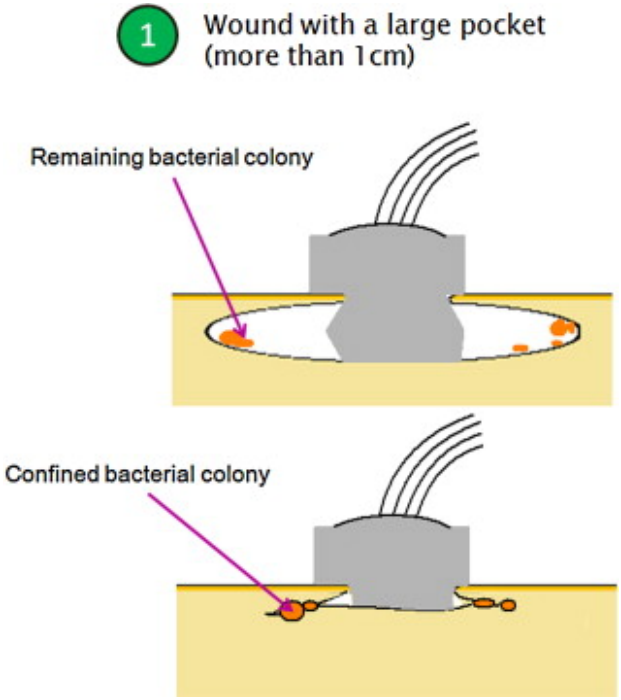

Figure 3: Mechanism of infection development in wounds with a pocket during NPWT

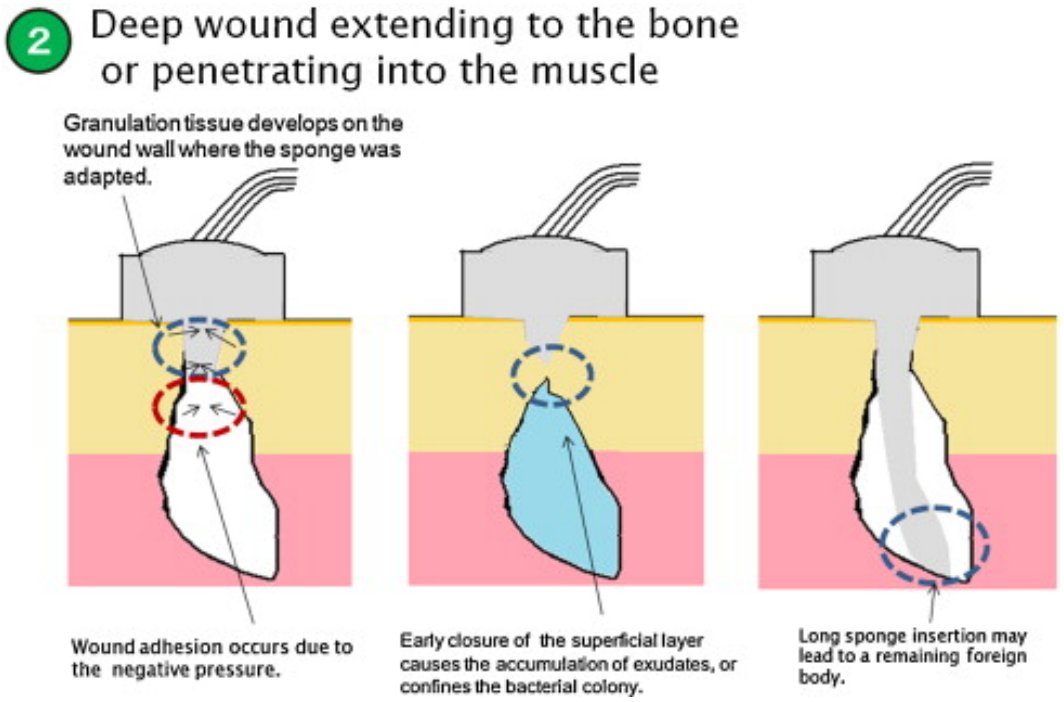

Figure 4: Mechanism of infection development in deep wounds during NPWT